U.S. NUCLEAR REGULATORY COMMISSION

REGION III

Report No. 50-483/OL-84-01

Docket No. 50-483 License No. NPF-30

Licensee: Union Electric Company
Post Office Box 149 - Mail Code 400
St. Louis, MO 63166

Facility Name: Callaway

Examination Administered At: Callaway

Examination Conducted: November 27, 28 and 29, 1984

R. L. Higgins

Examiners: R. L. Higgins
Region III

12/24/84
Date

R. L. Higgins for

M. Baldwin
ORNL

12/24/84
Date

R. L. Higgins for

R. Thornton
ORNL

12/24/84
Date

R. L. Higgins for

O. Burke
ORNL

12/24/84
Date

J. I. McMillen

Approved By: J. I. McMillen, Chief
Operator Licensing Section

12/24/84
Date

Examination Summary

The written examinations were administered on November 27, 1984 (Report No. 50-483/OL-84-01). Simulator and oral examinations were administered on November 28 and 29, 1984.

There were eight examinees: five Reactor Operator Candidates, two Senior Reactor Operator Candidates, and one Instructor Certification Candidate. The Instructor Certification candidate was also applying for a Reactor Operator License.

Results: All examinees passed all portions of the examination.

REPORT DETAILS

1. Examiners

R. Higgins, Region III, Chief Examination, SRO exam author and grader
M. Baldwin, ORNL, Examiner
R. Thornton, ORNL, Examiner
R. Ferrell, Region III, Observer
O. Burke, ORNL, RO exam author and grader

2. Examination Review Meeting

On November 27, 1984, at the conclusion of the written examinations, an examination review meeting was held. The SRO written examination was reviewed by J. F. Dampf, A. Daume, and R. J. Renz, all of whom are members of the Callaway Training Department. No problems were noted concerning the questions. Four modifications to the answer key were requested.

a. In the answer for question 6.10, the facility representatives noted that the answer "5 ppm chlorine" should be deleted since this is not installed at Callaway. Because facility system descriptions still contain this answer credit will still be awarded for the response "5 ppm chlorine".

b. The facility representatives wanted the answer for question 7.8.a changed to "South ESF Switchgear Room", the answer for question 7.8.b changed to "Front Standard of the Turbine", and the answer for question 7.8.c changed to "North HVAC Room". The justification for these requests was a revision to Procedure OTO-ZZ-00001. The current revision of the procedure was checked to verify the changes, and the answers were changed per the facility representatives' request.

c. The facility representatives requested that the answer for question 7.9.a be changed to 8 mils to reflect the current revision of the applicable procedure, OTO-AC-00002 Revision 1. The procedure was checked to verify the change, and the answer was changed per the facility representatives' request.

d. The facility representatives requested that the answer "prevent injecting the accumulators" also be accepted as a correct response. Since prevention of accumulator injection is the purpose of the procedural step, the facility's request was granted.

The RO written examination was reviewed by J. F. Dampf, R. J. Renz, D. W. Neterer, and W. O. Jessop, all of whom are members of the Callaway Training Department. The following modifications were made to the RO exam during its administration and were approved after the fact by the exam reviewers:

a. Added the clarification statement "but curve book values are not applicable since Tave is not being maintained at is programmed value" to distractor c of question 1-7.

b. Added the following clarification statement to 1-14.b: "Specify which controller affects which curve."

c. Modified question 2-4 by changing the term "category 1" to "seismic category 1" to clarify the meaning.

d. Modified the term "air supply" to "instrument air supply" to clarify the meaning of question 2-7.

e. Added the clarification statement "Meters or indications other than switches" to the end of question 2-14.

f. Corrected question 3-21 by including the term "no change" as a possible correct response.

The following changes to the answer key were made based on input from the reviewers:

a. Changed the answer for question 1-4 from 5.3 ± .3 to 6.15 in order to reflect curve book values.

b. Deleted the response "erratic running current" in the answer for question 1-15.b since there is no current indication on the control board.

c. Changed the steam generator level setpoint at which the AFW pumps automatically start to 23.5% in the answer for questions 2-3.a and b in order to correct a typing error.

d. Added the LOCA Sequencer and Shutdown Sequencer as correct responses for question 2-3.a.

e. Changed the answer for question 2-5 to reflect the current Callaway procedure OTO-ZZ-00003.

f. Added the responses "steam dump valves armed lights" and "Hi-1/Hi-2 light" as correct answers for question 2-14 to reflect the actual control board indication.

g. Changed the answer for question 2-15 to 12 seconds to agree with the value in Tech Specs.

h. Added as correct the response "Post accident sample system coolers" to the answer for question 2-16.a ir order to agree with print M-02 EG02(Q).

i. Added the clarification statement "in the affected loop" to the answer for question 3-4.a.

j. Deleted the phrase "and it will close automatically 120 seconds after the pump is started" from the answer for question 3-6.b per print E-03 BG23.

k. Changed the answer for question 3-21.d to "no change" since Callaway operates with a constant steam generator level setpoint of 50% regardless of power level.

3. Exit Meeting

On November 29, 1984, at the conclusion of the last simulator/oral exam, an exit meeting was held to discuss preliminary examination results, generic weaknesses of the examinees and overall impression of the plant. The following individuals from the Callaway Plant attended the exit meeting: Andrew Newhalfen, Assistant Plant Manager; Paul Appleby, Assistant Plant Manager; Mike Taylor, Superintendent of Operations; John Price, Superintendent of Training; Brian Stanfield, QA Supervisor; Roger Wink, Compliance; and Bill Jessop, Supervisor of License Training. Ron Higgins, Chief Examiner, and Ralph Ferrell were the NRC representatives.

The facility representatives were informed that all seven of the examinees who took the oral/simulator portion of the license exam passed that portion of the exam.

Generic weaknesses in the following areas were discovered during the course of the exams:

a. Liquid and gaseous radioactive waste system.

b. Subcooling monitors.

c. Power range nuclear instrument calorimetric gain adjustment.

d. Source of the diesel generator exciter current.

The following observations were made concerning plant personnel, procedures, and equipment:

a. Plant cleanliness had improved considerably since previous visits.

b. Some auxiliary building walls did not have sealant applied to them.

c. A discrepancy between procedure E-0 and ES-0.1 was discovered. The discrepancy concerned the steam generator wide range level which corresponded to the top of the U tubes.

d. Plant personnel were extremely cooperative.

On November 30, 1984, the Chief Examiner notified the Senior Resident Inspector, Bruce Little, by telephone of the major items discussed in the exit meeting.

Master

Facility Review Copy

U. S. NUCLEAR REGULATORY COMMISSION

REACTOR OPERATOR LICENSE EXAMINATION

J.F. DAMPF
R.J. Renz
D.W. NETERER
W.C. Jessep

Facility: Callaway

Reactor Type: PWR

Date Administered: 11/27/84

Examiner: Burke

Applicant:

INSTRUCTIONS TO APPLICANT:

Use separate paper for the answers. Write answers on one side only. Staple questions 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 Value	% of Total	Applicant's Score	% of Cat. Value	Category
25.0	25.0			1. Principles of Nuclear Power Plant Operations, Thermodynamics, Heat Transfer and Fluid Flow
25.0	25.0			2. Plant Design Including Safety and Emergency Systems
25.0	25.0			3. Instruments and Controls
25.0	25.0			4. Procedures -- Normal, Abnormal, Emergency & Radiological Control
100.0	100.0			TOTALS

Final Grade ______ %

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

Applicant's Signature

1. PRINCIPLES OF NUCLEAR POWER PLANT OPERATION, THERMODYNAMICS, HEAT TRANSFER & FLUID FLOW (25.0)

1-1 Following a reactor trip from 100% power, how long would you expect it to take for the source range instrumentation to be energized? Show by calculation and also state any assumptions used. (1.0)

1-2 Assume a reactor is shutdown by 6.5% delta K/K and has a count rate of 250 cps. If control rods worth 4.2% delta K/K are withdrawn, what will the new count rate be? Show all work. (2.0)

1-3 The time required to reach equilibrium xenon concentration after start-up of a xenon free core is approximately __________ hours. (0.5)

? 1-4 The largest xenon concentration peak occurs after a trip from 100% power. The negative reactivity due to xenon in this worst case is ___% $\delta K/K$. (0.5)

1-5 A reactor whose reactivity change information is given in figures 1.1 through 1.3, attains criticality at 100 steps on rod group D (using a 100 step overlap). Assume that the boron concentration is held constant at 900 ppm and that the reactor is initially at BOL and HZP, with all rods bottomed. Use $\beta = 0.007$ and $\lambda = 0.08$.

Scale on figure 1.1 Leaves room for interpretation on banks B and D

a. What <u>was</u> the actual shutdown reactivity with all rods bottomed? (1.0)

b. What <u>was</u> the initial k effective (with all rods bottomed)? Show all work. (0.5)

c. What would be the D group position required to obtain a stable 0.8 DPM startup rate (starting from a stable, just critical position of 100 steps on D bank)? Show all work. (1.0)

d. Assuming that this reactor is similar to your reactor, how would the control rod positions at 10^{-8} amps compare with the rod positions at 10^{-9} amps (assume steady state conditions at both power levels)? Explain. (0.5)

e. If the reactor power is increased to 30% of full power using rod motion only (constant boron concentration) and disregarding any long term poison effects, what will be the group D position at 30% steady power? (1.0)

1-6 In order to prevent overheating the fuel, the reactor is operated such that the point of DNB is not reached (DNBR > 1.3). What four (4) primary system parameters are monitored to assure that DNBR is > 1.3? (1.0)

(continued on next page)

1-7 Assume that you are starting up your reactor and the reactor is critical at a steady power level of 10^{-8} amps on the intermediate range NI's. If you should step change the reactivity by +10 pcm and not have any subsequent rod motion or boron concentration changes, which of the following statements best describes the subsequent reactor behavior? (1.0)

a. K_{eff} will increase, neutron population and core power will continue to increase indefinitely until the operator inserts -10pcm by inserting rods or boron.

b. K_{eff} will increase, neutron population and core power will increase, which will add negative reactivity due to temperature changes, cancelling out the +10 pcm. The core power will level out at the power level having a power defect of 10 pcm from the power defect curve in your curve book.

c. K_{eff} will increase. neutron population and core power will increase, which will add negative reactivity due to temperature changes cancelling out the +10pcm. The core power will level out by itself at some power level above POAH, but curve book values are not applicable since Tavg is not being maintained at its programmed value.

d. K_{eff} will increase, neutron population and core power will increase, which will add negative reactivity due to temperature changes cancelling out the +10pcm. The core power will return to the original power level.

1-8 Fissionable PU^{239} in appreciablé quantities is formed in the reactor by the fissioning of U^{238}. TRUE or FALSE. (0.5)

1-9 A startup is being performed 15 hours after a trip from extended full power operation using a calculated estimated critical position for the time the startup commenced. How would each of the following events or conditions affect the actual critical rod position compared to the estimated critical position? (1. <u>higher than</u> estimated, 2. <u>lower than</u> estimated, or 3. <u>no significant</u> difference.) Consider each item separately.

a. A steam generator's level is increased by 40%. (0.5)
b. The startup is delayed for appx. two (2) hours. (0.5)
c. The steam dump pressure setpoint is increased by 200 psi. (0.5)
d. A new boron sample is ten (10) ppm lower than the previous sample. (0.5)
e. Condenser vacuum decreases by two (2) inches H_g from 29 in. mercury. (0.5)

(continued on next page)

1-10 The "secondary source" in a reactor refers to the neutrons released as a result of radioactive decay of fission products. TRUE or FALSE (0.5)

1-11 A control rod is worth more in reactivity when it is adjacent to a withdrawn control rod as compared to its worth when adjacent to an inserted rod. TRUE or FALSE. (0.5)

1-12 The <u>major</u> source of the heat produced in the core of a reactor 5 minutes after it has been shut down is: (1.0)

a. Subcritical multiplication
b. Spontaneous fission
c. Fission product decay
d. Fission by delayed neutrons

1-13 Which of the following statements is true for a constant speed centrifugal pump? (1.0)

a. As the resistance to flow increases, the pump head increases and the volumetric flow rate decreases.

b. As the resistance to flow increases, the pump head decreases and the volumetric flow rate increases.

c. As resistance to flow decreases, the pump head increases and the volumetric flow rate increases.

d. As resistance to flow decreases, the pump head decreases and the volumetric flow rate decreases.

(continued on next page)

1-14 Assume that you are manually operating all of the controllers that contribute to steam generator level control. You determine that you need a feedwater flow rate of "X" gpm to match the existing steam flow rate.

a. From Figure 3-3, select the combination of feedwater pump characteristic curve (a,b,c) and system head loss curve (1,2,3) that would be most desirable in producing feedwater flow rate "X". (1.0)

b. Which controllers would you adjust to get each of the curves in the combination that you selected in part a? Specify which controller affects which curve. (1.0)

c. Give your reasons for not selecting each of the two (2) combinations that you did not select in part a. (1.0)

1-15 a. What is cavitation? (0.5)

b. What control room indications would alert the operator to cavitation of a centrifugal charging pump? List at least three (3). (1.5)

1-16 State what plant parameters are measured in performing a calorimetric. Explain why these parameters are chosen over other possible choices. (1.0)

1-17 a. Find the enthalpy change in an isentropic expansion of steam through a turbine into a condenser (NOTE: Pstm = 825 psia, saturated, Pcond = 2 psia). (1.0)

b. How would the enthalpy change in part a be affected by a less than ideal turbine (i.e., some degree of inefficiency)? Select one of the following answers. (0.5)

1. Higher
2. No change
3. Lower

1-18 a. List two types of events that can cause Pressurized Thermal Snock (PTS). (1.5)

b. List two other conditions in conjunction with PTS necessary to cause a safety problem.

c. Explain what operator actions can be taken to prevent PTS.

END OF SECTION 1

2. PLANT DESIGN INCLUDING SAFETY AND EMERGENCY SYSTEMS (25.0)

2-1 With the control rod drive controller in the "MANUAL" mode, would the following system variables increase, decrease, or remain the same in their initial response to a sudden turbine load decrease from a steady 60% load to 50% load? (2.5)

a. steam header pressure
b. S/G steam temperature
c. T_C
d. T(ave)
e. reactor power

2-2 With the exception of the charging pumps in the charging alignment, which component of the Emergency Core Cooling System is designed to act first to initially reflood the core after a design basis loss of coolant accident? (1.0)

a. High head safety injection system (centrifugal charging pumps) through the boron injection tank
b. The high volume-low head injection system
c. The cold leg safety injection accumulators
d. Intermediate head injection system

2-3 List all the start signals (including coincidence and setpoints where applicable) for:

a. Motor driven auxiliary feedwater pumps. (1.2)

b. Turbine driven auxiliary feedwater pumps. (1.2)

2-4 The condensate storage tank and its feeders to the auxiliary building are required to be seismic category 1. TRUE or FALSE (0.5)

2-5 List five (5) conditions that require the operator to initiate immediate boration. (2.5)

2-6 While in the immediate borate mode of boron addition, how can the operator determine the amount of boron that he has added? (1.0)

2-7 The loss of instrument air supply to the diaphragm of a S/G PORV causes that PORV to fail to the closed position. TRUE or FALSE (0.5)

2-8 The unit auxiliary transformer output breakers can be closed from the main control board panel PL016 provided certain conditions are met. What four (4) conditions must be met? (2.0)

(continued on next page)

2-9 Suppose that all four (4) undervoltage relays on your safeguards busses have tripped.

a. What would be the difference in the load shedding action with and without a concurrent SI signal? (0.5)

b. What would be the difference in the load sequencing action with or without a concurrent SI signal? (1.0)

2-10 The following reactor trips protect against what:

a. OTΔT? (0.5)
b. OPΔT? (0.5)

2-11 What is the function of the "delay pipe" in the letdown system? (1.0)

2-12 What two (2) conditions must be met before opening the RHR pump "A" suction valve from the containment recirculation sump, HV-8811A, from the main control board? (1.0)

2-13 The main condenser is a three shell, multi-pressure, deaerating type, surface condenser. Give three (3) ways that this multi-pressure condenser improves efficiency. (1.5)

2-14 The instrumentation displays on the operator console assist the operator in determining the status of the steam dump system. List five (5) principle displays. (2.0) Meters. or indications other than switches

2-15 According to design criteria, the emergency diesel generators must be capable of achieving rated voltage and frequency within ____ seconds of receiving a start signal. (0.6)

2-16 a. What five (5) heat loads are supplied by the safety loops of the Component Cooling Water System? (1.5)

b. What are the results of a Phase B containment isolation signal with respect to the CCW system? State what components are affected. (1.0)

2-17 What are the two (2) purposes of the 2-inch air operated bypass valves around the MSIV's? (0.75)

2-18 How is inadvertent criticality prevented in the spent fuel pool? (0.75)

END OF SECTION 2

3. INSTRUMENTS AND CONTROLS (25.0)

3-1 Which of the following steam dump valve conditions would you expect if Tavg has reached a value of 550°F during a cooldown, steam pressure control mode is selected, and you place the "Bypass Interlock" switches in the bypass position? (1.0)

- a. All 4 valve banks open or available.
- b. Valve banks 1, 2, & 3 open or available.
- c. Valve bank 1 open or available.
- d. All 4 valve banks closed.

3-2 Let us suppose that the (T_{ave}-T_{ref}) error signal input to the control rod drive controller has become disconnected so that the only input to the controller is the power mismatch signal. Turbine power is 100% and nuclear power is 95% and they have been at these values for 5 minutes. At the present time the control rods will be (controller in "auto"): (1.0)

- a. inserting
- b. withdrawing
- c. no control rod motion

3-3 Suppose that during normal full power operation of your plant you get "Tave Deviation" alarms from loops 2, 3 and 4, an alarm on (auct. high Tave-Tref), and an "auctioneered Tavg" alarm. A possible cause of these alarms is: (1.0)

- a. Loops 2, 3 and 4 hot leg RTD's failed high
- b. Loop 1 hot leg RTD failed low
- c. Loops 2, 3, & 4 hot leg RTD's failed low
- d. Loop 1 hot leg RTD failed high

3-4 If you were operating your plant at 80% full reactor power when a narrow range control channel $T_{(h)}$ RTD fails high, how would the following parameters be affected? (Answer with 1. increase, 2. decrease, or 3. remain the same. Assume that all control systems are in automatic and that there is no operator action.) (2.0)

- a. OTΔT setpoint
- b. charging flow
- c. rod insertion limit setpoint
- d. control rod bank position

(continued on next page)

3-5 Refer to Figure 3-5

a. Flow through the heavy black flow paths indicates that the ________ system is in operation. (0.5)

b. What function is being performed by this system with the indicated valve alignment? (0.5)

c. What is the major advantage of this system over the other system that is capable of performing the same function? (0.5)

3-6 Bypass valve (HV-8109) is located in the positive displacement charging pump (PDP) discharge line.

a. What purpose does this valve serve? (0.5)
b. Describe the manipulations of this valve as the PDP is placed in service from an "OFF" condition. (0.5)

3-7 a. Suppose a high activity alarm occurs in a Gaseous Radiation Monitor. If you reset the alarm and it comes back immediately, would you consider the alarm valid or invalid? Explain. (0.75)

b. If you PURGE the gaseous monitor after it alarms and the alarm does not clear, would you consider the alarm valid or invalid? Explain. (0.75)

3-8 List the four (4) <u>measured</u> or <u>sensed</u> system parameters used to generate the control rod drive controller demand signal. (1.0)

3-9 The RCP anti-reverse rotation device prevents back flow through the pump in case it loses its driving power. TRUE or FALSE (0.5)

3-10 a. What signal is used to automatically start the main steam turbine turning gear motor? (0.5)

b. What interlocks will prevent the above motor from starting? (Give set points when applicable.) (0.5)

c. At any given time, how does the operator know whether or not the interlocks will permit the motor to start? (0.5)

(continued on next page)

3-11 What operator action may be necessary if an intermediate range detector is undercompensated during a reactor shutdown? (1.0)

3-12 List two (2) advantages to be gained by using "auctioneered high" Tavg signals, rather than other temperature signals for control purposes. (1.0)

3-13 Which of the following will cause the OPΔT setpoint calculator to reduce its setpoint. (1.0)

a. T(ave) above rated
b. Rate of change of T(ave) [redacted] is decreasing
c. Pressure below 2235 psig
d. Delta flux exceeding the deadband

3-14 The input into the rod insertion limit calculator used as an indication of reactor power is: (1.0)

a. P(imp)
b. Auct. High T(ave)
c. Total steam flow
d. Auct. high ΔT

3-15 Match the correct control rod position indicating instrumentation with the functions listed below: (2.0)

1. Individual Rod Position Indication Circuitry
2. Group Demand Circuitry

    a. Measures actual rod position
    b. Provides an input to the step counters on main control board
    c. Provides an input to the rod insertion limit alarm circuit
    d. Actuates rod bottom lights

3-16 The steam generator level program receives an input from the turbine impulse pressure transmitter. If this transmitter should fail high, the level program output would: (1.0)

1. fail low
2. not be affected
3. fail high
4. oscillate between high and low

(continued on next page)

3-17 Pertaining to the steam dump system during normal, 100% power operation, what operator console items would you as an operator check to determine the readiness of the steam dump system to respond properly to a turbine trip or load rejection? (1.0)

3-18 Will the power range nuclear instrumentation channels indicate power that is higher than or lower than actual reactor power if they are calibrated from results of a calorimetric which used a feedwater temperature that was lower than the actual feedwater temperature. (1.0)

3-19 List two (2) phenomena that make gamma compensation unnecessary in the power range instrumentation. (1.0)

3-20 Which of the following signals is not used as an input to the steam generator level control system to modulate the main feedwater regulating valves? (1.0)

a. Actual steam generator level
b. Feedwater flow
c. Turbine impulse pressure
d. Steam flow
e. T(avg)

3-21 For each of the following situations indicate the initial direction of travel (open no change, or close) for the feedwater regulator valve. Assume that the plant is initially at steady full power for each case.

a. A steam generator level transmitter fails low. (0.5)

b. Controlling feed flow transmitter fails high. (0.5)

c. Controlling steam generator pressure transmitter fails low. (0.5)

d. Controllng first stage pressure transmitter fails low. (0.5)

END OF SECTION 3

4. PROCEDURES -- NORMAL, ABNORMAL, EMERGENCY & RADIOLOGICAL CONTROL (25.0)

4-1 Off-Normal procedure OTO-AB-00001, Steam Dump Malfunction, provides guidance in the event of an inadvertant steam dump system actuation.

a. Give five (5) symptoms of this event. (1.5)
b. Give six (6) immediate operator actions for this event. (1.8)

4-2 Off-Normal Procedure OTO-AC-00001 provides the instructions to be followed should a turbine trip without a reactor trip occur.

a. Give the symptom of this event. (0.5)
b. Give five (5) immediate operator actions for this event. (1.5)

4-3 One of the major purposes of emergency operating procedure E-0 (Reactor Trip or Safety Injection) is to ensure proper responses of the automatic protection systems following actuation of a reactor trip or safety injection.

a. Give the six (6) symptoms listed in the above procedure (assume a reactor trip and a S.I. actuation have occurred). (1.8)

b. The first eight (8) steps of this procedure are probably the most important and most urgent with regard to protecting the plant following a reactor trip and safety injection actuation. List these eight (8) steps and for each step give the required operator actions (assume that the response to each action is the expected response). (3.2)

4-4 The critical safety function status trees use a color coding scheme to indicate the level of response required of the reactor operator. For each color employed, give the corresponding condition of the critical safety function in question and the required operator action level. (2.0)

4-5 In procedure OTG-ZZ-00001, Plant Heatup Cold Shutdown to Hot Standby, the following statement is made. (1.0)

It is not required that each step within a section be performed in <u>precise sequence</u>, as long as all steps in a section are accomplished in a <u>timely manner</u> prior to proceeding to the next section. Deviations from the prescribed sequence is permissible with the consent and under the direction of the ____________________. (Fill in the blank.)

(continued on next page)

4-6 During a loss of forced coolant flow, the operator must ensure that certain key conditions are maintained in the primary and secondary systems. List three (3) of these key conditions and the methods employed by the operator to attain them or to verify their existance. (3.0)

4-7 What are the three (3) major objectives of the proper operator response to a steam generator tube rupture? (1.5)

4-8 Answer the following questions in accordance with the precautions and limitations stated in procedure OTG-ZZ-00002, Reactor Startup.

a. Criticality must be achieved by what means of changing the reactivity? (0.5)

b. If the count rate on either source range channel increases unexpectedly by a factor of ______ during any operation, immediately suspend the operation and evaluate the core reactivity and the reason for the change. (Fill in the blank) (0.5)

c. What conditions would require using an inverse count rate ratio in approaching criticality? (0.5)

4-9 What is the primary responsibility of the reactor operator during an emergency condition covered by the facility emergency plan? (1.0)

4-10 Define the term "High Radiation Area" in accordance with the Callaway Plant HP Program, APA-ZZ-00160. (1.0)

4-11 When you, as an operator, sign the RWP signature sheet or Health Physics access Control Log you are signifying that you have accepted three (3) responsibilities. What are they? (0.7)

4-12 While at 100% power, "B" Feed Reg[redacted] Valve fails shut. "B" Steam Generator level decreases to the Low-Low level setpoint, and the "Steam generator Low-Low Level Reactor Trip" annunciator alarms. The reactor does not trip. What actions are required by E-0 and related procedures to insure the reactor is tripped? (1.5)

4-13 For the below listed accidents, match the applicable symptoms with the proper accident. (1.5)

1. Loss of reactor coolant accident
2. Steam Break inside containment
3. S/G Tube Rupture

a. Low steam pressure
b. High containment sump level
c. Increased charging flow
d. steam flow > feed flow
e. Containment high radiation
f. Decreasing pressurizer level
g. Decreasing RCS pressure
h. High containment pressure
i. Tavg decreasing

END OF SECTION 4

U.S. NUCLEAR REGULATORY COMMISSION

INTEGRAL CONTROL BANK WORTH VERSUS STEPS WITHDRAWN WITHOUT OVERLAP (BOL AND HZP)

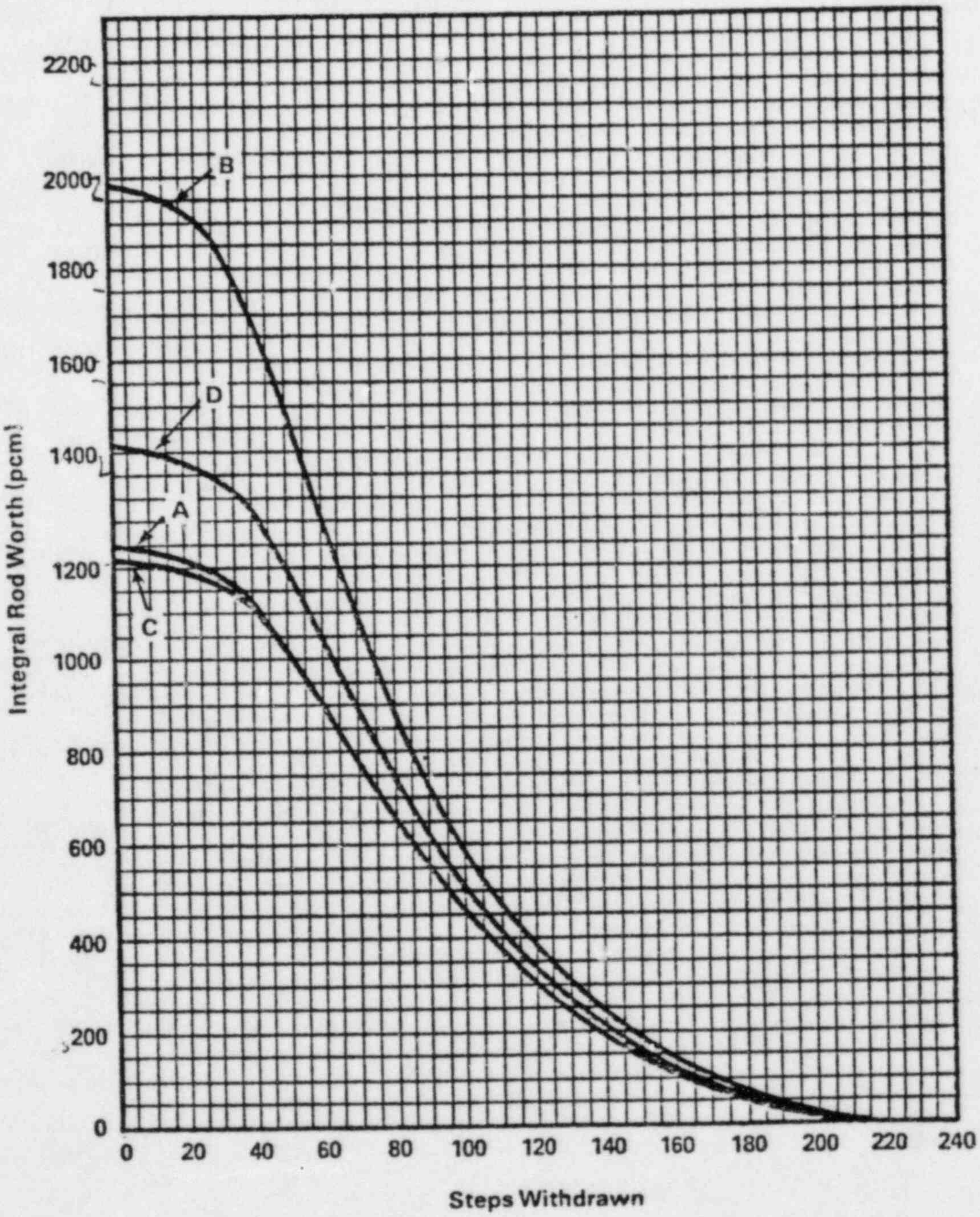


FIGURE I.1

U.S. NUCLEAR REGULATORY COMMISSION

INTEGRAL SHUTDOWN BANK WORTH VERSUS STEPS WITHDRAWN (BOL AND HZP)

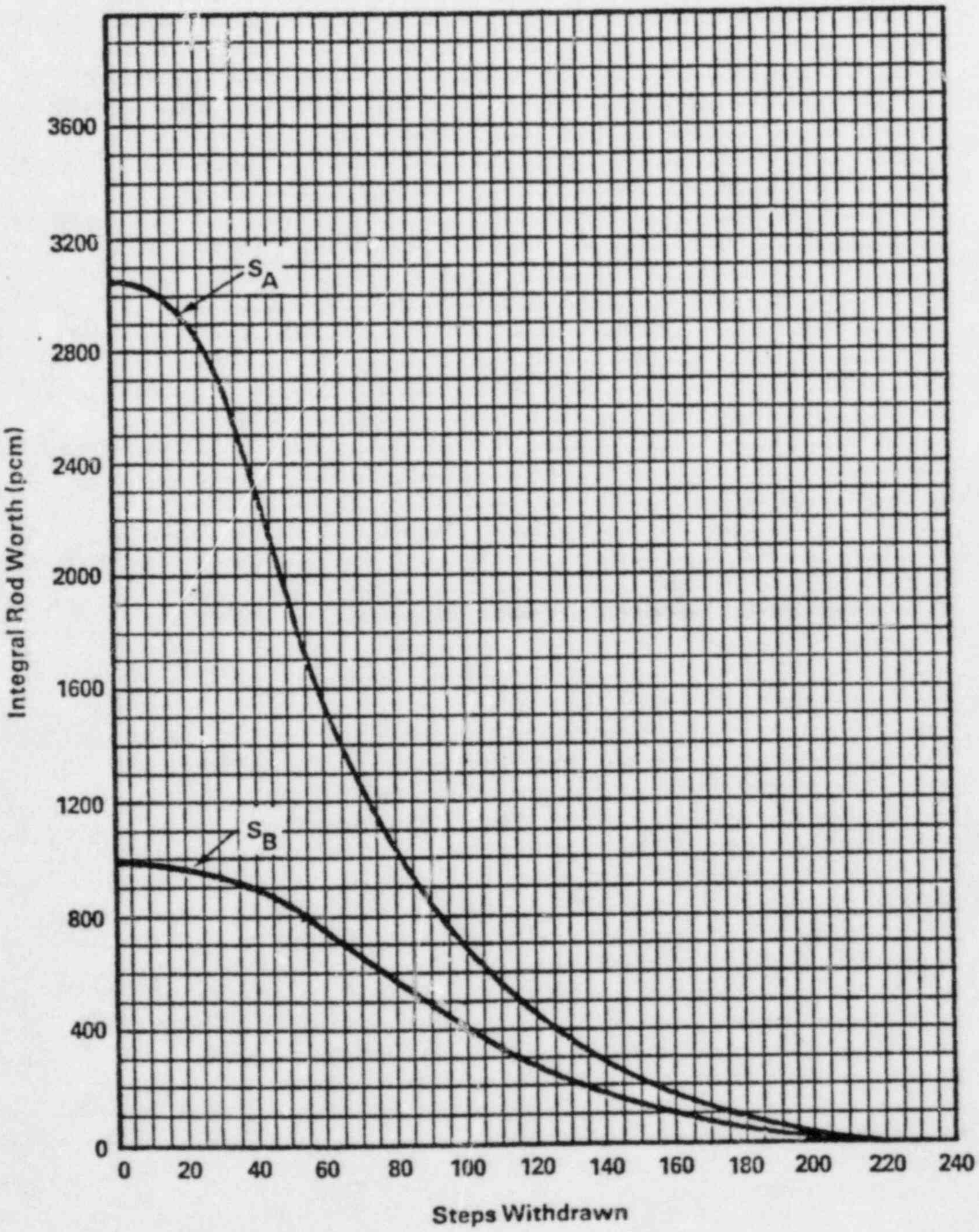


FIGURE I. 2

POWER DEFECT VERSUS PERCENT POWER

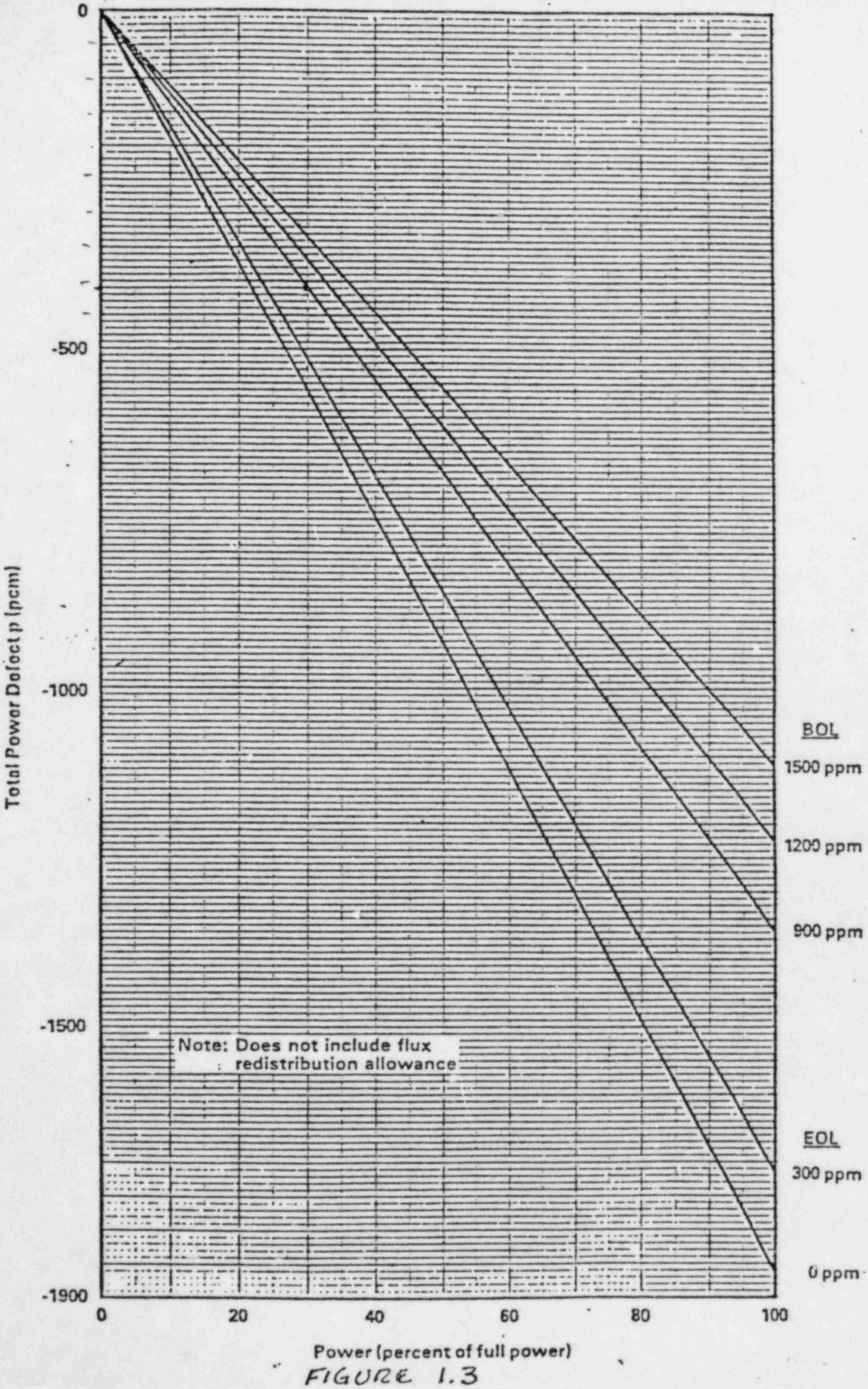


FIGURE 1.3

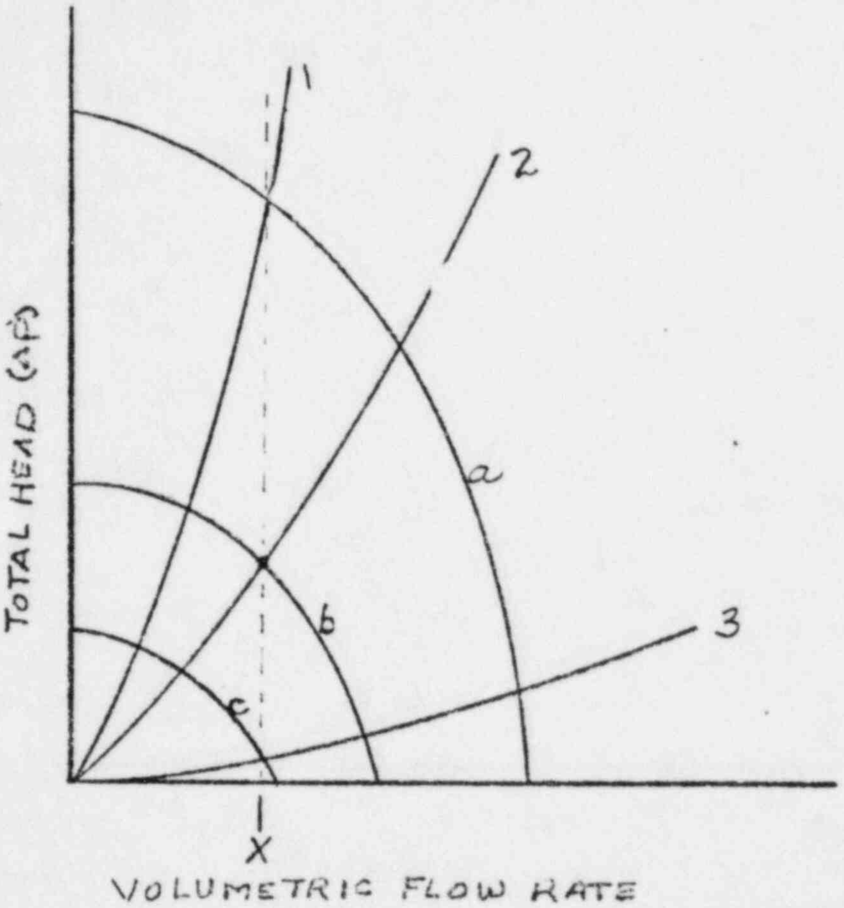


FIGURE 3-3

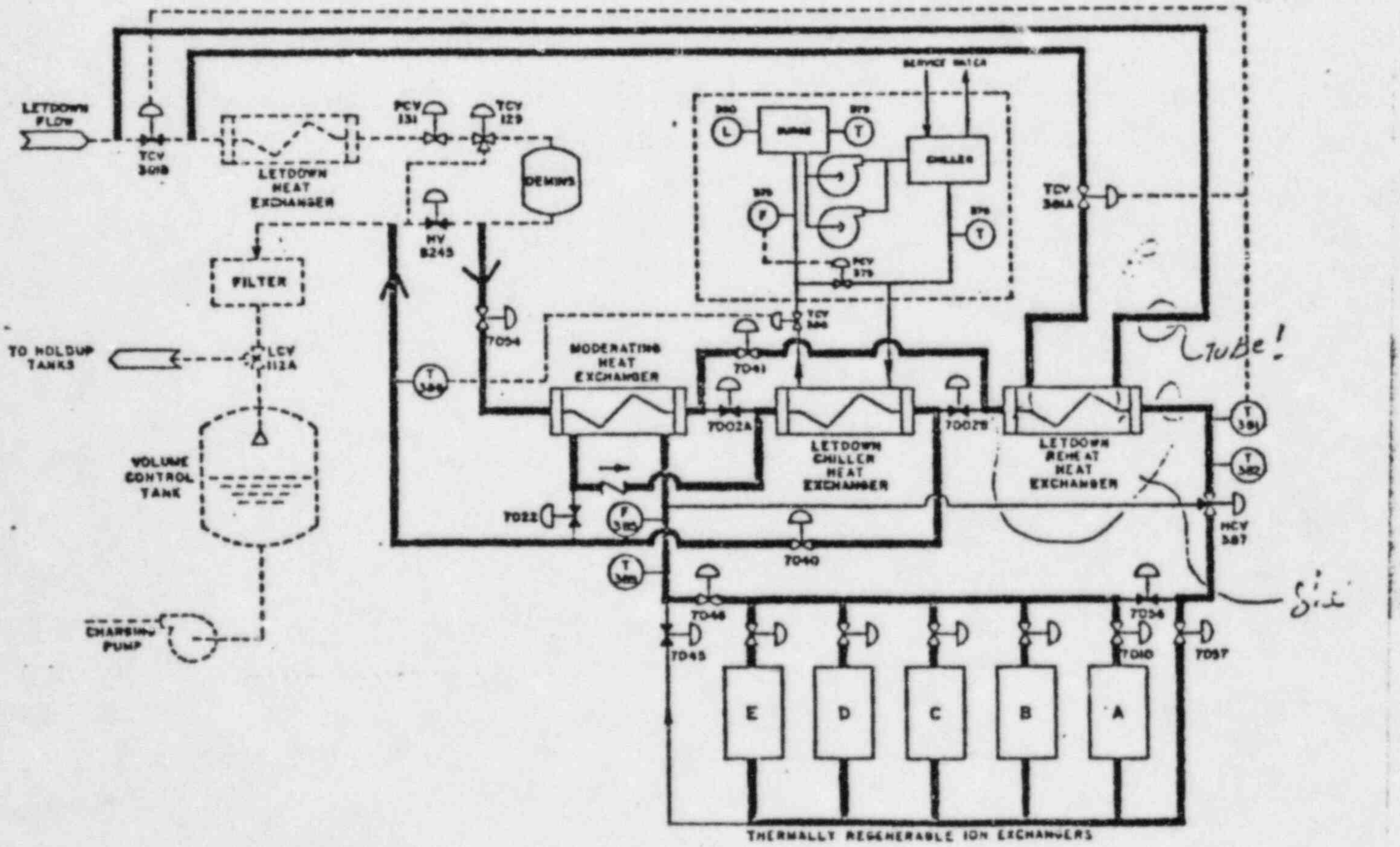


FIGURE 3-5

EQUATIONS/DATA SHEET

$1Ci = 3.7 \times 10^{10} d/s$

$\alpha_D = -1 \times 10^{-5} \frac{\Delta K}{K}/°F$

$\alpha_V = -1 \times 10^{-3} \frac{\Delta K}{K}/\%$ voids

$\alpha_M = -1.0 \times 10^{-4} \frac{\Delta K}{K}/\%°F$

$\alpha p = -4.5 \times 10^{-4} \frac{\Delta K}{K}/\%$ power

$I(t) = Io\ e^{-\lambda t}$

$T1/2 = \ln(2)/\lambda$

$Cp = (CP_{base})\ (Ks)\ (K_A)$

$$\frac{\rho_1}{\gamma} + Zi + \frac{V_1^2}{2g} + ha - hr - h_L = \frac{P^2}{\delta} + Z_2 + \frac{V_2^2}{2g}$$

$$\frac{V_2}{V^1} = \frac{(\Delta P_2)}{(\Delta p_1)}^{1/2}$$

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

$\Delta\rho = f \frac{L}{D} \frac{\rho V^2}{2g_c}$

$f = 64/Re$

$\rho = \frac{k(eff) - 1}{K(eff)}$

$\frac{1}{M} = \frac{CR1}{CR2} = \frac{1-K(eff)2}{1-K(eff)1}$

$\dot{Q} = M\Delta h$

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

$\lambda = 0.1$

$h_L = km\dot{V}^2$

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

$SUR = \frac{26.06}{\tau}$

$P = P_o\ e^{t}/\tau$

$A(x) = A_o e^{-\mu x}$

$M = 1/(1-k) = \frac{CR_1}{CR_0}$

$N(t) = No\ e^{-\lambda T}$

$\alpha_r \propto (L_f+L_s)\ \frac{(\phi rod)^2}{(\phi avg)}$

$n = \nu/(1 + d)$

$P = \Sigma\ \phi\ \nu/(3.7 \times 10^{10})$

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

$\tau = \bar{\ell}/\rho + (\beta-\rho)/\lambda\rho$

$\tau = \ell/(\rho-\beta)$

$v = v_f + xv_{fg}$

$H = xh_g + (1-x)\ h_f$

$S = xS_g + (1-x)\ S_f$

1 in = 2.54 cm

1 gal. = 3.785 liters

1 kg = 2.205 lb

$N = \rho A_0/A$

17.58 watts = 1 BTU/min

1psi = 6.895 Pa

1psi = 2.036 " H_g (@ 0C)

1psi = 27.68 " H^2O (@ 4C)

$\bar{\beta} = .0071$

$\bar{\ell} = 2 \times 10^{-5}$ sec

$\ell d = 12.5$

$RR = \Sigma_f \phi_{th}$

$SCR = \frac{S}{1-Keff}$

$\rho = \frac{\beta}{\lambda\tau + 1}$

Reactor thermal power = (h_2-h_1) x steam flow rate

$K = \frac{1}{1 - \rho}$

Master Facility Review Copy

J.F. DAMPF
R.J. Renz
D.W. NETERER
WO Jessop

1-1 $P(d) = P_o e^{+t/T}$

where $T = \frac{56 \text{ sec}}{.693}$ approximately 80 sec. (0.5)

Assume that after prompt drop, $P_o = 10^{-6}$ amps and that P-6 is energized at 10^{-10} amps.

$10^{-10} = 10^{-6}\ e^{+t/T}$

$-80 \ln \frac{10^{-10}}{10^{-6}} = +t$

737 sec = t

12.3 min. = t (0.5)

REF.: Callaway Theory, Chapter 7, Neutron Kinetics, Pages 7-12, 7-24, and 7-68.

1-2

$-6.5\% = \rho_1$

$+4.2\%$
$\overline{-2.3\%}\ \Delta k/k = \rho_2$

$C_1\ (1-K_1) = C_2\ (1-K_2)$

$250\ (1-.939) = C_2\ (1-.977)$

$\frac{250\ (.061)}{.023} = C_2$

$= 663$ cps. (1.0)

$K_1 = \frac{1}{1-\rho_1}$

$K_1 = \frac{1}{1-(-.065)} = 0.939$ (0.5)

$K_2 = \frac{1}{1-\rho_2}$

$K_2 = \frac{1}{1-(-.023)} = 0.977$ (0.5)

REF.: Callaway Theory, Chapter 5, Reactor Physics, Pages 5-21

(continued on next page)

1-3 45 (±5)

REF.: Large Pressurized Water Reactor core Control, Chapter 4, pages 4-15 (0.5)

1-4 5.3 ± 0.3 or 2.900 + 3.25 = 6.15 From curve book
↑Curve 4-1A ↖ Curve 4-2A

REF.: Large Pressurized Water Reactor Core Control Chapter 4, Pages 416 and 4-22

1-5 a. Get total rod worths when all bottomed using figures I.1 and I.2: (0.5)

Rod Bank	integral rod worth on bottom, pcm
A	1250
B	2030
C	1215
D	1465
S_A	3050
S_B	1000
	10,010 pcm - total rod worth

From figure I.1, we see that the total rod worth is appx. 500 pcm (all rods except D bank fully withdrawn.) (0.5)
SDM = 10,010 - 500 = 9510 pcm or 9.51% δk/k

b. (0.5)

$$p = \frac{K_{eff} - 1}{K_{eff}}$$

$$-.0951 = \frac{K_{eff-1}}{K_{eff}}$$

$$K_{eff} = \underline{0.9132}$$

NOTE: Full credit will be given if the correct method is used and an incorrect number from part A is used.

REF.: Callaway Theory, Chapter 5, Reactor Physics, page 5-51

(continued on next page)

c. $SUR = \frac{26}{\tau}$

$0.8 = \frac{26}{\tau}$; $.8\tau = 26$, $\tau = 32.5$ sec. (0.25)

$\tau = \frac{\beta - \rho}{\lambda\rho} = 32.5$

$\frac{0.007 - \rho}{.08\rho} = 32.5$

$\rho = .00194 = 194$ pcm (0.25)

Using figure I.1, this would put Group D at appx. 174 steps. (0.5)

REF.: Callaway Theory, Chapter 7, Neutron Kinetics, pages 7-20

d. The rod positions should be essentially the same (below sensible heat range). (0.5)

e. Using figure 1.3 at 900 ppm boron conc., the power defect at 30% power is appx. 410 pcm. We went critical with D at 100 steps (total rod worth appx. 500 pcm). (0.25)
500 - 410 = 90 pcm total rod worth at 30% power. (0.25)
From figure 1.1, group D would be at appx. 165 steps. (0.5)

1-6 Nuclear power, RCS temperature (Tave), RCS loop flow rates and RCS pressure. (0.25/

REF.: Thermal-Hydraulic principles and applications to the Pressurized Water Reactor II, Chaper 13, page 22

1-7 C (1.0)

1-8 F (0.5)

1-9 a. 2 (0.5)
b. 2 (0.5)
c. 1 (0.5)
d. 2 (0.5)
e. 3 (0.5)

1-10 False (0.5)

1-11 T (0.5)

1-12 C (0.5)

(continued on next page)

1-13 a. (0.5)

1-14 a. (b,2) (1.0)

b. Adjust the FWP speed to get curve b and adjust the feedwater flow control valve position to get curve 2 (or vice-versa). (1.0)

c. Combination (a,1) -- 1. Power required to drive the pump is excessive and wasteful of energy (0.2). 2. Feedwater flow control valve wear is excessive at this nearly closed position (0.2). 3. Valve is in non-linear operating range, making manual control more difficult (0.2). Combination (c,3) -- 1. The feedwater control valve is operating almost fully open, out of its linear range, making manual control more difficult (0.2). 2. Little head room for increasing feed flow rate (valve almost fully open) (0.2).

REF.:C.P.S., Vol. 3, Section 223-6, pages 6-15 through 6-21. Also, Thermal-Hydraulic Principles and Applications to the Pressurized Water Reactor II, Westinghouse Electric Corporation Nuclear Training Services, Chapter 10, Fluid Mechanics in Pumps and Piping pages 23 and 32.

1-15 a. Cavitation is the formation of vapor bubbles in the low pressure region of a pump or piping system followed by their collapse in a higher pressure region of the pump or system. (0.5)

No current Indication on Control board

b. ~~Erratic running current~~, flow reduction, Low Discharge Pressure. Flow oscillations (0.5/ea

1-16 Parameters

1. Feedwater flow rate for secondary mass flow rate. (0.2)
2. Steam generator pressure for determining steam generator exit enthalpy. (0.2)
3. Feedwater inlet temperature for determining steam generator inlet enthalpy. (0.2)

$$\dot{Q}_{Rx} = \dot{m}_{RCS} C_p (T_H - T_C) = UA (T_{avg} - T_{stm}) = \dot{m}_{sec} (h_e - h_i) \text{ S/G}$$

(0.2 ea of 2 reasons)

Feedwater flow rate is chosen because it is measured more accurately than the primary flow rate. Steam generator pressure and feedwater inlet temperature have relatively small accuracy errors when compared to the magnitude of their parameters and the differences in their associated enthalpies. The other possible parameters are not as accurately measured or have larger relative errors.

REF.: Thermal-Hydraulic Principles & Applications to the Pressurized Water Reactor II, Chapter 13, pgs. 39-42.
ALSO: Question no. 23, sections 2 & 7, submitted with the reference material from the Callaway Training Department.

(continued on next page)

1-17 a. 378 BTU/LBM (used Mollier diagram) (1.0)

b. 3 (0.5)

1-18 a. 1. A severe overcooling transient while maintaining a high system pressure. (0.25)

2. A severe overcooling transient with an initial depressurization followed by a system repressurization. (0.25)

b. 1. An initial vessel flaw of sufficient size to propagate, at a location where it will be subject to significant temperature reduction. (0.25)

2. A region of the vessel that has had a large shift in RT_{NDT} due to a high level of neutron irradiation and a relatively high content of the impurities copper and to a lesser extent, phosphorous. (0.25)

c. 1. Ensure adequate core cooling while avoiding adverse system repressurization from charging or safety injection pump flow following overcooling transients. (0.25)

2. Ensure adequate heat removal while avoiding overcooling the RCS while at high pressure. (0.25)

REF.: INPO SOER 82-7, June 28, 1982, Reactor Vessel Pressurized Thermal Shock. Also, Question no. 32, sections 2 & 7, submitted with the reference material from the Callaway Training Department.

2-1 a. increase (0.5)
b. increase (0.5)
c. increase (0.5)
d. increase (0.5)
e. decrease (0.5)

2-2 c. (1.0)

REF: Callaway Plant Systems (C.P.S.), Vol. 2, Section 221-2 Emergency Core Cooling System, page 2-23.

2-3 a. Motor driven AFW pump starts (0.4 pts ea)

1. manual actuation on MCB panel RL018 23.5%
2. S/G low low level, ~~32.3%~~ on 2/4 det. on any S/G Typo
3. Trip of both main feed pumps
4. LOCA Sequencer
5. Shutdown Sequencer

b. Turbine driven AFW pump starts (0.4 pts. each)

1. S/G low low level, 23.5% ~~32%~~ on 2/4 det. on 2/4 S/G's Typo
2. Manual actuation on MCB panel RL018
3. Undervoltage on (NB01) and NB02) - 2/4

REF.: Callaway Plant Systems, (C.P.S.), Vol. 3, chapter 5, Aux. Feed. Sys. p. 5-12.

2-4 FALSE

REF.: CPS Vol. III, Section 223-5, page 5-5

2-5 1. Failure of any rod control cluster assembly (RCCA) to fully insert following a reactor trip or shutdown. (0.5)

2. Control rod height below the insertion limit. (0.5)

3. Failure of the Reactor Makeup Control System to the extent that bypass is necessary to accomplish boration. (0.5)

4. Uncontrolled Reactor Coolant System cooldown following a reactor trip or shutdown not requiring safeguards system actuation. (0.5)

5. Unexplained or uncontrolled reactivity increase as indicated by abnormal control bank insertion, increasing temperature or nuclear power level or increasing neutron flux level during shutdown. (0.5)

See attached procedure

REF.: C.P.S., Vol.1, Section 217-2, page 2-35.

(continued on next page)

Question
2.5

Proced. No. OTO-ZZ-00003
Rev. 0

LOSS OF SHUTDOWN MARGIN

1.0 PURPOSE AND SCOPE

This procedure provides symptoms for identifying a loss of reactor shutdown margin and instructions for regaining sufficient reactor shutdown margin.

2.0 SYMPTOMS

2.1 Unexplained or uncontrolled reactivity increase.

2.2 Failure of one or more Rod Control Cluster Assembly (RCCA) to fully insert following a reactor trip or shutdown.

2.3 Uncontrolled cooldown not requiring safety injection.

2.4 Anytime a RCCA is at or less than the Lo-Lo insertion limit (ANN 81C)

2.5 Anytime minimum shutdown margin is in question.

2.6 Failure to successfully complete OSP-ZZ-00005, shutdown Margin Determination.

3.0 PROBABLE CAUSES

3.1 Uncontrolled steam bleed path from the steam generators.

3.2 Excessive feedwater addition to the steam generators.

3.3 Stuck RCCA.

3.4 Excessive generator load reduction.

3.5 Failure of the Reactor Makeup Control System (RMCS) to the extent that over dilution of the RCS has occurred.

3.6 Insufficient boron concentration in the RCS to maintain the RCCA's within the control band.

2-6 He must manually calculate the amount of boric acid addition by observing the boric acid flow rate and the time duration of the immediate boration. (1.0)

REF. CPS Vol. 1 Section 217-2. page 2-37

2-7 FALSE (NOTE There is a nitrogen charged accumlator backup.) (0.5)

REF CPS Vol III Section 223-4. page 4-21

2-8 The unit auxiliary transformer output breakers can be closed from the main control board panel PL016 provided the following conditions are met.

1. all breaker fault signals are cleared (0.5)
2. the synchroscope PAHS 07 is on (0.5)
3. the synchronizing check (sync check) relay is energized (0.5)
4. the startup transformer output breaker lockout is reset (0.5)

REF. C.P.S.. Vol. 1. Section 213-2, Page 2-5

2-9 a. No difference in load shedding (all loads are shed in both cases). (0.5)

b. With the SI signal present two (2) additional loads are sequenced on [SI pumps A (B) and RHR pump A (B)]

Containment coolers A-C (B-D) are in the slow speed with SI whereas they are in the fast speed without SI. (0.5)

REF. CPS Vol. 1 Section 213-3. pages 3-14 through 3-17

2-10 a. DNB conditions (0.5)
b. overpower conditions (0.5)

REF. CPS Vol. 1 Section 215-5. pages 5-9 through 5-13

2-11 Increases letdown flow transport time to allow nitrogen -16 gamma decay prior to the letdown flow leaving containment.

REF.. CPS. Vol. 1. Section 217-1. page 1-7.

(continued on next page)

2-12 1. Valve HV-8812A, RHR pump "A" suction from the refueling water storage tank, must be closed, <u>and</u> (0.5)

2. Valve HV-8701A or PV-8702A, RHR pump "A" suction from the reactor coolant system hot leg loop 1, must be closed. (0.5)

REF: C.P.S., Vol. 1, Section 217-4, pages 4-17 & 4-18

2-13 The use of a multi-pressure condenser results in an improvement in efficiency. This efficiency is gained in three (3) ways. First, the average condenser vacuum seen by the turbine is lower than in a single pressure condenser. This results in greater expansion of the steam in the turbine and more work is extracted from the steam. Secondly, the condensate is rejected in the highest pressure area, the hotwell area, so that condensate depression (subcooling below the saturation point) is minimized and less heat is rejected to the circulating water. Thirdly, warmer condensate results in less required extraction steam flow to the first and second stage heaters. This lower flow results in more mass flow of steam through the last stages of the turbine and more work is extracted from the steam. (0.5/ea

REF.: C.P.S., Vol. 3, Section 223-3, page 3-6

2-14 (5 @ 0.4 each)

1. Main steam bypass header pressure (AB-PI-507) on RL005
2. Total steam dump demand (AB-UC-500) on RL005
3. Steam dump valve fully open/fully closed lights on RL006
4. Cooldown dump valve position (AB-Z1-34 to 36) on RL006
5. C-7, C-9, and P-12 interlock status lights on RL024
6. Steam dump valves armed lights

REF.: CPS, Vol.3, Section 223-4, page 4-22

7. Hi-1/Hi-2 light

per Baldwin on Mn Control Board

2-15 10 12 seconds per Callaway Tech Specs Rev 1 Page 3/4 8-3 (0.6)

Step 4.8.1.1.2a.4.

REF.: CPS. Vol. 1, Section 213-4, pager 4-3

(continued on next page)

2-16 a. (0.3 pts. each)

1. Safety injection pump oil coolers
2. Centrifugal charging pump oil coolers
3. Spent fuel pool heat exchangers
4. Residual heat removal pump seal coolers
5. Residual heat removal heat exchangers

Post Accident Sample System Coolers M-02 EG02(a) area H-2

REF. Callaway System. Vol. 1. Section 217-5. page 5-10

b. Service loop components inside containment are isolated including: RCP coolers excess letdown HX and RCDT HX (1.0)

REF.: Callaway Systems. Vol. 1. Section 217-5. page 5-15

2-17 Provides one (1) warming of downstream steam lines and (2) equalizing steam pressure across the MSIV's. (0.75)

REF.: CPS. Vol. 3. Section 223-2, page 2-12

2-18 Water in the pool is normally borated to 2000 ppm and the geometry of the fuel racks is such that criticality is precluded even if the pool contained unborated water. (0.75)

REF. CPS. Vol. 2. Section 219-4. page 4-9

3-1 c. (1.0)

REF.:Callaway Plant Systems (C.P.S.), Vol. 3, Sec. 223-4, Steam Dump Lesson Text, pages 4-17 and 4-19.

3-2 c. (1.0)

REF.:C.P.S, Vol. 4, Sec. 227-4, rod control, page 4-12.

3-3 d. (1.0)

REF.: C.P.S. Vol. 1, Section 215-5, page 5-15

3-4 a. 2 in affected loop (0.5)
REF: C.P.S., Vol. 1, Sec. 215-5, page 5-10.

b. 1 (0.5)
REF: C.P.S., Vol. 1, Sec. 215-5, page 5-13.

c. 1 (0.5)
REF: C.P.S., Vol. 1, Sec. 215-5, page 5-8.

d. 2 (0.5)
REF: C.P.S., Vol. 4, Sec. 227-4, page 4-11.

(continued on next page)

3-5 a. The boron thermal regeneration system (BTRS). (0.5)

b. Boration (0.5)

c. The BTRS reduces the quantity of liquid waste that must be reprocessed. The reactor makeup system is the other system that is used for boration. (0.5)

REF.:C.P.S., Vol. 1, Sec. 217-3, pages 3-4 through 3-7

3-6 a. When the bypass valve is open, it allows a free flow path back to the VCT so that the pump does not start under a load. (0.5)

b. The valve must be open before the pump is started ~~and it will close automatically 120 seconds after the pump is started~~. (0.5) E-03B623

REF.:C.P.S., Vol. 1, Sec. 217-1, page 1-20

3-7 a. Alarm is valid RESET opens the electronic circuits but does not offset the detector. A high activity will alarm immediately when a path is re-established. (0.75)

b. Alarm is invalid. PURGE removes the activity from the sample volume. If the alarm does not clear, then it cannot be due to high activity. (0.75)

3-8 T_h, T_c, impulse pressure, and neutron flux or nuclear power. (0.25/

REF.: C.P.S., Vol. 4, Sec. 227-4, pages 4-3 and 4-11.

3-9 False (0.5)

REF.: C.P.S., Vol. 1, reactor coolant system, Sec. 215-3, page 3-9.

(continued on next page)

3-10 a. When in "automatic", the turning gear motor starts when the turbine speed reaches zero. (0.5)

b. Interlocks preventing turning gear motor from starting are:

1. Bearing oil pressure less than 15 psig (0.25)
2. No lift oil pumps running (0.25)

c. A red turning gear permissive light on the MCB indicates when the interlock conditions have been met. (0.5)

REF.:C.P.S., Vol. ~~4~~ 3, Sec. 225-4, page 4-10

3-11 He may have to manually activate the source range instrumentation by depressing the appropriate reset buttons. (1.0)

REF.: C.P.S., Vol. 4, Sec. 227-2, NIS, page 2-21.

3-12 1. It leads to the most conservative control. (0.5)
2. It eliminates all failures that cause the signal to fail low. Since failing low is the most common mode of failure, this increases control system reliability. (0.5)

REF.: C.P.S., Vol. 1, Sec. 215-5, RCS Temp., page 5-13.

3-13 a.

REF.: C.P.S., Vol. 1, Sec. 215-5, page 5-11. (1.0)

3-14 d.

REF.: C.P.S., Vol. 4, Sec. 227-3, page 3-15. (1.0)

(continued on next page)

3-15
a. 1 (0.5)
b. 2 (0.5)
c. 2 (0.5)
d. 1 (0.5)

REF.: C.P.S., Vol. 4, Sec. 227-3.

3-16 b. or 2

REF.:C.P.S., Vol. 3, Sec. 223-6, page 6-16

3-17 (1.0)
1. C-9 permissive indicators A, B, and C indicating condenser available.
2. Steam dump interlock selector switch in the ON position.
3. Steam dump control mode selector switch in the Tave position.

REF.: C.P.S., Vol. 3, steam dump lesson text, Sec. 223-4, page 4-17.

3-18 FW temp. too low → indicated feed to steam Δh too large → indicated S/G heat transfer rate too large → power calculated too high → PRNI indications are <u>higher than</u> actual power. (1.0)

3-19
1. Gamma flux is proportional to power. (0.5)
2. Gamma flux is relatively small and almost insignificant. (0.5)

REF.: C.P.S., Vol. 4, Sec. 227-2, NIS, page 2-11.

3-20 E. (1.0)

REF.: C.P.S., Vol. 3, Sec. 223-6, S/G water level control.

3-21
a. open (0.5)
b. close (0.5)
c. close (0.5)
d. ~~close~~ ~~at~~ no change (0.5)
maintain constant 50% level program

REF.: C.P.S. Vol.3, Section 223-6

4-1 a. 1. Valve position light(s) indicating valve(s) open (0.3)

2. T REF/T AUCT LO annuciator 65E (0.3)

3. Loop 1 (2 3 4) T AVG LO DEV annunciator 66D (67D 68D 69D) (0.3)

4. Increasing Steam/Feed Flow (0.3)

5. Decreasing RCS temperature (0.3)

b. 1. If a reactor trip occurs refer to E-0 Reactor Trip or Safety Injection (0.3)

2. If an Atmospheric Steam Dump Valve opens place the controller for the failed valve in MAN and CLOSE it. Ensure its setpoint is 1125 psig. (0.3)

3. If a Condenser Steam Dump Valve opens. place both Steam Dump Interlock select switches (AB-HS-63 and AB-HS-64) in the OFF/RESET position and verify dump valves close. (0.3)

4. Place rod control in MAN to prevent rod movement. (0.3)

5. Decrease turbine load as required to match Tavg/Tref and stabilize reactor power if at high load. ensure reactor power is < 100%. (0.3)

6. If unable to close the valve(s) from the Control Room dispatch an operator to close the manual isolation(s) for the affected valve(s). (0.3)

REF. Callaway Off-Noraml procedure OTO-AB-00001 Steam Dump Malfunctions

(continued on next page)

4-2 a. Red first-out annunciator alarm indicating turbine trip. (0.5)

b. 1. Ensure turbine stop valves, turbine control valves and combined intercept valves are closed. (0.3)

2. Ensure switchyard breakers V53 and V55 open approximately 30 seconds after turbine trip, if not, manually open breakers. (0.3)

3. Verify Tavg is approaching no load value. If rod control is in manual, insert control rods to reduce Tavg to 557°F. (0.3)

4. Ensure S/G level is returning to its programmed level. If main feedwater pumps have tripped, ensure auxiliary feedwater pumps have started. (0.3)

5. Verify buses PA01 and PA02 are being supplied from XMR01. (0.3)

REF.: Callaway Off-Normal Procedure OTO-AC-00001, Turbine Trip.

4-3 a. I. Following are symptoms of a reactor trip:

a. Any reactor trip annunciator lit. (0.3)
b. Rapid decrease in reactor power level as indicated by nuclear instrumentation. (0.3)
c. All shutdown and control rods are fully inserted. Rod bottom lights are lit. (0.3)
d. Rapid decrease in unit load to zero power. (0.3)

II. Following are symptoms of reactor trip and safety injection:

a. Any SI annunciator lit (0.3)
b. SI pumps in service (0.3)

b. 1. Ensure Reactor Trip (0.4)

Panel RL022

a. All rod bottom lights - LIT

Reactor Operator's Console

a. Reactor Trip and Trip Bypass Breakers - OPEN
b. NR-45 Recorder - DECREASING FLUX
c. NIS Indicators - DECREASING FLUX

(continued on next page)

2. Ensure Turbine Trip
   a. All turbine valves - CLOSED (0.4)
   b. Switchyard Breakers No. 1&2 - OPEN (appx. 30 sec. after turbine trip)

3. Verify At Least One 4.16 KV AC Emergency Bus Energized (0.4)
   a. AC Emergency Bus Voltage - NORMAL

4. Determine If Safety Injection Is Actuated (0.4)

   Annunciator Panel RK020

   a. SI (Window 58A) - LIT, AMBER

   Trip Status Panel (SB069)

   b. SI ACTUATE indicator - LIT

5. Ensure Feedwater Isolation (0.4)
   a. Feedwater Iso Vlvs - CLOSED
   b. FW Chem. Inj Vlvs - CLOSED
   c. MFW Control Vlvs - CLOSED
   d. MFW Control Byp Vlvs - CLOSED
   e. S/G Blowdown Ctmt Ios Vlvs - CLOSED

6. Ensure Containment Isolation Phase A
   a. Containment Isolation Phase A Indication (0.4)

      Annunciator Panel RK022u

      (1) CISA (Window 58B) - LIT

      ESF Status Panels (SA066X&Y)

      (2) CIS Phase A System and component lights on both panels - LIT, WHITE

7. Ensure AFW Actuation (0.4)
   a. Ensure MD AFW Pumps - RUNNING
   b. Ensure AFW Flow
   c. Ensure Aux FW Valves - Proper Emergency Alignment

      ESF Status Panels (SA066X&Y)

      1) AFAS system and component indicator lights - LIT, WHITE

(continued on next page)

8. Ensure SI Inititation (0.4)

a. Ensure ECCS Pumps Running

1) CCP A & B
2) SI Pumps A & B
3) RHR Pumps A & B

b. Ensure SI Flow

(1) Using Table 1, determine the system which should be injecting.

TABLE 1

	RCS Pressure (PSIG			
INJECT SYSTEM	>1536	1536 to 600	600 to 195	<195
CCP-A&B	YES	YES	YES	YES
SI-A&B	NO	YES	YES	YES
SI Accum	NO	NO	YES	YES
RHR A&B	NO	NO	NO	YES

2) Check flow for the system which should be injecting.

c. Ensure proper Emergency SI Valve Alignment.

ESF Status Panels (SA066X&Y)

1) SI component indicating lights both panel - LIT, WHITE

REF.: Callaway Emergency Operation Procedure, E-0, Reactor Trip or Safety Injection.

4-4 COLOR CODING SCHEME

1. Green - The Critical Safety Function is satisfied. No operator action is called for. (0.5)

2. Yellow - The Critical Safety Function is not fully satisifed. Operator action may eventally be needed. (0.5)

3. Orange - The Critical Safety Function is under severe challenge. Prompt operator action is necessary. (0.5)

4. Red - The Critical Safety Function is in jeopardy. Immediate operator action is required. (0.5)

REF. Callaway. Emergency Operating Procedure CSF-1. Critical Safety Function Status Trees.

4-5 Shift Supervisor (1.0)

REF. Callaway Procedure OTG-ZZ-00001. page 1.

4-6 1. Maintain the reactor in a subcritical condition by rod insertion boration and coolant temperature control. (1.0)

2. Ensure that heat removal matches or exceeds decay heat generation. This can be accomplished by verifying that all available heat removal paths are being used (e.g.. S/G relief valves. steam dump valves) and that the S/G water level is normal. The operator should also verify that a positive temperature difference exists between the core and steam generator. (1.0)

3. The coolant should remain subcooled. The operator should ensure that the core coolant outlet average temperature (i.e.. core exit thermocouple average reading) is lower than the saturation temperature for the pressurizer pressure. (1.0)

REF.: Thermal-hydraulic Principles and Applications to the PWR II. Chapter 14. Pages 27 and 28

4-7 1. Isolation of the affected steam generator (0.5)
2. Activation of the emergency core cooling system. (0.5)
3. Reduction of primary system pressure without initiating saturated conditions. (0.5)

REF. Thermal-Hydraulic Principles and Applications to the Pressurized Water Reactor II. Chapter 14, page 31

(continued on next page)

4-8 a. control rod withdrawal (0.5)
b. two or more (0.5)
c. criticality is anticipated with reactor conditions different from those for which previous criticality data is available and the differences are such as to cause a change of $\geq$ 0.5 % $\Delta K/K$ in core reactivity. (0.5)

REF.: Procedure OTG-ZZ-00002

4-9 The first responsibility of the reactor operator during an emergency condition is to maintain the plant in a stable and safe condition. (1.0)

4-10 <u>High Radiation Area</u>

Any area accessible to personnel where an individual could receive a whole body dose in excess of 100 mrem but less than 1000 mrem in any one hour. (1.0)

REF.: Callaway Plant Adm. Procedure, APA-ZZ-00160, p. 7

4-11
1. You have read the RWP
2. You understand the provisions of the RWP
3. You will comply with all of the requirements of the RWP

REF.: Administrative Procedure APA-ZZ-00161, page 6

4-12
1. Attempt to manually trip the reactor and initiate emergency boration. (0.5)
2. If the reactor does not trip, go to ECA-1 (0.5)
3. Trip PG-19, PG-20 breakers (0.5)

REF.: Question no. 4 from questions & answers from Callaway training department, Sections 5 & 9. Also, procedures E-o and ECA-1.

4-13
1. b, c, e, f, g, h (0.5)
2. a, b, c, d, f, g, h, i (0.5)
3. c, f, g, d, (if actual feed flow is compared to steam flow)

REF.: Question No. 5 from questions & answers from Callaway training department, section 5&9. Also, procedures E-1, E-2, and E-3

Review Copy
J.F. DAmpf
Al Daume
R.J. Renz
WO Jessop

Proctor Master

U.S. NUCLEAR REGULATORY COMMISSION
SENIOR REACTOR OPERATOR LICENSE EXAMINATION

FACILITY: Callaway
REACTOR TYPE: Westinghouse 4-LOOP PWR
DATE ADMINISTERED: November 27, 1984
EXAMINER: R. L. Higgins
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%.

Category Value	% Of Total	Applicant's Score	% Of Category Value	Category
25	25	_____	_____	5. Theory of Nuclear Power Plant Operation, Fluids, and Thermodynamics
25	25	_____	_____	6. Plant Systems Design, Control, and Instrumentation
25	25	_____	_____	7. Procedures - Normal, Abnormal, Emergency, and Radiological Control
25	25	_____	_____	8. Administrative Procedures, Conditions and Limitations
100	100	_____	_____	TOTALS

Final Grade ______%

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

____
Applicant's Signature

5. Theory of Nuclear Power Plant Operation, Fluids, and Thermodynamics

5.1 Define the term "Isothermal Temperature Coefficient." (1.5)

5.2 Why is the HFP, ARO, Equilibrium xenon axial offset at EOL less negative than the axial offset at BOL under the same conditions? Refer to figure 5.2-1. (2.0)

5.3 What is the "Importance Function", "I," and why is it less than one? Refer to figure 5.3-1. (1.5)

5.4 Why is the moderator temperature coefficient more negative when banks C&D are inserted than it is when bank D alone is inserted? Refer to figure 5.4-1. (2.0)

5.5 Why does equilibrium xenon reactivity display a nonlinear, proportional relationship to reactor power while equilibrium samarium reactivity is independent of reactor power? Refer to figures 5.5-1 and 5.5-2. (3.0)

5.6 a. Why is the shutdown margin requirement for mode 4 greater than it is for mode 5? (1.0)

b. How is an adequate shutdown margin determined for mode 1? (0.5)

5.7 a. What is the basis for the establishment of a Quadrant Power Tilt Ratio Limit? (1.0)

b. What is the minimum value of Quadrant Power Tilt Ratio at which operator action must be taken? (0.5)

c. Name three situations, other than instrumentation malfunctions, which could cause the Quadrant Power Tilt Ratio to exceed its limits? (1.5)

5.8 a. Which Safety Limit is applicable in modes 3, 4, and 5 as well as in modes 1 and 2? (0.5)

b. What two actions must be taken if this safety limit is exceeded when in mode 5? (1.5)

5.9 Why does the initial RT_{NDT} of the Reactor Vessel increase more at 1/4 T than it does at 3/4 T after several years of power operation? (2.0)

5.10 What value of Tave will cause the steam generator safety valve with the lowest setting to lift when the plant is at 100% power? Power = UA (Tave - Tsat). Steam generator pressure at 100% power is 1000 psia. Show your work! (2.0)

5.11 What five criteria must be satisfied for natural circulation verification (per ECA-2.1)? (2.5)

5.12 For all parts of this question refer to figure 5.12-1.

a. What is the basis for curve A? (0.5)

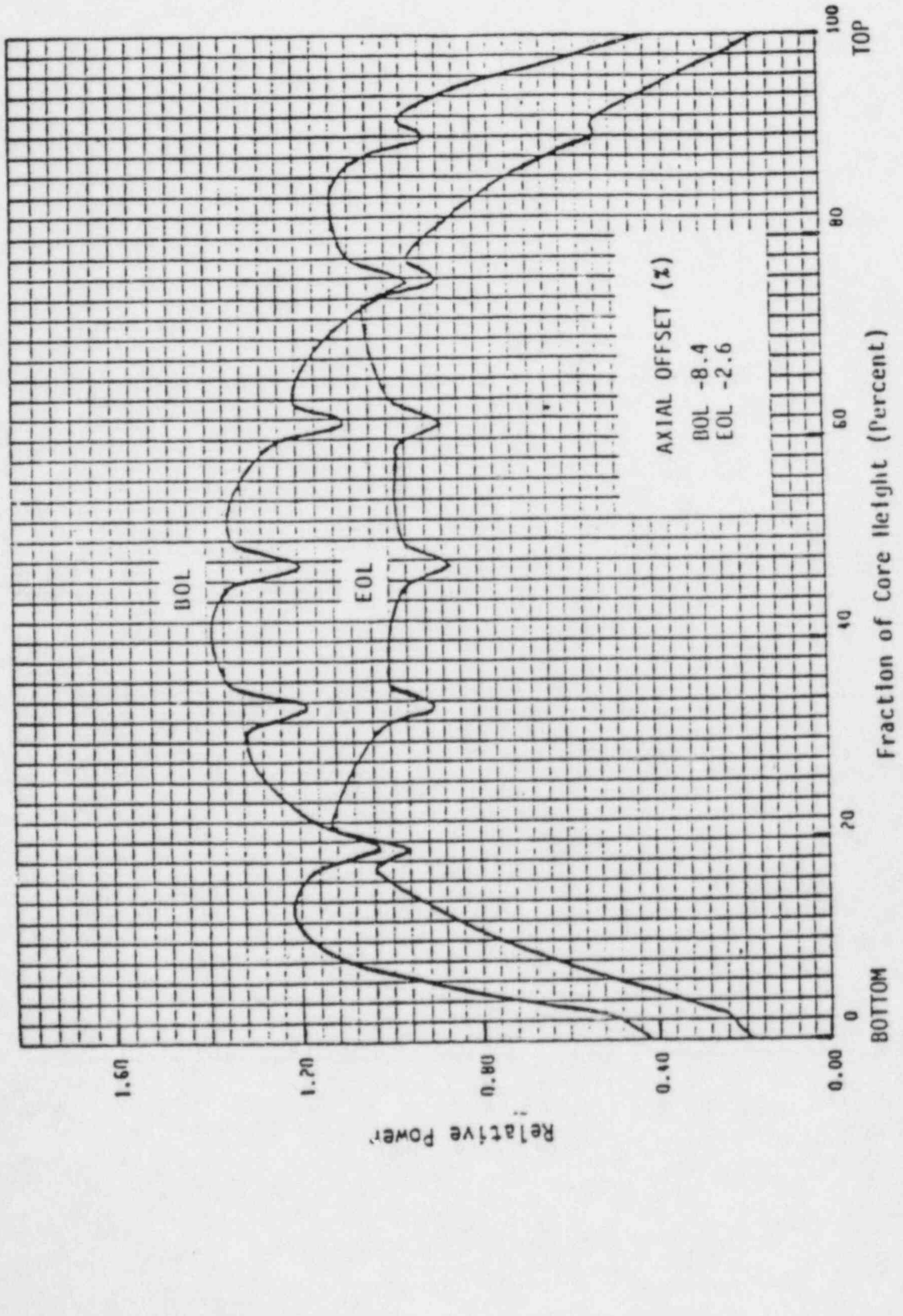
b. Why does curve A have a negative slope (why do the temperature values drop as power increases)? (1.0)

c. What safety feature prevents violating curve A when reactor power is 10% and RCS pressure is 2235 psig? (0.5)

(END OF SECTION 5)

FIGURE 5.2-1

7/26/83
Superintendent, Engineering Date



RELATIVE AXIAL POWER DISTRIBUTION

AT BOL AND EOL, HFP, ARO, EQUILIBRIUM XENON

[illegible]

FIGURE 5.3-1

R. H. Stell 7/26/83
Superintendent, Engineering Date

DELAYED NEUTRON DATA

CYCLE 1

Delayed Group	BOL		MOL		EOL	
	$\bar{\beta}_i$	λ_i (sec^{-1})	$\bar{\beta}_i$	λ_i (sec^{-1})	$\bar{\beta}_i$	λi (sec^{-1})
1	0.000217	0.0125	0.000168	0.0126	0.000146	0.0126
2	0.001461	0.0308	0.001207	0.0308	0.001117	0.0307
3	0.001349	0.1153	0.001082	0.1182	0.000984	0.1200
4	0.002815	0.3111	0.002206	0.3162	0.001993	0.3196
5	0.000954	1.2433	0.000771	1.2544	0.000713	1.2576
6	0.000321	3.3384	0.000267	3.3430	0.000250	3.3364

Total Delayed Neutron Fraction, $\bar{\beta}$	0.007117	0.005701	0.005203
Prompt Neutron Lifetime, ℓ^* (μ sec)	18.92	17.76	18.25
Importance Function, $\bar{I}$	0.970	0.970	0.970
Effective Delayed Neutron Fraction, $\bar{\beta}_{eff}$	0.006903	0.005530	0.005047

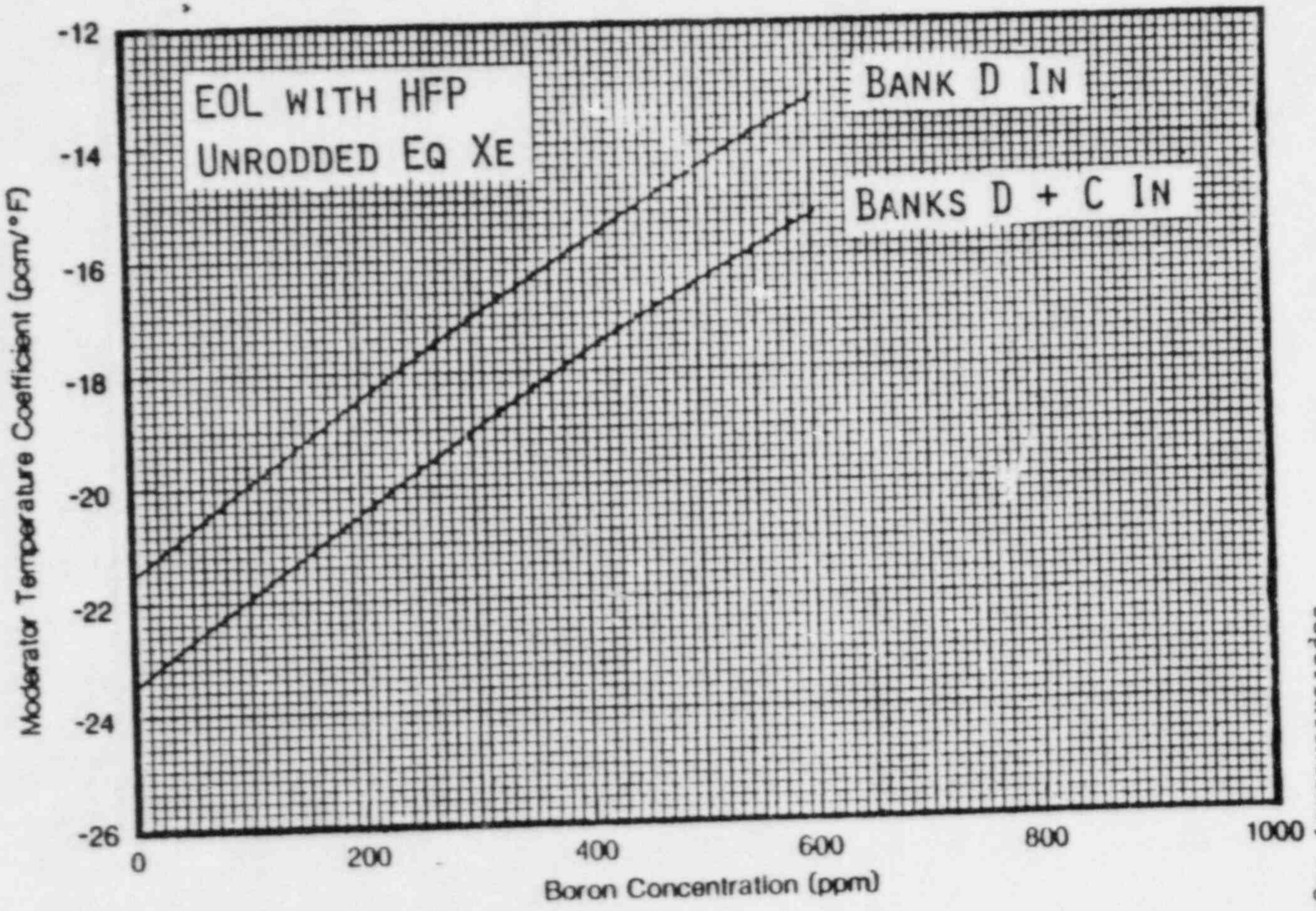


FIGURE 5.4-1

RODDED MODERATOR TEMPERATURE COEFFICIENTS
AT HZP VERSUS BORON CONCENTRATION
EOL, FULL POWER UNRODDED EQUILIBRIUM XENON
CYCLE 1

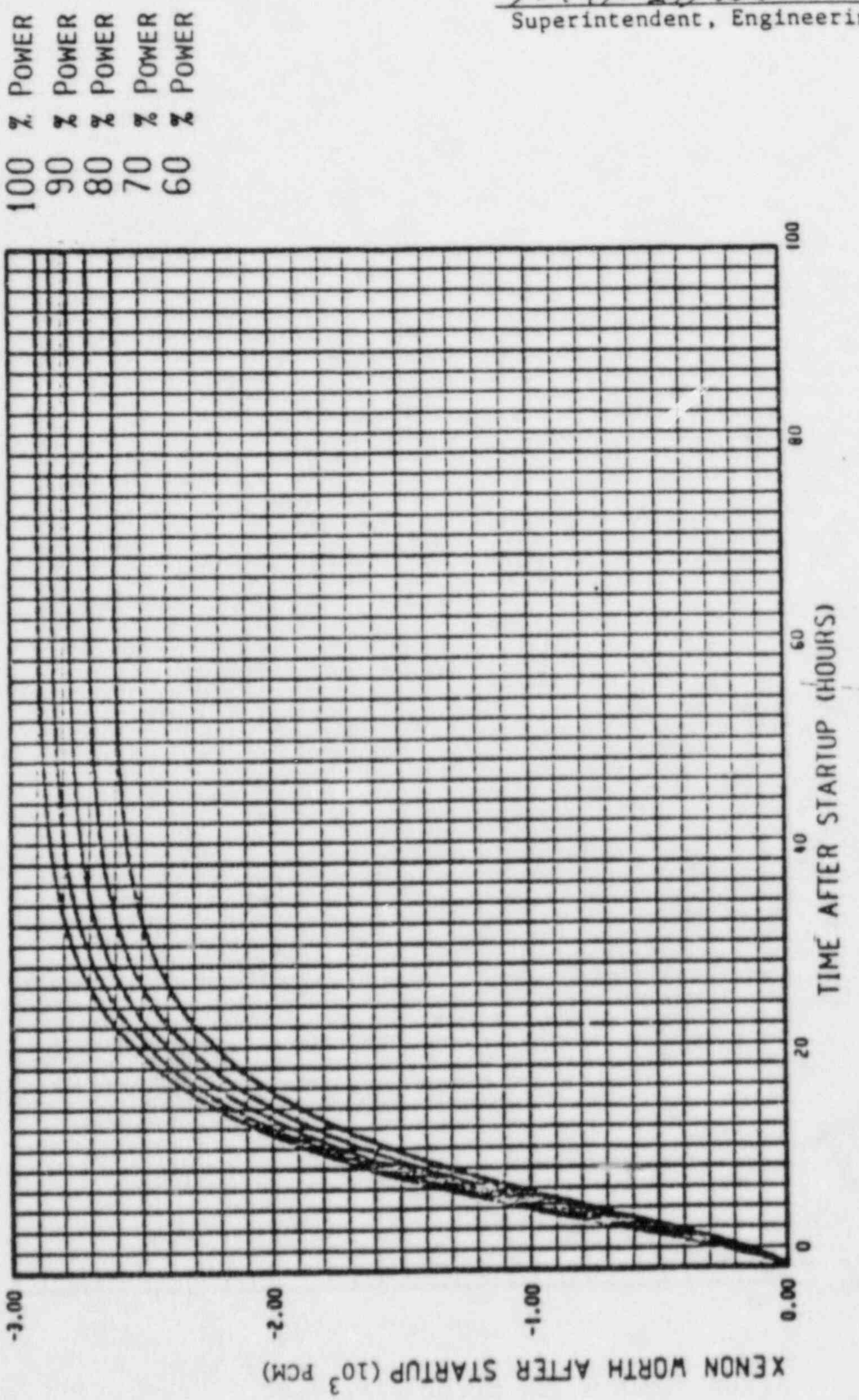
7/26/83

Superintendent, Engineering Date

FIGURE 5.5-1

W. H. Stahl 7/26/83

Superintendent, Engineering Date

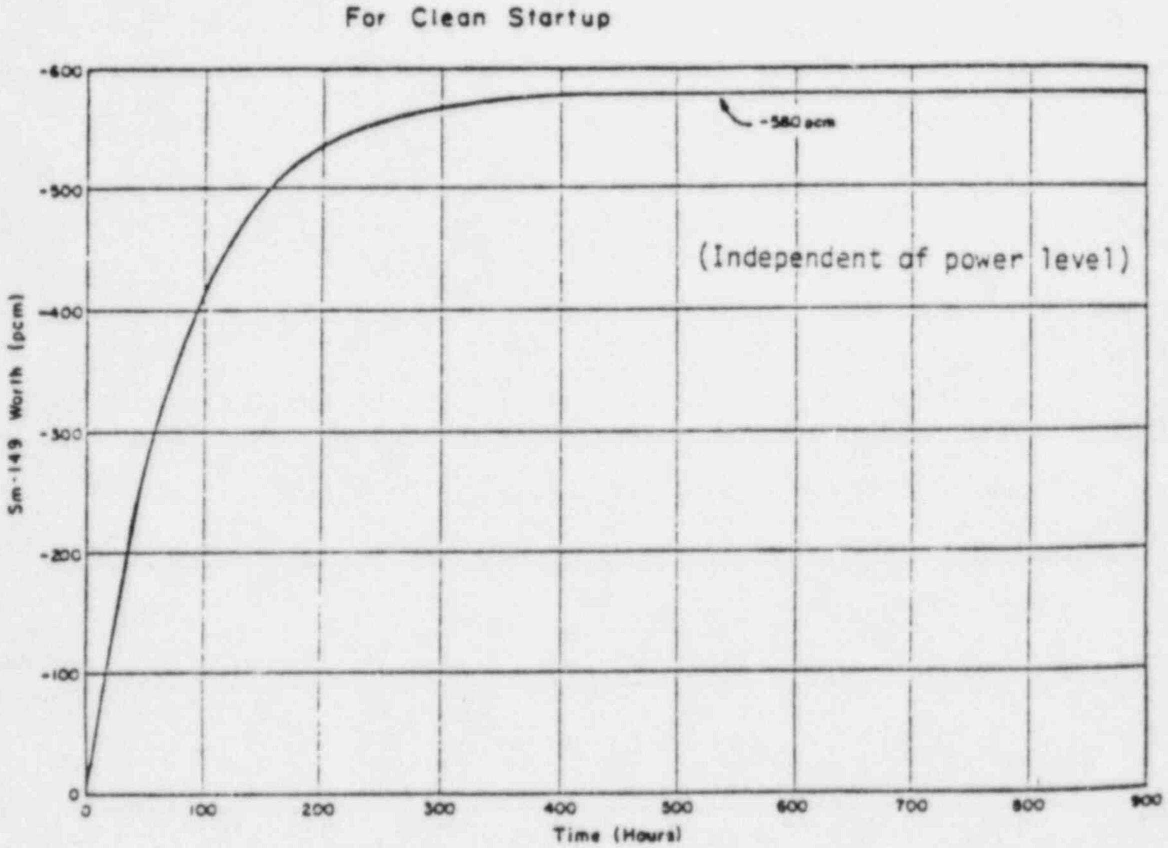


INTEGRAL WORTH OF XENON FOLLOWING PLANT STARTUP
AT BOL FOR VARIOUS POWER LEVELS VS. TIME

CYCLE 1

2.3.7 Samarium Curves for Zion

a. Figure 24. Samarium Buildup to Equilibrium For The Zion Station



Sm-149 BUILDUP TO EQUILIBRIUM

It should be noted that the -580 pcm value is valid for all reactor power levels at Zion.

Table 1. Saturated Steam: Temperature Table

Temp Fahr t	Abs Press Lb per Sq In p	Specific Volume Sat Liquid v_f	Specific Volume Evap v_{fg}	Specific Volume Sat Vapor v_g	Enthalpy Sat Liquid h_f	Enthalpy Evap h_{fg}	Enthalpy Sat Vapor h_g	Entropy Sat Liquid s_f	Entropy Evap s_{fg}	Entropy Sat Vapor s_g	Temp Fahr t
32.0*	0.08859	0.016022	3304.7	3304.7	-0.0179	1075.5	1075.5	0.0000	2.1873	2.1873	32.0*
34.0	0.09600	0.016021	3061.9	3061.9	1.996	1074.4	1076.4	0.0041	2.1762	2.1802	34.0
36.0	0.10395	0.016020	2839.0	2839.0	4.008	1073.2	1077.2	0.0081	2.1651	2.1732	36.0
38.0	0.11249	0.016019	2634.1	2634.2	6.018	1072.1	1078.1	0.0122	2.1541	2.1663	38.0
40.0	0.12163	0.016019	2445.8	2445.8	8.027	1071.0	1079.0	0.0162	2.1432	2.1594	40.0
42.0	0.13143	0.016019	2272.4	2272.4	10.035	1069.8	1079.9	0.0202	2.1325	2.1527	42.0
44.0	0.14192	0.016019	2112.8	2112.8	12.041	1068.7	1080.7	0.0242	2.1217	2.1459	44.0
46.0	0.15314	0.016020	1965.7	1965.7	14.047	1067.6	1081.6	0.0282	2.1111	2.1393	46.0
48.0	0.16514	0.016021	1830.0	1830.0	16.051	1066.4	1082.5	0.0321	2.1006	2.1327	48.0
50.0	0.17796	0.016023	1704.8	1704.8	18.054	1065.3	1083.4	0.0361	2.0901	2.1262	50.0
52.0	0.19165	0.016024	1589.2	1589.2	20.057	1064.2	1084.2	0.0400	2.0798	2.1197	52.0
54.0	0.20625	0.016026	1482.4	1482.4	22.058	1063.1	1085.1	0.0439	2.0695	2.1134	54.0
56.0	0.22183	0.016028	1383.6	1383.6	24.059	1061.9	1086.0	0.0478	2.0593	2.1070	56.0
58.0	0.23843	0.016031	1292.2	1292.2	26.060	1060.8	1086.9	0.0516	2.0491	2.1008	58.0
60.0	0.25611	0.016033	1207.6	1207.6	28.060	1059.7	1087.7	0.0555	2.0391	2.0946	60.0
62.0	0.27494	0.016036	1129.2	1129.2	30.059	1058.5	1088.6	0.0593	2.0291	2.0885	62.0
64.0	0.29497	0.016039	1056.5	1056.5	32.058	1057.4	1089.5	0.0632	2.0192	2.0824	64.0
66.0	0.31676	0.016043	989.0	989.1	34.056	1056.3	1090.4	0.0670	2.0094	2.0764	66.0
68.0	0.33889	0.016046	926.5	926.5	36.054	1055.2	1091.2	0.0708	1.9996	2.0704	68.0
70.0	0.36292	0.016050	868.3	868.4	38.052	1054.0	1092.1	0.0745	1.9900	2.0645	70.0
72.0	0.38844	0.016054	814.3	814.3	40.049	1052.9	1093.0	0.0783	1.9804	2.0587	72.0
74.0	0.41550	0.016058	764.1	764.1	42.046	1051.8	1093.8	0.0821	1.9708	2.0529	74.0
76.0	0.44420	0.016063	717.4	717.4	44.043	1050.7	1094.7	0.0858	1.9614	2.0472	76.0
78.0	0.47461	0.016067	673.8	673.9	46.040	1049.5	1095.6	0.0895	1.9520	2.0415	78.0
80.0	0.50683	0.016072	633.3	633.3	48.037	1048.4	1096.4	0.0932	1.9426	2.0959	80.0
82.0	0.54093	0.016077	595.5	595.5	50.033	1047.3	1097.3	0.0969	1.9334	2.0303	82.0
84.0	0.57702	0.016082	560.3	560.3	52.029	1046.1	1098.2	0.1006	1.9242	2.0248	84.0
86.0	0.61518	0.016087	227.5	527.5	54.026	1045.0	1099.0	0.1043	1.9151	2.0193	86.0
88.0	0.65551	0.016093	496.8	496.8	56.022	1043.9	1099.9	0.1079	1.9060	2.0139	88.0
90.0	0.69813	0.016099	468.1	468.1	58.018	1042.7	1100.8	0.1115	1.8970	2.0086	90.0
92.0	0.74313	0.016105	441.3	441.3	60.014	1041.6	1101.6	0.1152	1.8881	2.0033	92.0
94.0	0.79062	0.016111	416.3	416.3	62.010	1040.5	1102.5	0.1188	1.8792	1.9980	94.0
96.0	0.84072	0.016117	392.8	392.9	64.006	1039.3	1103.3	0.1224	1.8704	1.9928	96.0
98.0	0.89356	0.016123	370.9	370.9	66.003	1038.2	1104.2	0.1260	1.8617	1.9876	98.0
100.0	0.94924	0.016130	350.4	350.4	67.999	1037.1	1105.1	0.1295	1.8530	1.9825	100.0
102.0	1.00789	0.016137	331.1	331.1	69.995	1035.9	1105.9	0.1331	1.8444	1.9775	102.0
104.0	1.06965	0.016144	313.1	313.1	71.992	1034.8	1106.8	0.1366	1.8358	1.9725	104.0
106.0	1.1347	0.016151	296.16	296.16	73.99	1033.6	1107.6	0.1402	1.8273	1.9675	106.0
108.0	1.2030	0.016158	280.28	280.30	75.98	1032.5	1108.5	0.1437	1.8188	1.9626	108.0
110.0	1.2750	0.016165	265.37	265.39	77.98	1031.4	1109.3	0.1472	1.8105	1.9577	110.0
112.0	1.3505	0.016173	251.37	251.38	79.98	1030.2	1110.2	0.1507	1.8021	1.9528	112.0
114.0	1.4299	0.016180	238.21	238.22	81.97	1029.1	1111.0	0.1542	1.7938	1.9480	114.0
116.0	1.5133	0.016188	225.84	225.85	83.97	1027.9	1111.9	0.1577	1.7856	1.9433	116.0
118.0	1.6009	0.016196	214.20	214.21	85.97	1026.8	1112.7	0.1611	1.7774	1.9386	118.0
120.0	1.6927	0.016204	203.25	203.26	87.97	1025.6	1113.6	0.1646	1.7693	1.9339	120.0
122.0	1.7891	0.016213	192.94	192.95	89.96	1024.5	1114.4	0.1680	1.7613	1.9293	122.0
124.0	1.8901	0.016221	183.23	183.24	91.96	1023.3	1115.3	0.1715	1.7533	1.9247	124.0
126.0	1.9959	0.016229	174.08	174.09	93.96	1022.2	1116.1	0.1749	1.7453	1.9202	126.0
128.0	2.1068	0.016238	165.45	165.47	95.96	1021.0	1117.0	0.1783	1.7374	1.9157	128.0
130.0	2.2230	0.016247	157.32	157.33	97.96	1019.8	1117.8	0.1817	1.7295	1.9112	130.0
132.0	2.3445	0.016256	149.64	149.66	99.95	1018.7	1118.6	0.1851	1.7217	1.9068	132.0
134.0	2.4717	0.016265	142.40	142.41	101.95	1017.5	1119.5	0.1884	1.7140	1.9024	134.0
136.0	2.6047	0.016274	135.55	135.57	103.95	1016.4	1120.3	0.1918	1.7063	1.8980	136.0
138.0	2.7438	0.016284	129.09	129.11	105.95	1015.2	1121.1	0.1951	1.6986	1.8937	138.0
140.0	2.8892	0.016293	122.98	123.00	107.95	1014.0	1122.0	0.1985	1.6910	1.8895	140.0
142.0	3.0411	0.016303	117.21	117.22	109.95	1012.9	1122.8	0.2018	1.6534	1.8852	142.0
144.0	3.1997	0.016312	111.74	111.76	111.95	1011.7	1123.6	0.2051	1.6759	1.8810	144.0
146.0	3.3653	0.016322	106.58	106.59	113.95	1010.5	1124.5	0.2084	1.6684	1.8769	146.0
148.0	3.5381	0.016332	101.68	101.70	115.95	1009.3	1125.3	0.2117	1.6610	1.8727	148.0
150.0	3.7184	0.016343	97.05	97.07	117.95	1008.2	1126.1	0.2150	1.6536	1.8686	150.0
152.0	3.9065	0.016353	92.66	92.68	119.95	1007.0	1126.9	0.2183	1.6463	1.8646	152.0
154.0	4.1025	0.016363	88.50	88.52	121.95	1005.8	1127.7	0.2216	1.6390	1.8606	154.0
156.0	4.3068	0.016374	84.56	84.57	123.95	1004.6	1128.6	0.2248	1.6318	1.8566	156.0
158.0	4.5197	0.016384	80.82	80.83	125.96	1003.4	1129.4	0.2281	1.6245	1.8526	158.0
160.0	4.7414	0.016395	77.27	77.29	127.96	1002.2	1130.2	0.2313	1.6174	1.8487	160.0
162.0	4.9722	0.016406	73.90	73.92	129.96	1001.0	1131.0	0.2345	1.6103	1.8448	162.0
164.0	5.2124	0.016417	70.70	70.72	131.96	999.8	1131.8	0.2377	1.6032	1.8409	164.0
166.0	5.4623	0.016428	67.67	67.68	133.97	998.6	1132.6	0.2409	1.5961	1.8371	166.0
168.0	5.7223	0.016440	64.78	64.80	135.97	997.4	1133.4	0.2441	1.5892	1.8333	168.0
170.0	5.9926	0.016451	62.04	62.06	137.97	996.2	1134.2	0.2473	1.5822	1.8295	170.0
172.0	6.2736	0.016463	59.43	59.45	139.98	995.0	1135.0	0.2505	1.5753	1.8258	172.0
174.0	6.5656	0.016474	56.95	56.97	141.98	993.8	1135.8	0.2537	1.5684	1.8221	174.0
176.0	6.8690	0.016486	54.59	54.61	143.99	992.6	1136.6	0.2568	1.5616	1.8184	176.0
178.0	7.1840	0.016498	52.35	52.36	145.99	991.4	1137.4	0.2600	1.5548	1.8147	178.0

*The states shown are meta stable

Table 1. Saturated Steam: Temperature Table—*Continued*

Temp Fahr t	Abs Press Lb per Sq In p	Specific Volume			Enthalpy			Entropy			Temp Fahr t
		Sat Liquid v_f	Evap v_{fg}	Sat Vapor v_g	Sat Liquid h_f	Evap h_{fg}	Sat Vapor h_g	Sat Liquid s_f	Evap s_{fg}	Sat Vapor s_g	
180.0	7.5110	0.016510	50.21	50.22	148.00	990.2	1138.2	0.2631	1.5480	1.8111	180.0
182.0	7.850	0.016522	48.172	18.189	150.01	989.0	1139.0	0.2662	1.5413	1.8075	182.0
184.0	8.203	0.016534	46.232	46.249	152.01	987.8	1139.8	0.2694	1.5346	1.8040	184.0
186.0	8.568	0.016547	44.383	44.400	154.02	986.5	1140.5	0.2725	1.5279	1.8004	186.0
188.0	8.947	0.016559	42.621	42.638	156.03	985.3	1141.3	0.2756	1.5213	1.7969	188.0
190.0	9.340	0.016572	40.941	40.957	158.04	984.1	1142.1	0.2787	1.5148	1.7934	190.0
192.0	9.747	0.016585	39.337	39.354	160.05	982.8	1142.9	0.2818	1.5082	1.7900	192.0
194.0	10.168	0.016598	37.808	37.824	162.05	981.6	1143.7	0.2848	1.5017	1.7865	194.0
196.0	10.605	0.016611	36.348	36.364	164.06	980.4	1144.4	0.2879	1.4952	1.7831	196.0
198.0	11.058	0.016624	34.954	34.970	166.08	979.1	1145.2	0.2910	1.4888	1.7798	198.0
200.0	11.526	0.016637	33.622	33.639	168.09	977.9	1146.0	0.2940	1.4824	1.7764	200.0
204.0	12.512	0.016664	31.135	31.151	172.11	975.4	1147.5	0.3001	1.4697	1.7698	204.0
208.0	13.568	0.016691	28.862	28.878	176.14	972.8	1149.0	0.3061	1.4571	1.7632	208.0
212.0 ✓	14.696	0.016719	26.782	26.799	180.17	970.3	1150.5	0.3121	1.4447	1.7568	212.0
216.0	15.901	0.016747	24.878	24.894	184.20	967.8	1152.0	0.3181	1.4323	1.7505	216.0
220.0	17.186	0.016775	23.131	23.148	188.23	965.2	1153.4	0.3241	1.4201	1.7442	220.0
224.0	18.556	0.016805	21.529	21.545	192.27	962.6	1154.9	0.3300	1.4081	1.7380	224.0
228.0	20.015	0.016834	20.056	20.073	196.31	960.0	1156.3	0.3359	1.3961	1.7320	228.0
232.0	21.567	0.016864	18.701	18.718	200.35	957.4	1157.8	0.3417	1.3842	1.7260	232.0
236.0	23.216	0.016895	17.454	17.471	204.40	954.8	1159.2	0.3476	1.3725	1.7201	236.0
240.0	24.968	0.016926	16.304	16.321	208.45	952.1	1160.6	0.3533	1.3609	1.7142	240.0
244.0	26.826	0.016958	15.743	15.260	212.50	949.5	1162.0	0.3591	1.3494	1.7085	244.0
248.0	28.796	0.016990	14.264	14.281	216.56	946.8	1163.4	0.3649	1.3379	1.7028	248.0
252.0	30.883	0.017022	13.358	13.375	220.62	944.1	1164.7	0.3706	1.3266	1.6972	252.0
256.0	33.091	0.017055	12.520	12.538	224.69	941.4	1166.1	0.3763	1.3154	1.6917	256.0
260.0	35.427	0.017089	11.745	11.762	228.76	938.6	1167.4	0.3819	1.3043	1.6862	260.0
264.0	37.894	0.017123	11.025	11.042	232.83	935.9	1168.7	0.3876	1.2933	1.6808	264.0
268.0	40.500	0.017157	10.358	10.375	236.91	933.1	1170.0	0.3932	1.2823	1.6755	268.0
272.0	43.249	0.017193	9.738	9.755	240.99	930.3	1171.3	0.3987	1.2715	1.6702	272.0
276.0	46.147	0.017228	9.162	9.180	245.08	927.5	1172.5	0.4043	1.2607	1.6650	276.0
280.0	49.200	0.017264	8.627	8.644	249.17	924.6	1173.8	0.4098	1.2501	1.6599	280.0
284.0	52.414	0.01730	8.1280	8.1453	253.3	921.7	1175.0	0.4154	1.2395	1.6548	284.0
288.0	55.795	0.01734	7.6634	7.6807	257.4	918.8	1176.2	0.4208	1.2290	1.6498	288.0
292.0	59.350	0.01738	7.2301	7.2475	261.5	915.9	1177.4	0.4263	1.2186	1.6449	292.0
296.0	63.084	0.01741	6.8259	6.8433	265.6	913.0	1178.6	0.4317	1.2082	1.6400	296.0
300.0	67.005	0.01745	6.4483	6.4658	269.7	910.0	1179.7	0.4372	1.1979	1.6351	300.0
304.0	71.119	0.01749	6.0955	6.1130	273.8	907.0	1180.9	0.4426	1.1877	1.6303	304.0
308.0	75.433	0.01753	5.7655	5.7830	278.0	904.0	1182.0	0.4479	1.1776	1.6256	308.0
312.0	79.953	0.01757	5.4566	5.4742	282.1	901.0	1183.1	0.4533	1.1676	1.6209	312.0
316.0	84.688	0.01761	5.1673	5.1849	286.3	897.9	1184.1	0.4586	1.1576	1.6162	316.0
320.0	89.643	0.01766	4.8961	4.9138	290.4	894.8	1185.2	0.4640	1.1477	1.6116	320.0
324.0	94.826	0.01770	4.6418	4.6595	294.6	891.6	1186.2	0.4692	1.1378	1.6071	324.0
328.0	100.245	0.01774	4.4030	4.4208	298.7	888.5	1187.2	0.4745	1.1280	1.6025	328.0
332.0	105.907	0.01779	4.1788	4.1966	302.9	885.3	1188.2	0.4798	1.1183	1.5981	332.0
336.0	111.820	0.01783	3.9681	3.9859	307.1	882.1	1189.1	0.4850	1.1086	1.5936	336.0
340.0	117.992	0.01787	3.7699	3.7878	311.3	878.8	1190.1	0.4902	1.0990	1.5892	340.0
344.0	124.430	0.01792	3.5834	3.6013	315.5	875.5	1191.0	0.4954	1.0894	1.5849	344.0
348.0	131.142	0.01797	3.4078	3.4258	319.7	872.2	1191.1	0.5006	1.0799	1.5806	348.0
352.0	138.138	0.01801	3.2423	3.2603	323.9	868.9	1192.7	0.5058	1.0705	1.5763	352.0
356.0	145.424	0.01806	3.0863	3.1044	328.1	865.5	1193.6	0.5110	1.0611	1.5721	356.0
360.0	153.010	0.01811	2.9392	2.9573	332.3	862.1	1194.4	0.5161	1.0517	1.5678	360.0
364.0	160.903	0.01816	2.8002	2.8184	336.5	858.6	1195.2	0.5212	1.0424	1.5637	364.0
368.0	169.113	0.01821	2.6691	2.6873	340.8	855.1	1195.9	0.5263	1.0332	1.5595	368.0
372.0	177.648	0.01826	2.5451	2.5633	345.0	851.6	1196.7	0.5314	1.0240	1.5554	372.0
376.0	186.517	0.01831	2.4279	2.4462	349.3	848.1	1197.4	0.5365	1.0148	1.5513	376.0
380.0	195.729	0.01836	2.3170	2.3353	353.6	844.5	1198.0	0.5416	1.0057	1.5473	380.0
384.0	205.294	0.01842	2.2120	2.2304	357.9	840.8	1198.7	0.5466	0.9966	1.5432	384.0
388.0	215.220	0.01847	2.1126	2.1311	362.2	837.2	1199.3	0.5516	0.9876	1.5392	388.0
392.0	225.516	0.01853	2.0184	2.0369	366.5	833.4	1199.9	0.5567	0.9786	1.5352	392.0
396.0	236.193	0.01858	1.9291	1.9477	370.8	829.7	1200.4	0.5617	0.9696	1.5313	396.0
400.0	247.259	0.01864	1.8444	1.8630	375.1	825.9	1201.0	0.5667	0.9607	1.5274	400.0
404.0	258.725	0.01870	1.7640	1.7827	379.4	822.0	1201.5	0.5717	0.9518	1.5234	404.0
408.0	270.600	0.01875	1.6877	1.7064	383.8	818.2	1201.9	0.5766	0.9429	1.5195	408.0
412.0	282.894	0.01881	1.6152	1.6340	388.1	814.2	1202.4	0.5816	0.9341	1.5157	412.0
416.0	295.617	0.01887	1.5463	1.5651	392.5	810.2	1202.8	0.5866	0.9253	1.5118	416.0
420.0	308.780	0.01894	1.4808	1.4997	396.9	806.2	1203.1	0.5915	0.9165	1.5080	420.0
424.0	322.391	0.01900	1.4184	1.4374	401.3	802.2	1203.5	0.5964	0.9077	1.5042	424.0
428.0	336.463	0.01906	1.3591	1.3782	405.7	798.0	1203.7	0.6014	0.8990	1.5004	428.0
432.0	351.00	0.01913	1.30266	1.32179	410.1	793.9	1204.0	0.6063	0.8903	1.4966	432.0
436.0	366.03	0.01919	1.24887	1.26806	414.6	789.7	1204.2	0.6112	0.8816	1.4928	436.0
440.0	381.54	0.01926	1.19761	1.21687	419.0	785.4	1204.4	0.6161	0.8729	1.4890	440.0
444.0	397.56	0.01933	1.14874	1.16806	423.5	781.1	1204.6	0.6210	0.8643	1.4853	444.0
448.0	414.09	0.01940	1.10212	1.12152	428.0	776.7	1204.7	0.6259	0.8557	1.4815	448.0
452.0	431.14	0.01947	1.05764	1.07711	432.5	772.3	1204.8	0.6308	0.8471	1.4778	452.0
456.0	448.73	0.01954	1.01518	1.03472	437.0	767.8	1204.8	0.6356	0.8385	1.4741	456.0

Table 1. Saturated Steam: Temperature Table—*Continued*

Temp Fahr	Abs Press Lb per Sq In	Specific Volume			Enthalpy			Entropy			Temp Fahr
t	p	Sat Liquid v_f	Evap v_{fg}	Sat Vapor v_g	Sat Liquid h_f	Evap h_{fg}	Sat Vapor h_g	Sat Liquid s_f	Evap s_{fg}	Sat Vapor s_g	t
460.0	466.87	0.01961	0.97463	0.99424	441.5	763.2	1204.8	0.6405	0.8299	1.4704	460.0
464.0	485.56	0.01969	0.93588	0.95557	446.1	758.6	1204.7	0.6454	0.8213	1.4667	464.0
468.0	504.83	0.01976	0.89885	0.91862	450.7	754.0	1204.6	0.6502	0.8127	1.4629	468.0
472.0	524.67	0.01984	0.86345	0.88329	455.2	749.3	1204.5	0.6551	0.8042	1.4592	472.0
476.0	545.11	0.01992	0.82958	0.84950	459.9	744.5	1204.3	0.6599	0.7956	1.4555	476.0
480.0	566.15	0.02000	0.79716	0.81717	464.5	739.6	1204.1	0.6648	0.7871	1.4518	480.0
484.0	587.81	0.02009	0.76613	0.78622	469.1	734.7	1203.8	0.6696	0.7785	1.4481	484.0
488.0	610.10	0.02017	0.73641	0.75658	473.8	729.7	1203.5	0.6745	0.7700	1.4444	488.0
492.0	633.03	0.02026	0.70794	0.72820	478.5	724.6	1203.1	0.6793	0.7614	1.4407	492.0
496.0	656.61	0.02034	0.68065	0.70100	483.2	719.5	1202.7	0.6842	0.7528	1.4370	496.0
500.0	680.86	0.02043	0.65448	0.67492	487.9	714.3	1202.2	0.6890	0.7443	1.4333	500.0
504.0	705.78	0.02053	0.62938	0.64991	492.7	709.0	1201.7	0.6939	0.7357	1.4296	504.0
508.0	731.40	0.02062	0.60530	0.62592	497.5	703.7	1201.1	0.6987	0.7271	1.4258	508.0
512.0	757.72	0.02072	0.58218	0.60289	502.3	698.2	1200.5	0.7036	0.7185	1.4221	512.0
516.0	784.76	0.02081	0.55997	0.58079	507.1	692.7	1199.8	0.7085	0.7099	1.4183	516.0
520.0	812.53	0.02091	0.53864	0.55956	512.0	687.0	1199.0	0.7133	0.7013	1.4146	520.0
524.0	841.04	0.02102	0.51814	0.53916	516.9	681.3	1198.2	0.7182	0.6926	1.4108	524.0
528.0	870.31	0.02112	0.49843	0.51955	521.8	675.5	1197.3	0.7231	0.6839	1.4070	528.0
532.0	900.34	0.02123	0.47947	0.50070	526.8	669.6	1196.4	0.7280	0.6752	1.4032	532.0
536.0	931.17	0.02134	0.46123	0.48257	531.7	663.6	1195.4	0.7329	0.6665	1.3993	536.0
540.0	962.79	0.02146	0.44367	0.46513	536.8	657.5	1194.3	0.7378	0.6577	1.3954	540.0
544.0	995.22	0.02157	0.42677	0.44834	541.8	651.3	1193.1	0.7427	0.6489	1.3915	544.0
548.0	1028.49	0.02169	0.41048	0.43217	546.9	645.0	1191.9	0.7476	0.6400	1.3876	548.0
552.0	1062.59	0.02182	0.39479	0.41660	552.0	638.5	1190.6	0.7525	0.6311	1.3837	552.0
556.0	1097.55	0.02194	0.37966	0.40160	557.2	632.0	1189.2	0.7575	0.6222	1.3797	556.0
560.0	1133.38	0.02207	0.36507	0.38714	562.4	625.3	1187.7	0.7625	0.6132	1.3757	560.0
564.0	1170.10	0.02221	0.35099	0.37320	567.6	618.5	1186.1	0.7674	0.6041	1.3716	564.0
568.0	1207.72	0.02235	0.33741	0.35975	572.9	611.5	1184.5	0.7725	0.5950	1.3675	568.0
572.0	1246.26	0.02249	0.32429	0.34678	578.3	604.5	1182.7	0.7775	0.5859	1.3634	572.0
576.0	1285.74	0.02264	0.31162	0.33426	583.7	597.2	1180.9	0.7825	0.5766	1.3592	576.0
580.0	1326.17	0.02279	0.29937	0.32216	589.1	589.9	1179.0	0.7876	0.5673	1.3550	580.0
584.0	1367.7	0.02295	0.28753	0.31048	594.6	582.4	1176.9	0.7927	0.5580	1.3507	584.0
588.0	1410.0	0.02311	0.27608	0.29919	600.1	574.7	1174.8	0.7978	0.5485	1.3464	588.0
592.0	1453.3	0.02328	0.26499	0.28827	605.7	566.8	1172.6	0.8030	0.5390	1.3420	592.0
596.0	1497.8	0.02345	0.25425	0.27770	611.4	558.8	1170.2	0.8082	0.5293	1.3375	596.0
600.0	1543.2	0.02364	0.24384	0.26747	617.1	550.6	1167.7	0.8134	0.5196	1.3330	600.0
604.0	1589.7	0.02382	0.23374	0.25757	622.9	542.2	1165.1	0.8187	0.5097	1.3284	604.0
608.0	1637.3	0.02402	0.22394	0.24796	628.8	533.6	1162.4	0.8240	0.4997	1.3238	608.0
612.0	1686.1	0.02422	0.21442	0.23865	634.8	524.7	1159.5	0.8294	0.4896	1.3190	612.0
616.0	1735.9	0.02444	0.20516	0.22960	640.8	515.6	1156.4	0.8348	0.4794	1.3141	616.0
620.0	1786.9	0.02466	0.19615	0.22081	646.9	506.3	1153.2	0.8403	0.4689	1.3092	620.0
624.0	1839.0	0.02489	0.18737	0.21226	653.1	496.6	1149.8	0.8458	0.4583	1.3041	624.0
628.0	1892.4	0.02514	0.17880	0.20394	659.5	486.7	1146.1	0.8514	0.4474	1.2988	628.0
632.0	1947.0	0.02539	0.17044	0.19583	665.9	476.4	1142.2	0.8571	0.4364	1.2934	632.0
636.0	2002.8	0.02566	0.16226	0.18792	672.4	465.7	1138.1	0.8628	0.4251	1.2879	636.0
640.0	2059.9	0.02595	0.15427	0.18021	679.1	454.6	1133.7	0.8686	0.4134	1.2821	640.0
644.0	2118.3	0.02625	0.14644	0.17269	685.9	443.1	1129.0	0.8746	0.4015	1.2761	644.0
648.0	2178.1	0.02657	0.13876	0.16534	692.9	431.1	1124.0	0.8806	0.3893	1.2699	648.0
652.0	2239.2	0.02691	0.13124	0.15816	700.0	418.7	1118.7	0.8868	0.3767	1.2634	652.0
656.0	2301.7	0.02728	0.12387	0.15115	707.4	405.7	1113.1	0.8931	0.3637	1.2567	656.0
660.0	2365.7	0.02768	0.11663	0.14431	714.9	392.1	1107.0	0.8995	0.3502	1.2498	660.0
664.0	2431.1	0.02811	0.10947	0.13757	722.9	377.7	1100.6	0.9064	0.3361	1.2425	664.0
668.0	2498.1	0.02858	0.10229	0.13087	731.5	362.1	1093.5	0.9137	0.3210	1.2347	668.0
672.0	2566.6	0.02911	0.09514	0.12424	740.2	345.7	1085.9	0.9212	0.3054	1.2266	672.0
676.0	2636.8	0.02970	0.08799	0.11769	749.2	328.5	1077.6	0.9287	0.2892	1.2179	676.0
680.0	2708.6	0.03037	0.08080	0.11117	758.5	310.1	1068.5	0.9365	0.2720	1.2086	680.0
684.0	2782.1	0.03114	0.07349	0.10463	768.2	290.2	1058.4	0.9447	0.2537	1.1984	684.0
688.0	2857.4	0.03204	0.06595	0.09799	778.8	268.2	1047.0	0.9535	0.2337	1.1872	688.0
692.0	2934.5	0.03313	0.05797	0.09110	790.5	243.1	1033.6	0.9634	0.2110	1.1744	692.0
696.0	3013.4	0.03455	0.04916	0.08371	804.4	212.8	1017.2	0.9749	0.1841	1.1591	696.0
700.0	3094.3	0.03662	0.03857	0.07519	822.4	172.7	995.2	0.9901	0.1490	1.1390	700.0
702.0	3135.5	0.03824	0.03173	0.06997	835.0	144.7	979.7	1.0006	0.1246	1.1252	702.0
704.0	3177.2	0.04108	0.02192	0.06300	854.2	102.0	956.2	1.0169	0.0876	1.1046	704.0
705.0	3198.3	0.04427	0.01304	0.05730	873.0	61.4	934.4	1.0329	0.0527	1.0856	705.0
705.47*	3208.2	0.05078	0.00000	0.05078	906.0	0.0	906.0	1.0612	0.0000	1.0612	705.47*

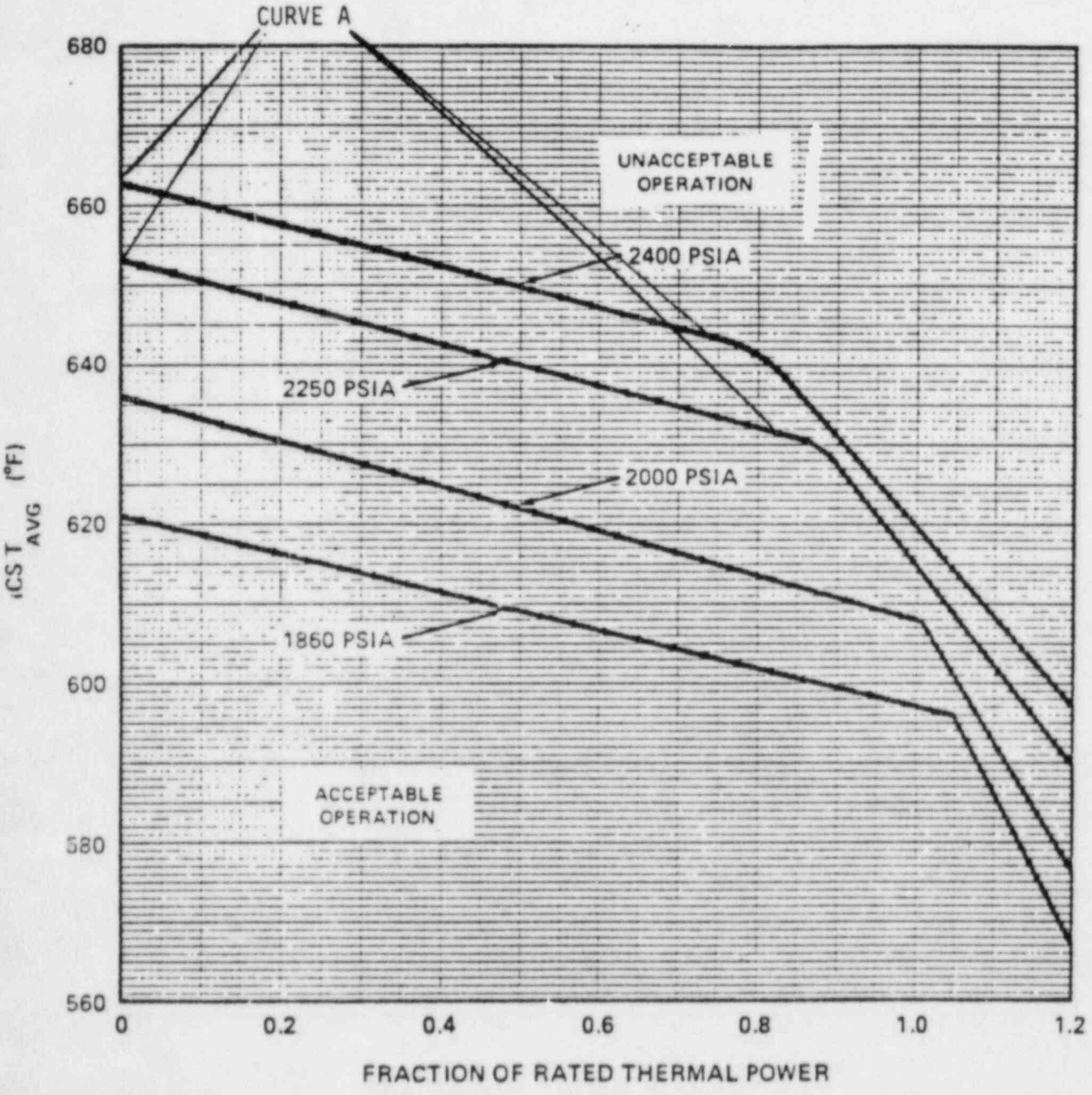
*Critical temperature

Table 2: Saturated Steam: Pressure Table

Abs Press. Lb/Sq In. p	Temp Fahr t	Specific Volume			Enthalpy			Entropy			Abs Press Lb/Sq In p
		Sat. Liquid v_f	Evap v_{fg}	Sat. Vapor v_g	Sat. Liquid h_f	Evap h_{fg}	Sat. Vapor h_g	Sat. Liquid s_f	Evap s_{fg}	Sat. Vapor s_g	
0.08865	32.018	0.016022	3302.4	3302.4	0.0003	1075.5	1075.5	0.0000	2.1872	2.1872	0.08865
0.25	59.323	0.016032	1235.5	1235.5	27.382	1060.1	1087.4	0.0542	2.0425	2.0967	0.25
0.50	79.586	0.016071	641.5	641.5	47.623	1048.6	1096.3	0.0925	1.9446	2.0370	0.50
1.0	101.74	0.016136	333.59	333.60	69.73	1036.1	1105.8	0.1326	1.8455	1.9781	1.0
5.0	162.24	0.016407	73.515	73.532	130.20	1000.9	1131.1	0.2349	1.6094	1.8443	5.0
10.0	193.21	0.016592	38.404	38.420	161.26	982.1	1143.3	0.2836	1.5043	1.7879	10.0
14.696	212.00	0.016719	26.782	26.799	180.17	970.3	1150.5	0.3121	1.4447	1.7568	14.696
15.0	213.03	0.016726	26.274	26.290	181.21	969.7	1150.9	0.3137	1.4415	1.7552	15.0
20.0	227.96	0.016834	20.070	20.087	196.27	960.1	1156.3	0.3358	1.3962	1.7320	20.0
30.0	250.34	0.017009	13.7266	13.7436	218.9	945.2	1164.1	0.3682	1.3313	1.6995	30.0
40.0	267.25	0.017151	10.4794	10.4965	236.1	933.6	1169.8	0.3921	1.2844	1.6765	40.0
50.0	281.02	0.017274	8.4967	8.5140	250.2	923.9	1174.1	0.4112	1.2474	1.6586	50.0
60.0	292.71	0.017383	7.1562	7.1736	262.2	915.4	1177.6	0.4273	1.2167	1.6440	60.0
70.0	302.93	0.017482	6.1875	6.2050	272.7	907.8	1180.6	0.4411	1.1905	1.6316	70.0
80.0	312.04	0.017573	5.4536	5.4711	282.1	900.9	1183.1	0.4534	1.1675	1.6208	80.0
90.0	320.28	0.017659	4.8779	4.8953	290.7	894.6	1185.3	0.4643	1.1470	1.6113	90.0
100.0	327.82	0.017740	4.4133	4.4310	298.5	888.6	1187.2	0.4743	1.1284	1.6027	100.0
110.0	334.79	0.01782	4.0306	4.0484	305.8	883.1	1188.9	0.4834	1.1115	1.5950	110.0
120.0	341.27	0.01789	3.7097	3.7275	312.6	877.8	1190.4	0.4919	1.0960	1.5879	120.0
130.0	347.33	0.01796	3.4364	3.4544	319.0	872.8	1191.7	0.4998	1.0815	1.5813	130.0
140.0	353.04	0.01803	3.2010	3.2190	325.0	868.0	1193.0	0.5071	1.0681	1.5752	140.0
150.0	358.43	0.01809	2.9958	3.0139	330.6	863.4	1194.1	0.5141	1.0554	1.5695	150.0
160.0	363.55	0.01815	2.8155	2.8336	336.1	859.0	1195.1	0.5206	1.0435	1.5641	160.0
170.0	368.42	0.01821	2.6556	2.6738	341.2	854.8	1196.0	0.5269	1.0322	1.5591	170.0
180.0	373.08	0.01827	2.5129	2.5312	346.2	850.7	1196.9	0.5328	1.0215	1.5543	180.0
190.0	377.53	0.01833	2.3847	2.4030	350.9	846.7	1197.6	0.5384	1.0113	1.5498	190.0
200.0	381.80	0.01839	2.2689	2.2873	355.5	842.8	1198.3	0.5438	1.0016	1.5454	200.0
210.0	385.91	0.01844	2.16373	2.18217	359.9	839.1	1199.0	0.5490	0.9923	1.5413	210.0
220.0	389.88	0.01850	2.06779	2.08629	364.2	835.4	1199.6	0.5540	0.9834	1.5374	220.0
230.0	393.70	0.01855	1.97991	1.99846	368.3	831.8	1200.1	0.5588	0.9748	1.5336	230.0
240.0	397.39	0.01860	1.89909	1.91769	372.3	828.4	1200.6	0.5634	0.9665	1.5299	240.0
250.0	400.97	0.01865	1.82452	1.84317	376.1	825.0	1201.1	0.5679	0.9585	1.5264	250.0
260.0	404.44	0.01870	1.75548	1.77418	379.9	821.6	1201.5	0.5722	0.9508	1.5230	260.0
270.0	407.80	0.01875	1.69137	1.71013	383.6	818.3	1201.9	0.5764	0.9433	1.5197	270.0
280.0	411.07	0.01880	1.63169	1.65049	387.1	815.1	1202.3	0.5805	0.9361	1.5166	280.0
290.0	414.25	0.01885	1.57597	1.59482	390.6	812.0	1202.6	0.5844	0.9291	1.5135	290.0
300.0	417.35	0.01889	1.52384	1.54274	394.0	808.9	1202.9	0.5882	0.9223	1.5105	300.0
350.0	431.73	0.01912	1.30642	1.32554	409.8	794.2	1204.0	0.6059	0.8909	1.4968	350.0
400.0	444.60	0.01934	1.14162	1.16095	424.2	780.4	1204.6	0.6217	0.8630	1.4847	400.0
450.0	456.28	0.01954	1.01224	1.03179	437.3	767.5	1204.8	0.6360	0.8378	1.4738	450.0
500.0	467.01	0.01975	0.90787	0.92762	449.5	755.1	1204.7	0.6490	0.8148	1.4639	500.0
550.0	476.94	0.01994	0.82183	0.84177	460.9	743.3	1204.3	0.6611	0.7936	1.4547	550.0
600.0	486.20	0.02013	0.74962	0.76975	471.7	732.0	1203.7	0.6723	0.7738	1.4461	600.0
650.0	494.89	0.02032	0.68811	0.70843	481.9	720.9	1202.8	0.6828	0.7552	1.4381	650.0
700.0	503.08	0.02050	0.63505	0.65556	491.6	710.2	1201.8	0.6928	0.7377	1.4304	700.0
750.0	510.84	0.02069	0.58880	0.60949	500.9	699.8	1200.7	0.7022	0.7210	1.4232	750.0
800.0	518.21	0.02087	0.54809	0.56896	509.8	689.6	1199.4	0.7111	0.7051	1.4163	800.0
850.0	525.24	0.02105	0.51197	0.53302	518.4	679.5	1198.0	0.7197	0.6899	1.4096	850.0
900.0	531.95	0.02123	0.47968	0.50091	526.7	669.7	1196.4	0.7279	0.6753	1.4032	900.0
950.0	538.39	0.02141	0.45064	0.47205	534.7	660.0	1194.7	0.7358	0.6612	1.3970	950.0
1000.0	544.58	0.02159	0.42436	0.44596	542.6	650.4	1192.9	0.7434	0.6476	1.3910	1000.0
1050.0	550.53	0.02177	0.40047	0.42224	550.1	640.9	1191.0	0.7507	0.6344	1.3851	1050.0
1100.0	556.28	0.02195	0.37863	0.40058	557.5	631.5	1189.1	0.7578	0.6216	1.3794	1100.0
1150.0	561.82	0.02214	0.35859	0.38073	564.8	622.2	1187.0	0.7647	0.6091	1.3738	1150.0
1200.0	567.19	0.02232	0.34013	0.36245	571.9	613.0	1184.8	0.7714	0.5969	1.3683	1200.0
1250.0	572.38	0.02250	0.32306	0.34556	578.8	603.8	1182.6	0.7780	0.5850	1.3630	1250.0
1300.0	577.42	0.02269	0.30722	0.32991	585.6	594.6	1180.2	0.7843	0.5733	1.3577	1300.0
1350.0	582.32	0.02288	0.29250	0.31537	592.3	585.4	1177.8	0.7906	0.5620	1.3525	1350.0
1400.0	587.07	0.02307	0.27871	0.30178	598.8	576.5	1175.3	0.7966	0.5507	1.3474	1400.0
1450.0	591.70	0.02327	0.26584	0.28911	605.3	567.4	1172.8	0.8026	0.5397	1.3423	1450.0
1500.0	596.20	0.02346	0.25372	0.27719	611.7	558.4	1170.1	0.8085	0.5288	1.3373	1500.0
1550.0	600.59	0.02366	0.24235	0.26601	618.0	549.4	1167.4	0.8142	0.5182	1.3324	1550.0
1600.0	604.87	0.02387	0.23159	0.25545	624.2	540.3	1164.5	0.8199	0.5076	1.3274	1600.0
1650.0	609.05	0.02407	0.22143	0.24551	630.4	531.3	1161.6	0.8254	0.4971	1.3225	1650.0
1700.0	613.13	0.02428	0.21178	0.23607	636.5	522.2	1158.6	0.8309	0.4867	1.3176	1700.0
1750.0	617.12	0.02450	0.20263	0.22713	642.5	513.1	1155.6	0.8363	0.4765	1.3128	1750.0
1800.0	621.02	0.02472	0.19390	0.21861	648.5	503.8	1152.3	0.8417	0.4662	1.3079	1800.0
1850.0	624.83	0.02495	0.18558	0.21052	654.5	494.6	1149.0	0.8470	0.4561	1.3030	1850.0
1900.0	628.56	0.02517	0.17761	0.20278	660.4	485.2	1145.6	0.8522	0.4459	1.2981	1900.0
1950.0	632.22	0.02541	0.16999	0.19540	666.3	475.8	1142.0	0.8574	0.4358	1.2931	1950.0
2000.0	635.80	0.02565	0.16266	0.18831	672.1	466.2	1138.3	0.8625	0.4256	1.2881	2000.0
2100.0	642.76	0.02615	0.14885	0.17501	683.8	446.7	1130.5	0.8727	0.4053	1.2780	2100.0
2200.0	649.45	0.02669	0.13603	0.16272	695.5	426.7	1122.2	0.8828	0.3848	1.2676	2200.0
2300.0	655.89	0.02727	0.12406	0.15133	707.2	406.0	1113.2	0.8929	0.3640	1.2569	2300.0
2400.0	662.11	0.02790	0.11287	0.14076	719.0	384.8	1103.7	0.9031	0.3430	1.2460	2400.0
2500.0	668.11	0.02859	0.10209	0.13068	731.7	361.6	1093.3	0.9139	0.3206	1.2345	2500.0
2600.0	673.91	0.02938	0.09172	0.12110	744.5	337.6	1082.0	0.9247	0.2977	1.2225	2600.0
2700.0	679.53	0.03029	0.08165	0.11194	757.3	312.3	1069.7	0.9356	0.2741	1.2097	2700.0
2800.0	684.96	0.03134	0.07171	0.10305	770.7	285.1	1055.8	0.9468	0.2491	1.1958	[illegible]
2900.0	690.22	0.03262	0.06158	0.09420	785.1	254.7	1039.8	0.9588	0.2215	1.1803	2900.0
3000.0	695.33	0.03428	0.05073	0.08500	801.8	218.4	1020.3	0.9728	0.1891	1.1619	3000.0
3100.0	700.28	0.03681	0.03771	0.07452	824.0	169.3	993.3	0.9914	0.1460	1.1373	3100.0
3200.0	705.08	0.04472	0.01191	0.05663	875.5	56.1	931.6	1.0351	0.0482	1.0832	3200.0
3208.2*	705.47	0.05078	0.00000	0.05078	906.0	0.0	906.0	1.0612	0.0000	[illegible]	3208.2*

*Critical pressure

FIGURE 5.12-1



REACTOR CORE SAFETY LIMIT - FOUR LOOPS IN OPERATION

6. Plant Systems Design, Control, and Instrumentation

6.1 The plant is in the process of refueling with power range channel 44 defeated for testing. A power surge occurs on 120V AC instrument bus NN01 causing power range channel 41 to fail high. How will this failure affect fuel movement? (2.0)

6.2 A plant heatup is being conducted. Shutdown banks are withdrawn, RCS pressure is 1500 psig. A voltage spike causes turbine first stage pressure PT-506 to fail high. A reactor trip occurs immediately. Explain why the reactor trip occurred. (2.0)

6.3 Two sets of conditions will automatically close the startup transformer output breakers for automatic bus transfer. What are they? (2.0)

6.4 Explain what will occur if an undervoltage condition occurs when a Containment Spray Actuation Signal is present. Include the loading sequence and time of start. (3.0)

6.5 What are the two reasons for installing orifices in the Reactor Vessel Head Venting System vent lines? (2.0)

6.6 What three parameters are used to generate the signal for feedwater pump speed? (1.5)

6.7 a. What interlock must be satisfied in order to manually shut the letdown isolation valve (LCV-459) from the control board? (0.5)

b. What is the basis for this interlock? (1.0)

6.8 What four interlocks must be satisfied in order to open the RHR pump A suction valves from the RCS loop 1 hot leg? (2.0)

6.9 a. How is the fuel transfer car moved in the event of a roller chain breakage? (1.0)

b. What interlock is associated with the new fuel elevator, and what is the purpose of this interlock? (1.0)

6.10 What five signals will generate a Control Room Ventilation Isolation? (2.0)

6.11 What is the Hydrogen Purge System designed to do? (1.0)

6.12 List and explain the four permissive interlocks (or arming signals) associated with the control circuitry of the steam dump system. (3.0)

6.13 What signals will automatically initiate ESW to the AFW system? (1.0)

(END OF SECTION 6)

7. Procedures - Normal, Abnormal, Emergency, and Radiological Control

7.1 a. If, during the execution of an ORANGE condition FR, a RED condition arises, what action should be taken? (1.0)

b. How long should the CSF Status Trees be continuously scanned? (0.5)

c. When may Tree scanning be terminated? (1.0)

7.2 What are the three SI reinitiation criteria (setpoints are not required) following a Spurious SI? (1.5)

7.3 What are the RCP trip criteria during a Loss of Reactor Coolant emergency? (2.0)

7.4 a. What is the AFW supply switchover criteria? (0.5)

b. What is the Cold Leg Recirculation switchover criteria? (0.5)

7.5 What five valves must be shut to ensure feedwater isolation? (2.0)

7.6 What are the four methods, specified in Emergency Procedure E-3, for identifying the steam generator which has a ruptured steam generator tube? (2.0)

7.7 The Anticipated Transient Without Trip procedure cautions against manually actuating a SIS if MFW is required to maintain levels in S/Gs. What is the reason for this caution? (1.0)

7.8 In the event of a Control Room evacuation because of fire, what is the initial location to which the following personnel proceed:

a. Reactor Operator (0.5)

b. BOP (0.5)

c. Equipment Operator (0.5)

7.9 a. When turbine speed is at 150 RPM during turbine startup, what level of turbine vibration requires an immediate trip? (0.5)

b. What value of turbine exhaust pressure requires a manual turbine trip when the generator output is below 30% of rated load? (0.5)

c. What stator cooling water system conductivity requires an immediate manual turbine trip? (0.5)

7.10 a. Why is it necessary to isolate the SI accumulators when RCS pressure drops below 1000 psig? (1.0)

b. During a cooldown, when does the PORV cold overpressure protection system have to be armed? (0.5)

c. What is the limitation on the rate of power increase during initial startup after refueling when power is above 20%? (0.5)

7.11 a. When does a reactor startup require an Inverse Count Rate Ratio? (1.0)

b. What action must be taken if the reactor becomes critical below the control rod insertion limit during a startup? (1.0)

7.12 Explain why EXTREME CAUTION must be observed when isolating a condensate pump during plant operations. (1.0)

7.13 a. What limitation, if any, is imposed on plant output if one string of low pressure heaters is removed from service? (0.5)

b. Why should charging flow through the regenerative heat exchangers be stopped if normal letdown is lost when the RCS temperature is above 350°F? (1.0)

7.14 An Electric Thermal Hydrogen Recombiner must be removed from service or kept from being placed in service if hydrogen concentration approaches or exceeds a certain value.

a. What is this concentration? (0.5)

b. What is the basis for this limitation? (1.0)

7.15 Why, during a plant startup, must steam generator pressure not be reduced below 615 psig when RCS pressure is above 1970 psig? (1.0)

7.16 Why must RCS hydrogen concentration exceed 15 cc/kg prior to raising power above 1MW? (1.0)

(END OF SECTION 7)

8. Administrative Procedures, Conditions, and Limitations

8.1 The individual during off-normal hours who has the authority to authorize restarts following unit trips is the _______. (0.5)

a. Shift Supervisor
b. Emergency Duty Officer
c. Emergency Coordinator
d. Operating Supervisor

8.2 The individual responsible for ensuring that fire watches are established is the _________. (0.5)

a. Operating Supervisor
b. Fire Brigade Leader
c. Fire Protection Engineer
d. Shift Supervisor

8.3 The individual who normally serves as the Fire Brigade Leader is the ___________. (0.5)

a. Operating Supervisor
b. Fire Protection Engineer
c. Shift Supervisor
d. Shift Technical Advisor

8.4 If an oncoming shift worker is late, the shift compliment may be one less than the minimum requirements for a maximum of ________. (0.5)

a. one hour
b. two hours
c. four hours
d. zero hours

8.5 What does an asterisk appearing to the right of a step in a procedure signify? (1.0)

8.6 How are neutron exposures monitored? (1.0)

8.7 What is the purpose of an NDT RWP? (1.0)

8.8 In order to properly tag out motor-operated valves, tags must be placed on what three components? (1.5)

8.9 What is priority E maintenance? (1.0)

8.10 Frangible locking devices are used on certain valves in the Fire Protection System. What is a "frangible locking device"? (1.0)

8.11 If a determination must be made of the number of turns which a locked throttle valve is open, how is it accomplished? (2.0) clarify

2 person's title

3 type of calculation (or [illegible])

8.12 To receive ORE above the applicable Plant Administrative Exposure Limit requires ______ approval and ______ calculations. (1.0)

8.13 a. The weekly whole body alert exposure limit for employees over 18 years of age without NRC form 4 is __________. (0.5)

b. The yearly whole body plant administrative exposure limit for employees over 18 years of age without NRC form 4 is __________. (0.5)

type → c. The quarterly federal whole body exposure limit for employees over 18 years of age with NRC form4 is _________. (0.5)

d. The quarterly federal limit for exposure to the extremities for employees over 18 years of age with NRC form 4 is _________. (0.5)

8.14 What is meant by the term "Radiological Exclusion Area"? (1.0)

8.15 Which individual must be notified if a key is broken? (1.0)

8.16 What two locations comprise the Operational Support Center? (1.0)

8.17 What is the lowest emergency classification at which the following actions must be taken?

a. Call out of the On-site Emergency Organization. (0.5)

b. Activation of the Interim EOF Organization. (0.5)

8.18 What emergency duties are assigned to the STA during an emergency? (1.0)

8.19 Name two specific responsibilities of the Emergency Coordinator which may not be delegated to anyone other than the Recovery Manager. (2.0)

8.20 What five conditions must be satisfied in order to establish and maintain containment integrity? (2.5)

8.21 What is the purpose of a Local Control Tag? (1.0)

8.22 What method is used to identify control board indications which cannot be considered operable? (1.0)

(END OF SECTION 8)

Proctor
Master

Section 5 - Answers

5.1 The core reactivity change due to a uniform change in both the fuel (0.5) and moderator temperatures (0.5) while the reactor is at zero power (isothermal condition). (0.5)

Ref: Westinghouse Reactor Theory Review Text p. 5.22

5.2 Fuel depletion in the lower portion of the reactor, resulting in a flux shift towards the undepleted regions which are mostly located in the top of the core. (2.0)

5.3 The importance function relates the relative importance in the neutron multiplication cycle of a delayed neutron to a prompt neutron. (0.5) It is less than one because the decrease in the amount of fast fission (because delayed neutrons are born below the threshold of fast fission) (0.5) is more important than the increase in the fast nonleakage probability (delayed neutrons are born at lower energy so they have less chance of leaking out of the reactor). (0.5)

Ref: Westinghouse Reactor Theory Review Text p. 3.9 and 3.10

5.4 With both banks C and D inserted into the reactor the probability of a neutron being absorbed by a control rod, "leaking" from the reactor, is increased. (1.0) Since an increase in leakage will cause the moderator temperature coefficient to become more negative, the moderator temperature coefficient will be more negative with both banks C and D inserted than it will be with only bank D inserted (1.0)

or

More control rods inserted will increase the buckling of the reactor. (.75) Increased buckling means more neutrons are close to the boundary of the reactor and are therefore more likely to leak out. (0.5) More leakage means that the moderator temperature coefficient will be more negative. (.75)

Ref: Westinghouse Reactor Theory Review Text p. 5.10

5.5 Xenon 135 is produced by the decay of iodine 135 and directly from fission. (0.5) Iodine 135 is produced directly from fission. Xenon 135 is removed by neutron absorption and by decay. (0.5) Both methods of production and the first method of removal are flux dependent, but the second method of removal is independent of flux. (0.5) So as power increases, the removal rate will increase, but not as greatly as the production rate, so xenon concentration will increase. (0.5)

Samarium 149 is produced by the decay of promethium 149 and directly from fission, while it is only removed by neutron absorption. (0.5) Since both methods of production and the only method of removal are directly proportional to flux, as the power increases the production and removal will increase at the same rate, so the equilibrium concentration will not change with power. (0.5)

Ref: Westinghouse PWR Core Physics Text FND-119, Phase I, B-4, p. 9 and 38

5.6 a. In mode 4 Tave is above 200°F, while in mode 5 Tave is below 200°F (0.5), so the reactivity transients resulting from a postulated steam line break cooldown are minimal for the mode 5 case. (0.5)

Ref: Tech Spec Bases 3/4.1

b. Ensuring that the control rods are above the rod insertion limit. (0.5)

Ref: Tech Spec 4.1.1.1.1

5.7 a. Assure that radial power distribution satisfies the design values used in the power capability analysis. (1.0)

Ref: Tech Spec Bases 3/4.2.4

b. 1.02 (0.5)

Ref: Tech Spec 3.2.4

c. Any three of the following.

(1) Dropped or misaligned control rod (0.5)
(2) Coolant blockage in a flow channel in the reactor (0.5)
(3) Fuel loading error (0.5)
(4) Radial xenon oscillation (0.5)

5.8 a. RCS pressure shall not exceed 2735 psig. (0.5)

Ref: Tech Spec 2.1.2

b. (1) Reduce RCS pressure to less than 2735 psig within five minutes. 1.0 (~~0.75~~)

(2) Notify the NRC Operations office within one hour. 0.5 (~~0.75~~)

Ref: Tech Spec 6.7.1

5.9 Because the fast neutron fluence at 3/4 T is less than it is at 1/4 T due to the shielding provided by the reactor vessel (.75), the neutron embrittlement at 3/4 T will be less than it is at 1/4 T. (.75) Therefore the RT_{NDT} will show a greater increase at 1/4 T than it does at 3/4 T. (0.5)

Ref: Westinghouse Thermal Sciences FND-121 Lesson D-5

5.10 Steam generator Safety Valve with the lowest setting will lift at 1185 psig. (0.25)

1185 psig = 1200 psia (0.25)

Normal steam generator operating pressure at full power is 1000 psia. (0.25)

1000 psia corresponds to 544.58 F (0.25)

1200 psia corresponds to 567.19 F (0.25)

567.19 - 544.58 = 22.61 F (0.25)

Tave must rise 22.61 F from its value at full power to cause the steam generator safety valve with the lowest setting to lift.

The normal value of Tave at full power is 588.5. (.25) The value of Tave which would cause the steam generator safety valve with the lowest setting to lift is 588.5 + 22.61 = 611.11 (.25)

Ref: Tech Spec p. 2-9, 3/4 7-3; Systems 223 p. 1-16, 2-3, 2-8

5.11
1. RCS subcooling - more subcooled than instrument error (0.5)
2. Steam Pressure - stable (0.5)
3. RCS hot leg temperature - stable or slowly decreasing (0.5)
4. RCS cold leg temperature - near saturation temperature for steam pressure (0.5)
5. Core exit TCs - Stable or slowly decreasing (0.5)

Ref: ECA-2.1 Attachment 6

5.12 a. Curve A is based on not reaching saturation temperature in the hot leg. (0.5)

b. As power increases, the difference between hot leg temperature and cold leg temperature increases. (0.5) Since the graph portrays average temperature, the curve must have a negative slope to maintain the hot leg temperature below the saturation value. (0.5)

Ref: Westinghouse Thermal-Hydraulic Principles and Applications to the Pressurized Water Reactor II p. 13-53

c. Steam Generator Safety Valves (0.5)

Section 6 - Answers

6.1 Two power range channels will be defeated or failed high. (0.5) This will result in the activation of P-10. (0.5) P-10 activated will automatically deenergize both source range channels. (0.5) Fuel movement must cease until both source range channels can be reenergized. (0.5)

Ref: SNUPPS Instrument Failure Reference Manual, Source Range and Power Range; Systems Manual 213-5 p. 12; Tech Specs 3/4 p. 9-2

6.2 The reactor would trip due to low pressure. (0.5) When the turbine first stage pressure failed high the P-13 at power permissive cleared. (.75) This caused the P-7 at power permissive to clear, reinstating the low pressure trip. (.75)

Ref: SNUPPS Instrument Failure Reference Manual, p. E-7

6.3 (1) control switch in normal (0.25)
main generator output breakers open (0.5)
Sync check relay satisfied (0.25)

(2) unit auxiliary transformer output breaker open (0.5)
undervoltage condition on that bus (0.5)

Ref: System Descriptions 213 p. 2-7

6.4 (1) The diesel starts (0.5)
(2) All loads are shed form the safeguards bus (0.5)
(3) Once the diesel is running and the breakers from the preferred power supplies are open, the diesel output breaker will automatically shut. (0.5)
(4) Then the following loads will start

Load		Time (seconds)	
CC pump A(B)	(0.1)	0	(0.1)
SI and CCW Pump A(B)	(0.1)	5	(0.1)
RHR pump A(B) and CCW Pump C(D) if A(B) fails to start	(0.1)	10	(0.1)
Containment Spray pump A(B)	(0.1)	15	(0.1)
ESW Pump A(B)	(0.1)	20	(0.1)
Control Room and Class 1E Electrical Room A/C Units (0.1) and AFW Pump A(B)	(0.1)	30	(0.1)
Containment Coolers A and C (B and D) in Slow Speed	(0.1)	35	(0.1)

Ref: Systems Descriptions 213 p. 3-16

6.5 (1) Limit the flow of hydrogen from the RCS to permit a reasonable venting period without exceeding containment atmosphere combustible limits. (1.0)

(2) Limit flow to within the capacity of one CC pump (in the event of a ruptured vent line or an inadvertent opening of the vent valves). (1.0)

Ref: Systems Descriptions 215 p. 1-10

6.6 (1) feedwater pump discharge pressure (0.5)
(2) steam generator header pressure (0.5)
(3) total steam flow (0.5)

Ref: SNUPPS Instrument Failure Reference Manual, p. D-2

6.7 a. All letdown orifice isolation valves must be shut. (0.5)

b. Insure the regenerative heat exchanger is always at RCS pressure (0.5) to prevent steam flashing which could damage its tubes. (0.5)

Ref: System Descriptions 217 p. 1-7

6.8 (1) Valve HV-8811A, containment sump to RHR pump A suction, must be shut. (0.5)

(2) Valve HV-8812A, RWST to RHR pump A suction, must be shut. (0.5)

(3) Valve HV-8804A, RHR pump A discharge to the centrifugal charging pumps suction and safety injection pump A suction, must be closed. (0.5)

(4) RCS pressure less than 425 psig. (0.5)

Ref: System Descriptions 217 p. 4-15

6.9 a. Emergency pull-out cable (1.0)

Ref: System Descriptions 219 p. 4-33

b. Prevent inadvertent upward movement when the elevator is loaded (0.5), thus preventing inadvertent removal of fuel from the pool. (0.5)

Ref: System Descriptions 219 p. 4-36

6.10 (5 ppm chlorine (detected by supply unit)) Not installed at Callaway (0.4)
hi-hi process radiation alarm on supply system (0.4)
fuel building ventilation isolation (0.4)
containment isolation signal (phase A) (0.4)
containment purge isolation signal (0.4)
Manual is also acceptable

Ref: System Descriptions 221 p. 4-19

6.11 Purge the containment atmosphere through the fuel/auxiliary building emergency exhaust system. to reduce the hydrogen concentration in containment. (1.0)

Ref: System Descriptions 221 p. 1-21

6.12 (1) P-4 (reactor trip interlock) (.25) - shifts the Tave mode from the load rejection function to the plant trip function. (0.5)

(2) C-9 (condenser available interlock) (.25) - blocks steam dump actuation if vacuum is inadequate. (0.5)

(3) C-7 (loss of load interlock) (.25) - arms the steam dumps following a load rejection of greater than 10 percent in two minutes. (0.5)

(4) P-12 (low-low Tavg interlock) (.25) - closes all dump valves when Tavg reaches 550°F. (0.5)

Ref: System Descriptions 223 p. 4-6

6.13 Low AFW pump suction pressure (0.5) when an Auxiliary Feed Activation Signal is present. (0.5)

Ref: System Descriptions 223 p. 5-8

Section 7 - Answers

7.1 a. The RED condition FR shall be implemented (0.4) and the ORANGE condition FR suspended (0.3) until completion of the RED condition FR. (0.3)

b. As long as a condition higher than YELLOW exists. (0.5)

c. After the Reactor Protection System (0.3) and the Engineered Safeguards System (0.3) are both restored to OPERABLE status (0.4) (SI reset and Reactor Trip Breakers closed)

Ref: CSF-1 p. 3

7.2 RCS pressure (0.5)
RCS subcooling (0.5)
Pressurizer level (0.5)

Ref: Foldout for E-0

7.3 CCW to the RCP pump motor is lost for more than two minutes. (0.5)
Upper or lower RCP bearing temperatures reach 195°F. (0.5)

Trip all RCPs if BOTH conditions below are met:

a. SI is actuated with flow indicated. (0.5)

b. RCS pressure - 1405 psig or less. (0.5)

Ref: Foldout for E-1

7.4 a. CST level drops below 15%. (0.5)

b. RWST level drops below 36%. (0.5)

Ref: Foldout for E-2

7.5 (1) feedwater isolation valves (0.4)
(2) feedwater chemical injection valves (0.4)
(3) main feedwater control valves (0.4)
(4) main feedwater control bypass valves (0.4)
(5) steam generator blowdown containment isolation valves (0.4)

Ref: ES-01. p. 2

7.6 (1) Unexpected rise in any steam generator narrow range level with decreasing feed flow to the same steam generator. (0.5)
(2) High radiation in and isolation of the steam generator blowdown line. (0.5)

(3) High radiation from any steam generator sample. (0.5)
(4) High radiation from any steam generator steamline, determined by operator walkdown with detector. (0.5)

Ref: E-3 p. 1

7.7 A safety injection will cause a feedwater isolation, thereby creating the potential of a loss of heat sink with the reactor still at power. (1.0)

Ref: ECA-1 p. 2

7.8 a. South ~~HVAC Room (1501)~~ (Train B) ESF Switchgear Room R L Higgins (0.5)
b. ~~ASP~~ (Manually trip Reactor and close MSIVs) go to front standard of turbine R L Higgins (0.5)
c. ~~South (Train B) ESF Switchgear Room (3302)~~ North HVAC room R L Higgins (0.5)

Ref: OTO-ZZ-00001 Attachments 1, 2, 3

7.9 a. 8 ~~12~~ mils R L Higgins (0.5)

Ref: OTO-AC-00002 p. 2

b. 5 inches of mercury-absolute (0.5)

Ref: OTO-AD-00001 p. 2

c. 9.9 umhos/cm (0.5)

Ref: OTO-MA-00006 p. 1

7.10 a. Prevent introduction of nitrogen into the RCS. (1.0)
also correct: prevents introducing large amounts of borated water into the RCS (1.0)
b. Prior to any RCS cold leg temperature dropping to 368°F. (0.5)

Ref: OTG-ZZ-00006 p. 12

c. 3% per hour (0.5)

Ref: OTG-ZZ-00004 p. 2

7.11 a. Anytime criticality is anticipated with reactor conditions different from those for which previous criticality data are available and the differences are .5% delta K/K or greater. (1.0)

b. Terminate the startup by fully inserting all control rods. (1.0)

Ref: OTG-ZZ-00002 steps 2.9 and 4.2.7

7.12 If the pump's suction side pressure is excessive (greater than 55 psig) the expansion joint could rupture. (1.0)

Ref: OTN-AD-00001 step 2.13

7.13 a. Load is limited to 85% of the turbine nameplate rating. (0.5)

Ref: OTN-AF-00001 p. 1

b. Prevent thermal shock to the RCS loop penetration (1.0)

Ref: OTN-BG-00001 step 2.2

7.14 a. 6% by volume (0.5)

b. Prevent an explosion. (1.0)

Ref: OTN-GS-00001 step 2.2

7.15 At the low steam generator pressure, SI will occur because it will be automatically unblocked when RCS pressure rises above 1970 psig. (1.0)

Ref: Tech Spec 3/4 320

7.16 Ensure enough hydrogen is available to recombine with oxygen which will be generated by the dissociation of water due to the high radiation fields in the reactor when it is at power. (1.0)

Section 8 - Answers

8.1 b. Emergency Duty Officer (0.5)

Ref: APA-ZZ-00001 step 4.3.1.2.2

8.2 d. Shift Supervisor (0.5)

Ref: APA-ZZ-00010 step 4.2.3.14

8.3 a. Operating Supervisor (0.5)

Ref: APA-ZZ-00010 step 4.2.4.5

8.4 d. zero hours (0.5)

Ref: APA-ZZ-00010 step 6.6

8.5 The step is referenced on the procedure's deficiency list. (1.0)

Ref: APA-ZZ-00101 step 3.4.3

8.6 Portable neutron survey instrumentation (0.5) and calculated stay times. (0.5)

Ref: APA-ZZ-00160 step 4.6.2.3

8.7 Provide instruction to personnel who have entered under a GRWP for general RCA access (0.5) and are entering a room or area in the RCA where radiological conditions dictate protective requirements in addition to those specified on the GRWP. (0.5)

Ref: APA-ZZ-00161 step 2.1.3

8.8 The handwheel (0.5), the supply breaker (0.5), and the control switch (0.5).

Ref: APA-ZZ-00310 step 4.1.13

8.9 Emergency maintenance (0.5) to prevent or mitigate the consequences of accidents, prevent the release of radioactive material to the environment or to protect human life and/or property. (0.5)

Ref: APA-ZZ-00320 step 2.9.4

8.10 Any locking device which can be readily or easily broken (such as plastic or lead seals and breakaway locks). (1.0)

Ref: ODP-ZZ-00004 step 2.1

8.11 (1) SS permission is obtained (0.4) (.6)
(2) Valve shall be closed while counting the turns. (0.4) (.7)
(3) Valve is reopened by counting the turns back to the original position. (0.4) (.7)
(4) The locking device is reinstalled. ~~(0.4)~~
(5) A second verification of locking device installation is obtained. E L Higgins ~~(0.4)~~

Ref: ODP-ZZ-00004 step 6.3.3

8.12 plant manager (0.5); stay time (0.5)

Ref: HDP-ZZ-01400 step 2.10

8.13 a. 300 mrem (0.5)

b. 4800 mrem (0.5)

c. 3 rem (0.4) not to exceed 5 (N-18). (0.1)

d. 18.75 rem (0.5)

Ref: HDP-ZZ-01400 Attachment 1

8.14 Any area where the federal external exposure limits could be exceeded in a very short time. (1.0)

Ref: HDP-ZZ-01500 step 3.2.1.5

8.15 Key room officer (1.0)

Ref: SDP-ZZ-PP006

8.16 Service Building Lunch Room (0.5)
Health Physics Office (0.5)

Ref: Radiological Emergency Response Plan p. 1-4

8.17 a. Alert
b. Site Emergency

Ref: RERP step 5.2.1

8.18 Monitor the plant instrumentation and SPDS throughout the emergency and provide technical recommendations to the SS concerning reactor safety. (1.0)

Ref: RERP step 5.2.2.3

8.19 Any two of the following

(1) Classifying and declaring emergencies (1.0)
(2) Directing notifications to offsite agencies to commence (1.0)
(3) Making protective action recommendations to offsite authorities (1.0)
(4) Requesting offsite assistance including Federal, State and local (1.0)
(5) Authorizing personnel exposure in excess of 10 CFR 20 limits (1.0)

Ref: RERP step 5.2.3.1

8.20 (1) All penetrations required to be closed during accident conditions are capable of being closed automatically or are manually secured in their closed positions. (0.5)
(2) All equipment hatches are closed and sealed. (0.5)
(3) Each airlock is secured in accordance with Tech Spec requirements. (0.5)
(4) Containment leakage rates are within Tech Spec limits. (0.5)
(5) The sealing mechanism associated with each penetration is operable. (0.5)

Ref: Tech Spec 1.7

8.21 Authorizes someone other than the regular operator to operate a piece of equipment for maintenance and ensure no one operates that equipment without his approval. (1.0)

Ref: APA-ZZ-00310 step 2.1.3

8.22 Either of the following: "Work Request Submitted" sticker or a WPA tag. (Hold-off or Caution) (1.0)

Ref: Standing Order #84-27