



UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION II
101 MARIETTA STREET, N.W.
ATLANTA, GEORGIA 30323

ENCLOSURE 1

EXAMINATION REPORT - 50-325/OL-85-03

Facility Licensee: Carolina Power and Light Company
P. O. Box 1551
Raleigh, NC 27602

Facility Name: Brunswick Steam Electric Plant

Facility Docket Nos.: 50-325 and 50-324

Written, oral, and simulator examinations were administered at the Brunswick Steam Electric Plant near Southport, North Carolina.

Chief Examiner: John F. Munro 12/12/85
John F. Munro Date Signed

Approved by: Bruce A. Wilson 12/12/85
for Bruce A. Wilson, Section Chief Date Signed

Summary:

Examinations on October 7-10, 1985

Written and operating examinations were administered to seven candidates; five of whom passed.

8512270452 851219
PDR ADOCK 05000324
Q PDR

REPORT DETAILS

1. Facility Employees Contacted:

G. Barnes, Senior Specialist - Operator Training
*S. Morgan, Senior Specialist - Operator Training
*N. Stuart, Senior Specialist - Operator Training
W. Culver, Senior Specialist - Operator Training
L. Dunlap, Instructor (RTS)
*E. Bishop, Operations Manager
*A. Hegler, Operations Superintendent
*E. Enzor, Regulatory Compliance

*Attended Exit Meeting

2. Examiners:

*J. Munro
D. Stadler
B. Wilson
G. Sly (PNL)

*Chief Examiner

3. Examination Review Meeting

At the conclusion of the written examinations, the examiners provided N. Stuart with a copy of the written examination and answer key for review. No comments were made by the facility reviewers.

4. Exit Meeting

At the conclusion of the site visit the examiners met with representatives of the plant staff to discuss the results of the examination. Those individuals who clearly passed the oral examination were identified.

There were no generic weaknesses (greater than 75 percent of candidates giving incorrect answers to one examination topic) noted during the oral examination.

The cooperation given to the examiners and the effort to ensure an atmosphere in the control room conducive to oral examinations was also noted and appreciated.

The licensee did not identify as proprietary any of the material provided to or reviewed by the examiners.

MASTER COPY

ENCLOSURE 3

U. S. NUCLEAR REGULATORY COMMISSION
REACTOR OPERATOR LICENSE EXAMINATION

FACILITY: BRUNSWICK 1&2
REACTOR TYPE: BWR-GE4
DATE ADMINISTERED: 85/10/08
EXAMINER: KING, M.
APPLICANT: _____

INSTRUCTIONS TO APPLICANT:

Use separate paper for the answers. Write answers on one side only. Staple question sheet on top of the answer sheets. Points for each question are indicated in parentheses after the question. The passing grade requires at least 70% in each category and a final grade of at least 80%. Examination papers will be picked up six (6) hours after the examination starts.

CATEGORY	% OF	APPLICANT'S	% OF	CATEGORY
VALUE	TOTAL	SCORE	VALUE	
25.50	25.50			1. PRINCIPLES OF NUCLEAR POWER PLANT OPERATION, THERMODYNAMICS, HEAT TRANSFER AND FLUID FLOW
23.75	23.75			2. PLANT DESIGN INCLUDING SAFETY AND EMERGENCY SYSTEMS
25.50	25.50			3. INSTRUMENTS AND CONTROLS
25.25	25.25			4. PROCEDURES - NORMAL, ABNORMAL, EMERGENCY AND RADIOLOGICAL CONTROL
100.00	100.00			TOTALS

FINAL GRADE _____%

All work done on this examination is my own. I have neither given nor received aid.

APPLICANT'S SIGNATURE

QUESTION 1.01 (.50)

Why is it necessary to remove noncondensable gases from the main condenser ?

(0.5)

QUESTION 1.02 (2.00)

The reactor is operating at 75% power. Recirculation flow is subsequently increased to provide 100% power. Briefly explain the reactivity transient caused by the flow/power increase with emphasis on the following:

Provide Justification For transient Responses.

- a. Core void content
- b. Core reactivity

(1.0)

(1.0)

QUESTION 1.03 (2.00)

The reactor has been operating at high power for several weeks.

- a. How much thermal power, in MEGAWATTS, is being produced approximately 1 SECOND following a scram? After 1 MINUTE? (1.0)
- b. Why does this power NOT INDICATE on the nuclear instrumentation? (1.0)

QUESTION 1.04 (2.00)

- a. How does the percentage of delayed neutrons produced in the CORE vary over core life and WHY? (1.0)
- b. How do delayed neutrons contribute to the control capability of a commercial BWR reactor? (1.0)

QUESTION 1.05 (1.00)

Concerning control rod worths during a reactor startup from 100% PEAK XENON versus a startup under XENON-FREE conditions, which statement is correct?

(1.0)

- a. PERIPHERAL control rod worth will be LOWER during the PEAK XENON startup than during the XENON-FREE startup.
- b. CENTRAL control rod worth will be HIGHER during the PEAK XENON startup than during the XENON-FREE startup.
- c. BOTH control rod worths will be the SAME regardless of core Xenon conditions.
- d. PERIPHERAL control rod worth will be HIGHER during the PEAK XENON startup than during the XENON-FREE startup.

QUESTION 1.06 (2.00)

Explain why installed neutron sources are no longer required at BSEP during reactor startups (Your answer should include THREE sources of source neutrons currently present at BSEP)?

(2.0)

QUESTION 1.07 (2.00)

The reactor has been operating at 95% power for several days. An operator RAPIDLY reduces reactor power to 60% by reducing the speed of the recirculation pumps. During the next FEW MINUTES (2-3 minutes) the operator notices that reactor power slowly increases approximately 3% EXPLAIN the cause of this effect.

QUESTION 1.08 (2.50)

Fill in the blanks with one of the given choices in the paragraph below describing the INVERSE POWER RESPONSE to rod movements.

"As a shallow rod is inserted during power operation, the [a]_____ (INCREASED, DECREASED) void formation propagates all the way up to the top of the core, causing a reactivity [b]_____ (INCREASE, DECREASE) which more than offsets the reactivity [c]_____ (ADDITION, SUBTRACTION) due to the insertion of the control rod. The net effect is a small reactivity [d]_____ (INCREASE, DECREASE), resulting in a small [e]_____ (INCREASE, DECREASE) in reactor power." (2.5)

QUESTION 1.09 (1.50)

The reactor has been operating at 75% power for several days when power is increased to 100% power by recirculation flow. With no further operator action, Explain HOW and WHY reactor power will vary over the next several HOURS.
(Take your discussion to when reactivities have stabilized.)

QUESTION 1.10 (2.50)

Given the following plant (Unit 1) conditions:

Reactor power:	~100%
Reactor pressure:	~1010 psig
Throttle pressure:	~949 psig
Maximum combined flow limit:	normal setting
Load limit:	normal setting
Load set:	normal setting
Bypass valve capacity:	25%
Recirc flow control:	master manual
Bypass valve jack:	0% (closed)

Assume the EHC "A" pressure regulator fails low.
Using the enclosed EHC figures, explain the effects of the failure on each of the following:

- The bypass valves
- The control valves
- Reactor vessel pressure
- Throttle pressure
- Reactor power

(5 @ 0.5 ea.)

QUESTION 1.11 (1.00)

Which of the following correctly describes the Maximum Fraction of Limiting Power Density (MFLPD)?

- LHGR-actual / LHGR-limit ; must be maintained < 1
- LHGR-limit / LHGR-actual ; must be maintained > 1
- LHGR-limit / LHGR-actual ; must be maintained < 1
- LHGR-actual / LHGR-limit ; must be maintained > 1

QUESTION 1.12 (1.00)

When does a constant-speed centrifugal pump motor draw the LEAST current?

- a. at "runout" conditions
- b. at its "operating point"
- c. while "cavitating"
- d. at "shutoff head" conditions

QUESTION 1.13 (1.50)

Consider the following two cases (i and ii) during a reactor startup:

- i. The reactor is slightly subcritical ($k_{eff} = 0.995$)
- ii. The reactor is greatly subcritical ($k_{eff} = 0.950$)

Control rods are withdrawn adding a specific and equal amount of reactivity in each case.

Select the best answer from those provided to complete the following statements.

- a. The change in the count rate in the slightly subcritical reactor (i) would be _____ (greater than, less than, equal to) the change in count rate of the greatly subcritical reactor (ii).
- b. The rise in the count rate in the slightly subcritical reactor (i) would be _____ (faster, slower, the same) as the rise in count rate of the greatly subcritical reactor (ii).
- c. The time required to reach the equilibrium count rate in the slightly subcritical reactor (i) would be _____ (shorter, longer, ~~the same~~) as in the greatly subcritical reactor (ii).

equal to the
↓
time

than the
↑
than the

QUESTION 1.14 (1.00)

Which of the following actions will INCREASE BSEP's thermodynamic cycle efficiency?

- a. DECREASING power from 100% to 25% .
- b. LOWERING condenser vacuum from 29" to 25" .
- c. REMOVING a high pressure FW heater from service .
- d. DECREASING the amount of condensate depression .

QUESTION 1.15 (1.00)

CALCULATE the QUALITY of a 540 degree F vapor-liquid mixture whose specific enthalpy is 1175 BTU/lbm.

QUESTION 1.16 (2.00)

- a. DEFINE "Critical Power" .
- b. Which one of the following conditions would tend to INCREASE the Critical Power level assuming all other variables remain unchanged?
 - 1. inlet subcooling is DECREASED
 - 2. Reactor pressure is DECREASED
 - 3. The axial power peak is RAISED
 - 4. Coolant flow rate is DECREASED

QUESTION 2.01 (1.00)

During high power operation, a SLOW decrease in main condenser vacuum occurs. LIST FOUR (4) items (reasons) which could be causing this decrease.

(1.0)

QUESTION 2.02 (2.00)

Give TWO (2) design features that prevent the possibility of draining the water from the spent fuel storage pool below the top of the fuel stored there.

(2.0)

QUESTION 2.03 (3.00)

An automatic RCIC initiation has occurred. Subsequently, RCIC injection was automatically terminated due to high reactor water level.

- a. What component in the RCIC system functioned to terminate the injection? (0.5)
- b. Assuming no operator action, how will RCIC respond to a subsequent decreasing water level? (1.0)
- c. If a RCIC "Turbine Test" had been in progress when the initial automatic initiation signal had been received, how would the system have responded? (1.0)
- d. If, following the initiation, the RCIC turbine had tripped on overspeed, could it be reset from the Control Room? (0.5)

QUESTION 2.04 (3.00)

When a scram signal occurs at power, describe IN DETAIL how the Control Rod Drive and its associated Hydraulic Control Unit function to insert the control rod. As a MINIMUM in your answer include which components open, close, energize, deenergize, and what supplies the motive force for the ENTIRE rod travel.

(3.0)

QUESTION 2.05 (2.00)

Briefly, EXPLAIN HOW the HPCI System will respond to a valid auto initiation signal if the HPCI DC condensate pump (gland seal) trips on overload one minute after the initiation signal is received? Discuss what specifically happens in the HPCI System assuming NO OPERATOR ACTION and state whether the system will perform its intended function.

(2.0)

QUESTION 2.06 (.50)

Indicate whether the following statement is TRUE or FALSE.

Cooling water flow enters the CRD exhaust port and will leak past seals into the reactor vessel.

(0.5)

QUESTION 2.07 (1.00)

Which of the following is the only normally CLOSED valve in the RCIC steam supply flow path in the at power Standby lineup?

- a. Steam Supply Valve (FO45)
- b. Outboard Steam Isolation Valve (FO08)
- c. Turbine Trip Throttle Valve
- d. Turbine Governor Valve

QUESTION 2.08 (1.00)

Which of the following sequences of components correctly reflects the normal RCIC water flow path for injection into the Reactor for unit 11?

- a. CST - Pump - "B" FW Line, upstream of FW Flow detector
- b. CST - Pump - "B" FW Line, downstream of FW Flow detector
- c. CST - Pump - "A" FW Line, upstream of FW Flow detector
- d. CST - Pump - "A" FW Line, downstream of FW Flow detector

QUESTION 2.09 (1.00)

How would a loss of instrument air affect the operation of the Standby Liquid Control System (SBLC)?

- a. The SBLC tank level indication would be inoperable.
- b. The SBLC tank air sparger would be inoperable.
- c. The SBLC tank level indication and air sparger would be inoperable.
- d. It would have NO impact since the service air system supplies all SBLC needs.

QUESTION 2.10 (.50)

Reactor pressure is 900 psig and RHR-LPCI is running in response to a valid initiation signal. What is the approximate expected flow indication on the pump discharge flow meter on the 601 panel?

QUESTION 2.11 (1.00)

Reactor Feed Pump (RFP) turbine speed is controlled by either a Motor Speed Changer (MSC) or an Motor Gear Unit (MGU). The MGU ... (CHOOSE ONE)

- a. ... will control the RFP turbine's speed only if its speed signal is greater than that from the MSC.
- b. ... is normally used to control feed flow rate over a turbine speed of 0 - 5500 rpm.
- c. ... unlike the MSC, does NOT afford the capability of manual speed control by use of a local handwheel.
- d. ... will lock in place to prevent a ramp response to a false signal, if it loses its signal from the flow controller.

QUESTION 2.12 (1.00)

The Reactor Recirculation Pump seal cartridge assemblies consist of two sets of sealing surfaces and breakdown bushing assemblies. Failure of the #2 seal assembly at rated conditions would result in.....(CHOOSE ONE)

- a. ...an increase in #2 seal cavity pressure from approximately 500 psig to approximately 1000 psig.
- b. ...a decrease in #2 seal cavity pressure from approximately 500 psig to approximately 0 psig.
- c. ...an increase in #1 seal cavity pressure from approximately 500 psig to approximately 1000 psig.
- d. ...a decrease in #1 seal cavity pressure from approximately 500 psig to approximately 0 psig.

QUESTION 2.13 (2.25)

- a. The LPCS system design has features to protect piping from over pressure. To manually open the LPCS inboard and outboard isolation valves the correct sequence is.....(CHOOSE ONE) (1.0)
(ASSUME CS pumps are OFF and both valves are closed.)
 - 1. reactor pressure <410 psig, outboard then inboard
 - 2. reactor pressure <410 psig, inboard then outboard
 - 3. reactor pressure >410 psig, outboard then inboard
 - 4. reactor pressure >410 psig, inboard then outboard
- b. Describe the operation of the core spray sparger break detection system. Include in your answer WHERE pressure is physically sensed, WHAT delta pressures are sensed, the normal berton gauge (meter) reading (100% power) and the alarm berton gauge (meter) reading. (1.25)

QUESTION 2.14 (1.00)

Attached Figure 2 depicts the UPS power supply line-up and switch contact alignment for Unit 2 UPS with Inverter 2A supplying. Utilizing Figure 2 as a reference, describe what will AUTOMATICALLY occur if inverter output 2A is lost, ie, what is the new source of UPS power AND what switch contacts change positions?

(1.0)

QUESTION 2.15 (1.00)

Which of the following logic signal combinations most correctly detail the COMPLETE logic sequence for the automatic initiation of the RHR System in the LPCI Mode?

(1.0)

- a. Reactor vessel low level (LL #3)
-- or --
Drywell high pressure
- b. Reactor vessel low level (LL #3) with Reactor vessel low pressure
-- or --
Drywell high pressure with Reactor vessel low pressure
- c. Reactor vessel low level (LL #3) with Reactor vessel low pressure
-- or --
Drywell high pressure
- d. Reactor vessel low level (LL #3)
-- or --
Drywell high pressure with reactor vessel low pressure

QUESTION 2.16 (1.00)

There is a Check Valve and a Check Valve Bypass located in the discharge line immediately downstream of each Core Spray Pump. STATE the purpose of this Check Valve -AND- the Check Valve Bypass.

QUESTION 2.17 (~~2.00~~)

EXPLAIN how corrosion and fouling are MINIMIZED in the Vital Service Water header.

(0.5)

QUESTION 2.18 (1.00)

The recirculation Motor-generator (MG) oil system is in its normal lineup for power operations then the running AC oil pump(s) trip(s). The DC oil pump auto starts when the standby (S/B) AC oil pump(s) fail(s) to restore oil pressure above 20 psig. Which of the following statements is correct ?

- a. The AC S/B oil pump(s) AND the MG set drive motor have tripped
- b. The AC S/B oil pump(s) continue to run AND the MG set drive motor trips.
- c. The AC S/B oil pump(s) have tripped AND the MG set drive motor continues to run.
- d. The AC S/B oil pump(s) AND the MG set drive motor continue to run.

QUESTION 3.01 (2.00)

The plant is operating at 100% power. APRM channels A and C have failed high. You call the I&C Technician to investigate while the SS researches Tech. Specs. A Plant Auxiliary Operator wants to shift RPS B power supply to its alternate power source for training. WOULD you let him? EXPLAIN why or why not. Direct your answer toward system(s) response(s) instead of administrative requirements.

(2.0)

QUESTION 3.02 (3.00)

For each of the IRM (Intermediate Range Monitoring) range changes below, provide the following: (Mode switch is in STARTUP)

1. The indicated level on the NEW RANGE.
 2. All automatic actions initiated as a result of the indicated level on the NEW RANGE.
- a. Switching from range 5, reading 25, up to range 7. (1.5)
- b. Switching from range 6, reading 39, down to range 5. (1.5)

A copy of IRM scale readings is provided.

QUESTION 3.03 (2.00)

For each of the following, state whether a ROD BLOCK, HALF-SCRAM, FULL SCRAM, or NO PROTECTIVE ACTION is generated for that condition. NOTE: IF two or more actions are generated, i.e. rod block and a half-scrum, state the most severe, i.e. half-scrum. Assume NO operator actions.

- a. APRM A Downscale, Mode Switch in RUN (0.5)
- b. <11 LPRM inputs to APRM B, Mode Switch in STARTUP (0.5)
- c. Both Flow Conv. Units Upscale (>110% flow), Mode Switch in RUN (0.5)
- d. APRM C and D >20%, Mode Switch in STARTUP (0.5)

QUESTION 3.04 (2.50)

Answer the following questions about the Rod Worth Minimizer's control of rod movement, when the rod selected results in a select error.

- a. WHAT happens when the rod is withdrawn one notch? (0.5)
- b. Assuming the rod has been withdrawn one notch in "a" above, HOW much further can the rod be withdrawn and WHY? (0.5)
- c. WHAT happens when the rod is inserted and HOW far can it be inserted? (1.5)

QUESTION 3.05 (1.00)

WHAT are TWO automatic actions which should occur, OTHER THAN a Group 1 isolation, if Main Steam Line Radiation Monitors "A" and "B" reach their High-High trip setpoint? (2 @ 0.5)

QUESTION 3.06 (1.50)

Unit 2 is operating at 90% rated load with recirculation flow control in Master Manual, when RFP 2A trips. WHAT will be the response of the recirculation and flow control system with no operator action? INCLUDE final recirculation pump speeds AND any setpoints associated with your response. (1.5)

QUESTION 3.07 (2.00)

Given the following data for APRM Channel C:

LPRM Level:	A	B	C	D
Number of LPRM's assigned:	5	4	4	4
Number of LPRM's bypassed:	2	3	1	0

- a. If APRM Channel C selector switch on the local (back) panel was placed to the COUNT position, what would be the expected meter reading? (Show calculation) (1.0)
- b. Based on the above data, is APRM Channel C operable? Answer YES or NO and explain why. (1.0)

QUESTION 3.08 (1.00)

For the following situation, select the correct Feedwater Control System/plant response from the list (a through d) which follows. NO operator actions are taken.

The plant is operating at 100% power in three element control, when one of the steam flow detectors fails downscale. (1.0)

- a. Reactor water level decreases and stabilizes at a lower level.
- b. Reactor water level decreases and initiates a reactor scram.
- c. Reactor water level increases and stabilizes at a higher level.
- d. Reactor water level increases and initiates a turbine trip and Reactor Scram.

QUESTION 3.09 (2.00)

A LPCI initiation of RHR will open various valves. Two of the valves in each division have timers associated with them. WHAT valves are these and what is the purpose of the timers. (setpoint not required). (2 @ 1.0)

QUESTION 3.10 (3.00)

For each of the three normally closed valves in the HPCI steam supply:

- a. Identify the valve.
- b. Identify the specific signal that opens the valve.
(If no specific signal exist state so)
- c. Identify the motive (power) source for the valve.

(3 @ 1.0)

QUESTION 3.11 (1.00)

After completing a diesel generator (D.G.) test the operator inadvertently presses the EMERGENCY STOP button. Which ONE of the following statements is correct?.....

- a. The D.G. lockout relay will prevent the diesel from restarting until reset.
- b. The D.G. can be started by depressing the local start button.
- c. A D.G. auto-start signal will attempt to start the D.G. one time
- d. The D.G. can be started by depressing the control room start button.

QUESTION 3.12 (1.00)

Each core spray pump has indicating lamps associated with it. The white light, when illuminated indicates.....(choose one)

- a. loss of control power
- b. pump auto-start signal is over-ridden
- c. core spray pump 4160 V breaker is closed
- d. indicates pump-runout

(1.0)

QUESTION 3.13 (1.00)

Select which ONE of the following an operator does to increase VARS

- a. INCREASE generator speed
- b. INCREASE capacity factor
- c. INCREASE generator voltage
- d. INCREASE generator stator cooling (1.0)

QUESTION 3.14 (2.50)

Both the SRM & IRM compensate their detector signals with a unique type of discrimination process.

- a. WHAT type of radiation does the discriminator eliminate? (0.5)
- b. BRIEFLY DESCRIBE HOW each system, SRM & IRM, accomplish this task? (1.0)
- c. WHY is there a difference between the two (2) discrimination processes? (1.0)

QUESTION 4.01 (3.75)

- a. A fire of unknown sources breaks out in the Control Room resulting in heavy smoke. The Shift Foreman makes the decision to evacuate the Control Room. As the Unit Control Operator what are 8 actions you should take prior to leaving the Control Room (per AOP-32) ? (2.5)
- b. If you could take NO actions prior to leaving the Control Room, what actions should you take outside the Control Room and WHERE would you take them (per AOP-32)? (1.25)

QUESTION 4.02 (3.00)

- a. What are the two entry conditions for procedure EOP-01-LEP-03, Alternate Boron Injection ? (2 @ 0.5 ea.)
- b. List four systems that may be used per procedure LEP-03 to inject boron. (4 @ 0.5 ea.)

QUESTION 4.03 (1.00)

The Multiple Clearances, as described in AI-58 (Equipment Clearance Procedure),.....(choose one)

- a. CAN only be issued after a Master Clearance as been issued.
- b. CAN tag out several pieces of equipment for work by one individual.
- c. CANNOT be used on radwaste systems.
- d. CAN tag out equipment for two individuals.

QUESTION 4.04 (2.00)

OG-4, Engineered Safety Feature Operability, lists reasons when the ESF status board would have a green light lit for an ESF system. What are two reasons ? (2 @ 1.0 ea.)

QUESTION 4.05 (1.50)

OI-1, Operating Principles and Philosophy, defines the terms "shall", "should", and "may" as they apply to BSEP procedures. Briefly define these three terms per OI-1. (3 @ 0.50 ea.)

QUESTION 4.06 (1.00)

You may install an "operator aid" when professionally constructed and approved by.....(choose one)

- a. NRC licenced operator
- b. SF/SOS
- c. 2 SRO's
- d. Manager-Operations

QUESTION 4.07 (2.00)

A unit startup is in progress with the reactor at 9% power. APRM E is in bypass. IRM A becomes erratic and is placed into bypass by the operator.

Explain if the unit startup can or cannot continue by procedure. i.e. place mode switch to run, turbine roll up and sync.

(see supplemental material provided)

QUESTION 4.08 (3.50)

- a. The main turbine is on a roll up (increasing speed) to 1800 RPM. List FOUR conditions that could occur where the operator should "Trip the turbine" in accordance with GP-03 "Unit Startup and Synchronization". (Setpoints not required) (4 @ 0.5)
- b. After depressing the 100 rpm speed select push button for a turbine start-up, you should verify valve motion and light indication. Put the following in the order that you would see them per GP-03, Unit Startup and Synchronization. (6 @ 0.25)
1. Intercept valves #1 and 3 - open slowly
 2. Main stop valves #1,3, and 4 - open slowly
 3. Increasing speed light comes on
 4. Main stop valve #2 - begins to open
 5. Control valves - throttle open
 6. Intercept valves #2 & 4 - start to open

QUESTION 4.09 (1.00)

When placing RCIC in standby, the sequential steps are as follows:

1. Verify the steam supply outboard isolation valve, E51-F008 is closed.
2. Verify the steam supply inboard isolation valve, E51-F007 is closed.
3. Open the supply drain pot drain bypass valve, E51-F054.
4. Open the steam supply outboard isolation valve, E51-F008.
5. Slowly throttle open the steam supply inboard isolation valve E51-F007.

Why are you performing these steps, AND what are the consequences of opening F007 quickly ?

(1.0)

QUESTION 4.10 (1.00)

Level Detectors N036/N037 are not included in the EOP-01/UG caution (CAUTION #6) concerning high temperatures near the reference leg vertical runs. EXPLAIN WHY these instruments are EXCEPTED from this caution and WHEN, if ever, these instruments would develop excessive inaccuracies.

(See EOP-01-UG caution #6 attached)

QUESTION 4.11 (1.00)

Per the BSEP Radiological Emergency Plan:

- a. STATE the NORMAL OSC location. (0.5)
- b. STATE the NORMAL EOF location. (0.5)

QUESTION 4.12 (1.00)

EOP-01-UG states in caution #15 to open the SRV's in the following sequence: A, E, J, B, F, D, G, C, H. Explain WHY this sequence and WHY SRV's K and L are not on the list.

QUESTION 4.13 (1.50)

BSEP AOP-04.4, Jet Pump Failure, lists 6 symptoms of a jet pump failure. Three of the symptoms are:

- a. Decrease in generator megawatt output
- b. Increase in total core flow
- c. Recirculation loop flow increase in the loop with the failed jet pump.

Explain how a failed jet pump would cause each of the above (3) symptoms to occur.

QUESTION 4.14 (1.00)

An improper RBCCW system lineup could result in possible damage to the pumps and/or heat exchangers as stated in the "cautions" of the system operating procedure (OP-21). Which of the following lineups would minimize the likelihood of component damage over an extended operating period?

- a. Running one RBCCW pump with two RBCCW heat exchangers.
- b. Running two RBCCW pumps with two RBCCW heat exchangers.
- c. Running two RBCCW pumps with one RBCCW heat exchanger.
- d. Running two RBCCW pumps with three RBCCW heat exchangers.

QUESTION 4.15 (1.00)

BSEP procedure OP-25 (Unit II Main Steam System Operating Procedure) requires control rods to be withdrawn ^{in order} to open the first bypass valve to 20% when reactor pressure reaches 250 psig. Briefly EXPLAIN why this step is done.

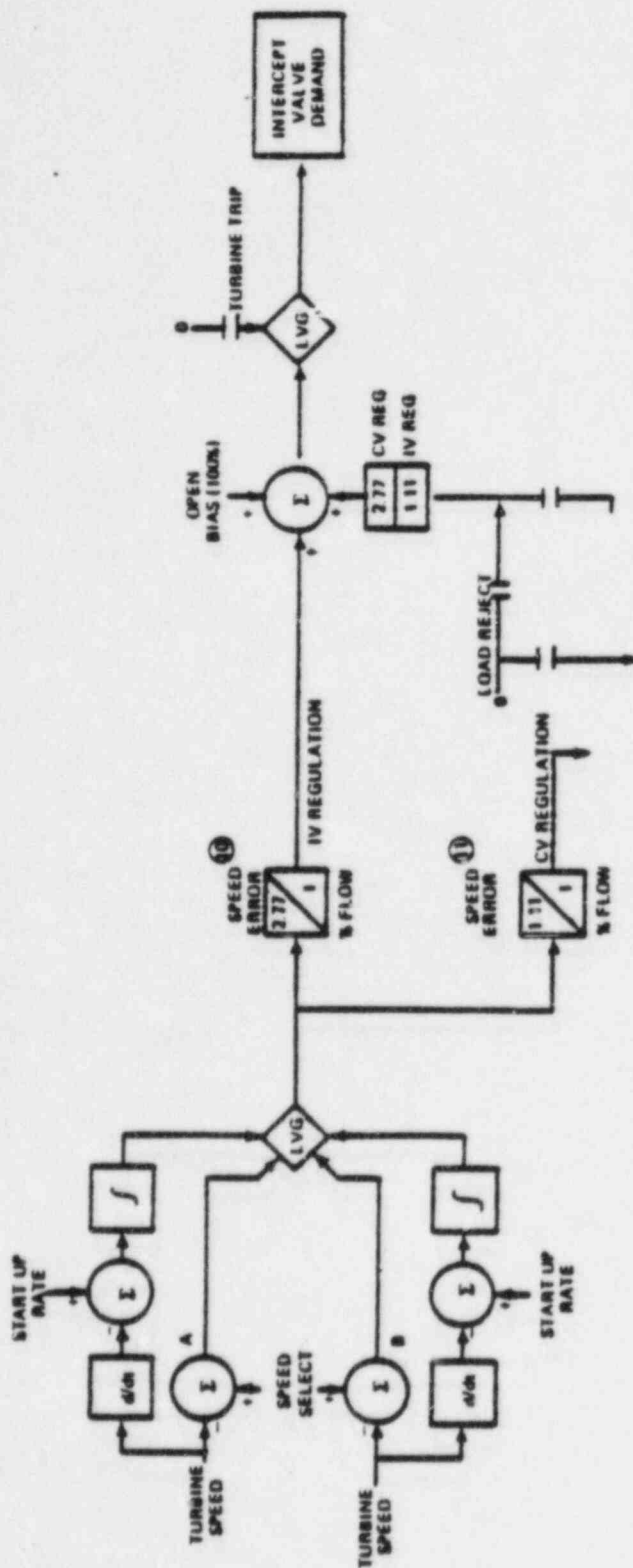


Figure 26.2-2 Speed Control Units

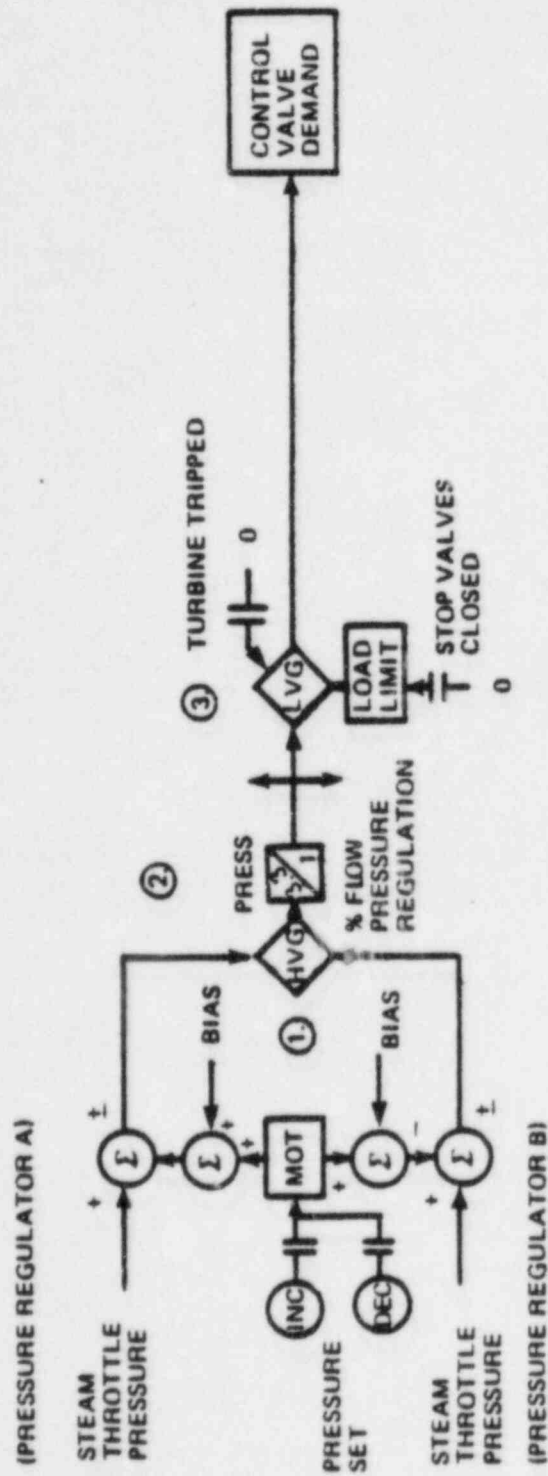


Figure 26.2-3 Pressure Control Units

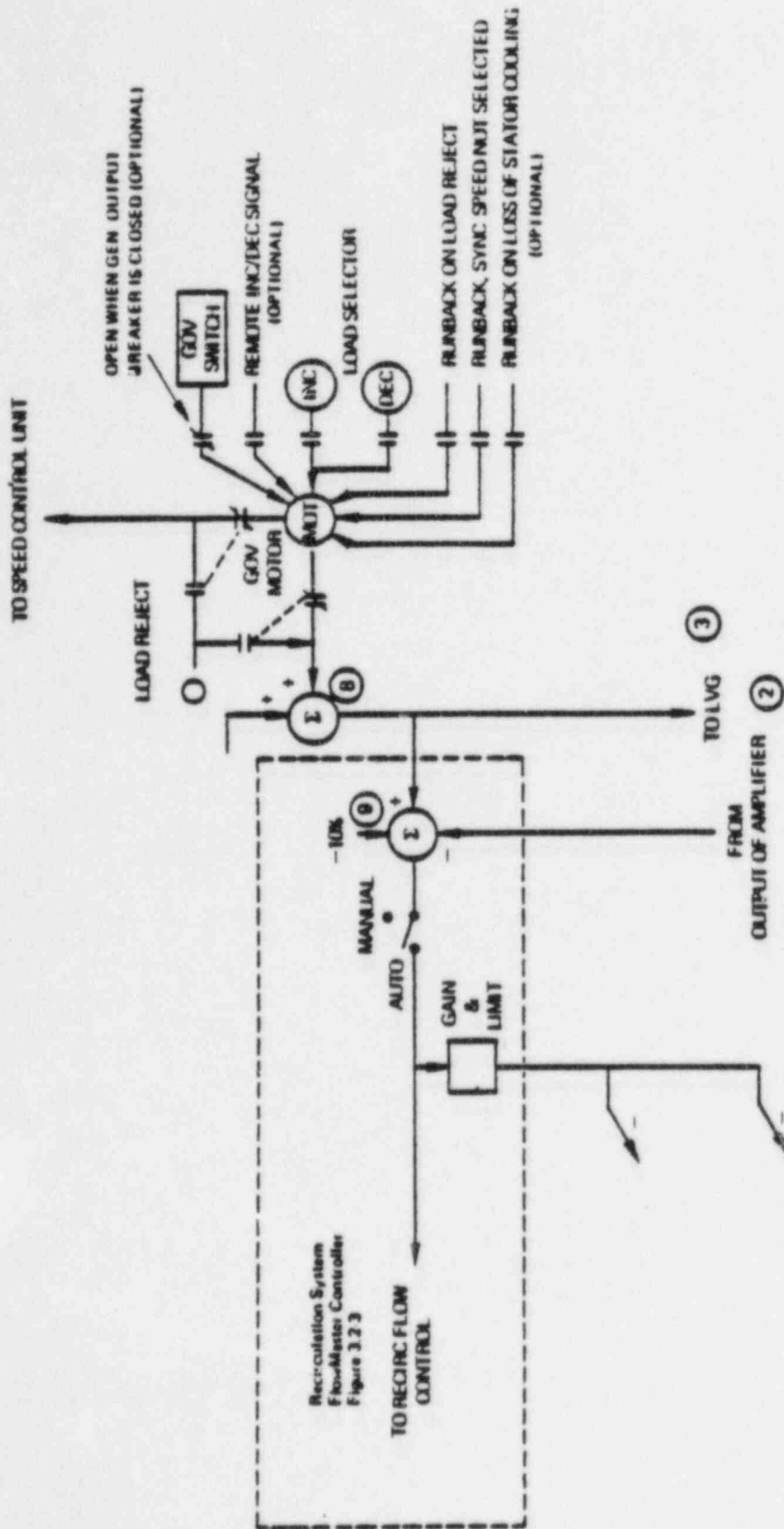


Figure 26.2-4 Load Control Unit

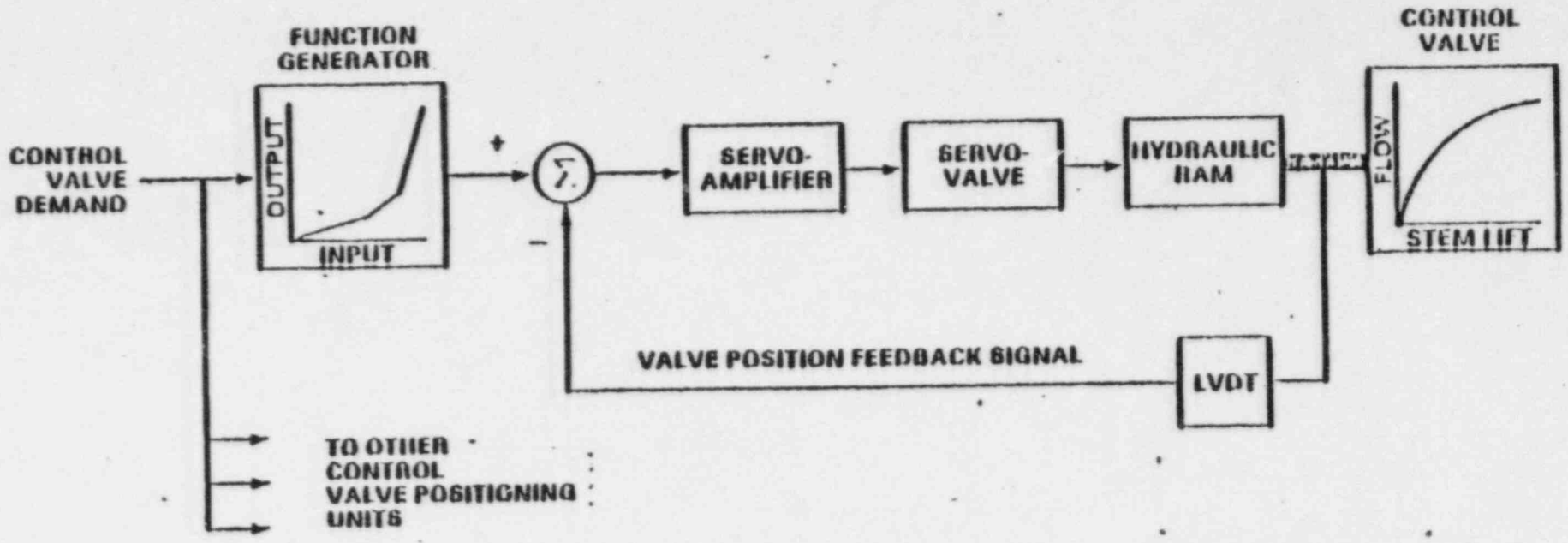


Figure 26.2-5 Control Valve Positioning Unit

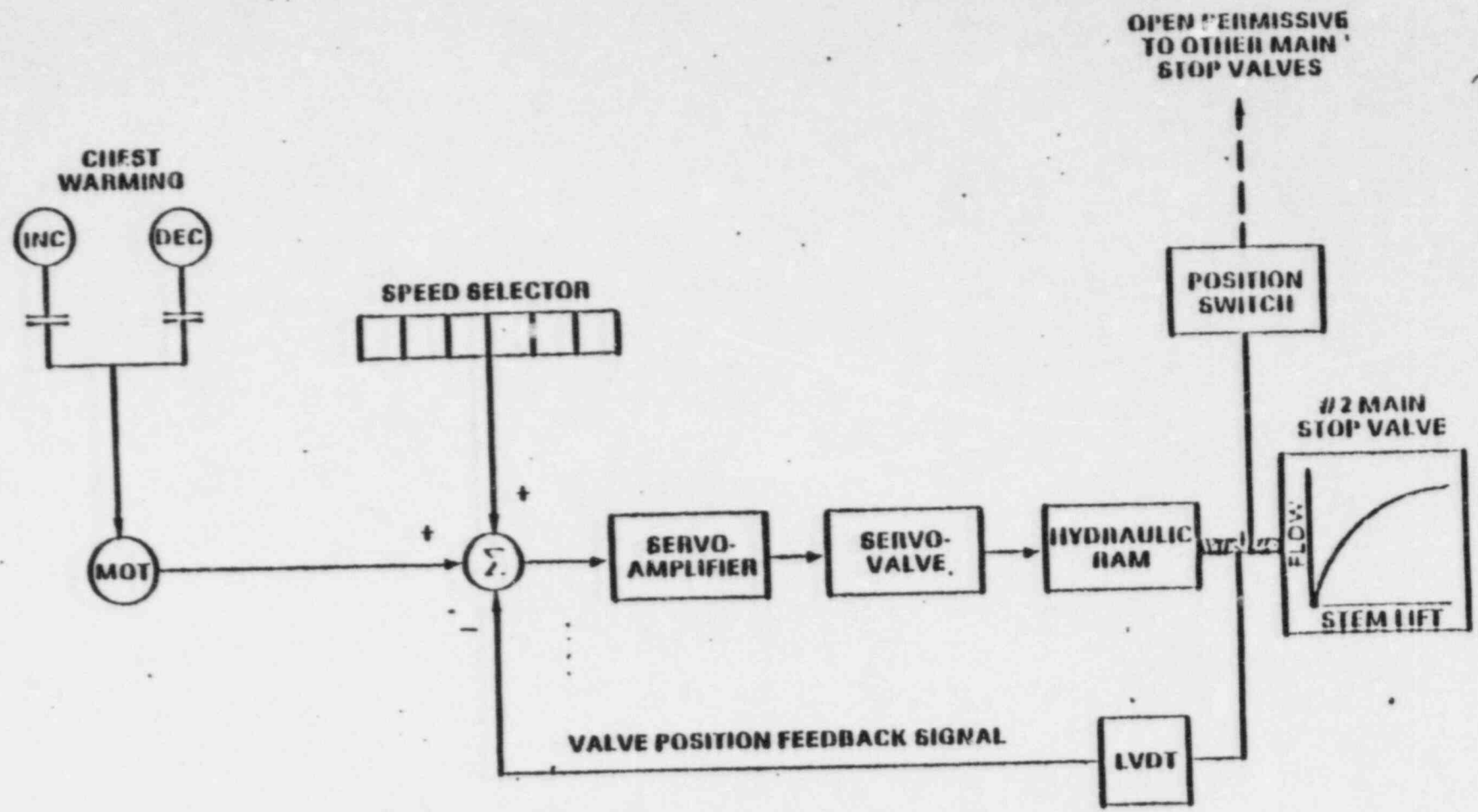


Figure 26.2-6 No. 2 Main Stop Valve Positioning Unit

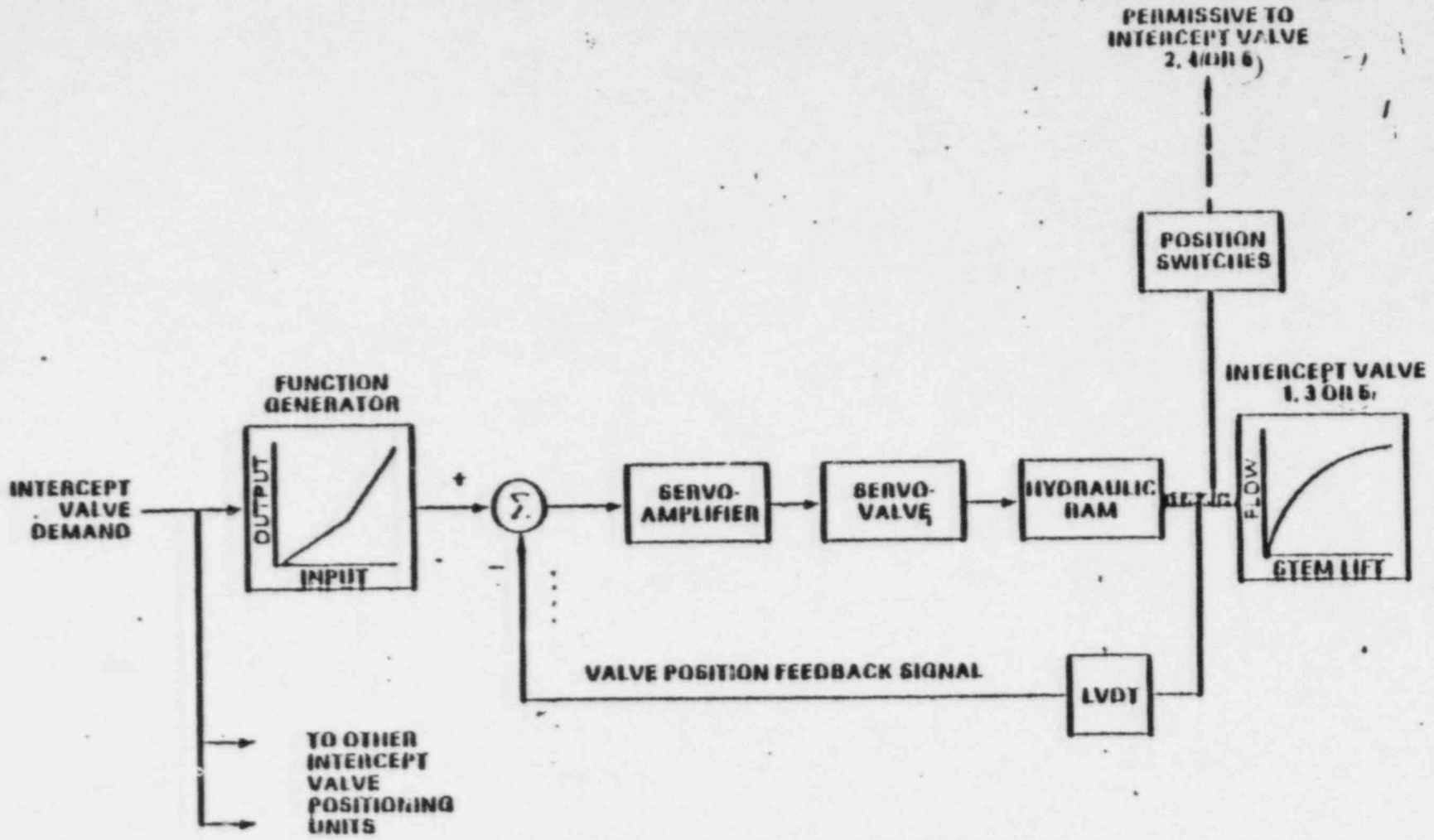


Figure 26.2-7 Intercept Valve Positioning Unit

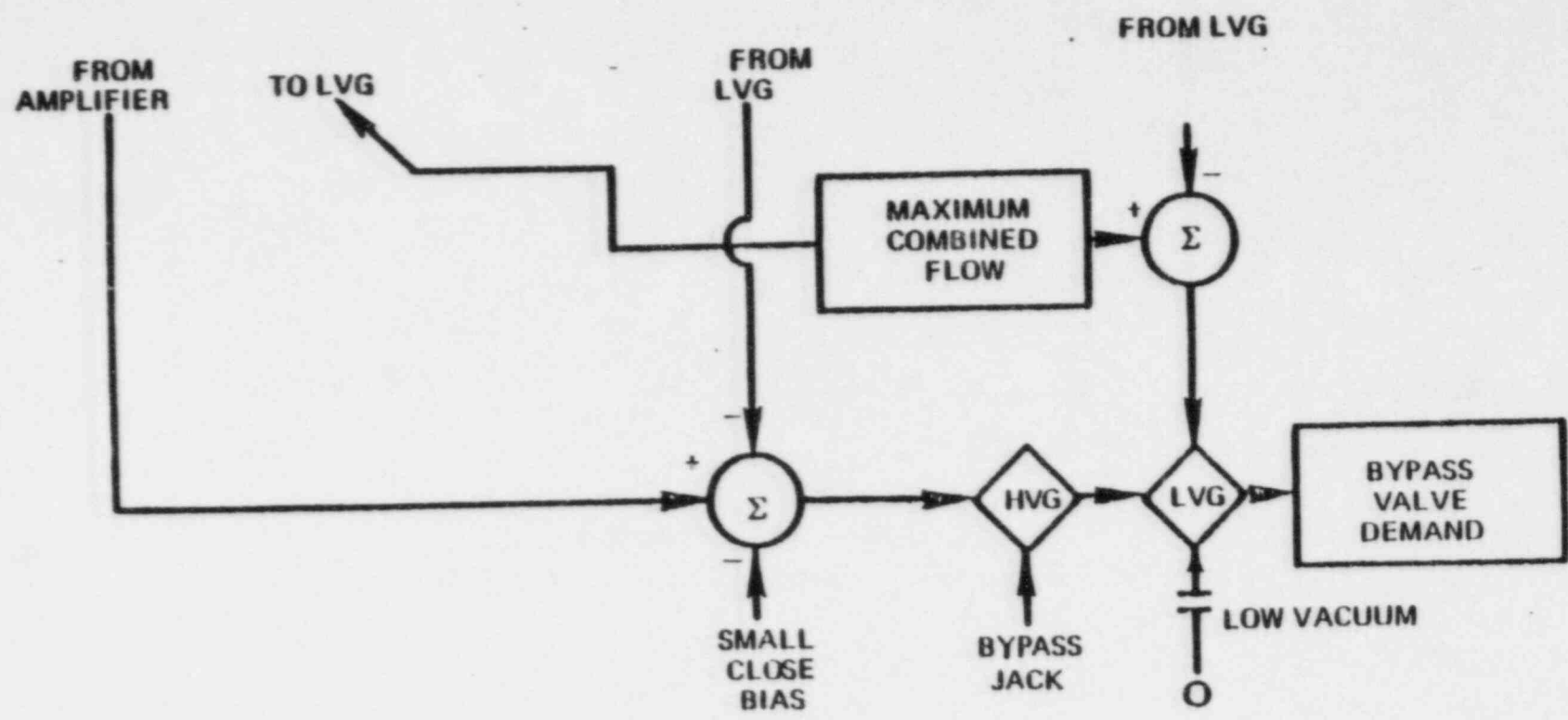


Figure 26.2-8 Bypass Valve Control Unit

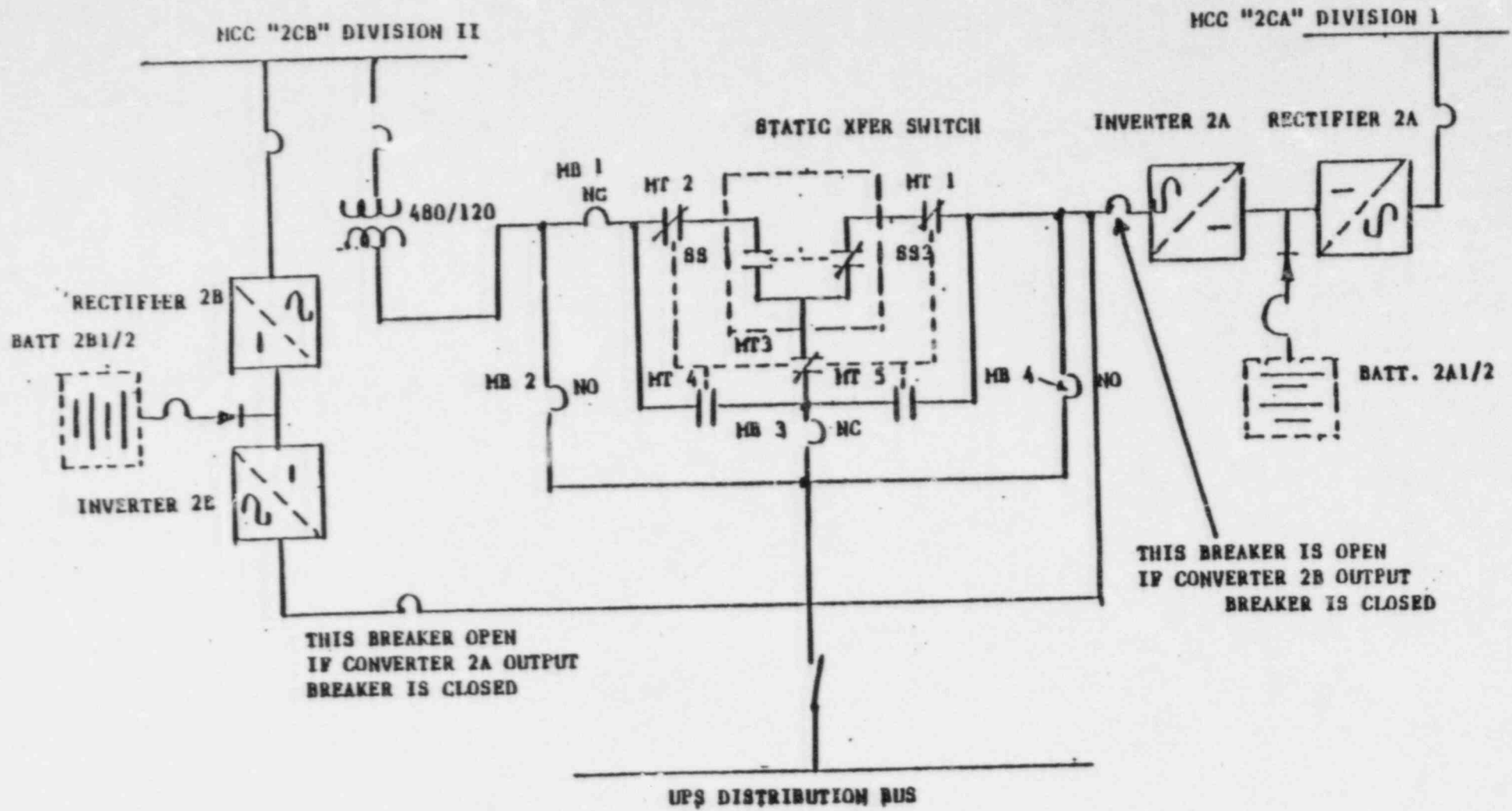


FIGURE 2
UNIT 2 UPS SYSTEM

FIGURE 8
IRM RANGE AND SCALE RELATIONSHIPS

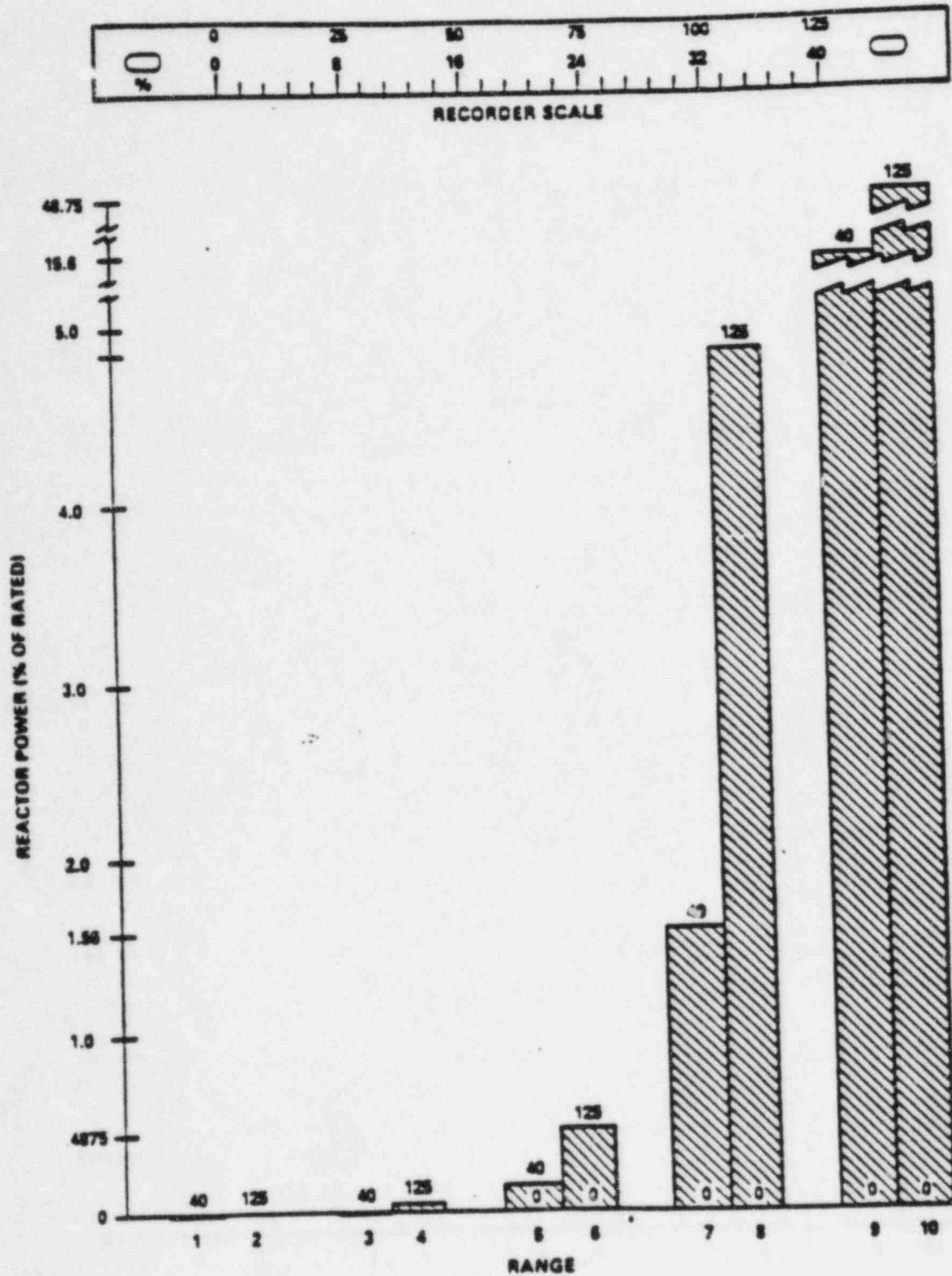


FIGURE 9

IRM ROD BLOCKS

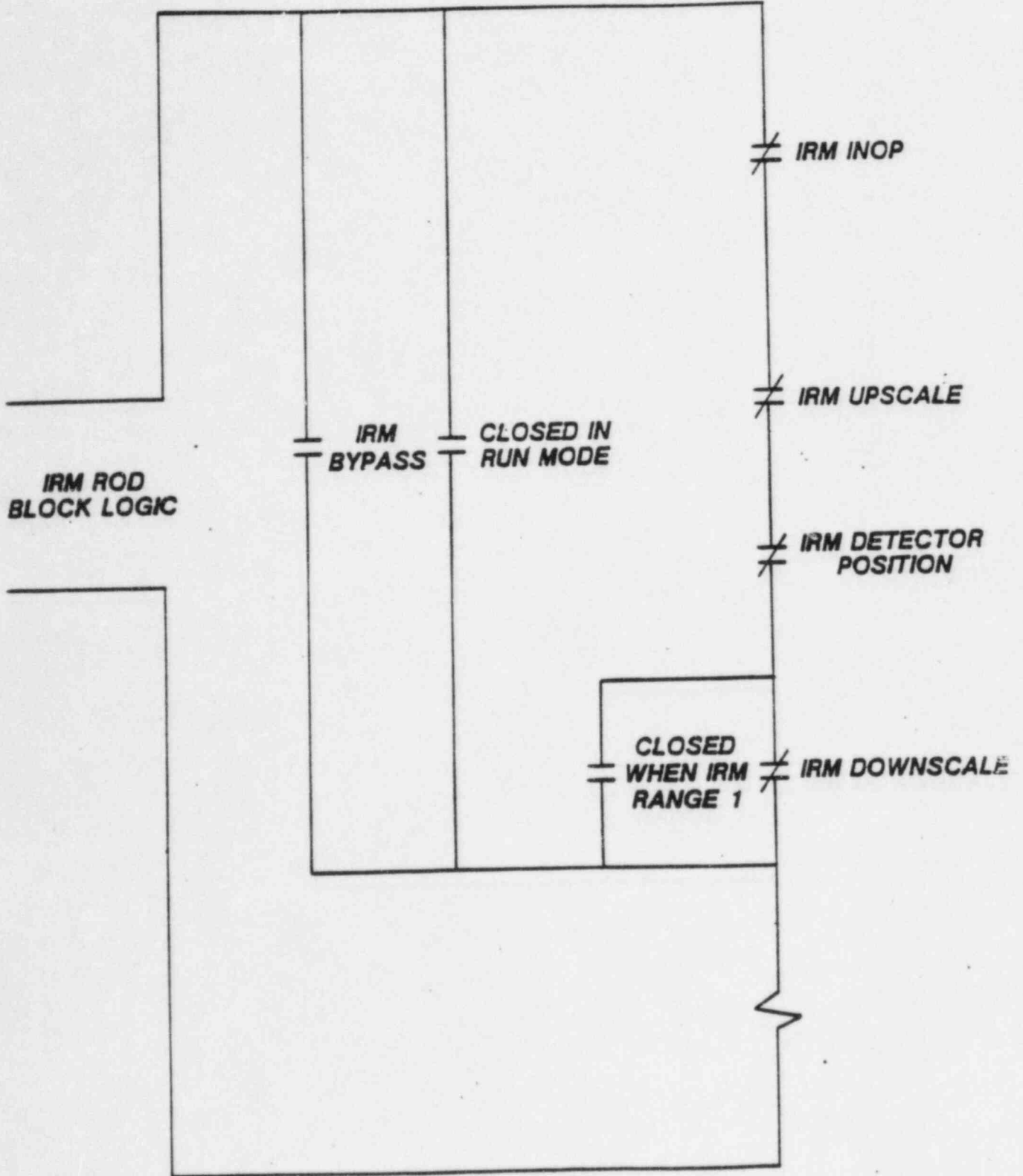
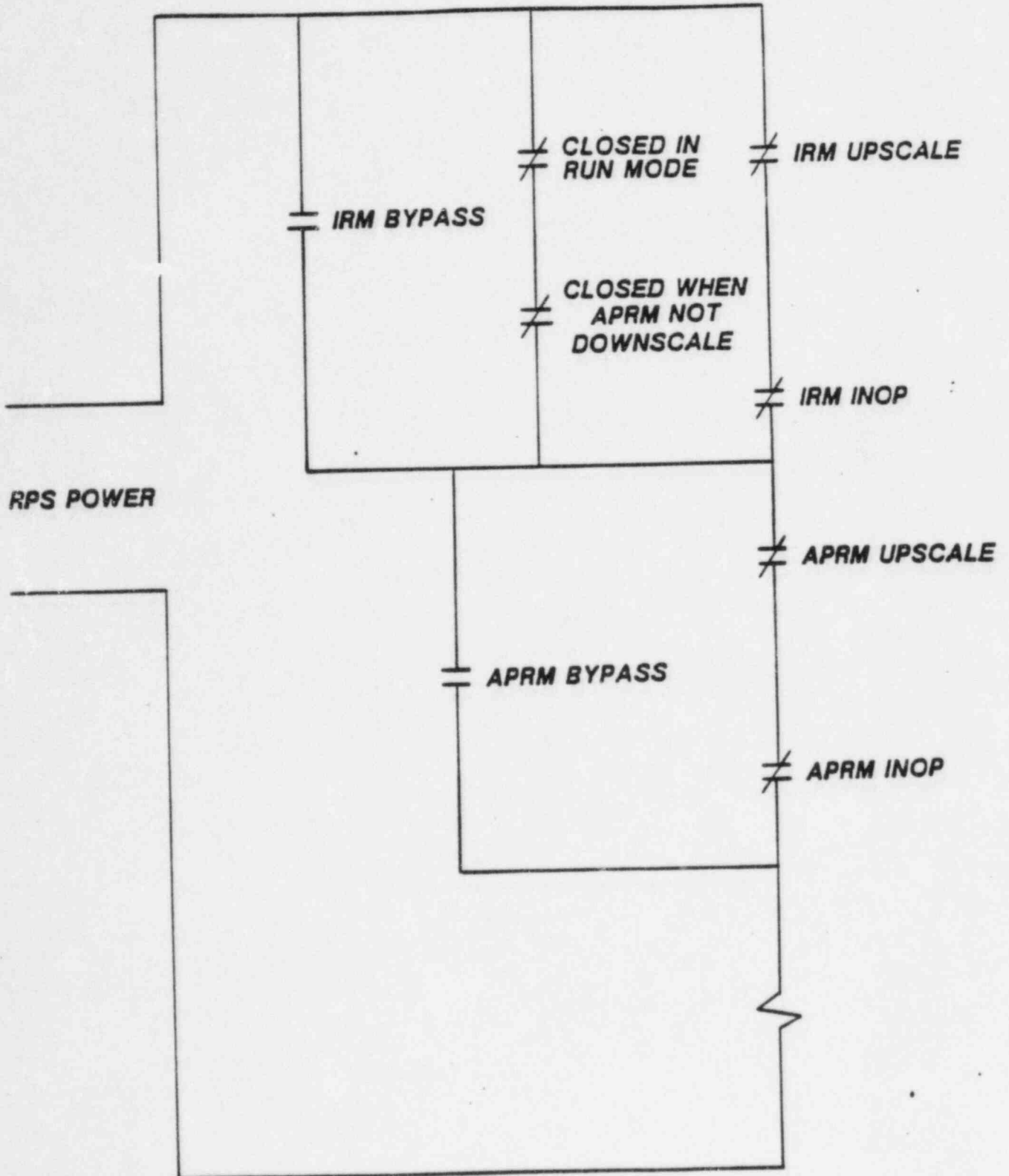


FIGURE 10

IRM/APRM SCRAMS



3/4.3 INSTRUMENTATION

3/4.3.1 REACTOR PROTECTION SYSTEM INSTRUMENTATION

LIMITING CONDITION FOR OPERATION

3.3.1 As a minimum, the reactor protection system instrumentation channels shown in Table 3.3.1-1 shall be OPERABLE with REACTOR PROTECTION SYSTEM RESPONSE TIME as shown in Table 3.3.1-2. Set points and interlocks are given in Table 2.2.1-1.

APPLICABILITY: As shown in Table 3.3.1-1.

ACTION:

- a. With the requirements for the minimum number of OPERABLE channels not satisfied for one trip system, place the inoperable channel(s) and/or trip system in the tripped condition* within one hour.
- b. With the requirements for the minimum number of OPERABLE channels not satisfied for both trip systems, place at least one trip system** in the tripped condition within one hour and take the ACTION required by Table 3.3.1-1.
- c. The provisions of Specification 3.0.3 are not applicable in OPERATIONAL CONDITION 5.

SURVEILLANCE REQUIREMENTS

4.3.1.1 Each reactor protection system instrumentation channel shall be demonstrated OPERABLE by the performance of the CHANNEL CHECK, CHANNEL CALIBRATION and CHANNEL FUNCTIONAL TEST operations during the OPERATIONAL CONDITIONS and at the frequencies shown in Table 4.3.1-1.

4.3.1.2 LOGIC SYSTEM FUNCTIONAL TESTS and simulated automatic operation of all channels shall be performed at least once per 18 months and shall include calibration of time delay relays and timers necessary for proper functioning of the trip system.

4.3.1.3 The REACTOR PROTECTION SYSTEM RESPONSE TIME of each reactor trip function of Table 3.3.1-2 shall be demonstrated to be within its limit at least once per 18 months. Each test shall include at least one logic train such that both logic trains are tested at least once per 36 months and one channel per function such that all channels are tested at least once every N times 18 months where N is the total number of redundant channels in a specific reactor trip function.

* An inoperable channel need not be placed in the tripped condition where this would cause the Trip Function to occur. In these cases, the inoperable channel shall be restored to OPERABLE status within 2 hours or the ACTION required by Table 3.3.1-1 for that Trip Function shall be taken.

** If more channels are inoperable in one trip system than in the other, place the trip system with more inoperable channels in the tripped condition, except when this would cause the Trip Function to occur.

TABLE 3.3.1-1

REACTOR PROTECTION SYSTEM INSTRUMENTATION

<u>FUNCTIONAL UNIT AND INSTRUMENT NUMBER</u>	<u>APPLICABLE OPERATIONAL CONDITIONS</u>	<u>MINIMUM NUMBER OPERABLE CHANNELS PER TRIP SYSTEM (a)</u>	<u>ACTION</u>
1. Intermediate Range Monitors: (C51-IRM-K601A,B,C,D,E,F,G,H)			
a. Neutron Flux - High	2, 5 ^(b) 3, 4	3 2	1 2
b. Inoperative	2, 5 3, 4	3 2	1 2
2. Average Power Range Monitor (C51-APRM-CH.A,B,C,D,E,F)			
a. Neutron Flux - High, 15%	2, 5 ^(b)	2	3
b. Flow Biased Neutron Flux - High	1	2	4
c. Fixed Neutron Flux - High, 120%	1	2	4
d. Inoperative	1, 2, 5	2	5
e. Downscale	1	2	4
f. LPRM	1, 2, 5	(c)	NA
3. Reactor Vessel Steam Dome Pressure - High (B21-PT-NO23A,B,C,D) (B21-PTM-NO23A-1,B-1,C-1,D-1)	1, 2 ^(d)	2	6
4. Reactor Vessel Water Level - Low, Level 1 (B21-LT-NO17A-1,B-1,C-1,D-1) (B21-LTM-NO17A-1,B-1,C-1,D-1)	1, 2	2	6
5. Main Steam Isolation Valve - Closure (B21-F022A,B,C,D and B21-F028A,B,C,D)	1	4	4
6. Main Steam Line Radiation - High (D12-RM-K603A,B,C,D)	1, 2 ^(d)	2	7

TABLE 3.3.1-1 (Continued)

REACTOR PROTECTION SYSTEM INSTRUMENTATION

<u>FUNCTIONAL UNIT AND INSTRUMENT NUMBER</u>	<u>APPLICABLE OPERATIONAL CONDITIONS</u>	<u>MINIMUM NUMBER OPERABLE CHANNELS PER TRIP SYSTEM (a)</u>	<u>ACTION</u>
7. Drywell Pressure - High (C72 PF-N002A,B,C,D) (C72 PCH-N002A-1,B-1,C-1,D-1)	1, 2 ^(e)	2	6
8. Scram Discharge Volume Water Level - High (C12-LSH-N01A,B,C,D) (C12-LSH-4516A,B,C,D)	1, 2, 5 ^(f)	2	5
9. Turbine Stop Valve - Closure (EHC-SVOS-1X, 2X, 3X, 4X)	1 ^(g) x x	4	8
10. Turbine Control Valve Fast Closure, Control Oil Pressure - Low (EHC-PSL-1756, 1757, 1758, 1759)	1 ^(g)	4	8
11. Reactor Mode Switch in Shutdown Position (C72A-S1)	1, 2, 3, 4, 5	1	9
12. Manual Scram (C72A-S1A,B)	1, 2, 3, 4, 5	1	10

TABLE 3.3.1-1 (Continued)

REACTOR PROTECTION SYSTEM INSTRUMENTATION

ACTION

- ACTION 1 - In CONDITION 2, be in at least HOT SHUTDOWN within 6 hours.
In CONDITION 5, suspend all operations involving CORE ALTERATIONS or positive reactivity changes and fully insert all insertable control rods within one hour.
- ACTION 2 - Lock the reactor mode switch in the Shutdown position within one hour.
- ACTION 3 - In OPERATIONAL CONDITION 2, be in at least HOT SHUTDOWN within 6 hours.
In OPERATIONAL CONDITION 5, suspend all operations involving CORE ALTERATIONS or positive reactivity changes and fully insert all insertable control rods within one hour.
- ACTION 4 - Be in at least START-UP within 2 hours.
- ACTION 5 - In OPERATIONAL CONDITION 1 or 2, be in at least HOT SHUTDOWN within 6 hours.
In OPERATIONAL CONDITION 5, suspend all operations involving CORE ALTERATIONS or positive reactivity changes and fully insert all insertable control rods within one hour.
- ACTION 6 - Be in at least HOT SHUTDOWN within 6 hours.
- ACTION 7 - Be in START-UP with the main steam line isolation valves closed within 2 hours or in at least HOT SHUTDOWN within 6 hours.
- ACTION 8 - Initiate a reduction in THERMAL POWER within 15 minutes and be at less than 30% of RATED THERMAL POWER within 2 hours.
- ACTION 9 - In OPERATIONAL CONDITION 1 or 2, be in at least HOT SHUTDOWN within 6 hours.
In OPERATIONAL CONDITION 3 or 4, immediately and at least once per 12 hours verify that all control rods are fully inserted.
In OPERATIONAL CONDITION 5, suspend all operations involving CORE ALTERATIONS or positive reactivity changes and fully insert all insertable control rods within one hour.

TABLE 3.3.1-1 (Continued)

REACTOR PROTECTION SYSTEM INSTRUMENTATION

- ACTION 10 - In OPERATIONAL CONDITION 1 or 2, be in at least HOT SHUTDOWN within 6 hours.
- In OPERATIONAL CONDITION 3 or 4, lock the reactor mode switch in the Shutdown position within one hour.
- In OPERATIONAL CONDITION 5, suspend all operations involving CORE ALTERATIONS or positive reactivity changes and fully insert all insertable control rods within one hour.

TABLE NOTATIONS

- a. A channel may be placed in an inoperable status for up to 2 hours for required surveillance without placing the trip system in the tripped condition, provided at least one OPERABLE channel in the same trip system is monitoring that parameter.
- b. The "shorting links" shall be removed from the RPS circuitry prior to and during the time any control rod is withdrawn* and during shutdown margin demonstrations.
- d. These functions are not required to be OPERABLE when the reactor pressure vessel head is unbolted or removed.
- e. This function is not required to be OPERABLE when PRIMARY CONTAINMENT INTEGRITY is not required.
- f. With any control rod withdrawn. Not applicable to control rods removed per Specification 3.9.10.1 or 3.9.10.2.
- g. These functions are bypassed when THERMAL POWER is less than 30% of RATED THERMAL POWER.

*Not required for control rods removed per Specification 3.9.10.1 or 3.9.10.2.

CAUTION #6

Whenever temperature near the level instrument reference leg vertical runs exceeds the temperature in the table and the instrument reads below the indicated level in the table, the actual RPV water level may be anywhere below the elevation of the lower instrument tap. (See detailed discussion in Section 9.1.)

<u>Temperature</u>	<u>Indicated Level</u>	<u>Instrument</u>
any	255"	N027 (Shutdown Range Level) 150-550 Inches Cold Reference Leg (Uncompensated)
304°F	170"	N004 (Narrow Range Level) 150-210 Inches Cold Reference Leg

Objective: Specify conditions under which RPV level instrument may provide misleading trend information.

CAUTION #13

Cooldown rates above 100°F/hr (RPV cooldown rate LCO) may be required to accomplish this step.

Objective: Inform the operator that rapid cooldown rates may result from the prescribed actions.

CAUTION #14

Do not depressurize the RPV below 120 psig (HPCI low pressure isolation setpoint) unless motor driven pumps sufficient to maintain RPV water level are running and available for injection.

Objective: Ensure a source of RPV makeup water is available following RPV depressurization.

CAUTION #15

Open SRV's in the following sequence if possible: A,E,J,B,F,D,G,C,H.

5.0 PROCEDURAL STEPS

5.1 Transferring The Reactor Mode Switch To RUN

5.1.1 Verify the following low steam line pressure relays are energized by observing they are pulled in from their stop screws.

On Panel H12-P609

5.1.1.1 A71-K4A

5.1.1.2 A71-K4C

On Panel H12-P611

5.1.1.3 A71-K4B

5.1.1.4 A71-K4D

*Note
to model
out*

5.1.2 Verify the following MSIV limit switch relays are energized by observing they are pulled in from their stop screws:

On Panel H12-P609

5.1.2.1 C71(72)-K3A

5.1.2.2 C71(72)-K3C

5.1.2.3 C71(72)-K3E

5.1.2.4 C71(72)-K3G

On Panel H12-P611

5.1.2.5 C71(72)-K3B

5.1.2.6 C71(72)-K3D

5.1.2.7 C71(72)-K3F

5.1.2.8 C71(72)-K3H

5.1.3 Increase power to 6-10% by withdrawing control rods in accordance with OP-07 in the sequence designated by GP-10, Rod Sequence Checkoff Sheets.

CAUTION

At least two APRM downscale and companion IRM upscale scram channels per RPS Trip System are required operable. Companion APRMs/IRMs are as follows:

Trip System A

APRM A AND IRM A

APRM C AND IRM C

APRM E AND IRM E

APRM G AND IRM G

Trip System B

APRM B AND IRM B

APRM D AND IRM D

APRM F AND IRM F

APRM H AND IRM H

5.1.4 Momentarily select each APRM channel on the IRM/APRM recorders and verify that all operable APRMs indicate between 3% and 10%.

5.0 PROCEDURAL STEPS

5.1 Transferring The Reactor Mode Switch To RUN

5.1.1 Verify the following low steam line pressure relays are energized by observing they are pulled in from their stop screws.

On Panel H12-P609

5.1.1.1 A71-K4A

5.1.1.2 A71-K4C

On Panel H12-P611

5.1.1.3 A71-K4B

5.1.1.4 A71-K4D

5.1.2 Verify the following MSIV limit switch relays are energized by observing they are pulled in from their stop screws:

On Panel H12-P609

5.1.2.1 C71(72)-K3A

5.1.2.2 C71(72)-K3C

5.1.2.3 C71(72)-K3E

5.1.2.4 C71(72)-K3G

On Panel H12-P611

5.1.2.5 C71(72)-K3B

5.1.2.6 C71(72)-K3D

5.1.2.7 C71(72)-K3F

5.1.2.8 C71(72)-K3H

5.1.3 Increase power to 6-10% by withdrawing control rods in accordance with OP-G7 in the sequence designated by GP-10, Rod Sequence Checkoff Sheets.

CAUTION

At least two APRM downscale and companion IRM upscale scram channels per RPS Trip System are required operable.

5.1.4 Momentarily select each APRM channel on the IRM/APRM recorders and verify that all operable APRMs indicate between 3% and 10%.

EQUATION SHEET

$$f = ma$$

$$v = s/t$$

$$\text{Cycle efficiency} = (\text{Net work out}) / (\text{Energy in})$$

$$w = mg$$

$$s = v_0 t + 1/2 at^2$$

$$E = mc^2$$

$$KE = 1/2 mv^2$$

$$a = (v_f - v_0)/t$$

$$\lambda = \lambda N$$

$$A = A_0 e^{-\lambda t}$$

$$PE = mgn$$

$$V_f = V_0 + at$$

$$w = a/t$$

$$\lambda = \ln 2 / t_{1/2} = 0.693 / t_{1/2}$$

$$t_{1/2}^{\text{eff}} = \frac{[(t_{1/2})(t_b)]}{[(t_{1/2}) + (t_b)]}$$

$$W = v \Delta P$$

$$A = \frac{\pi D^2}{4}$$

$$\Delta E = 931 \Delta m$$

$$\dot{m} = V_{av} A_0$$

$$I = I_0 e^{-\Sigma x}$$

$$\dot{Q} = mCp\Delta t$$

$$\dot{Q} = UA\Delta T$$

$$Pwr = W_f \Delta h$$

$$I = I_0 e^{-ux}$$

$$I = I_0 10^{-x/TVL}$$

$$TVL = 1.3/u$$

$$HVL = -0.693/u$$

$$P = P_0 10^{\text{SUR}(t)}$$

$$P = P_0 e^{t/T}$$

$$SUR = 26.06/T$$

$$SCR = S/(1 - K_{\text{eff}})$$

$$CR_x = S/(1 - K_{\text{eff}x})$$

$$CR_1(1 - K_{\text{eff}1}) = CR_2(1 - K_{\text{eff}2})$$

$$SUR = 26a/\bar{\lambda} + (a - \rho)T$$

$$T = (\bar{\lambda}/\rho) + [(a - \rho)/\bar{\lambda}\rho]$$

$$T = \bar{\lambda}/(\rho - a)$$

$$T = (a - \rho)/(\bar{\lambda}\rho)$$

$$\rho = (K_{\text{eff}} - 1)/K_{\text{eff}} = \Delta K_{\text{eff}}/K_{\text{eff}}$$

$$M = 1/(1 - K_{\text{eff}}) = CR_1/CR_0$$

$$M = (1 - K_{\text{eff}0})/(1 - K_{\text{eff}1})$$

$$SDM = (1 - K_{\text{eff}})/K_{\text{eff}}$$

$$\bar{\lambda} = 10^{-4} \text{ seconds}^{-1}$$

$$\bar{\lambda} = 0.1 \text{ seconds}^{-1}$$

$$\rho = [(a^*/(T K_{\text{eff}}))] + [\bar{\lambda}_{\text{eff}}/(1 + \bar{\lambda}T)]$$

$$P = (\Sigma aV)/(3 \times 10^{10})$$

$$z = \rho N$$

$$I_1 d_1 = I_2 d_2$$

$$I_1 d_1^2 = I_2 d_2^2$$

$$R/hr = (0.5 CE)/d^2 (\text{meters})$$

$$R/hr = 6 CE/d^2 (\text{feet})$$

Water Parameters

$$1 \text{ gal.} = 8.345 \text{ lbm.}$$

$$1 \text{ gal.} = 3.78 \text{ liters}$$

$$1 \text{ ft}^3 = 7.48 \text{ gal.}$$

$$\text{Density} = 62.4 \text{ lbm/ft}^3$$

$$\text{Density} = 1 \text{ gm/cm}^3$$

$$\text{Heat of vaporization} = 970 \text{ Btu/lbm}$$

$$\text{Heat of fusion} = 144 \text{ Btu/lbm}$$

$$1 \text{ Atm} = 14.7 \text{ psi} = 29.9 \text{ in. Hg.}$$

$$1 \text{ ft. H}_2\text{O} = 0.4335 \text{ lbf/in.}$$

Miscellaneous Conversions

$$1 \text{ curie} = 3.7 \times 10^{10} \text{ dps}$$

$$1 \text{ kg} = 2.21 \text{ lbm}$$

$$1 \text{ hp} = 2.54 \times 10^3 \text{ Btu/hr}$$

$$1 \text{ mw} = 3.41 \times 10^6 \text{ Btu/hr}$$

$$1 \text{ in} = 2.54 \text{ cm}$$

$$^{\circ}\text{F} = 9/5^{\circ}\text{C} + 32$$

$$^{\circ}\text{C} = 5/9 (^{\circ}\text{F} - 32)$$

$$1 \text{ BTU} = 778 \text{ ft-lbf}$$

EQUATION SHEET

$$f = ma$$

$$v = s/t$$

$$\text{Cycle efficiency} = (\text{Net work out})/(\text{Energy in})$$

$$w = mg$$

$$s = v_0 t + 1/2 at^2$$

$$E = mc^2$$

$$KE = 1/2 mv^2$$

$$a = (v_f - v_0)/t$$

$$A = \lambda N$$

$$A = A_0 e^{-\lambda t}$$

$$PE = mgh$$

$$v_f = v_0 + at$$

$$w = a/t$$

$$\lambda = \ln 2 / t_{1/2} = 0.693 / t_{1/2}$$

$$t_{1/2 \text{ eff}} = \frac{[(t_{1/2})(t_b)]}{[(t_{1/2}) + (t_b)]}$$

$$W = v \Delta P$$

$$A = \frac{\pi D^2}{4}$$

$$\Delta E = 931 \Delta m$$

$$\dot{m} = V_{av} A_0$$

$$I = I_0 e^{-\Delta x}$$

$$\dot{Q} = mCp\Delta t$$

$$\dot{Q} = UA\Delta T$$

$$Pwr = W_p \Delta h$$

$$I = I_0 e^{-ux}$$

$$I = I_0 10^{-x/TVL}$$

$$TVL = 1.3/u$$

$$HVL = -0.693/u$$

$$P = P_0 10^{\text{sur}(t)}$$

$$P = P_0 e^{ct/T}$$

$$SUR = 25.06/T$$

$$SCR = S/(1 - K_{\text{eff}})$$

$$CR_x = S/(1 - K_{\text{eff}x})$$

$$CR_1(1 - K_{\text{eff}1}) = CR_2(1 - K_{\text{eff}2})$$

$$SUR = 25a/\bar{\lambda} + (a - \rho)T$$

$$T = (\bar{\lambda}/a) + [(a - \rho)/\bar{\lambda}a]$$

$$T = \bar{\lambda}/(a - \rho)$$

$$T = (a - \rho)/(\bar{\lambda}a)$$

$$\rho = (K_{\text{eff}} - 1)/K_{\text{eff}} = \Delta K_{\text{eff}}/K_{\text{eff}}$$

$$M = 1/(1 - K_{\text{eff}}) = CR_1/CR_0$$

$$M = (1 - K_{\text{eff}0})/(1 - K_{\text{eff}1})$$

$$SDM = (1 - K_{\text{eff}})/K_{\text{eff}}$$

$$\bar{\lambda} = 10^{-4} \text{ seconds}^{-1}$$

$$\bar{\lambda} = 0.1 \text{ seconds}^{-1}$$

$$\rho = [(\bar{\lambda}/(T K_{\text{eff}}))] + [\bar{\lambda}_{\text{eff}}/(1 + \bar{\lambda}T)]$$

$$P = (\bar{\lambda}V)/(3 \times 10^{10})$$

$$\bar{\lambda} = \rho N$$

$$I_1 d_1 = I_2 d_2$$

$$I_1 d_1^2 = I_2 d_2^2$$

$$R/hr = (0.5 CE)/d^2 (\text{meters})$$

$$R/hr = 6 CE/d^2 (\text{feet})$$

Water Parameters

$$1 \text{ gal.} = 8.345 \text{ lbm.}$$

$$1 \text{ gal.} = 3.78 \text{ liters}$$

$$1 \text{ ft}^3 = 7.48 \text{ gal.}$$

$$\text{Density} = 62.4 \text{ lbm/ft}^3$$

$$\text{Density} = 1 \text{ gm/cm}^3$$

$$\text{Heat of vaporization} = 970 \text{ Btu/lbm}$$

$$\text{Heat of fusion} = 144 \text{ Btu/lbm}$$

$$1 \text{ atm} = 14.7 \text{ psi} = 29.9 \text{ in. Hg.}$$

$$1 \text{ ft. H}_2\text{O} = 0.4335 \text{ lbf/in.}$$

Miscellaneous Conversions

$$1 \text{ curie} = 3.7 \times 10^{10} \text{ dps}$$

$$1 \text{ kg} = 2.21 \text{ lbm}$$

$$1 \text{ hp} = 2.54 \times 10^3 \text{ Btu/hr}$$

$$1 \text{ mw} = 3.41 \times 10^6 \text{ Btu/hr}$$

$$1 \text{ in} = 2.54 \text{ cm}$$

$$^{\circ}\text{F} = 9/5^{\circ}\text{C} + 32$$

$$^{\circ}\text{C} = 5/9 (^{\circ}\text{F} - 32)$$

$$1 \text{ BTU} = 778 \text{ ft-lbf}$$

$$s = v_0 t + 1/2 a t^2$$

$$E = mc^2$$

$$KE = 1/2 mv^2$$

$$PE = mgh$$

$$V_f = V_0 + at$$

$$W = v \Delta P$$

$$\Delta E = 931 \Delta m$$

$$\dot{Q} = \dot{m} h$$

$$\dot{Q} = m C_p \Delta T$$

$$\dot{Q} = UA \Delta T$$

$$P_{wr} = W_f \Delta h$$

$$P = P_0 10^{\text{SUR}(\tau)}$$

$$P = P_0 e^{\tau/T}$$

$$\text{SUR} = 26.06/T$$

$$\text{SUR} = 26\rho/\lambda^* + (\beta - \rho)T$$

$$T = (\lambda^*/\rho) + [(\beta - \rho)/\bar{\lambda}_0]$$

$$T = \lambda/(\rho - \beta)$$

$$T = (\beta - \rho)/(\bar{\lambda}_0)$$

$$\rho = (K_{\text{eff}} - 1)/K_{\text{eff}} = \Delta K_{\text{eff}}/K_{\text{eff}}$$

$$\rho = [(\lambda^*/(T K_{\text{eff}}))] + [\bar{\lambda}_{\text{eff}}/(1 + \bar{\lambda}T)]$$

$$P = (\Sigma_0 V)/(3 \times 10^{10})$$

$$I = \sigma N$$

Water Parameters

$$1 \text{ gal.} = 8.345 \text{ lbm.}$$

$$1 \text{ gal.} = 3.78 \text{ liters}$$

$$1 \text{ ft}^3 = 7.48 \text{ gal.}$$

$$\text{Density} = 62.4 \text{ lbm/ft}^3$$

$$\text{Density} = 1 \text{ gm/cm}^3$$

$$\text{Heat of vaporization} = 970 \text{ Btu/lbm}$$

$$\text{Heat of fusion} = 144 \text{ Btu/lbm}$$

$$1 \text{ Atm} = 14.7 \text{ psi} = 29.9 \text{ in. Hg.}$$

$$1 \text{ ft. H}_2\text{O} = 0.4335 \text{ lbf/in.}$$

t)/(Energy in)

$$a = (v_f - v_0)/t$$

$$w = e/t$$

$$A = \frac{\pi D^2}{4}$$

$$\dot{m} = V_{\text{av}} A \rho$$

$$A = \lambda N$$

$$A = A_0 e^{-\lambda t}$$

$$\lambda = \ln 2 / t_{1/2} = 0.693 / t_{1/2}$$

$$t_{1/2}^{\text{eff}} = \frac{[(t_{1/2})(\tau_b)]}{[(t_{1/2}) + (\tau_b)]}$$

$$I = I_0 e^{-\Sigma x}$$

$$I = I_0 e^{-ux}$$

$$I = I_0 10^{-x/T/L}$$

$$\text{TVL} = 1.3/u$$

$$\text{HVL} = -0.693/u$$

$$\text{SCR} = S/(1 - K_{\text{eff}})$$

$$\text{CR}_x = S/(1 - K_{\text{eff}x})$$

$$\text{CR}_1(1 - K_{\text{eff}1}) = \text{CR}_2(1 - K_{\text{eff}2})$$

$$M = 1/(1 - K_{\text{eff}}) = \text{CR}_1/\text{CR}_0$$

$$M = (1 - K_{\text{eff}0})/(1 - K_{\text{eff}1})$$

$$\text{SDM} = (1 - K_{\text{eff}})/K_{\text{eff}}$$

$$\lambda^* = 10^{-4} \text{ seconds}$$

$$\bar{\lambda} = 0.1 \text{ seconds}^{-1}$$

$$I_1 d_1 = I_2 d_2$$

$$I_1 d_1^2 = I_2 d_2^2$$

$$R/\text{hr} = (0.5 \text{ CE})/d^2(\text{meters})$$

$$R/\text{hr} = 6 \text{ CE}/d^2(\text{feet})$$

Miscellaneous Conversions

$$1 \text{ curie} = 3.7 \times 10^{10} \text{ dps}$$

$$1 \text{ kg} = 2.21 \text{ lbm}$$

$$1 \text{ hp} = 2.54 \times 10^3 \text{ Btu/hr}$$

$$1 \text{ mw} = 3.41 \times 10^6 \text{ Btu/hr}$$

$$1 \text{ in} = 2.54 \text{ cm}$$

$$^\circ\text{F} = 9/5^\circ\text{C} + 32$$

$$^\circ\text{C} = 5/9(^\circ\text{F} - 32)$$

$$1 \text{ BTU} = 778 \text{ ft-lbf}$$

$$e = 2.718$$

Temp F	Press. psia	Volume, ft ³ /lb			Enthalpy, Btu/lb			Entropy, Btu/lb x F			Temp F
		Water	Evap	Steam	Water	Evap	Steam	Water	Evap	Steam	
		v_f	v_{fg}	v_g	h_f	h_{fg}	h_g	s_f	s_{fg}	s_g	
32	0.08859	0.01602	3305	3305	-0.02	1075.5	1075.5	0.0000	2.1873	2.1873	32
35	0.09991	0.01602	2948	2948	3.00	1073.8	1076.8	0.0061	2.1706	2.1767	35
40	0.12163	0.01602	2446	2446	8.03	1071.0	1079.0	0.0162	2.1432	2.1594	40
45	0.14744	0.01602	2037.7	2037.8	13.04	1068.1	1081.2	0.0262	2.1164	2.1426	45
50	0.17795	0.01602	1704.8	1704.8	18.05	1065.3	1083.4	0.0361	2.0901	2.1262	50
60	0.2561	0.01603	1207.6	1207.6	28.06	1059.7	1087.7	0.0555	2.0391	2.0946	60
70	0.3629	0.01605	868.3	868.4	38.05	1054.0	1092.1	0.0745	1.9900	2.0645	70
80	0.5068	0.01607	633.3	633.3	48.04	1048.4	1096.4	0.0932	1.9426	2.0359	80
90	0.6981	0.01610	468.1	468.1	58.02	1042.7	1100.8	0.1115	1.8970	2.0086	90
100	0.9492	0.01613	350.4	350.4	68.00	1037.1	1105.1	0.1295	1.8530	1.9825	100
110	1.2750	0.01617	265.4	265.4	77.98	1031.4	1109.3	0.1472	1.8105	1.9577	110
120	1.6927	0.01620	203.25	203.26	87.97	1025.6	1113.6	0.1646	1.7693	1.9339	120
130	2.2230	0.01625	157.32	157.33	97.96	1019.8	1117.8	0.1817	1.7295	1.9112	130
140	2.8892	0.01629	122.98	123.00	107.95	1014.0	1122.0	0.1985	1.6910	1.8895	140
150	3.718	0.01634	97.05	97.07	117.95	1008.2	1126.1	0.2150	1.6536	1.8686	150
160	4.741	0.01640	77.27	77.29	127.96	1002.2	1130.2	0.2313	1.6174	1.8487	160
170	5.993	0.01645	62.04	62.06	137.97	996.2	1134.2	0.2473	1.5822	1.8295	170
180	7.511	0.01651	50.21	50.22	148.00	990.2	1138.2	0.2631	1.5480	1.8111	180
190	9.340	0.01657	40.94	40.96	158.04	984.1	1142.1	0.2787	1.5148	1.7934	190
200	11.526	0.01664	33.62	33.64	168.09	977.9	1146.0	0.2940	1.4824	1.7764	200
210	14.123	0.01671	27.80	27.82	178.15	971.6	1149.7	0.3091	1.4509	1.7600	210
212	14.696	0.01672	26.78	26.80	180.17	970.3	1150.5	0.3121	1.4447	1.7568	212
220	17.186	0.01678	23.13	23.15	188.23	965.2	1153.4	0.3241	1.4201	1.7442	220
230	20.779	0.01685	19.364	19.381	198.33	958.7	1157.1	0.3388	1.3902	1.7290	230
240	24.968	0.01693	16.304	16.321	208.45	952.1	1160.6	0.3533	1.3609	1.7142	240
250	29.825	0.01701	13.802	13.819	218.59	945.4	1164.0	0.3677	1.3323	1.7000	250
260	35.427	0.01709	11.745	11.762	228.76	938.6	1167.4	0.3819	1.3043	1.6862	260
270	41.856	0.01718	10.042	10.060	238.95	931.7	1170.6	0.3960	1.2769	1.6729	270
280	49.200	0.01726	8.627	8.644	249.17	924.6	1173.8	0.4098	1.2501	1.6599	280
290	57.550	0.01736	7.443	7.460	259.4	917.4	1176.8	0.4236	1.2238	1.6473	290
300	67.005	0.01745	6.448	6.466	269.7	910.0	1179.7	0.4372	1.1979	1.6351	300
310	77.67	0.01755	5.609	5.626	280.0	902.5	1182.5	0.4506	1.1726	1.6232	310
320	89.64	0.01766	4.896	4.914	290.4	894.8	1185.2	0.4640	1.1477	1.6116	320
340	117.99	0.01787	3.770	3.788	311.3	878.8	1190.1	0.4902	1.0990	1.5892	340
360	153.01	0.01811	2.939	2.957	332.3	862.1	1194.4	0.5161	1.0517	1.5678	360
380	195.73	0.01836	2.317	2.335	353.6	844.5	1198.0	0.5416	1.0057	1.5473	380
400	247.26	0.01864	1.8444	1.8630	375.1	825.9	1201.0	0.5667	0.9607	1.5274	400
420	305.78	0.01894	1.4808	1.4997	396.9	806.2	1203.1	0.5915	0.9165	1.5080	420
440	381.54	0.01926	1.1976	1.2169	419.0	785.4	1204.4	0.6161	0.8729	1.4890	440
460	466.9	0.0196	0.9746	0.9942	441.5	763.2	1204.8	0.6405	0.8299	1.4704	460
480	566.2	0.0200	0.7972	0.8172	464.5	739.6	1204.1	0.6648	0.7871	1.4518	480
500	680.9	0.0204	0.6545	0.6749	487.9	714.3	1202.2	0.6890	0.7443	1.4333	500
520	812.5	0.0209	0.5386	0.5596	512.0	687.0	1199.0	0.7133	0.7013	1.4146	520
540	962.8	0.0215	0.4437	0.4651	536.8	657.5	1194.3	0.7378	0.6577	1.3954	540
560	1133.4	0.0221	0.3651	0.3871	562.4	625.3	1187.7	0.7625	0.6132	1.3757	560
580	1326.2	0.0228	0.2994	0.3222	589.1	589.9	1179.0	0.7876	0.5673	1.3550	580
600	1543.2	0.0236	0.2438	0.2675	617.1	550.6	1167.7	0.8134	0.5196	1.3310	600
620	1786.9	0.0247	0.1962	0.2208	646.9	506.3	1153.2	0.8403	0.4659	1.3052	620
640	2059.9	0.0260	0.1543	0.1802	679.1	454.6	1133.7	0.8666	0.4134	1.2821	640
660	2365.7	0.0277	0.1166	0.1443	714.9	392.1	1107.0	0.8995	0.3502	1.2498	660
680	2708.6	0.0304	0.0808	0.1112	758.5	310.1	1068.5	0.9365	0.2720	1.2086	680
700	3094.3	0.0366	0.0386	0.0752	822.4	172.7	995.2	0.9901	0.1490	1.1390	700
705.5	3208.2	0.0508	0	0.0508	906.0	0	906.0	1.0612	0	1.0612	705.5

TABLE A.2 PROPERTIES OF SATURATED STEAM AND SATURATED WATER (TEMPERATURE)

Press. psia	Temp F	Volu. ft ³ /lb			Enthalpy, Btu/lb			Entropy, Btu/lb x F			Energy, Btu/lb		Press. psia
		Water	Evap	Steam	Water	Evap	Steam	Water	Evap	Steam	Water	Steam	
		v_f	v_{fg}	v_g	h_f	h_{fg}	h_g	s_f	s_{fg}	s_g	u_f	u_g	
0.0886	32.018	0.01602	3302.4	3302.4	0.00	1075.5	1075.5	0	2.1872	2.1872	0	1021.3	0.0886
0.10	35.023	0.01602	2945.5	2945.5	3.03	1073.8	1076.8	0.0061	2.1705	2.1766	3.03	1022.3	0.10
0.15	45.453	0.01602	2004.7	2004.7	13.50	1067.9	1081.4	0.0271	2.1140	2.1411	13.50	1025.7	0.15
0.20	53.160	0.01603	1526.3	1526.3	21.22	1063.5	1084.7	0.0422	2.0738	2.1160	21.22	1028.3	0.20
0.30	64.484	0.01604	1039.7	1039.7	32.54	1057.1	1089.7	0.0641	2.0168	2.0809	32.54	1032.0	0.30
0.40	72.869	0.01606	792.0	792.1	40.92	1052.4	1093.3	0.0799	1.9762	2.0562	40.92	1034.7	0.40
0.5	79.586	0.01607	641.5	641.5	47.62	1048.6	1096.3	0.0925	1.9446	2.0370	47.62	1036.9	0.5
0.6	85.218	0.01609	540.0	540.1	53.25	1045.5	1098.7	0.1028	1.9186	2.0215	53.24	1038.7	0.6
0.7	90.09	0.01610	466.93	466.94	58.10	1042.7	1100.8	0.3	1.8966	2.0083	58.10	1040.3	0.7
0.8	94.38	0.01611	411.67	411.69	62.39	1040.3	1102.6	0.1117	1.8775	1.9970	62.39	1041.7	0.8
0.9	98.24	0.01612	368.41	368.43	66.24	1038.1	1104.3	0.1264	1.8606	1.9870	66.24	1042.9	0.9
1.0	101.74	0.01614	333.59	333.60	69.73	1036.1	1105.8	0.1326	1.8455	1.9781	69.73	1044.1	1.0
2.0	126.07	0.01623	173.74	173.76	94.03	1022.1	1116.2	0.1750	1.7450	1.9200	94.03	1051.8	2.0
3.0	141.47	0.01630	118.71	118.73	109.42	1013.2	1122.6	0.2009	1.6854	1.8864	109.41	1056.7	3.0
4.0	152.96	0.01636	90.63	90.64	120.92	1006.4	1127.3	0.2199	1.6428	1.8626	120.90	1060.2	4.0
5.0	162.24	0.01641	73.515	73.53	130.20	1000.9	1131.1	0.2349	1.6094	1.8443	130.18	1063.1	5.0
6.0	170.05	0.01645	61.967	61.98	138.03	996.2	1134.2	0.2474	1.5820	1.8294	138.01	1065.4	6.0
7.0	176.84	0.01649	53.634	53.65	144.83	992.1	1136.9	0.2581	1.5587	1.8168	144.81	1067.4	7.0
8.0	182.86	0.01653	47.328	47.35	150.87	988.5	1139.3	0.2676	1.5384	1.8060	150.84	1069.2	8.0
9.0	188.27	0.01656	42.385	42.40	156.30	985.1	1141.4	0.2760	1.5204	1.7964	156.28	1070.8	9.0
10	193.21	0.01659	38.404	38.42	161.26	982.1	1143.3	0.2836	1.5043	1.7879	161.23	1072.3	10
14.696	212.00	0.01672	26.782	26.80	180.17	970.3	1150.5	0.3121	1.4447	1.7568	180.12	1077.6	14.696
15	213.03	0.01673	26.274	26.29	181.21	969.7	1150.9	0.3137	1.4415	1.7552	181.16	1077.9	15
20	227.96	0.01683	20.070	20.087	196.27	960.1	1156.3	0.3358	1.3962	1.7320	196.21	1082.0	20
30	250.34	0.01701	13.7266	13.744	218.9	945.2	1164.1	0.3682	1.3313	1.6995	218.8	1087.9	30
40	267.25	0.01715	10.4794	10.497	236.1	933.6	1169.8	0.3921	1.2844	1.6765	236.0	1092.1	40
50	281.02	0.01727	8.4967	8.514	250.2	923.9	1174.1	0.4112	1.2474	1.6586	250.1	1095.3	50
60	292.71	0.01738	7.1562	7.174	262.2	915.4	1177.6	0.4273	1.2167	1.6440	262.0	1098.0	60
70	302.93	0.01748	6.1875	6.205	272.7	907.8	1180.6	0.4411	1.1905	1.6316	272.5	1100.2	70
80	312.04	0.01757	5.4536	5.471	282.1	900.9	1183.1	0.4534	1.1675	1.6208	281.9	1102.1	80
90	320.28	0.01766	4.8777	4.895	290.7	894.6	1185.3	0.4643	1.1470	1.6113	290.4	1103.7	90
100	327.82	0.01774	4.4133	4.431	298.5	888.6	1187.2	0.4743	1.1284	1.6027	298.2	1105.2	100
120	341.27	0.01789	3.7097	3.728	312.6	877.8	1190.4	0.4919	1.0960	1.5879	312.2	1107.6	120
140	353.04	0.01803	3.2010	3.219	325.0	868.0	1193.0	0.5071	1.0681	1.5752	324.5	1109.6	140
160	363.55	0.01815	2.8155	2.834	336.1	859.0	1195.1	0.5205	1.0435	1.5641	335.5	1111.2	160
180	373.08	0.01827	2.5129	2.531	346.2	850.7	1196.9	0.5328	1.0215	1.5543	345.6	1112.5	180
200	381.80	0.01839	2.2689	2.287	355.5	842.8	1198.3	0.5438	1.0016	1.5454	354.8	1113.7	200
250	400.97	0.01865	1.8245	1.8432	376.1	825.0	1201.1	0.5679	0.9585	1.5264	375.3	1115.8	250
300	417.35	0.01889	1.5238	1.5427	394.0	808.9	1202.9	0.5882	0.9223	1.5105	392.9	1117.2	300
350	431.73	0.01913	1.3064	1.3255	409.8	794.2	1204.0	0.6055	0.8909	1.4968	408.6	1118.1	350
400	444.60	0.0193	1.14162	1.1610	424.2	780.4	1204.6	0.6217	0.8630	1.4847	422.7	1118.7	400
450	456.28	0.0195	1.01224	1.0318	437.3	767.5	1204.8	0.6360	0.8378	1.4738	435.7	1118.9	450
500	467.01	0.0198	0.90787	0.9276	449.5	755.1	1204.7	0.6490	0.8148	1.4639	447.7	1118.8	500
550	476.94	0.0199	0.82183	0.8418	460.9	743.3	1204.3	0.6611	0.7936	1.4547	458.9	1118.6	550
600	485.20	0.0201	0.74962	0.7698	471.7	732.0	1203.7	0.6723	0.7738	1.4461	469.5	1118.2	600
700	502.08	0.0205	0.63505	0.6556	491.6	710.2	1201.8	0.6928	0.7377	1.4304	488.9	1116.9	700
800	518.21	0.0209	0.54809	0.5690	509.8	689.6	1199.4	0.7111	0.7051	1.4163	506.7	1115.2	800
900	531.95	0.0212	0.47968	0.5009	526.7	669.7	1196.4	0.7279	0.6753	1.4032	523.2	1113.0	900
1000	544.38	0.0216	0.42435	0.4460	542.6	650.4	1192.9	0.7434	0.6476	1.3910	537.6	1110.4	1000
1100	555.28	0.0220	0.37863	0.4005	557.5	631.5	1189.1	0.7578	0.6216	1.3794	553.1	1107.5	1100
1200	565.19	0.0223	0.34013	0.3625	571.9	613.0	1184.8	0.7714	0.5969	1.3683	566.9	1104.3	1200
1300	574.42	0.0227	0.30722	0.3299	585.6	594.6	1180.2	0.7843	0.5733	1.3577	580.1	1100.9	1300
1400	583.07	0.0231	0.27871	0.3018	598.8	576.5	1175.3	0.7966	0.5507	1.3474	592.9	1097.1	1400
1500	591.20	0.0235	0.25372	0.2772	611.7	558.4	1170.1	0.8085	0.5283	1.3373	605.7	1093.1	1500
2000	635.80	0.0257	0.16256	0.1883	672.1	466.2	1138.3	0.8625	0.4256	1.2881	662.6	1058.6	2000
2500	665.11	0.0266	0.10209	0.1307	731.7	361.6	1093.3	0.9139	0.3206	1.2345	718.5	1032.9	2500
3000	695.33	0.0343	0.05073	0.0850	801.8	218.4	1020.3	0.9728	0.1891	1.1619	782.8	973.1	3000
3208.2	701.47	0.0408	0	0.0508	906.0	0	906.0	1.0612	0	1.0612	875.9	875.9	3208.2

TABLE A.3 PROPERTIES OF SATURATED STEAM AND SATURATED WATER (PRESSURE)

Abs press. lb/sq in. (sat. temp)	Temperature, F															
	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	
1 (101.74)	v	0.0161	392.5	452.3	511.9	571.5	631.1	690.7								
	h	68.00	1150.2	1195.7	1241.8	1288.6	1336.1	1384.5								
	s	0.1295	2.0509	2.1152	2.1722	2.2237	2.2708	2.3144								
5 (162.24)	v	0.0161	78.14	90.24	102.24	114.21	126.15	138.08	150.01	161.94	173.86	185.78	197.70	209.62	221.53	233.45
	h	68.01	1146.6	1194.8	1241.3	1288.2	1335.9	1384.3	1433.6	1483.7	1534.7	1586.7	1639.6	1693.3	1748.0	1803.5
	s	0.1295	1.8716	1.9369	1.9943	2.0460	2.0932	2.1367	2.1776	2.2159	2.2521	2.2866	2.3194	2.3509	2.3811	2.4101
10 (197.21)	v	0.0161	38.84	44.93	51.03	57.04	63.03	69.00	74.98	80.94	86.91	92.87	98.84	104.80	110.76	116.72
	h	68.02	1146.6	1193.7	1240.6	1287.8	1335.5	1384.0	1433.4	1483.5	1534.6	1586.6	1639.5	1693.3	1747.9	1803.4
	s	0.1295	1.7928	1.8593	1.9173	1.9692	2.0166	2.0603	2.1011	2.1394	2.1757	2.2101	2.2430	2.2744	2.3046	2.3337
15 (213.03)	v	0.0161	0.0166	29.899	33.963	37.985	41.986	45.978	49.964	53.946	57.926	61.905	65.882	69.858	73.833	77.807
	h	68.04	168.09	1192.5	1239.9	1287.3	1335.2	1383.8	1433.2	1483.4	1534.3	1586.3	1639.3	1693.1	1747.8	1803.4
	s	0.1295	0.2940	1.8134	1.8720	1.9242	1.9717	2.0155	2.0563	2.0946	2.1309	2.1653	2.1982	2.2297	2.2599	2.2890
20 (227.96)	v	0.0161	0.0166	22.356	25.428	28.457	31.466	34.465	37.458	40.447	43.435	46.420	49.405	52.388	55.370	58.352
	h	68.05	168.11	1191.4	1239.2	1286.9	1334.9	1383.5	1432.9	1483.2	1534.3	1586.3	1639.3	1693.1	1747.8	1803.3
	s	0.1295	0.2940	1.7805	1.8397	1.8921	1.9397	1.9836	2.0244	2.0628	2.0991	2.1336	2.1665	2.1979	2.2282	2.2572
40 (267.25)	v	0.0161	0.0166	11.035	12.624	14.165	15.685	17.195	18.699	20.199	21.697	23.194	24.689	26.183	27.676	29.168
	h	68.10	168.15	1186.6	1236.4	1285.0	1333.6	1382.5	1432.1	1482.5	1533.7	1585.8	1638.8	1692.7	1747.5	1803.0
	s	0.1295	0.2940	1.6992	1.7608	1.8143	1.8624	1.9065	1.9476	1.9860	2.0224	2.0569	2.0899	2.1224	2.1516	2.1807
60 (292.71)	v	0.0161	0.0156	7.257	8.354	9.400	10.425	11.438	12.446	13.450	14.452	15.452	16.450	17.448	18.445	19.441
	h	68.15	168.20	1181.6	1233.5	1283.2	1332.3	1381.5	1431.3	1481.8	1533.2	1585.3	1638.4	1692.4	1747.1	1802.8
	s	0.1295	0.2939	1.6492	1.7134	1.7681	1.8168	1.8612	1.9024	1.9410	1.9774	2.0120	2.0450	2.0765	2.1068	2.1359
80 (312.04)	v	0.0161	0.0166	0.0175	6.218	7.018	7.794	8.560	9.319	10.075	10.829	11.581	12.331	13.081	13.829	14.577
	h	68.21	168.24	269.74	1230.5	1281.3	1330.9	1380.5	1430.5	1481.1	1532.6	1584.9	1638.0	1692.0	1746.8	1802.5
	s	0.1295	0.2939	0.4371	1.6790	1.7349	1.7842	1.8289	1.8702	1.9089	1.9454	1.9800	2.0131	2.0446	2.0750	2.1041
100 (327.82)	v	0.0161	0.0166	0.0175	4.935	5.588	6.216	6.833	7.443	8.050	8.655	9.258	9.860	10.460	11.060	11.659
	h	68.26	168.29	269.77	1227.4	1279.3	1329.6	1379.5	1429.7	1480.4	1532.0	1584.4	1637.6	1691.6	1746.5	1802.2
	s	0.1295	0.2939	0.4371	1.6516	1.7088	1.7586	1.8036	1.8451	1.8839	1.9205	1.9552	1.9883	2.0199	2.0502	2.0794
120 (341.27)	v	0.0161	0.0166	0.0175	4.0786	4.6341	5.1637	5.6831	6.1929	6.7006	7.2060	7.7096	8.2119	8.7130	9.2134	9.7130
	h	68.31	168.35	269.81	1224.1	1277.4	1328.1	1378.4	1428.8	1479.8	1531.4	1583.9	1637.1	1691.3	1746.2	1802.0
	s	0.1295	0.2939	0.4371	1.6286	1.6872	1.7376	1.7829	1.8246	1.8635	1.9001	1.9349	1.9680	1.9996	2.0300	2.0592
140 (353.04)	v	0.0161	0.0166	0.0175	3.4651	3.9526	4.4119	4.8585	5.2995	5.7364	6.1709	6.6036	7.0349	7.4652	7.8946	8.3233
	h	68.37	168.38	269.85	1220.8	1275.3	1326.8	1377.4	1428.0	1479.1	1530.8	1583.4	1636.7	1690.9	1745.9	1801.7
	s	0.1295	0.2939	0.4370	1.6085	1.6686	1.7196	1.7652	1.8071	1.8461	1.8828	1.9176	1.9508	1.9825	2.0129	2.0421
160 (363.95)	v	0.0161	0.0166	0.0175	3.0060	3.4413	3.8480	4.2420	4.6295	5.0132	5.3945	5.7741	6.1522	6.5293	6.9055	7.2811
	h	68.42	168.42	269.89	1217.4	1273.3	1325.4	1376.4	1427.2	1478.4	1530.3	1582.9	1636.3	1690.5	1745.6	1801.4
	s	0.1294	0.2938	0.4370	1.5906	1.6522	1.7039	1.7499	1.7919	1.8310	1.8678	1.9027	1.9359	1.9676	1.9980	2.0273
180 (373.08)	v	0.0161	0.0166	0.0174	2.6474	3.0433	3.4093	3.7621	4.1064	4.4505	4.7907	5.1289	5.4657	5.8014	6.1363	6.4704
	h	68.47	168.47	269.92	1213.8	1271.2	1324.0	1375.3	1426.3	1477.7	1529.7	1582.4	1635.9	1690.2	1745.3	1801.2
	s	0.1294	0.2938	0.4370	1.5743	1.6376	1.6900	1.7362	1.7784	1.8176	1.8545	1.8894	1.9227	1.9545	1.9849	2.0142
200 (381.80)	v	0.0161	0.0166	0.0174	2.3598	2.7247	3.0583	3.3783	3.6915	4.0008	4.3077	4.6128	4.9165	5.2191	5.5209	5.8219
	h	68.52	168.51	269.96	1210.1	1269.0	1322.6	1374.3	1425.5	1477.0	1529.1	1581.9	1635.4	1689.8	1745.0	1800.9
	s	0.1294	0.2938	0.4359	1.5593	1.6242	1.6776	1.7239	1.7663	1.8057	1.8426	1.8776	1.9109	1.9427	1.9732	2.0025
250 (400.97)	v	0.0161	0.0166	0.0174	0.0186	2.1504	2.4662	2.6872	2.9410	3.1909	3.4382	3.6837	3.9278	4.1709	4.4131	4.6546
	h	68.56	168.63	270.05	375.10	1263.5	1319.0	1371.6	1423.4	1475.3	1527.6	1580.6	1634.4	1688.9	1744.2	1800.2
	s	0.1294	0.2937	0.4368	0.5667	1.5951	1.6502	1.6976	1.7405	1.7801	1.8173	1.8524	1.8858	1.9177	1.9482	1.9776
300 (417.35)	v	0.0161	0.0166	0.0174	0.0186	1.7665	2.0044	2.2263	2.4407	2.6509	2.8585	3.0643	3.2688	3.4721	3.6746	3.8764
	h	68.79	168.74	270.14	375.15	1257.7	1315.2	1368.9	1421.3	1473.6	1526.2	1579.4	1633.3	1688.0	1743.4	1799.6
	s	0.1294	0.2937	0.4367	0.5665	1.5703	1.6274	1.6758	1.7192	1.7591	1.7964	1.8317	1.8652	1.8972	1.9278	1.9572
350 (431.73)	v	0.0161	0.0166	0.0174	0.0186	1.4913	1.7028	1.8970	2.0332	2.2652	2.4445	2.6219	2.7980	2.9730	3.1471	3.3205
	h	68.92	168.85	270.24	375.21	1251.5	1311.4	1366.2	1419.2	1471.8	1524.7	1578.2	1632.3	1687.1	1742.6	1798.9
	s	0.1293	0.2935	0.4367	0.5664	1.5483	1.6077	1.6571	1.7009	1.7411	1.7787	1.8141	1.8477	1.8795	1.9105	1.9400
400 (444.60)	v	0.0161	0.0166	0.0174	0.0186	1.2841	1.4763	1.6490	1.8151	1.9759	2.1339	2.2901	2.4450	2.5987	2.7515	2.9037
	h	69.05	168.97	270.33	375.27	1245.1	1307.4	1363.4	1417.0	1470.1	1523.3	1576.9	1631.2	1686.2	1741.9	1798.2
	s	0.1293	0.2935	0.4365	0.5663	1.5282	1.5901	1.6406	1.6850	1.7255	1.7632	1.7985	1.8325	1.8647	1.8955	1.9250
500 (457.01)	v	0.0161	0.0166	0.0174	0.0186	0.9919	1.1584	1.3037	1.4397	1.5708	1.6992	1.8256	1.9507	2.0746	2.1977	2.3200
	h	69.32	169.19	270.51	375.38	1231.2	1299.1	1357.7	1412.7	1466.6	1520.3	1574.4	1629.1	1684.4	1740.3	1796.9
	s	0.1292	0.2934	0.4364	0.5660	1.4971	1.5595	1.6123	1.6578	1.6990	1.7371	1.7730	1.8069	1.8393	1.8702	1.8998

TABLE A.4 PROPERTIES OF SUPERHEATED STEAM AND COMPRESSED WATER (TEMPERATURE AND PRESSURE)
A.5

Abs press. lb/sq in. (sat. temp)	Temperature, F															
	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	
600 (486.20)	v	0.0161	0.0166	0.0174	0.0186	0.7944	0.9456	1.0726	1.1892	1.3008	1.4093	1.5160	1.6211	1.7252	1.8284	1.9309
	h	69.58	169.42	270.70	375.49	1215.9	1290.3	1351.8	1408.3	1463.0	1517.4	1571.9	1627.0	1682.6	1738.8	1795.6
	s	0.1292	0.2933	0.4362	0.5657	1.4590	1.5329	1.5844	1.6351	1.6769	1.7155	1.7517	1.7859	1.8184	1.8494	1.8792
700 (503.68)	v	0.0161	0.0166	0.0174	0.0186	0.0204	0.7928	0.9072	1.0102	1.1078	1.2023	1.2948	1.3858	1.4757	1.5647	1.6530
	h	69.04	169.65	270.89	375.61	487.93	1281.0	1345.6	1403.7	1459.4	1514.4	1569.4	1624.8	1680.7	1737.2	1794.3
	s	0.1291	0.2932	0.4360	0.5655	0.6889	1.5090	1.5673	1.6154	1.6580	1.6970	1.7335	1.7679	1.8005	1.8318	1.8617
800 (518.2.)	v	0.0161	0.0166	0.0174	0.0186	0.0204	0.6774	0.7829	0.8759	0.9631	1.0470	1.1289	1.2093	1.2835	1.3669	1.4446
	h	70.11	169.88	271.07	375.73	487.88	1271.1	1339.2	1399.1	1455.8	1511.4	1566.9	1622.7	1678.9	1735.0	1792.9
	s	0.1290	0.2930	0.4358	0.5652	0.6885	1.4869	1.5484	1.5980	1.6413	1.6807	1.7175	1.7522	1.7851	1.8164	1.8464
900 (531.95)	v	0.0161	0.0166	0.0174	0.0186	0.0204	0.5869	0.6858	0.7713	0.8504	0.9262	0.9998	1.0720	1.1430	1.2131	1.2825
	h	70.37	170.10	271.26	375.84	487.83	1260.6	1332.7	1394.4	1452.2	1508.5	1564.4	1620.6	1677.1	1734.1	1791.6
	s	0.1290	0.2929	0.4357	0.5649	0.6881	1.4659	1.5311	1.5822	1.6263	1.6667	1.7033	1.7382	1.7713	1.8028	1.8329
1000 (544.58)	v	0.0161	0.0166	0.0174	0.0186	0.0204	0.5137	0.6080	0.6875	0.7603	0.8295	0.8966	0.9622	1.0266	1.0901	1.1529
	h	70.63	170.33	271.44	375.96	487.79	1249.3	1325.9	1389.6	1448.5	1504.4	1561.9	1618.4	1675.3	1732.5	1790.3
	s	0.1289	0.2928	0.4355	0.5647	0.6876	1.4457	1.5149	1.5677	1.6126	1.6530	1.6905	1.7256	1.7589	1.7905	1.8207
1100 (556.28)	v	0.0161	0.0166	0.0174	0.0185	0.0203	0.4531	0.5440	0.6188	0.6865	0.7505	0.8121	0.8723	0.9313	0.9894	1.0468
	h	70.90	170.56	271.63	375.08	487.75	1237.3	1318.8	1384.7	1444.7	1502.4	1559.4	1616.3	1673.5	1731.0	1789.0
	s	0.1289	0.2927	0.4353	0.5644	0.6872	1.4259	1.4996	1.5542	1.6000	1.6410	1.6787	1.7141	1.7475	1.7793	1.8097
1200 (567.19)	v	0.0161	0.0166	0.0174	0.0185	0.0203	0.4016	0.4905	0.5615	0.6250	0.6845	0.7418	0.7974	0.8519	0.9055	0.9584
	h	71.16	170.78	271.82	376.20	487.72	1224.2	1311.5	1379.7	1440.9	1499.4	1556.9	1614.2	1671.6	1729.4	1787.6
	s	0.1288	0.2926	0.4351	0.5642	0.6868	1.4061	1.4851	1.5415	1.5883	1.6298	1.6679	1.7035	1.7371	1.7691	1.7996
1400 (587.07)	v	0.0161	0.0166	0.0174	0.0185	0.0203	0.3176	0.4059	0.4712	0.5282	0.5809	0.6311	0.6798	0.7272	0.7737	0.8195
	h	71.68	171.24	272.19	376.44	487.65	1194.1	1296.1	1369.3	1432.2	1493.2	1551.8	1609.9	1668.0	1726.3	1785.0
	s	0.1287	0.2923	0.4348	0.5636	0.6859	1.3652	1.4575	1.5182	1.5670	1.6096	1.6484	1.6845	1.7185	1.7508	1.7815
1600 (604.87)	v	0.0161	0.0166	0.0173	0.0185	0.0202	0.2315	0.3072	0.3500	0.3988	0.4426	0.4836	0.5229	0.5609	0.5980	0.6343
	h	72.21	171.69	272.57	376.69	487.60	616.77	1279.4	1358.5	1425.2	1486.9	1546.6	1605.6	1664.3	1723.2	1782.3
	s	0.1286	0.2921	0.4344	0.5631	0.6851	0.8129	1.4312	1.4963	1.5478	1.5916	1.6312	1.6678	1.7022	1.7344	1.7657
1800 (621.72)	v	0.0160	0.0165	0.0173	0.0185	0.0202	0.2906	0.3500	0.3988	0.4426	0.4836	0.5229	0.5609	0.5980	0.6343	0.6703
	h	72.73	172.15	272.95	376.93	487.56	615.58	1261.1	1347.2	1417.1	1480.6	1541.1	1601.2	1660.7	1720.1	1779.7
	s	0.1284	0.2918	0.4341	0.5626	0.6843	0.8109	1.4054	1.4768	1.5302	1.5753	1.6156	1.6528	1.6876	1.7204	1.7516
2000 (635.80)	v	0.0160	0.0165	0.0173	0.0184	0.0201	0.2488	0.3072	0.3534	0.3942	0.4320	0.4680	0.5027	0.5365	0.5695	0.6025
	h	73.26	172.60	273.32	377.19	487.53	614.48	1240.9	1353.4	1408.7	1447.1	1536.2	1596.9	1657.0	1717.0	1777.1
	s	0.1283	0.2916	0.4337	0.5621	0.6834	0.8091	1.3794	1.4578	1.5138	1.5603	1.6014	1.6391	1.6743	1.7075	1.7389
2500 (668.11)	v	0.0160	0.0165	0.0173	0.0184	0.0200	0.1681	0.2293	0.2712	0.3068	0.3390	0.3692	0.3980	0.4259	0.4529	0.4795
	h	74.57	173.74	274.27	377.82	487.50	612.08	1176.7	1303.4	1386.7	1457.5	1522.9	1585.9	1647.8	1709.2	1770.4
	s	0.1280	0.2910	0.4329	0.5609	0.6815	0.8048	1.3076	1.4129	1.4766	1.5269	1.5703	1.6094	1.6456	1.6796	1.7116
3000 (695.33)	v	0.0160	0.0165	0.0172	0.0183	0.0200	0.0982	0.1755	0.2161	0.2484	0.2770	0.3033	0.3282	0.3522	0.3753	0.3978
	h	75.83	174.88	275.22	378.47	487.52	610.08	1060.5	1267.0	1363.2	1440.2	1503.4	1574.8	1635.5	1701.4	1761.8
	s	0.1277	0.2904	0.4320	0.5597	0.6796	0.8009	1.1966	1.3692	1.4429	1.4975	1.5434	1.5841	1.6214	1.6561	1.6888
3200 (705.08)	v	0.0160	0.0165	0.0172	0.0183	0.0199	0.0335	0.1588	0.1987	0.2301	0.2576	0.2827	0.3065	0.3291	0.3510	0.3725
	h	76.4	175.3	275.6	378.7	487.5	609.4	800.8	1250.9	1353.4	1433.1	1503.8	1570.3	1634.8	1698.3	1761.2
	s	0.1276	0.2902	0.4317	0.5592	0.6788	0.7994	0.9708	1.3515	1.4300	1.4866	1.5335	1.5749	1.6126	1.6477	1.6806
3500	v	0.0160	0.0164	0.0172	0.0183	0.0199	0.0225	0.0307	0.1364	0.1764	0.2066	0.2326	0.2563	0.2784	0.2995	0.3198
	h	77.2	176.0	276.2	379.1	487.6	608.4	779.4	1224.6	1338.2	1422.2	1495.5	1563.3	1629.2	1693.6	1757.2
	s	0.1274	0.2899	0.4312	0.5585	0.6777	0.7973	0.9508	1.3242	1.4112	1.4709	1.5194	1.5618	1.6002	1.6358	1.6691
4000	v	0.0159	0.0164	0.0172	0.0182	0.0198	0.0223	0.0287	0.1052	0.1463	0.1752	0.1994	0.2210	0.2411	0.2601	0.2783
	h	78.5	177.2	277.1	379.8	487.7	606.5	763.0	1174.3	1311.6	1403.0	1481.3	1552.2	1619.8	1685.7	1750.6
	s	0.1271	0.2893	0.4304	0.5573	0.6760	0.7940	0.9343	1.2754	1.3807	1.4461	1.4976	1.5417	1.5812	1.6177	1.6516
5000	v	0.0159	0.0164	0.0171	0.0181	0.0196	0.0219	0.0268	0.0591	0.1038	0.1312	0.1529	0.1718	0.1890	0.2050	0.2203
	h	81.1	179.5	279.1	381.2	488.1	604.6	746.0	1042.9	1252.5	1364.6	1452.1	1529.1	1603.9	1676.0	1747.4
	s	0.1265	0.2881	0.4287	0.5550	0.6726	0.7880	0.9153	1.1593	1.3207	1.4001	1.4582	1.5061	1.5481	1.5863	1.6216
6000	v	0.0159	0.0163	0.0170	0.0180	0.0195	0.0216	0.0256	0.0397	0.0757	0.1020	0.1221	0.1391	0.1544	0.1684	0.1817
	h	83.7	181.7	281.0	382.7	488.6	602.9	736.1	945.1	1188.8	1323.6	1422.3	1505.9	1582.0	1654.2	1724.7
	s	0.1258	0.2870	0.4271	0.5528	0.6693	0.7826	0.9026	1.0176	1.2615	1.3574	1.4229	1.4748	1.5194	1.5593	1.5962
7000	v	0.0158	0.0163	0.0170	0.0180	0.0193	0.0213	0.0248	0.0334	0.0573	0.0816	0.1004	0.1160	0.1298	0.1424	0.1542
	h	86.2	184.4	283.0	384.2	489.3	601.7	729.3	901.8	1124.9	1281.7	1392.2	1482.6	1563.1	1639.6	1711.1
	s	0.1252	0.2859	0.4256	0.5507	0.6563	0.7777	0.8926	1.0350	1.2055	1.3111	1.3904	1.4406	1.4938	1.5385	1.5735

TABLE A.4 PROPERTIES OF SUPERHEATED STEAM AND COMPRESSED WATER (TEMPERATURE AND PRESSURE) (CONTINUED)
A.6

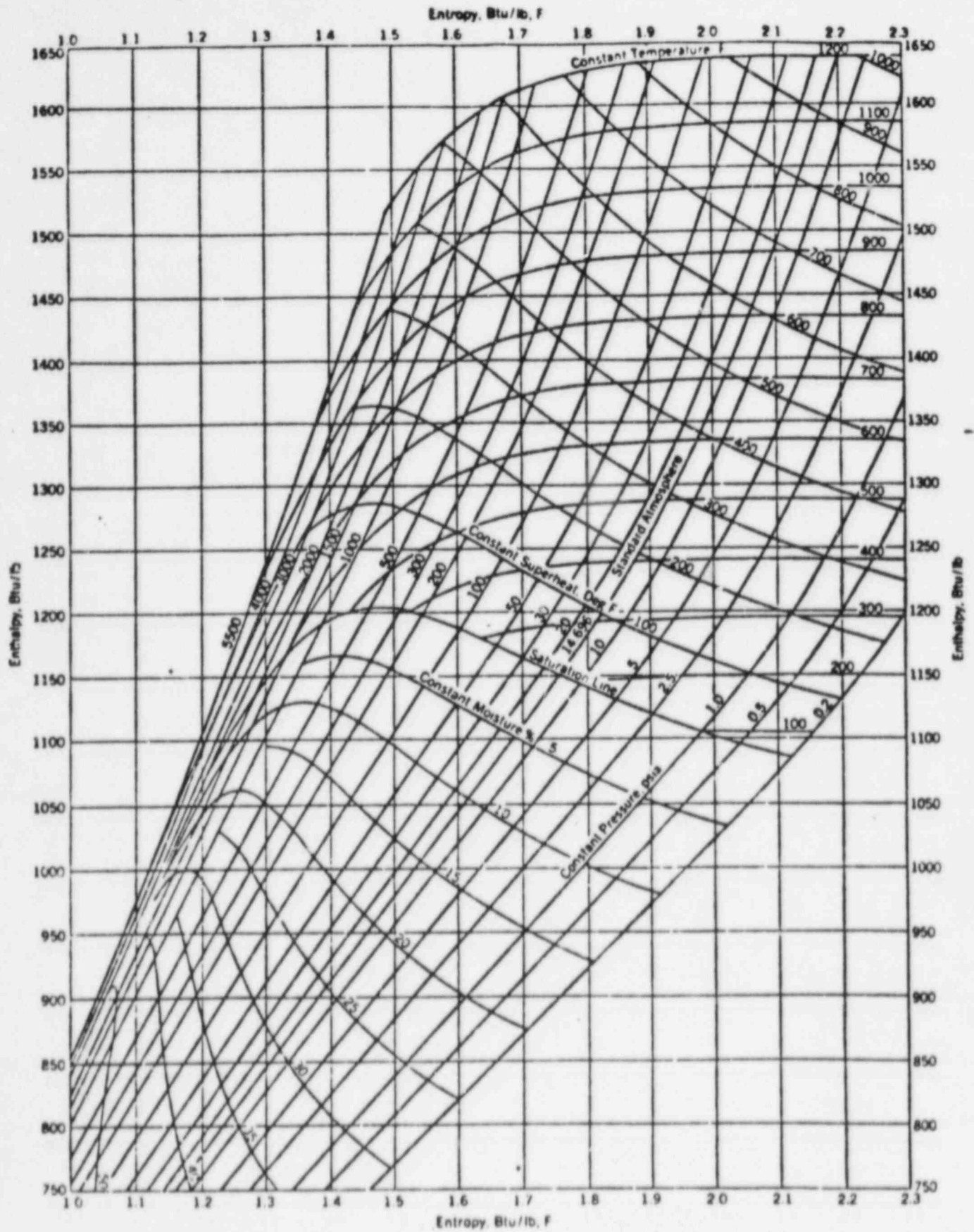


FIGURE A.5 MOLLIER ENTHALPY-ENTROPY DIAGRAM

PROPERTIES OF WATER

Density ρ
(lbs/ft³)

Temp (°F)	Saturated Liquid	PSIA							
		1000	2000	2100	2200	2300	2400	2500	3000
32	62.414	62.637	62.846	62.867	62.888	62.909	62.93	62.951	63.056
50	62.38	62.55	62.75	62.774	62.798	62.822	62.846	62.87	62.99
100	61.989	62.185	62.371	62.390	62.409	62.427	62.446	62.465	62.559
200	60.118	60.314	60.511	60.53	60.549	60.568	60.587	60.606	60.702
300	57.310	57.537	57.767	57.79	57.813	57.836	57.859	57.882	57.998
400	53.651	53.903	54.218	54.249	54.28	54.311	54.342	54.373	54.529
410	53.248	53.475	53.79	53.825	53.86	53.89	53.925	53.95	54.11
420	52.798	53.025	53.36	53.40	53.425	53.46	53.50	53.53	53.69
430	52.356	52.575	52.925	52.95	52.99	53.02	53.065	53.09	53.265
440	51.921	52.125	52.42	52.45	52.475	52.51	52.54	52.56	52.75
450	51.546	51.66	52.025	52.065	52.10	52.14	52.175	52.21	52.41
460	51.020	51.175	51.56	51.61	51.64	51.68	51.725	51.76	51.96
470	50.505	50.70	51.1	51.14	51.175	51.22	51.25	51.30	51.50
480	50.00	50.20	50.62	50.66	50.7	50.74	50.78	50.825	51.035
490	49.505	49.685	50.13	50.175	50.22	50.265	50.31	50.35	50.575
500	48.943	49.097	49.618	49.666	49.714	49.762	49.81	49.858	50.098
510	48.31	48.51	49.05	49.101	49.152	49.203	49.254	49.305	49.56
520	47.85	47.91	48.46	48.515	48.57	48.625	48.68	48.735	49.01
530	47.17	47.29	47.86	47.919	47.978	48.037	48.096	48.155	48.45
540	46.51		47.23	47.296	47.362	47.428	47.494	47.56	47.89
550	45.87		46.59	46.658	46.726	46.794	46.862	46.93	47.27
560	45.25		45.92	45.994	46.068	46.142	46.216	46.29	46.66
570	44.64		45.22	45.30	45.38	45.46	45.54	45.62	46.02
580	43.86		44.50	44.586	44.672	44.758	44.844	44.93	45.36
590	43.10		43.73	43.825	43.92	44.015	44.11	44.205	44.68
600	42.321		42.913	43.017	43.122	43.226	43.33	43.434	43.956
610	41.49		41.96	42.08	42.196	42.314	42.432	42.55	43.14
620	40.552		40.950	41.083	41.217	41.35	41.483	41.616	42.283
630	39.53								41.44
640	38.491								40.388
650	37.31								39.26
660	36.01								38.008
670	34.48								36.52
680	32.744								34.638
690	30.516								32.144

TABLE A.6 PROPERTIES OF WATER, DENSITY

5.0 PROCEDURAL STEPS

5.1 Transferring The Reactor Mode Switch To RUN

5.1.1 Verify the following low steam line pressure relays are energized by observing they are pulled in from their stop screws.

On Panel H12-P609

5.1.1.1 A71-K4A

5.1.1.2 A71-K4C

On Panel H12-P611

5.1.1.3 A71-K4B

5.1.1.4 A71-K4D

5.1.2 Verify the following MSIV limit switch relays are energized by observing they are pulled in from their stop screws:

On Panel H12-P609

5.1.2.1 C71(72)-K3A

5.1.2.2 C71(72)-K3C

5.1.2.3 C71(72)-K3E

5.1.2.4 C71(72)-K3G

On Panel H12-P611

5.1.2.5 C71(72)-K3B

5.1.2.6 C71(72)-K3D

5.1.2.7 C71(72)-K3F

5.1.2.8 C71(72)-K3H

5.1.3 Increase power to 6-10% by withdrawing control rods in accordance with OP-07 in the sequence designated by GP-10, Rod Sequence Checkoff Sheets.

CAUTION

At least two APRM downscale and companion IRM upscale scram channels per RPS Trip System are required operable. Companion APRMs/IRMs are as follows:

Trip System A

Trip System B

APRM A AND IRM A

APRM B AND IRM B

APRM C AND IRM C

APRM D AND IRM D

APRM E AND IRM E

APRM F AND IRM F

APRM E AND IRM G

APRM F AND IRM H

5.1.4 Momentarily select each APRM channel on the IRM/APRM recorders and verify that all operable APRMs indicate between 3% and 10%.

ANSWERS -- BRUNSWICK 1&2

-85/10/08-KING, M.

MASTER COPY

ANSWER 1.01 (0.50)

Prevents loss or decrease of condenser vacuum. (0.5)

REFERENCE

SSM BOOK 8, CH 16-C REV 0, SEC 2.1, PG 3

ANSWER 1.02 (2.00)

- a. Voids initially decrease(0.25) as increased flow moves the boiling boundary higher into the core(0.25). As power increases, the rate of boiling increases(0.25), and the boiling boundary is returned to near its original level(0.25). (1.0)
- b. Core reactivity initially becomes positive as void content decreases(0.25). Power increases & void content increases back to near its original value(0.25). The Power increase will also cause doppler to add neg. reactivity(0.25). The net core reactivity returns to zero (with core at a higher power level)(0.25). (1.0)

REFERENCE

SSM BOOK 7, CH 6-C REV 0, SEC 2.0, PG 10,11

ANSWER 1.03 (2.00)

- a. 1 second: $6\% \times 2436 \text{ MWT} = 146.16 \text{ MWT}$ (Accept $6\% +1\% - 8\%$) (0.5)
1 minute: $4.0\% \times 2436 \text{ MWT} = 97.4 \text{ MWT}$ (Accept $4.0\% +or- 5\%$) (0.5)
- b. The nuclear instrumentation indicate neutrons, while the decay heat power is from beta decay of fission fragments and decay gammas. (1.0)

REFERENCE

SSM BOOK 2, CH 2-A, SEC 14.4, PG 179 & FIG. 70

Change to \pm per NEDB 281108, 9/85, Fig 2-4 SJKER

ANSWERS -- BRUNSWICK 1&2

-85/10/08-KING, M.

ANSWER 1.04 (2.00)

- a. Decreases due to the production of Plutonium(0.5) which has a lower delayed neutron fraction than U-235(0.5). (1.0)
- b. Delayed neutrons increase the average neutron generation time(0.5), increasing the control time of the reactor by a very large--(7000 to 9000)--factor(0.5). (1.0)

REFERENCE

SSM BOOK 2, CH 2-A, SEC 12.3 PG 120, 124, 121

ANSWER 1.05 (1.00)

d (1.0)

REFERENCE

SSM BOOK 2, CH 2-A, SEC 13.7, PG 161

ANSWER 1.06 (2.00)

After power operation, the gamma and deuterium(0.67) concentrations are high enough to produce significant numbers of source neutrons, along with the alpha-oxygen reaction(0.67) and spontaneous fission of U-238(0.66).

ALTERNATE ANSWER: Spontaneous fission of Cm-242 and Cm-244, for low and high exposure fuel respectively, provide sufficient numbers of source neutrons. (2.0)

REFERENCE

SSM BOOK 2, CH 2-A, SEC 12.1, PG 111, 112
SEC 6.4, PG 49, 47

ANSWERS -- BRUNSWICK 1&2

-85/10/08-KING, M.

ANSWER 1.07 (2.00)

The reactor is now producing less steam to go to the turbine. ~~(0.5)~~ sm
There will be less extraction steam and reheater drain steam going
to the feedwater heater. ~~(0.5)~~ sm Therefore less feedwater heating will occur
resulting in colder feedwater entering the vessel ~~(0.5)~~ sm which will cause
reactor power to increase about 3% from the positive reactivity
addition (alpha m). ~~(0.5)~~ ^(1.0) (2.0)

REFERENCE

SSM BOOK 9, CH 18-A, SEC 2.2.4, PG 39

Answer modified to be congruent w/ question. sm

ANSWER 1.08 (2.50)

- a. Decreased. (0.5)
- b. Increase. (0.5)
- c. Subtraction. (0.5)
- d. Increase. (0.5)
- e. Increase. (0.5)

REFERENCE

SSM BOOK 7, CH 6-C, SEC 1.2.1, PG 4.5

ANSWER 1.09 (1.50)

Reactor power would increase above 100% because of the removal rate
(by burnout) exceeds the production rate of xenon [0.5] (These rates
are different because iodine production increase immediately, while
xenon production increases only after iodine starts to decay).
When iodine starts decaying and the production of xenon is increased
reactor power will decrease and continue to decrease until
equilibrium xenon is reached [0.5]. Power will be less than 100%
when stabilized [0.5].

REFERENCE

SSM BOOK 7, CH 6-C, SEC 3.1.4, PG 28,29

SSM BOOK 2, CH 2-A, SEC 14.2.1.3, PG 175,176

ANSWERS -- BRUNSWICK 1&2

-85/10/08-KING, M.

ANSWER 1.10 (2.50)

- a. No bypass valve action
- b. TCV throttle close due to indicated low pressure then open as backup regulator responds
- c. Reactor pressure will increase 10 psig to ~1020 (unit one)
- d. Throttle pressure will increase 10 psig to ~959
- e. Reactor power will increase ~1.0%

REFERENCE

SD 26.2, Sec 1.2.2.2, pg 5 & EHC figures pg 38, 39, 41, & 44
Sim Malfunction Book 2, malfunction # 163, pg 147

ANSWER 1.11 (1.00)

a

REFERENCE

BSEP T.S. 3/4.2.4 LHGR LCO, pg 3/4 2-15
SSM Book 7, Sec 3.2, pg 9,11

ANSWER 1.12 (1.00)

d

REFERENCE

SSM Book 13, Ch 7, Pg 7-110

ANSWER 1.13 (1.50)

- a. less than
- b. slower
- c. longer

REFERENCE

SSM Book 2, Ch 2-A, Sec 12.2, pg 113

ANSWERS -- BRUNSWICK 1&2

-85/10/08-KING, M.

ANSWER 1.14 (1.00)

d

REFERENCE

BFNP RANKINE CYCLE LP, P. 5, 7-8

BSEP SSM Book 13, Ch 6

ANSWER 1.15 (1.00)

$$(1175 - 536.8) / 657.5 = 0.971$$

REFERENCE

GGNS OP-HF-503, P. 5

BSEP SSM Book 13, Ch 4, pg 17

ANSWER 1.16 (2.00)

a. The assembly power which would cause the onset of transition boiling
at some point in the assembly. (1.0)

b. 2

REFERENCE

BFNP TRANSITION BOILING & ATLAS TESTING LP, P. 5-6

GEXL CORRELATION & CRITICAL POWER LP, P. 3

GGNS MCD, THERMAL LIMITS, P. 26, 32-33

BSEP SSM Book 7, Ch 6-A, Sec 3.9, 3.10, 3.11, pg 17-19

ANSWERS -- BRUNSWICK 1&2

-85/10/08-KING, M.

ANSWER 2.01 (1.00)

1. Decreased cooling water flow
2. Increased cooling water temperature
3. Fouling of condenser tubes
4. Air leakage/buildup in the condenser
5. Air in the water box
6. Flooded hotwell

(4 required at .25 each) (1.0)

REFERENCE

APP UA-23, PG 5.23

ANSWER 2.02 (2.00)

- a. 1. There are no connections to spent fuel pool which would allow the pool to be drained below the pool gate between the fuel and reactor well. (1.0)
2. Each spent fuel pool diffuser line is fitted with a vacuum breaker valve. This prevents draining through siphoning action. (1.0)

*Other Reasonable Design Features For FPCC System Accepted
Per SD-13 & Sd. Co Design*

REFERENCE

SD-13, SEC 1.3.1, PG 3 & 4

ANSWER 2.03 (3.00)

- a. The Steam Supply Valve (F045) (0.5)
- b. When level decreases to the initiation level, the F045 valve will reopen. (1.0)
- c. The turbine test circuitry would be automatically bypassed and the flow controller would control normally. (1.0)
- d. No (0.5)

REFERENCE

SD-16, PG 9.13.15

ANSWERS -- BRUNSWICK 1&2

-85/10/08-KING, M.

ANSWER 2.04 (3.00)

A scram signal deenergizes the scram pilot valves(0.5), venting air from the scram inlet and outlet valves, allowing them to open(0.5). This vents water from the overpiston area of the CRD to the SDV(0.5) and applies HCU accumulator water to the underpiston area of the CRD(0.5). This dp provides the initial motive force for the rod(0.5). As accumulator pressure drops below reactor pressure, a ball check valve in the CRD opens to apply reactor pressure to the CRD to complete the scram stroke(0.5).

REFERENCE

SSM BOOK 4, CH 9-A & 9-B

SSM BOOK 6, CH 28-A, PG 7-13

ANSWER 2.05 (2.00)

The gland seal condenser will gradually fill with condensate [0.5] decreasing its ability to condense gland seal steam [0.5]. Eventually turbine gland seal will be lost and steam will leak from the turbine through the seals [0.5]. The system will, however, perform its intended function [0.5].

REFERENCE

SSM Book 10, Ch 14-B, Sec 2.2.3

ANSWER 2.06 (.50)

F (Cooling water flow enters the insert port and leaks past seals into the Reactor Vess.)

(0.5)

REFERENCE

SSM Book 4, Sec 4.1.5, pg 19

SD-3, Sec 1.2.2.1, pg 2

ANSWER 2.07 (1.00)

a

ANSWERS -- BRUNSWICK 1&2

-85/10/08-KING, M.

REFERENCE

SSM Book 11, Ch 14-C, Sec 2.2.6 thru 2.2.9, pg 17-18, & fig 8

ANSWER 2.08 (1.00)

b

REFERENCE

SD-17, fig 15-5, pg 55

SSM Book 10, Ch 14-D, Sec 4.2.6, pg 46

ANSWER 2.09 (1.00)

a

REFERENCE

SSM Book 11, Ch 14-H, Sec 4.2, pg 14,15

ANSWER 2.10 (.50)

zero gpm

REFERENCE

SSM Book 10, Ch 14-D, Sec 4.2.4, pg 45

ANSWER 2.11 (1.00)

d

REFERENCE

SD-32.2, Sec 2.3.2, pg 16

Sec 2.3.2.3, pg 18

ANSWER 2.12 (1.00)

b

REFERENCE

SSM Book 5, Ch 10-A, Fig 5, pg 79

ANSWERS -- BRUNSWICK 1&2

-85/10/08-KING, M.

ANSWER 2.13 (2.25)

- a. "1" (1.0)
- b. Differential pressure is sensed between the core spray injection line [0.25] and the instrumentation pressure tap which measures above core plate pressure [0.25]. A break in the CS piping outside the shroud would cause the dp to increase from a normal neg. reading, ^{at -100"} *H₂O*, to a positive reading (alarm at 5psig > than normal) [0.75] (Outer pipe of SBLC injection line acceptable for ref. side) (1.25)

(CAF normal 100% power reading and alarm reading)

-100" H₂O by phone comm. w/ G. Barnes, BSEP values = .05 GA.

REFERENCE

SSM Book 10, Ch 14-E, Sec 3.2.2.2, pg 12
Sec 3.1.1, pg 8,9

ANSWER 2.14 (1.00)

Alternate power source (480/120 VAC Transformer) (0.5)

SS1 shuts [0.25] and SS2 opens [0.25] (0.5)

REFERENCE

SSM Book 6, Ch 20-F, Sec 3.3.1, pg 9 & 10
Fig 2

ANSWER 2.15 (1.00)

d. (1.0)

REFERENCE

SSM Book 10, Ch 14-D, Sec 2.1.3.1, pg 6

ANSWER 2.16 (1.00)

CHECK VALVE -- (The check valve is located below the level of the Suppression Pool and) keeps the Core Spray line downstream of it full of water (prevents draining to the Suppression Pool) (0.5)

CHECK VALVE BYPASS - (This allows bypassing the discharge check valve) to drain the discharge line for maintenance. (0.5)

ANSWERS -- BRUNSWICK 1&2

-85/10/08-KING, M.

REFERENCE

BSEP: HO 14-2/3-E, Section 2.2.2 (Obj. e)

ANSWER 2.17 ~~(2.00)~~ on

Bypass Valves provide continuous flow thru the system

(0.5)

REFERENCE

BSEP: SD-43, p 3

ANSWER 2.18 (1.00)

a

REFERENCE

Recirculation system equal lesson plan.

ANSWERS -- BRUNSWICK 1&2

-85/10/08-KING, M.

ANSWER 3.01 (2.00)

No (.5) When transferring RPS power supplies, the RPS is momentarily deenergized because the transfer is break before make. This would result in a scram due to the 1/2 scram already present. (1.5)

(2.0)

REFERENCE

SSM BOOK 6, CH 28-A, SEC 2.2.1, PG 6

ANSWER 3.02 (3.00)

A. New reading on range 7 is 2.5
no auto actions

(0.5)

(1.0)

B. New reading on range 5 is 39
IRM high rod block and HI-HI half scram will be in.

(0.5)

(1.0)

REFERENCE

SSM BOOK 6, CH 25-B, PG 12,14

ANSWER 3.03 (2.00)

- a. rod block or half-scram (if concurrent hi IRM assumed) *On NR pin ques.*
 b. half-scram
 c. rod block
 d. full scram [4 @ 0.5 ea]

(2.0)

REFERENCE

SSM BOOK 6, CH 25-D, PG 14,15

ANSWER 3.04 (2.50)

- a. A withdrawal error and withdrawal block occur. (0.5)
 b. Zero notches because of the withdrawal block that is imposed. (0.5)
 c. The first notch in clears the withdrawal error and block [0.5].
 The next notch causes an insert error [0.5]. The rod can be driven in to the 00 position [0.5]. (1.5)

ANSWERS -- BRUNSWICK 1&2

-85/10/08-KING, M.

REFERENCE

SSM BOOK 6, CH 27-B, PG 10-11

ANSWER 3.05 (1.00)

- o Reactor Scram. (0.5)
- o Mechanical vacuum pump trip and/or associated valves, *OG-mar-47* (0.5)

REFERENCE

SD-11, Sec 1.2.1.1, pg 2

SSM 16-c

ANSWER 3.06 (1.50)

When RFP 2A flow decreases to <20%[0.5] and level decreases to <182"[0.5], the recirculation pumps will run back to 45% speed[0.5] (due to the #2 speed limiter).

REFERENCE

SD-1, SD-2

SSM Book 5, Ch 10-A, Fig "Recirculation System Flow Control Network", pg 89

ANSWER 3.07 (2.00)

- a. 55% (volts)[0.5]. 5% (volts) for each LPRM input not bypassed[0.5].
- b. No[0.5]. There are fewer than 2 operable inputs on the B level[0.5].

(2 @ 1.0)

REFERENCE

SD-9, Sec 1.2.3.3, pg 10

SSM Book 6, Ch 25-D

BSEP T.S. table 3.3.1-1, pg 3/4 3.5, note c

ANSWER 3.08 (1.00)

i. a

(1.0)

ANSWERS -- BRUNSWICK 1&2

-85/10/08-KING, M.

REFERENCE

SSM Book 8, Ch 17-B, Sec 3.2.17, pg 23, & fig 2

ANSWER 3.09 (2.00)

The valves are FO48A/B (RHR heat exchanger bypass) and FO17A/B (LPCI admission valves).

(2 @ 0.5)

The purpose of the timer is to prevent the valves from being throttled before the timer times out (3 min and 5 min).

(2 @ 0.5)

REFERENCE

SSM Book 10, Ch 14-D, sec 3.2.1.D & E, pg 23

ANSWER 3.10 (3.00)

1. F001, signal from HPCI initiation signal, DC motor driven
2. V8, no init signal, opened by hydraulic control oil from aux lube oil pump
3. V9, signal from flow control sys, opened by hydraulic control oil from aux lube oil pump.

(3 @ 1.0)

(CAF: F001, V8 & V9 valve names for alt. acceptable answer)

REFERENCE

SSM Book 10, Ch 14-B, Sec 3.2.1, pg 15,16

ANSWER 3.11 (1.00)

c

REFERENCE

SSM Book 10, Ch 20-D, Sec 3.2.4, pg 24

ANSWER 3.12 (1.00)

b

REFERENCE

SSM Book 10, Ch 14-E, Sec 3.2.1, pg 9

ANSWERS -- BRUNSWICK 1&2

-85/10/08-KING, M.

ANSWER 3.13 (1.00)

c

REFERENCE

BSEP GP-03 rev 3, Sec 5.0, pg 18

ANSWER 3.14 (2.50)

- a. Gama (0.5)
- b. Pulse height, Cambelling OR mean square voltage (1.0)
- c. Due to the low number of events and greater sensitivity (0.25), the SRM deals with individual counts (pulses) (0.25) where the IRM pulse signal overlap (0.5) (1.0)

REFERENCE

SSM Book 6, Ch 15-A, Sec. 6.2.1.E, Pg. 11
CH 25-B, Sec. 2.2.1, Pg. 3

ANSWERS -- BRUNSWICK 1&2

-85/10/08-KING, M.

ANSWER 4.01 (3.75)

- A.
1. OBTAIN SHUTDOWN PANEL KEYS
 2. MANUALLY SCRAM THE REACTOR
 3. TRIP THE MAIN TURBINE
 4. VERIFY OR XFER POWER TO SAT.
 5. WHEN STEAM FLOW IS $< 3.0E6$ LB/HR, PLACE MODE SWITCH IN S/D.
 6. TRIP BOTH RECIRC. PUMPS
 7. REDUCE REACTOR PRESSURE TO 700 PSIG WITH BYPASS JACK
 8. CLOSE MSIV AT 700 PSIG
 9. PLACE BOOSTER PUMPS IN MAN.
 10. ENTER EOP-01 (8 @ 0.30 EA.)
- B.
1. Go to the cable spreading room (.25)
 2. Open RPS MG output breakers (.5)
 3. Place RPS alternate feed switch (LG3) to the mid position (.5) (1.25)

REFERENCE

AOP-32, Plant S/D Outside The Control Room, Rev 5, pg 5

ANSWER 4.02 (3.00)

- a.
1. Boron injection is required and the SLC system is not available. (0.5)
 2. The SLC tank is empty and cannot be refilled AND further boron injection is required. (0.5)
- b.
1. RWCU (via SLC) *NE RE QUESTION ON*
 2. RWCU (with borax)
 3. condensate system
 4. HPCI
 5. RCIC
 6. CRD (4 req. @ 0.5 ea.) (2.0)

REFERENCE

EOP-LEP-03 rev 00, pg 3

ANSWER 4.03 (1.00)

d.

ANSWERS -- BRUNSWICK 1&2

-85/10/08-KING, M.

REFERENCE

AI-41, Equip. Clearance Proc, pg 2

ANSWER 4.04 (2.00)

1. When a system is found inoperable
2. When a system is made inoperable
3. when a system is not in stand~~by~~ readiness mode

(2 req. @ 1.0 ea.)

REFERENCE

OG-4, ESF Operability, Sec 5.1, pg 1

ANSWER 4.05 (1.50)

- a. SHALL: denotes a requirement
- b. SHOULD: denotes a recommendation
- c. MAY: denotes permission

(3 @ ~~0.5~~ 0.5)

REFERENCE

OI-1, Sec 2.0, pg 1

ANSWER 4.06 (1.00)

d

REFERENCE

OI-1, Operating Principles and Philosophy, sec 13, pg 9

ANSWER 4.07 (2.00)

The startup cannot continue. (1.0)

The APRM, IRM individually do not affect the startup. However the combination of APRM E and IRM A in bypass together reduces the number of APRM downscale/IRM upscale trips to less than 2 and the startup may not continue. (1.0)

ANSWERS -- BRUNSWICK 1&2

-85/10/08-KING, M.

REFERENCE

GP-03 rev 3, sec 5.1.3, pg 5

ANSWER 4.08 (3.50)

- a. 1. Turbine shell to rotor diff. expansion indicating in the red band.
2. Turbine journal bearing high vibration near the critical speeds or any other speeds
3. High journal bearing metal temp.
4. High thrust bearing metal temp.
5. High diff. temp. between inlet oil and bearing drain oil temp.
6. Loss of turbine speed control. (4 @ 0.5)
- b. 4, 2, 1, 6, 5, 3 (6 @ 0.25)

REFERENCE

BSEP GP-03 rev 2, pg 14, pg 15
OP-26 rev 25, pg 17

ANSWER 4.09 (1.00)

- Warming and pressurizing steamlines. (0.5)
Water hammer in the steam lines. (0.5)

REFERENCE

BSEP OP-16

ANSWER 4.10 (1.00)

These instruments have a cold reference leg ~~(0.4) and are~~
(uncompensated) ~~(0.5)~~ *on per EOP-01/UG*

They are not affected until D/W temperature exceeds the RPV saturation temperature (0.5)

REFERENCE

BSEP: EOP-01/UG, CAUTION # 6, p 36

ANSWERS -- BRUNSWICK 1&2

-85/10/08-KING, M.

ANSWER 4.11 (1.00)

- a. Service Building (0.5)
- b. Training Building (0.5)

REFERENCE

EIH: 63EP-EIP-061-0
BSEP: R.E.P. Sections 5.3, 5.4

ANSWER 4.12 (1.00)

To distribute heat evenly in the suppression pool. (0.5)

K & L are not on the list because they discharge near the exhaust
of HPCI and RCIC (0.5)

REFERENCE

EOP Vol 6, EOP-01-UG, caution #15, pg 40

ANSWER 4.13 (1.50)

The failed jet pump allows recirc flow to bypass jet pump.
The bypass flow is LESS RESTRICTIVE than flow thru the jet pump.
This is "seen" by the recirc pump and recirc flow will increase (in
failed jet pump loop)[0.5]. Depending on the severity of the failure
flow thru the jet pump may reverse. This would cause an increase in
the INDICATED total core flow[0.5]. ACTUAL core flow will decrease,
causing increased voiding which will lower core power and result in
LOWER GEN. MW. output[0.5].

REFERENCE

BSEP AOP-04.4 rev 00, pg 3
BSEP Sim. Malfunction list, Customer Malfunction #125

ANSWER 4.14 (1.00)

b

ANSWERS -- BRUNSWICK 1&2

-85/10/08-KING, M.

REFERENCE

BSEP OP-21 rev 21, Sec 4.0, pg 5

ANSWER 4.15 (1.00)

^{Pressure}
Opening the bypass valve to 20% to prevent:

- a. power osc. due to variation in RFP steam demand ~~to 5%~~ and/or ~~DM~~ (1.0)
- b. prevent sudden oscillation in reactor pressure ~~to 5%~~
_{Power}

REFERENCE

BSEP OP-25 rev 19, Main Steam OP. Proc, pg 12