U.S. NUCLEAR REGULATORY COMMISSION

REGION III

Reports No. 50-295/OLS-86-01

Docket Nos. 50-295; 50-304 Licenses No. DPR-39; DRP-48

Licensee: Commonwealth Edison Company
Zion Generating Station
Zion, Illinois

Facility Name: Zion Generating Station

Examination Administered At: Zion, Illinois

Examination Conducted: September 30, October 1, 2, 3, and 16, 1985

Examiners: R. L. Higgins — 11/4/85 Date

W. C. Hemming — 11/4/85 Date

P. V. Doyle — 11/4/85 Date

Approved By: J. I. McMillen, Chief
Operating Licensing Section — 11/4/85 Date

Examination Summary

The simulator and plant walk-through portions of the examination were administered on September 30, October 1, 2, 3, and 16, 1985. The written portion of the examination was administered on October 16, 1985 (Report No. 50-295/OLS-86-01). Five reactor operators and five senior reactor operators (one of whom was retaking the examination) were administered all portions of the examination.
Results: Five reactor operators and four senior reactor operators passed.

REPORT DETAILS

1. Examiners

*R. L. Higgins, Region III
P. V. Doyle, Headquarters
W. C. Hemming, INEL
*Chief Examiner

2. Examination Review Meeting

An examination review meeting is no longer conducted. Specific facility comments, followed by the NRC response, are included in the following paragraphs.

The facility comments concerning the RO exam, followed by the NRC response, appear below.

Question 1.06 Facility Comment:
The graph provided makes it difficult to arrive at the answers as stated in the key. It is requested that more tolerance be allowed when grading this question.

NRC Response: Reasonable answers which give approximate power levels and time frames were awarded full credit.

Question 1.08.b Facility Comment:
Answer should be 5850 pcm.

NRC Response: Agree. The answer key was changed.

Question 1.11 Facility Comment:
It is requested that a larger margin of error be allowed due to the difficulty in reading the Mollier Diagram.

NRC Response: Agree. Answers within 10 BTU per pound mass of the correct answer were awarded full credit.

Question 2.01 Facility Comment:
At the time of examination Zion Unit 1 RCFC's had been modified significantly. Unit 2 RCFC's, presently in the original state, are scheduled for similar modification. The candidates responses could differ from the answers (2.01.a. and 2.01.c.) since these answers do not include modification information. The stated reference (Zion SD 11-4) is currently undergoing reprint to reflect Mod M22-2-84-40, which involves changing the RCFC's to a one flowpath system. It has been determined that the moisture separators and HEPA filters are not necessary during accident conditions. Therefore, there is no longer any need for two separate flowpaths within the RCFC's. Switching the RCFC's to a one flowpath

system makes their operation inherently more reliable as there are no longer any RCFC dampers that must shift during accident conditions. The result of this modification is that the only condition required for an RCFC to be in the accident mode is to have the fan in low speed.

NRC Response : Agree. The answer key was changed to include this current modification as a correct response. Since both units have not been modified, the original answer will also receive full credit.

Question 2.07 Facility Comment:
In addition to the answers listed, Zion also utilizes jacket water heaters. The purpose of these heaters is to keep the jacket warm thereby keeping the cylinders warm to provide lower friction for starting.

NRC Response: Agree. The answer key was changed to accept "jacket water heaters" as a correct response.

Question 2.08 Facility Comment:
The letdown orifice isolation valves will also close on a Containment Phase "A" Isolation. (Zion SD Chapt 5a, page 59, attached).

NRC Response: Agree. The answer key was changed to require "Containment Phase "A" Isolation" as a required response. Credit was awarded for "SI" in lieu of "Phase A."

Question 3.03.c Facility Comment:
The answer should state that only outward rod motion will be prevented.

NRC Response: Agree. The answer key was changed to read "preventing any auto or manual outward rod motion."

Question 3.10.d Facility Comment:
The correct answer is "d." (Zion 50 Chapter 3c page 23 , attached).

NRC Response: Agree. The answer key was changed to choice "d," auctioneered high Tavg.

Question 4.12 Facility Comment:
The answer key should be changed to reflect the actual sequence of automatic actions listed in AOP-21, and the statement "after 30 seconds" should be changed to "within 30 seconds" per AOP-21.

NRC Response: Agree. The answer key was changed.

The facility comments concerning the SRO exam, followed by the NRC response, appear below:

Question 6.01.b Facility Comment:
The correct answer should be " overpower differential temperature" per Technical Specification bases, pages 21 and 22.

NRC Response: Agree. The answer key was changed to "overpower differential temperature."

Question 6.02.a Facility Comment:
The word "activate" could lead candidate to provide trip setpoints and coincidence vice logic to enable these trips. Please consider this when grading.

NRC Response: Agree. The wording of the question does not necessarily elicit the answer from the answer key. The answer key was modified to grant full credit to the following responses:

"Single loop loss of flow: 2/3 flow detectors less than 90% in one loop"

"Two loop loss of flow: 2/3 flow detectors less than 90% in two loops"

Question 6.03a Facility Comment:
Technical Specification bases, page 248, also discuss iodine activity which should be included as part of the answer.

NRC Response: Agree. The answer key was modified to grant full credit to the response "remove iodine activity."

Question 6.04 Facility Comment:
Answers a.4 and b.1 do not apply to Zion.

a. 4 should be "Reactor Coolant Pumps Thermal Barrier Cooling Water Flow High."

b. 1 should be "closure upon high flow of 190 gpm."

NRC Response: Agree. The answer key was changed.

Question 6.07.c Facility Comment:
The answer key should be changed to:

(1) Steamline differential pressure S.I.
(2) High Steamflow with Lo Tave or Lo Steam Pressure S.I.
(3) Lo-Lo S/G Level Reactor Trip
(4) Hi-Hi S/G Level Reactor Trip
(5) S/G Low Level with SF/FF mismatch Reactor Trip

NRC Response: Partially agree. There is no "Hi-Hi S/G Level Reactor Trip." There is a "Hi-Hi S/G Level feedwater pump trip, turbine trip and feedwater isolation." The answer key was modified accordingly.

Question 6.08.a.2 Facility Comment:
Motor Driven AFW pumps auto start on Low-Low Level in one S/G.

NRC Response: Agree. The answer key was changed.

Question 6.08.b Facility Comment:
Zion does not have a circuit to isolate S/G Blowdown upon receipt of an AFW auto-start signal. This is incorrectly stated in the

reference as shown by the attached electrical drawing 22-1-4840 page BD-17. Reference will be corrected to prevent any future error in this regard.

NRC Response: Agree. The answer key was changed. The facility should ensure that the reference material sent to the NRC is free from errors to avoid having to modify the answer key after the exam is administered.

Question 7.04.a Facility Comment:
Question asks for conditions to verify adequate subcooling while answer states conditions to verify natural circulation. Please consider this when grading.

NRC Response: Agree. The question was somewhat ambiguous. Reasonable answers will be awarded credit.

Question 7.07.b Facility Comment:
Due to information provided in part a., candidate may consider the core to be preconditioned to 50% power which will affect the final time.

NRC Response: Agree. Full credit will be awarded if the examinee assumes that the core was preconditioned to 50% power, in which case the correct answer will be 19.2 hours.

Question 8.04 Facility Comment:
Zion's training program for administrative controls informs students to only regard those reporting requirements which are most restrictive. In the case of exceeding a Safety Limit the one hour reporting requirement as set forth in 10 CFR 50.72 is highly stressed. Although the question asks for the time per Technical Specifications the candidates may answer in accordance with the most restrictive limitation due to the fact it will supersede the Technical Specifications requirement. Please consider this when grading.

NRC Response: Agree. The answer was changed to "b," 1 hour.

Question 8.06 Facility Comment:
The correct answer is flawed by the fact that, IAW Zion Technical Specifications, in Mode 2 reactivity is zero or greater and therefore Keff is 1.0 or greater. If the question is in regard to a transient this should be stated for purposes of clarification.

NRC Response: Disagree. When rods are being withdrawn during a startup the reactor is in Mode 2.

3. Exit Meeting

On October 3, 1985, representatives of the NRC met with facility representatives to discuss preliminary results of the simulator and plant walk-through examinations, as well as any relevant observations made by the examiners. The following NRC personnel were in attendance:

M. M. Holzmer, Zion Senior Resident Inspector
R. L. Higgins, Region III Operator Licensing Examiner

The following facility personnel were in attendance:

George Pliml, Zion Station Manager
Ed Fuerst, Zion Superintendent of Operations
Terry Rieck, Zion Superintendent of Services
Mark Carnahan, Zion Training Supervisor
Ray Landrum, Zion Principal Instructor

a. The facility representatives were informed that of the ten oral/simulator examinations administered, eight examinees definitely passed and two examinees were marginal.

b. While conducting the simulator examinations, the examiners noted that some examinees blindly followed emergency procedures during situations which differed materially from the plant conditions for which the procedures were written. It was felt that the procedures would be better utilized if they were used in a more flexible manner. Though this technique would require more thought and analysis on the operator's part, it would still allow the procedures to be used as a guide and an aid. The examiners believe this is preferable to performing procedural steps which are inappropriate or erroneous for the actual plant condition.

c. The facility was complimented for being extremely clean. Cleanliness was particularly noteworthy because one of the units was in an outage condition.

d. Facility and Westinghouse Training Center personnel were complimented for being cooperative during the administration of the examinations.

Master

U. S. NUCLEAR REGULATORY COMMISSION
REACTOR OPERATOR LICENSE EXAMINATION

FACILITY: ZION 1&2

REACTOR TYPE: PWR-WEC4

DATE ADMINISTERED: 85/09/30

EXAMINER: HEMMING, W.

APPLICANT: _____

INSTRUCTIONS TO APPLICANT:

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

CATEGORY VALUE	% OF TOTAL	APPLICANT'S SCORE	% OF CATEGORY VALUE	CATEGORY
25.00	25.00			1. PRINCIPLES OF NUCLEAR POWER PLANT OPERATION, THERMODYNAMICS, HEAT TRANSFER AND FLUID FLOW
25.00	25.00			2. PLANT DESIGN INCLUDING SAFETY AND EMERGENCY SYSTEMS
25.00	25.00			3. INSTRUMENTS AND CONTROLS
25.00	25.00			4. PROCEDURES - NORMAL, ABNORMAL, EMERGENCY AND RADIOLOGICAL CONTROL
100.00	100.00			TOTALS

FINAL GRADE _____%

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

_____
APPLICANT'S SIGNATURE

QUESTION 1.01 (1.00)

During a reactor startup from an initial Keff of .90, the first reactivity addition caused count rate to increase from 10 cps to 16 cps. The second reactivity addition caused count rate to increase from 16 cps to 32 cps. Which of the following statements BEST describes the relationship between the first and second reactivity additions?

a. The first reactivity addition was the larger of the two.

b. The second reactivity addition was the larger of the two.

c. The first and second reactivity additions were equal.

d. There is not enough data given to determine the relationship.

QUESTION 1.02 (1.00)

TRUE or FALSE?

a. During 100% power operation, Departure from Nucleate Boiling Ratio (DNBR) is greater than the DNBR for 20% reactor power.

b. As the temperature difference between the fuel rod surface and the saturation temperature of the coolant (Twall-Tsat) increases at a constant linear rate,(0-10E4), the heat flux across the fuel surface (BTU/hr sq. ft.) increases at a constant linear rate.

QUESTION 1.03 (1.50)

TRUE or FALSE?

a. The faster a centrifugal pump rotates, the greater the NPSH required to prevent cavitation.

b. One of the pump laws for centrifugal pumps states that the volumetric flow rate is inversely proportional to the speed of the pump.

c. Pump runout is the term used to describe the condition of a centrifugal pump running with no volumetric flow rate.

(***** CATEGORY 01 CONTINUED ON NEXT PAGE *****)

QUESTION 1.04 (2.00)

a. If the reactor is operating in the power range, how long will it take to raise power from 20% to 40% with a +0.5 DPM Start-up rate?

b. Will it take the same amount of time to raise power from 40% to 60% if the same startup is maintained? EXPLAIN.

QUESTION 1.05 (1.00)

Which of the following best describes the effect on MTC if the RCS temperature is LOWERED?

a. It becomes less negative; Boron and water molecules are swept into the core as a result of the outsurge from the pressurizer, therefore, neutrons spend more time in the resonance region.

b. It becomes less negative; The rate of change in the density of water per degree F is less at lower temperatures causing a reduction in the rate of change in resonance escape probability.

c. It becomes more negative; Thermal utilization increases and resonance escape probability decreases.

d. It becomes more negative; As temperature is lowered the moderator becomes more dense. This increases the amount of water molecules in the core, therefore neutrons have a greater probability of colliding with a water molecule which increases the negative reactivity effect.

(***** CATEGORY 01 CONTINUED ON NEXT PAGE *****)

QUESTION 1.06 (4.00)

Using the attached Xenon worth curve, Fig. 1.1, answer the following.

a. Power at T0 was at 70%. What was the power level between T1 and T2?

b. What was the lenth of time between T2 and T3?

c. What happened at T2?

d. At time T4... (choose one)

1. all Xenon production has stopped.

2. Iodine decay to Xenon has stopped.

3. All Xenon production remains constant, but burnout increases.

4. Xenon production directly from fission has stopped, but Xenon production fron Iodine decay continues.

QUESTION 1.07 (1.00)

Delayed neutrons play a major role in the operation of the core because they ...

a. are born at (thermal) slow energy levels (less than 1 ev) and therefore are more apt to cause a fission as compared to being absorbed by a poison.

b. are considered as epithermal neutrons and therefore they will not travel far enough to leak out of the core.

c. are born so much later than the prompt neutrons and provide controlability during steady state operations and power transients.

d. provide 70% of the fission neutron inventory and have higher importance factors associated with them as compared to prompt neutrons.

(xxxxx CATEGORY 01 CONTINUED ON NEXT PAGE xxxxx)

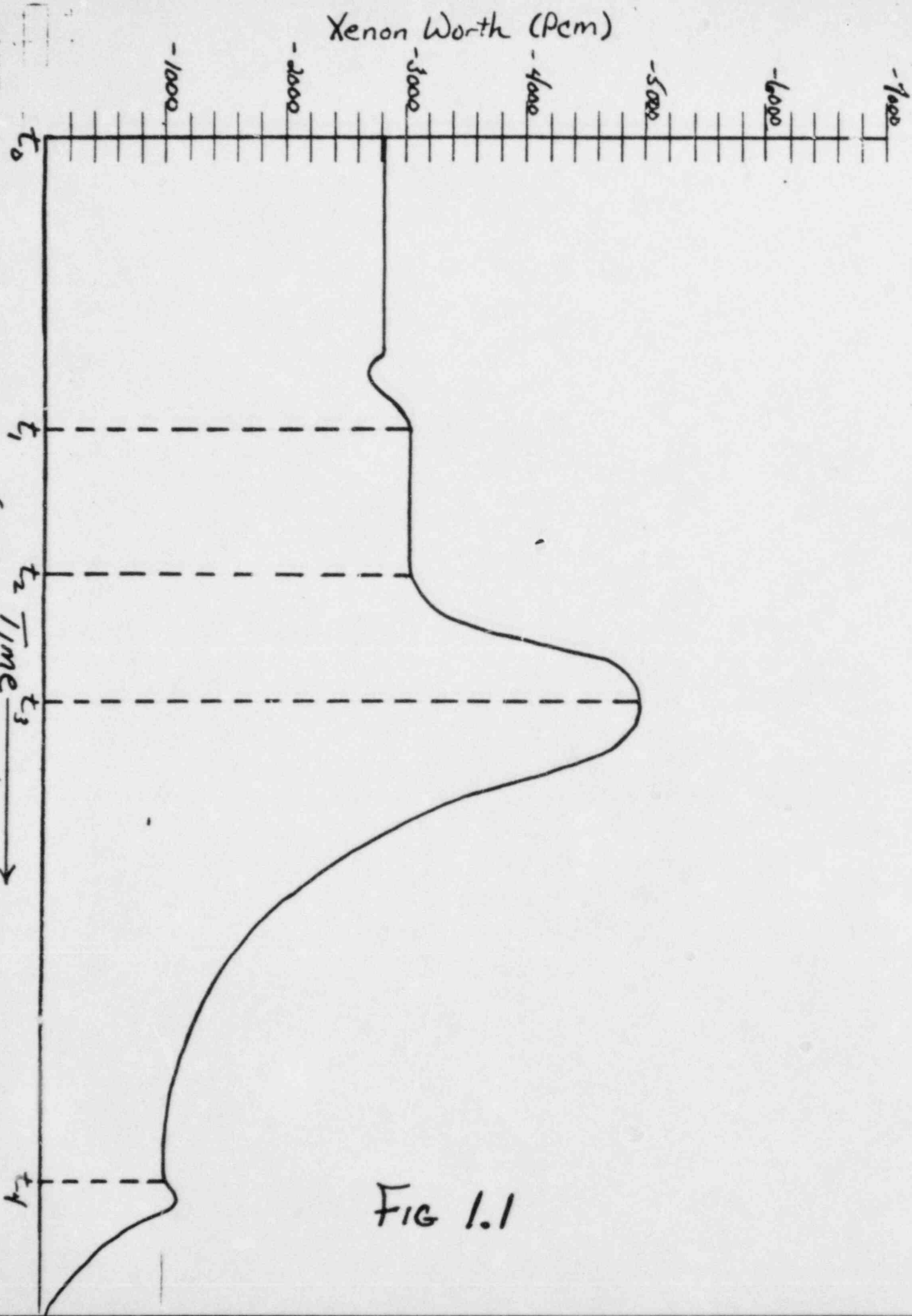

Xenon Worth (Pcm)
-1000
-2000
-3000
-4000
-5000
-6000
-7000
t_0
t_1
t_2
t_3
t_4
Time
(Time not to scale)

FIG 1.1

QUESTION 1.08 (2.00)

a. If the Source Range (SR) instruments indicate 50 cps with Keff equal to 0.9, what would the SR instrument indicate if rods were withdrawn to bring Keff equal to 0.95? Assume BOL conditions.

b. How much reactivity was added? (Include units.)

QUESTION 1.09 (1.50)

Compare the calculated Estimated Critical Position (ECP) for a startup 15 hours after a trip to the actual Critical Rod Position (ACP) if the following events/conditions occurred. Consider each independently. Limit your answer to:

a. ACP higher than ECP.

b. ACP lower than ECP.

c. ACP would not be significantly different than ECP.

1. One Reactor Coolant Pump is stopped one minute prior to criticality.
2. The steam dump pressure setpoint is increased to a value just below the code safties setpoints.
3. The startup is delayed 2 more hours.

QUESTION 1.10 (1.00)

TRUE or FALSE?

a. During a RCS heatup, as temperature gets higher, it will take a smaller letdown flow rate to maintain a constant pressurizer level.

b. Increasing condensate depression (subcooling) will cause BOTH a decrease in plant efficiency AND an increase in condensate (hotwell) pump available NPSH.

(***** CATEGORY 01 CONTINUED ON NEXT PAGE *****)

QUESTION 1.11 (1.00)

Steam exiting the HP turbine is at 785 psig, 90% quality. Steam entering the LP turbine is superheated to 100 F. What is the enthalpy change of the steam?

QUESTION 1.12 (1.00)

In order to maintain a 200 F subcooling margin in the RCS when reducing RCS pressure to 1600 psig, the steam generator pressure must be reduced to ____ psig.

QUESTION 1.13 (1.00)

During a Xenon-free reactor startup, critical data was inadvertently taken two decades below the required Intermediate Range (IR) level (1xE-10 amps). The critical data was taken again at the proper IR level (1xE-8 amps). Assuming RCS temperatures and boron concentrations were the same for each set of data, which of the following statements is correct?

a. The critical rod position taken at the proper IR level is LESS THAN the critical rod position taken two decades below the proper IR level.

b. The critical rod position taken at the proper IR level is THE SAME AS the critical rod position taken two decades below the proper IR level.

c. The critical rod position taken at the proper IR level is GREATER THAN the critical rod position taken two decades below the proper IR level.

d. There is not enough information given to determine the relationship between the critical rod position taken at the proper IR level and the critical rod position taken two decades below the proper IR level.

QUESTION 1.14 (2.00)

If steam goes through a throttling process, indicate whether the following parameters will INCREASE, DECREASE, or REMAIN THE SAME.

a. Enthalpy
b. Pressure
c. Entropy
d. Temperature

(***** CATEGORY 01 CONTINUED ON NEXT PAGE *****)

QUESTION 1.15 (2.00)

Indicate how the following will affect Unit efficiency (increase, decrease, no change) at a steady state power level. (Consider each case separately.)

a. Absolute condenser pressure changes from 1 psi to 1.25 psi.

b. Total S/G blowdown is changed from 35 gpm to 40 gpm.

c. Condenser hotwell temperature changes from 125 F to 130 F. (Assume no change in condenser pressure.)

d. Steam quality changes from 99.8% to 99.7%.

QUESTION 1.16 (2.00)

a. Which parameter below will have the MOST effect on the shape of a Differential Rod Worth Curve?

1) Core radial flux profile
2) Core axial flux profile
3) Core axial temperature profile
4) Time of core cycle

b. TRUE or FALSE?

The effect of the bank overlap program on the Differential Rod Worth curve is to make the shape of the curve more linear.

(***** END OF CATEGORY 01 *****)

QUESTION 2.01 (2.50)

a. Describe the normal flowpath of air circulated by a Reactor Containment Fan Cooler (RCFC). Include the major components that air is directed to. (1.0)

b. How many RCFC's are needed during normal operation? During accident operations? (0.5)

c. How is the RCFC system affected by a Safety Injection signal. (1.0)

QUESTION 2.02 (2.50)

a. With the Component Cooling Water Pump Control Switch in the 'AUTO' position, what will automatically start the standby pump? (Setpoints not required.) (.75)

b. Under what conditions will component cooling water automatically be isolated to the RCP's? (0.5)

c. What signal will isolate the CCW return water from the Excess LDHX by closing valve 1A0V-CC9437? (Setpoints not required.) (0.5)

d. What is the approximate setpoint of the CCW relief valve downstream of the thermal barrier heat exchanger? Why is it set at this value? (.75)

QUESTION 2.03 (2.00)

a. Diesel Generator 0 is loaded and paralleled to 4 KV Bus 147 when a complete loss of offsite power occurs (LOSP). In conjunction with the LOSP, unit two undergoes a safety injection. Explain the affect on D/G 0 and it's output breaker. Be specific. (1.0)

b. Explain the purpose of the 345 KV Local Breaker Backup relays.(LBB) How does LBB action differ when breakers 1718 and 1819 (unit one main generator output breakers) are affected? (1.0)

(***** CATEGORY 02 CONTINUED ON NEXT PAGE *****)

QUESTION 2.04 (2.75)

a. What THREE different parameters are used for input to the Main Feedwater Pump Net Positive Suction Head (FWPNPSH) Control System? (Be specific.) (.75)

b. If the available FWPNPSH decreases to 275 psig, an alarm sounds. What other FOUR actions automatically occur when a low FWP suction pressure condition exists? (2.0)

QUESTION 2.05 (2.50)

a. State the rated flow of each type of auxiliary feedwater pump below:
   - motor driven.
   - turbine driven. (1.0)

b. State FOUR signals that will automatically start the TURBINE driven auxiliary feedwater pump. (Include coincidences) (1.0)

c. Which S/G's can supply steam to the turbine driven auxiliary feedwater pump? (0.5)

QUESTION 2.06 (2.50)

a. The flowrate through the RCP #1 seal is not constant for all plant conditions. EXPLAIN when AND why the flowrate will be at it's highest and lowest value. (1.0)

b. What is/are the flowpath(s) for the RCP #1 seal leakoff during a safety injection? (1.0)

c. What determines the differential pressure across the RCP #1 seal? (0.5)

QUESTION 2.07 (2.25)

List THREE support systems used to ensure that the emergency diesel engine will rapid start within the required time limit. INCLUDE what each system does for the engine to ensure that it will rapid start. (Do not include maintenance or surveillance items.) (2.25)

(***** CATEGORY 02 CONTINUED ON NEXT PAGE *****)

QUESTION 2.08 (2.50)

a. What will cause the letdown orifice isolation valves (8149 A,B,C) to automatically close with no operator action? (control switch for the valves in the auto/open position).

b. What is the function AND purpose of valve PCV 131 (letdown pressure control valve) during each of the below. Be specific.

1. normal operations.
2. solid plant operations. (1.5)

QUESTION 2.09 (2.50)

a. List TWO reasons for maintaining a minimum pressurizer spray line flow during normal 'at power' operations (1.0)

b. What gives indication to the operator that minimum spray flow is not being maintained? (0.5)

c. What creates the motive force for pressurizer spray flow? (1.0)

QUESTION 2.10 (3.00)

a. Describe the difference in flowpaths used for ALTERNATE DILUTE and DILUTE modes of operation in the Reactor Makeup Control System. Why are two dilution paths necessary? (1.5)

b. What is the major concern with fluids containing boric acid? What is done to alleviate this concern? Include all methods used. (1.5)

(***** END OF CATEGORY 02 *****)

QUESTION 3.01 (2.50)

Indicate which of the Excore Nuclear Instrumentation Ranges (SOURCE, INTERMEDIATE, POWER, OR NONE) will correctly match the following statements. More than one may apply to each.

a. Provides a direct input to the Rod Control System.

b. Has a reactor trip function that is blocked at some time between startup and full power operation.

c. It's detector operation is unaffected by gamma radiation.

d. Utilizes a Boron-10 coating in it's detectors.

e. Operates in the 'Ion Chamber' region of the 'Gas Filled Detector Characteristic Curve'. (2.5)

QUESTION 3.02 (2.00)

a. Pressurizer pressure channels 455 and 456 are selected for control. Explain the response of the pressurizer pressure control system if PT-456 failed high. (1.0)

b. With pressurizer pressure channels 455 and 456 selected for control, will one Pressurizer PORV open before the other if pressurizer pressure rises at a rapid rate? EXPLAIN. (1.0)

QUESTION 3.03 (2.00)

BRIEFLY EXPLAIN the response of the Rod Control System for each of the following instrument failures. Include in your answer direction of motion, why the motion occurs as it does, and any controls or permissives encountered (and their effects). Assume the plant at 75% power with all systems in automatic and no operator action or protective trips occur.

a. Loop B(2) Cold Leg RTD fails LOW.

b. Turbine Impulse Pressure (PT-505) fails LOW.

c. Power Range lower detector (NI-44) fails HIGH.

(xxxxx CATEGORY 03 CONTINUED ON NEXT PAGE xxxxx)

QUESTION 3.04 (3.00)

List FOUR signals that will initiate a safety injection. Include with each any permissive that will block or allow blocking of the signal. Setpoints not required.

QUESTION 3.05 (3.00)

The reactor is operating at 100% power with all systems in automatic control. For the following failures, state the protective signal which will cause the reactor to trip. Provide an explanation of why the trip occurs. Assume no operator action and consider each failure independently.

a. The controlling pressurizer level channel fails HIGH.

b. The controlling cold leg temperature detector fails HIGH.

QUESTION 3.06 (2.50)

a. Explain the purpose of the steam pressure input used in the developement of a steam flow signal for the S/G water level control system. (1.0)

b. How would INDICATED steam flow compare to ACTUAL steam flow if, during a power increase from 0-100%, the steam pressure signal stuck at its 50% power value. Briefly explain why. (1.5)

QUESTION 3.07 (3.00)

a. Define 'Coincidence' as it applies to the Reactor Protection System (RPS). (1.0)

b. What is the minimum degree of redundancy that is allowed for protection instrumentation? (1.0)

c. Protective signals that initiate Reactor Protection and Engineering Safety Features use a 'de-energize to operate' bistable principle. State the one protective feature that does not use this principle and explain why. (1.0)

(***** CATEGORY 03 CONTINUED ON NEXT PAGE *****)

QUESTION 3.08 (3.00)

Match the proper Steam Dump Control(s) or Controller(s) in Column B to each statement in Column A. More than one in Column B may apply to each in column A. Place answers on your answer page.

COLUMN A	COLUMN B
____a. Operates Steam Dumps based on a temperature deviation (Tavg-Tref).	1. Turbine trip controller.
____b. Used to reset the C-7 arming signal.	2. Steam pressure controller.
____c. Contains no trip open features.	3. Load rejection controller.
____d. Uses auctioneered high Tavg.	4. Steam Dump Control Mode Selector.
____e. Compares the actual parameter to that of a pre-set value for operation	5. Steam Dump Interlock Selector.
____f. Used to allow cooldown valves to open below P-12.	
____g. Used to turn the system off.	
____h. Uses quick open bistables for rapid transients.	

QUESTION 3.09 (1.00)

The THREE input signals to the Steam Generator Water Level Control are:

a. Tavg, compensated feed flow, uncompensated steam flow.

b. Feed flow, compensated steam flow, water level error.

c. Compensated feed flow, water level, compensated steam flow.

d. Uncompensated feed flow, compensated steam flow, water level.

(xxxxx CATEGORY 03 CONTINUED ON NEXT PAGE xxxxx)

QUESTION 3.10 (1.00)

Programmed Pressurizer level is based on:

a. Auctioneered High Power.

b. Loop Tavg.

c. Tref from Pimp.

d. Auctioneered High Tavg.

QUESTION 3.11 (1.00)

Which of the following core parameters does the OT delta T protective circuit prevent exceeding?

a. Power density.

b. Departure from Nucleate Boiling.

c. Total core power.

d. Redistribution.

QUESTION 3.12 (1.00)

The OP delta T setpoint is a calculated value determined by 109% full power delta T, minus correction proportional to the rate of:

a. increase of Tavg, minus correction proportional to variation of delta T above full load value.

b. increase of Thot, minus correction proportional to varation of Thot above full load Thot

c. increase of Tavg, minus correction proportional to varation of Tavg above full load Tavg.

d. increase of delta T, minus correction proportional to variation of delta T above full load.

(***** END OF CATEGORY 03 *****)

QUESTION 4.01 (2.50)

Briefly describe the automatic actions that occur when the following Radiation Monitoring System channels reach their alarm setpoints.

a. Steam Generator Blowdown Liquid Monitor (R-19)

b. Component Cooling Water System Monitor (R-17)

c. Fire Sump Monitor (ORT-PR17)

d. Air Ejector Monitor (R-15)

(2.5)

QUESTION 4.02 (2.50)

Complete the following statements utilizing information found in "Plant Heatup" (GOP-1).

a. For normal heatup of the Pressurizer, a rate of _____ F/hour will not be exceeded.

b. Spray Flow into the Pressurizer will not be initiated if the temperature difference between the Pzr and Spray fluid exceeds _____ F.

c. If Component Cooling flow to the RCP oil coolers is lost for any reason during RCP operation, the RCP(s) must be stopped before bearing temperature reaches _____ F.

d. Heat-up must be terminated or spray initiated if RC Loop Boron Concentration decrease approaches _____ ppm or if PZR Boron approaches _____ ppm less than RC Loop Concentration.

QUESTION 4.03 (2.50)

a. What action must be taken if, while performing a startup per procedure GOP-2 (Plant Startup), criticality is achieved below the Control Bank Low-Low insertion limit? (1.0)

b. What are the THREE reasons for maintaining Control Banks above the Low-Low insertion limits? (1.5)

(***** CATEGORY 04 CONTINUED ON NEXT PAGE *****)

QUESTION 4.04 (1.50)

Define the following Technical Specification terms.

a. INADVERTENT TRIP

b. DEGREE OF REDUNDANCY

QUESTION 4.05 (1.00)

Which of the following defines a RESTRICTED AREA per 10 CFR 20?

a. The area surrounding the reactor in which the licensee has the authority to determine all activities including the removal of personnel or property from the area.

b. An area where an individual located at any point on it's boundary for two hours following a postulated accident will not receive in excess of 25 rems whole body or 300 rems to the thyroid

c. An area in which access is controlled by the licensee for purposes of protection of individuals from exposure to radiation and radioactive materials.

d. An area where an individual located at any point on it's boundary following a postulated accident will not receive in excess of 25 rems whole body or 300 rems to the thyroid.

QUESTION 4.06 (1.00)

According to 10 CFR 20, what is the maximum dose any individual may receive with Form NRC-4 on file?

a. 1 1/4 rems/quarter not to exceed 5(n-18).

b. 3 rems/quarter not to exceed 5(n-18).

c. 5 rems/quarter not to exceed 5(n-18).

d. 5(n-18).

(***** CATEGORY 04 CONTINUED ON NEXT PAGE *****)

QUESTION 4.07 (2.50)

a. Located in EOP-0, Appendix B, (Recovery From Inadvertant SI), is a caution directing the operator to manually reinitiate safety injection if any of three conditions are exhibited. List the three conditions, be specific. (1.5)

b. The caution in part 'a' above and a note preceeding the caution indicates that automatic safety injection is not available. Explain why only manual initiation is available at this time. (1.0)

QUESTION 4.08 (1.50)

List the three symptoms that indicate inadequate core cooling according to EOP-11, Inadequate Core Cooling, if the computer is not available. Be specific.

QUESTION 4.09 (2.00)

EOP-5, Emergency Boration, lists four ways to emergency borate. List the four ways and indicate which of the four is/are not preferred. (Individual procedural steps not required.)

QUESTION 4.10 (2.50)

a. If leakage into a S/G is diagnosed and AOP-19, S/G. Tube Leak, is in use, what plant conditions require exiting AOP-19 and where are you directed to proceed? (1.0)

b. AOP-19 directs the centrifugal charging pump (CCP) miniflow isolation valves to be closed if additional charging flow is needed. When may the valves be closed? When are they required to be reopened and why must they be reopened at this time? (1.5)

(***** CATEGORY 04 CONTINUED ON NEXT PAGE *****)

QUESTION 4.11 (3.00)

a. Technical Specifications Section 3.3.1 (RCS Operational Components) makes provisions for all reactor coolant pumps and decay heat removal pumps to be stopped when in mode 4. How long can they be stopped and what requirements must be met while they are stopped? (1.25)

b. According to AOP-20, Loss of RHR Shutdown Cooling, what are the immediate operator actions if RHR is lost because of the following faults:

1. MOV-RH 8701 or 8702 closes.
2. HCV-RH 606 or 607 closes. (1.75)

QUESTION 4.12 (2.50)

AOP-21, Degraded 4 KV ESF Bus Voltage, states that certain delayed automatic actions will occur if a degraded condition of 3850 volts remains for 8 seconds. State the length of this delay and the automatic actions that occur. (Include any loads that are shed or auto-start.)

(***** END OF CATEGORY 04 *****)
(**********END OF EXAMINATION **********)

EQUATIONS

REACTOR THEORY

$$P = P_o e^{t/\tau} = P_o 10^{SUR \cdot t}$$

$$\tau = \frac{\bar{l}_x}{\rho} + \frac{\beta - \rho}{\lambda\rho} \quad \text{or} \quad \tau = \frac{\beta - \rho}{\lambda\rho}$$

$$\rho = \frac{k - 1}{k} \qquad \frac{k_2 - k_1}{k_2 k_1} = \Delta\rho$$

$$\frac{cps_2}{cps_1} = \frac{1 - k_1}{1 - k_2} \qquad k < 1$$

$$\frac{1}{M} = 1 - k$$

$$\frac{1}{M} = \frac{cps_o}{cps_n}$$

$$\rho_{net} = \Delta(\rho_{doppler} + \rho_{mod} + \rho_{void} + \rho_{Xe} + \rho_{Sm} + \rho_{Pu} + \rho_{Boron} + \rho_{rod} + \rho_{fuel} + \rho_{Poisons})$$

$$k_2 = k_1 + \delta k$$

$$\delta k = k - 1$$

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

$$P = \frac{I\phi V}{3.1 \times 10^{16}}$$

$$I = N\sigma$$

$$\phi = nv$$

Defect = Coeff x Δ Parameter

RADIATION

$$N = N_o e^{-\lambda t}$$

$$A = \lambda N$$

$$I = I_o e^{-\mu x} = I_o 10^{-x/TVT}$$

$$\lambda T_{\frac{1}{2}} = 0.693$$

$$R/hr \text{ @ } d \text{ feet} = \frac{6CE}{d^2}$$

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

$I_1 d_1 = I_2 d_2$ - line source

R/hr x time = R

Rad x QF = Rem

$$T_{\frac{1}{2}eff} = \frac{T_{\frac{1}{2}Bio} \times T_{\frac{1}{2}Rad}}{T_{\frac{1}{2}Bio} + T_{\frac{1}{2}Rad}}$$

MATH

$$y^a = b$$

$$\log_y b = a$$

$$\log_{y_c} x = c \log x$$

$$\log \frac{x}{y} = \log x - \log y$$

$$\log xy = \log x + \log y$$

FLUIDS/THERMO/HEAT TRANSFER

$$\dot{m} = A_1\rho_1 V_1 = A_2\rho_2 V_2$$

$$Q = A_1 V_1 = A_2 V_2$$

$$E_{in} = E_{out} + \Delta E_{stored}$$

$$E = KE + PE + U + pV + Q + W$$

$$PE = \frac{mg}{g_c} z$$

$$KE = \frac{1}{2} m \frac{V^2}{g_c}$$

reduced for - turbine, SG pump, nozzle, orifice, condenser, pipe, Rx

flow $\alpha \sqrt{dp}$

$$\text{head loss} = f\frac{L}{D}\frac{V^2}{2g_c} \quad \text{or head loss } \alpha\ V^2 \quad \text{head loss } \alpha\ \Delta p$$

$$p = h + p_{ambient} \qquad = k\frac{V^2}{2g_c}$$

$$F = pA$$

$$\Delta p_{2\,phase} = \Delta p_{1\,phase} \times K$$

k = f(quality & Pressure)

Pump laws speed α flow

(speed)^2 α pressure

(speed)^3 α power

$$Q = kA\Delta T = hA\Delta T = UA\Delta T$$

$$Q = mc_p\Delta T$$

$$Q = m\Delta h$$

$$Q = \epsilon\sigma T$$

$$\Delta H = mc_p\Delta T$$

$$\Delta U = mc_v\Delta T$$

$$H = U + pV$$

$$\Delta S = \frac{\Delta Q}{T}$$

$$pV = nRT$$

$$\frac{p_1V_1}{T_1} = \frac{p_2V_2}{T_2}$$

$$C_1V_1 + C_2V_2 = C_3(V_1 + V_2)$$

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	0.31626	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	814.1	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	2.0359	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	527.5	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	296.18	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	1.3509	0.016173	251.37	251.39	79.98	1030.2	1110.2	0.1507	1.8021	1.9528	112.0
114.0	1.4309	0.016180	238.21	238.22	81.97	1029.1	1111.0	0.1542	1.7938	1.9480	114.0
116.0	1.5153	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	1.6977	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	1.6834	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	1.8525	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 values shown are metastable

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

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
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	48.189	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	15.243	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	938.8	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	5.4747	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	0.01807	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*

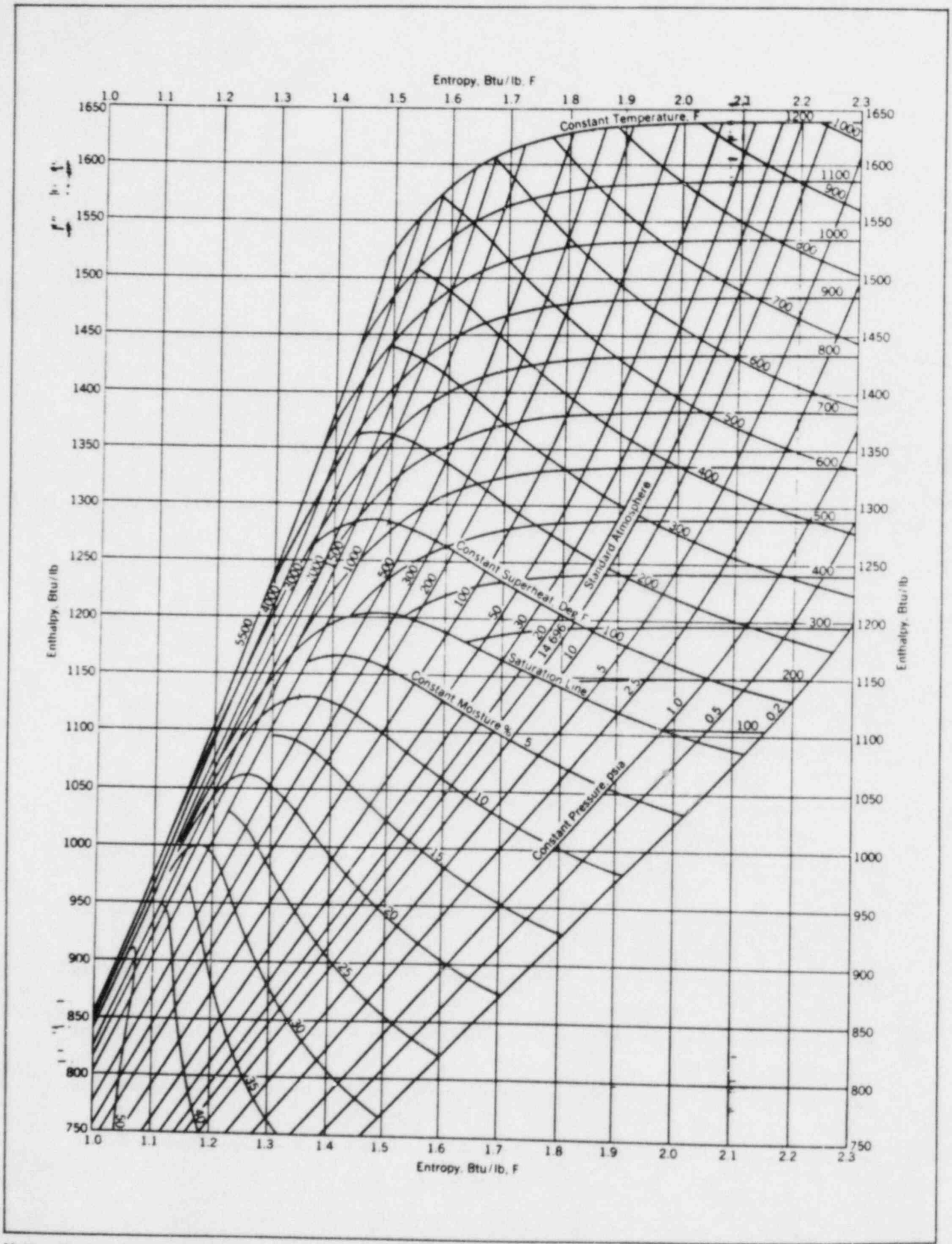
Temp Fahr t	Abs Press Lb per Sq In p	Specific Volume: Sat Liquid v_f	Specific Volume: Evap v_{fg}	Specific Volume: Sat Vapor v_g	Enthalpy: Sat Liquid h_f	Enthalpy: Evap h_{fg}	Enthalpy: Sat Vapor h_g	Entropy: Sat Liquid s_f	Entropy: Evap s_{fg}	Entropy: Sat Vapor s_g	Temp Fahr t
468.0	466.87	0.01961	0.97463	0.99424	441.5	763.2	1204.8	0.6405	0.8299	1.4704	468.0
470.0	485.56	0.01969	0.93588	0.95557	446.1	758.6	1204.7	0.6454	0.8213	1.4667	470.0
472.0	504.83	0.01976	0.89885	0.91862	450.7	754.0	1204.6	0.6502	0.8127	1.4629	472.0
474.0	524.67	0.01984	0.86345	0.88329	455.2	749.3	1204.5	0.6551	0.8042	1.4592	474.0
476.0	545.11	0.01992	0.82958	0.84950	459.9	744.5	1204.3	0.6599	0.7956	1.4555	476.0
478.0	566.15	0.02000	0.79716	0.81717	464.5	739.6	1204.1	0.6648	0.7871	1.4518	478.0
480.0	587.81	0.02009	0.76613	0.78622	469.1	734.7	1203.8	0.6696	0.7785	1.4481	480.0
482.0	610.10	0.02017	0.73641	0.75658	473.8	729.7	1203.5	0.6745	0.7700	1.4444	482.0
484.0	633.03	0.02026	0.70794	0.72820	478.5	724.6	1203.1	0.6793	0.7614	1.4407	484.0
486.0	656.61	0.02034	0.68065	0.70100	483.2	719.5	1202.7	0.6842	0.7528	1.4370	486.0
488.0	680.86	0.02043	0.65448	0.67492	487.9	714.3	1202.2	0.6890	0.7443	1.4333	488.0
490.0	705.78	0.02053	0.62938	0.64991	492.7	709.0	1201.7	0.6939	0.7357	1.4296	490.0
492.0	731.40	0.02062	0.60530	0.62592	497.5	703.7	1201.1	0.6987	0.7271	1.4258	492.0
494.0	757.72	0.02072	0.58218	0.60289	502.3	698.2	1200.5	0.7036	0.7185	1.4221	494.0
496.0	784.76	0.02081	0.55997	0.58079	507.1	692.7	1199.8	0.7085	0.7099	1.4183	496.0
498.0	812.53	0.02091	0.53864	0.55956	512.0	687.0	1199.0	0.7133	0.7013	1.4146	498.0
500.0	841.04	0.02102	0.51814	0.53916	516.9	681.3	1198.2	0.7182	0.6926	1.4108	500.0
502.0	870.31	0.02112	0.49843	0.51955	521.8	675.5	1197.3	0.7231	0.6839	1.4070	502.0
504.0	900.34	0.02123	0.47947	0.50070	526.8	669.6	1196.4	0.7280	0.6752	1.4032	504.0
506.0	931.17	0.02134	0.46123	0.48257	531.7	663.6	1195.4	0.7329	0.6665	1.3993	506.0
508.0	962.79	0.02146	0.44367	0.46513	536.8	657.5	1194.3	0.7378	0.6577	1.3954	508.0
510.0	995.22	0.02157	0.42677	0.44834	541.8	651.3	1193.1	0.7427	0.6489	1.3915	510.0
512.0	1028.49	0.02169	0.41048	0.43217	546.9	645.0	1191.9	0.7476	0.6400	1.3876	512.0
514.0	1062.59	0.02182	0.39479	0.41660	552.0	638.5	1190.6	0.7525	0.6311	1.3837	514.0
516.0	1097.55	0.02194	0.37966	0.40160	557.2	632.0	1189.2	0.7575	0.6222	1.3797	516.0
518.0	1133.38	0.02207	0.36507	0.38714	562.4	625.3	1187.7	0.7625	0.6132	1.3757	518.0
520.0	1170.10	0.02221	0.35099	0.37320	567.6	618.5	1186.1	0.7674	0.6041	1.3716	520.0
522.0	1207.72	0.02235	0.33741	0.35975	572.9	611.5	1184.5	0.7725	0.5950	1.3675	522.0
524.0	1246.26	0.02249	0.32429	0.34678	578.3	604.5	1182.7	0.7775	0.5859	1.3634	524.0
526.0	1285.74	0.02264	0.31162	0.33426	583.7	597.2	1180.9	0.7825	0.5766	1.3592	526.0
528.0	1326.17	0.02279	0.29937	0.32216	589.1	589.9	1179.0	0.7876	0.5673	1.3550	528.0
530.0	1367.7	0.02295	0.28753	0.31048	594.6	582.4	1176.9	0.7927	0.5580	1.3507	530.0
532.0	1410.0	0.02311	0.27608	0.29919	600.1	574.7	1174.8	0.7978	0.5485	1.3464	532.0
534.0	1452.3	0.02328	0.26499	0.28827	605.7	566.8	1172.6	0.8030	0.5390	1.3420	534.0
536.0	1497.8	0.02345	0.25425	0.27770	611.4	558.8	1170.2	0.8082	0.5293	1.3375	536.0
538.0	1543.2	0.02364	0.24384	0.26747	617.1	550.6	1167.7	0.8134	0.5196	1.3330	538.0
540.0	1589.7	0.02382	0.23374	0.25757	622.9	542.2	1165.1	0.8187	0.5097	1.3284	540.0
542.0	1637.3	0.02402	0.22394	0.24796	628.8	533.6	1162.4	0.8240	0.4997	1.3238	542.0
544.0	1686.1	0.02422	0.21442	0.23865	634.8	524.7	1159.5	0.8294	0.4896	1.3190	544.0
546.0	1735.9	0.02444	0.20516	0.22960	640.8	515.6	1156.4	0.8348	0.4794	1.3141	546.0
548.0	1786.9	0.02466	0.19615	0.22081	646.9	506.3	1153.2	0.8403	0.4689	1.3092	548.0
550.0	1839.0	0.02489	0.18737	0.21226	653.1	496.6	1149.8	0.8458	0.4583	1.3041	550.0
552.0	1892.4	0.02514	0.17880	0.20394	659.5	486.7	1146.1	0.8514	0.4474	1.2988	552.0
554.0	1947.0	0.02539	0.17044	0.19583	665.9	476.4	1142.2	0.8571	0.4364	1.2934	554.0
556.0	2002.8	0.02566	0.16226	0.18792	672.4	465.7	1138.1	0.8628	0.4251	1.2879	556.0
558.0	2059.9	0.02595	0.15427	0.18021	679.1	454.6	1133.7	0.8686	0.4134	1.2821	558.0
560.0	2118.3	0.02625	0.14644	0.17269	685.9	443.1	1129.0	0.8746	0.4015	1.2761	560.0
562.0	2178.1	0.02657	0.13876	0.16534	692.9	431.1	1124.0	0.8806	0.3893	1.2699	562.0
564.0	2239.2	0.02691	0.13124	0.15816	700.0	418.7	1118.7	0.8868	0.3767	1.2634	564.0
566.0	2301.7	0.02728	0.12387	0.15115	707.4	405.7	1113.1	0.8931	0.3637	1.2567	566.0
568.0	2365.7	0.02768	0.11663	0.14431	714.9	392.1	1107.0	0.8995	0.3502	1.2498	568.0
570.0	2431.1	0.02811	0.10947	0.13757	722.9	377.7	1100.6	0.9064	0.3361	1.2425	570.0
572.0	2498.1	0.02858	0.10229	0.13087	731.5	362.1	1093.5	0.9137	0.3210	1.2347	572.0
574.0	2566.6	0.02911	0.09514	0.12424	740.2	345.7	1085.9	0.9212	0.3054	1.2266	574.0
576.0	2636.8	0.02970	0.08799	0.11769	749.2	328.5	1077.6	0.9287	0.2892	1.2179	576.0
578.0	2708.6	0.03037	0.08080	0.11117	758.5	310.1	1068.5	0.9365	0.2720	1.2086	578.0
580.0	2782.1	0.03114	0.07349	0.10463	768.2	290.2	1058.4	0.9447	0.2537	1.1984	580.0
582.0	2857.4	0.03204	0.06595	0.09799	778.8	268.2	1047.0	0.9535	0.2337	1.1872	582.0
584.0	2934.5	0.03313	0.05797	0.09110	790.5	243.1	1033.6	0.9634	0.2110	1.1744	584.0
586.0	3013.4	0.03455	0.04916	0.08371	804.4	212.8	1017.2	0.9749	0.1841	1.1591	586.0
588.0	3094.3	0.03662	0.03857	0.07519	822.4	172.7	995.2	0.9901	0.1490	1.1390	588.0
590.0	3135.5	0.03824	0.03173	0.06997	835.0	144.7	979.7	1.0006	0.1246	1.1252	590.0
592.0	3177.2	0.04108	0.02192	0.06300	854.2	107.0	956.2	1.0169	0.0876	1.1046	592.0
593.0	3198.3	0.04427	0.01306	0.05730	873.0	61.4	934.4	1.0329	0.0527	1.0856	593.0
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 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	Abs Press Lb/Sq In p
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	1.2187	1.6440	60.0
70.0	302.93	0.017482	6.1875	6.2050	272.7	907.8	1180.6	0.4411	1.1935	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	2.06775	2.08625	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	1.89905	1.91765	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	407.82	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	409.6	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	0.8149	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	0.68611	0.70643	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	1.3526	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	2800.0
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
3206.2*	705.47	0.05078	0.00000	0.05078	906.0	0.0	906.0	1.0612	0.0000	1.0612	3206.2*

*Critical pressure



Mollier diagram (*h*-*s*) for steam.

Master

ANSWERS -- ZION 1&2 -85/09/30-HEMMING, W.

ANSWER 1.01 (1.00)

a

REFERENCE
HBR, Reactor Theory, Sessions 41 and 42
Cook, WNTC Theory text, pp. I-4.26 -27.
Zion, NUS book 3, sections 12.1, 12.4.

ANSWER 1.02 (1.00)

a. False

b. False [0.5 ea.]

REFERENCE
Cook, Westinghouse Thermal Science, Chapter 13, Pp. 17-23. KA002/000,K5.01
Zion, Same as Cook.

ANSWER 1.03 (1.50)

a. True

b. False

c. False [0.5 each]

REFERENCE
Cook, Westinghouse Thermal Science, Chapter 10, Pp. 41-49
Zion, Same as Cook.

ANSWER 1.04 (2.00)

a. 36 seconds. (+/- 2)

b. No.[.25] Power escallation is a log function and therefore increases at an increaseing rate. [.75] (2.0)

REFERENCE
Cook Theory, Pp. I3.15-16. KA001/010,K5.37,3.2.
Zion, NUS book 3, section 6.4

THERMODYNAMICS, HEAT TRANSFER AND FLUID FLOW

ANSWERS -- ZION 1&2 -85/09/30-HEMMING, W.

ANSWER 1.05 (1.00)

b.

REFERENCE
SQNP, 6 Factor Formula lesson, pp. 3 - 5 KA001/000,K5.26,3.3.
Cook Theory, Pp I-5.2-15.
Zion, NUS book 3, section 8.3

ANSWER 1.06 (4.00)

a. 90% (full credit - increase power between 85 and 100%)

b. ~~9 hours.~~ (full credit - 6-10 hours) (no power level -.8)

c. reactor power was reduced to 10%. (full credit - 10-25%) (½ credit - reactor tripped)

d. 4 [1.0 ea] (4.0)

REFERENCE
SQNP, Review of core poisons lesson, p. 6 KA004/000,K5.20,3.6.
Cook Theory, Pp. I-5.57-77.
Zion, NUS book 3, sections 10.2,10.3,10.4.

ANSWER 1.07 (1.00)

c.

REFERENCE
SQNP, Review of Neutron Kinetics, p. 5 KA001/000,K5.49,2.9.
Cook Theory, Pp. I-3.3-10.
Zion, NUS book 3, section 5.5.

ANSWER 1.08 (2.00)

a. 100 cps. (+/- 10)

b. 5850 pcm. (+/- 15) [1.0 ea] (2.0)

(585 pcm - ½ credit)

(5000 pcm - ~~0~~ ½ credit)

ANSWERS -- ZION 1&2 -85/09/30-HEMMING, W.

REFERENCE
SQNP, Subcritical Multiplication lesson, p. 5; Review of Kinetics, p. 3
Cook Theory, Pp. I-4.13-15. KA001/000,K5.49,2.9.
Zion, NUS book 3, section 12.1.

ANSWER 1.09 (1.50)

1. c (same)

2. a (ACP higher)

3. b (ACP lower) [0.5 ea.]

REFERENCE
SQNP, Review of Core Poisons, pp. 4 - 7 KA001/000,K5.18,4.2.
Cook Theory, Pp. I-36-45.
Zion, NUS book 3, section 12.5.

ANSWER 1.10 (1.00)

a. FALSE

b. TRUE [0.5 ea.]

REFERENCE
SQNP,General Physics, HT&FF, pp. 155 and 320 and KA056/000,K5.02,1.5
Subcooled Liquid Density Tables K5.05,1.7
Cook,Westinghouse Thermal Science,Chapter 10, Pp 9-24 KA004/020,K5.06,2.4
Chapter 09, Pp 21-23.
Zion, Same as Cook.

ANSWER 1.11 (1.00)

156 BTU/LBM ~~(+/- 5)~~ (+/- 10)

REFERENCE
SQNP, HTFF text, pp. 23 - 24
Cook, Westinghouse Thermal Science, Chsapter 7, Pp 32-46.
Zion, Same as Cook.

ANSWERS -- ZION 1&2 -85/09/30-HEMMING, W.

ANSWER 1.12 (1.00)

245 psig. (not converting from psig to psia - .8 credit)

REFERENCE
Shearon Harris-Thermo-LP-1.1 and steam tables KA002/000,K5.01,3.1
Cook-Westinghouse Thermal Science,Chapter 2,Pp 63-70,79. /020,K5.06,3.4
Zion, Same as Cook.

ANSWER 1.13 (1.00)

b

REFERENCE
NUS, Nuclear Energy Training, Module 3, Unit 6
Westinghouse Reactor Physics, Sect. 3, Neutron Kinetics and Sect. 5, Core Physics
HBR, Reactor Theory, Sessions 20 and 24 - 31
Zion, NUS book 3, sections 6.5, 6.6, 6.7, 12.4, 12.5.

ANSWER 1.14 (2.00)

a. REMAIN THE SAME
b. DECREASE
c. INCREASE
d. DECREASE [.5 each] (2.0)

REFERENCE
Steam Tables

ANSWER 1.15 (2.00)

a. Decrease

b. Decrease

c. Increase

d. Decrease [0.5 ea.]

THERMODYNAMICS, HEAT TRANSFER AND FLUID FLOW

ANSWERS -- ZION 1&2 -85/09/30-HEMMING, W.

REFERENCE
SQNP; HTFF, page 15
Cook, Westinghouse Therm. and Hyd. Prin., Chap. 7 pp. 64 - 67
Zion, Same as Cook.

ANSWER 1.16 (2.00)

a. 2

b. TRUE [1.0 each]

REFERENCE
IP-3, ECI Rx Theory; Chapter 7, Pages 21, 22, and 27
DCC, Rx Theory Review Text, pp. I-5.42 - .50
Zion, NUS book 3, sections 7.3, 7.4, 7.5, 13.2, 13.7.

ANSWERS -- ZION 1&2 -85/09/30-HEMMING, W.

ANSWER 2.01 (2.50)

a. Suction from risers 50 feet above operating floor, into the RCFC's fan and cooling coils.[.5] Discharges to the inside periphery of the secondary shield to the RCP's, S/G's and then up to the operating floor.[.5] (1.0)

b. Normal ops- four RCFC's.
Accident ops- three RCFC's. (0.5)

c. Each unit is shifted to slow speed (and dampers removed shift directing air flow into a moisture separator removed and HEPA filter.) (1.0)

REFERENCE
Zion SD; 11-4

ANSWER 2.02 (2.50)

a. Low pump discharge pressure (80 psig)
Blackout Sequence
SI Sequence (.75)

b. Phase "B" isolation. (0.5)

c. Phase "A" isolation. (SI) (0.5)

d. 2484 psig. [.25]
The piping it protects may be subjected to full RCS pressure if a thermal barrier HX leak developes. [.5] (.75)

REFERENCE
Zion SD 15, Pp 10-11,12,30-31.

ANSWERS -- ZION 1&2 -85/09/30-HEMMING, W.

ANSWER 2.03 (2.00)

a. The D/G breaker to bus 147 will open automatically from the SI.[.5] Once the breaker interlocks are satisfied the D/G breaker for Bus 247 will close and reload the diesel via the SI sequencer.[.5](1.0)

b. LBB trips all sources of fault current adjacent to the affected breaker should it fail to open after 8 cycles. [.5] Local Breaker Backup relays trip the generator if OCB's 1718 and 1819 fail to open on fault. [.5] (1.0)

REFERENCE
Zion SD 1, Pp 47,58,61 and 70.

ANSWER 2.04 (2.75)

a. - FWP flowrate (separate for each pump).
- Feed suction header temperature.
- Feed suction header pressure. [0.25 each] (.75)

b. - Gland seal condenser bypass valves trip open
- Standby Cond./Cond. Booster Pump starts
- Cond. Booster Pump recirc valves trip shut
- Heater Drain Level Control overrides (to allow full HDTP flow to go to the FWP). [0.5 each] (2.0)

REFERENCE
Zion SD; 25a-44

ANSWER 2.05 (2.50)

a. Motor Driven- 495 GPM (at 3099 ft of head). 445 -.8 credit
Turbine Driven- 990 GPM (at 3099 ft of head). 890 -.8 credit (1.0)

b. 2/3 low-low levels in 2/4 S/G's.
2/4 reactor coolant pump bus voltages low.
Any safty injection signal.
Any blackout signal. (1.0)

c. A and D. (0.5)

ANSWERS -- ZION 1&2 -85/09/30-HEMMING, W.

REFERENCE
Zion S.D.12c, Pp 2,6,and 9.

ANSWER 2.06 (2.50)

a. As the plant pressure changes so will the delta-P across the #1 seal thus changing the seal flowrate. [.5] Flow is high at high pressures and low at low pressures. [.5] (1.0)

b. (Through #2 seal to the RCDT) and the #1 seal return line relief valve to the PRT. (1.0)

c. RCS pressure compared to the backpressure created by the VCT. (0.5)
seal injection press - partial credit

REFERENCE
Millstone System Descriptions, topic 1, lesson 2, Pp 15 and figure RP 14
Zion S.D. 3b, Pp 9-11 and drawing M-54.

ANSWER 2.07 (2.25)

Lube oil system;	prewarming and prelubing ensures the engine will run and assume load immediately.
Air start system;	precharged reservoir insures starting air is available immediately.
Fuel system;	auxilary air driven pump to insure immediate priming to the engine during starting and Day tank insures immediate reservoir of fuel.

jacket water system [.25 ea system, .5 ea reason] (2.25)
jacket water heater to avoid thermal shock when diesel starts

REFERENCE
Millstone System Descriptions, diesel generator and support systems, Pp 5-7, 25-26, 32-33.
Zion S.D. 31, Pp. 3-6.

ANSWERS -- ZION 1&2 -85/09/30-HEMMING, W.

ANSWER 2.08 (2.50)

a. 1) SI or phase A isolation
2) Pzr. level = 17% or less. (Low Pzr. level.)
3) Loss of all charging pumps. (1.0)
(Loss of air is a faiure, not an automatic feature.)

b. 1. Controls pressure downstream of the letdown orifices to eliminate flashing and two phase flow.

2. Controls flowrate out of the RCS via RHR to control system pressure. (1.5)

REFERENCE
Millstone System Descriptions, topic 2, lesson 1, Pp 9, 11-12
Zion S.D.5a, Pp.39,60, and 72.

ANSWER 2.09 (2.50)

a. (1) Reduces thermal stress to the spray line and spray nozzle.
(2) Maintains pressurizer chemistry uniform with RCS (1.0)

b. Spray line low temp alarms (0.5)

c. Differential pressure across the reactor vessel (and is aided by the use of scoops in the RCS.) (1.0)

REFERENCE
Millstone System Descriptions, topic 1, lesson 4, Pp 6-8 and figure PR-2
Zion S.D.3c, p.5.

ANSWERS -- ZION 1&2 -85/09/30-HEMMING, W.

ANSWER 2.10 (3.00)

a. Dilute mode travels only to the top of the VCT (spray nozzle). Alternate Dilute travels to the top of the VCT and also to the suction of the charging pumps. [.75]
A routine path using the spray nozzle of the VCT dilutes without affecting the chemistry of the RCS.(Dilute mode). An alternate path offers a faster method when needed but partially bypasses the chemistry control of the VCT (Alternate Dilute). [.75] (1.5)

b. Boric acid leaving solution (precipitation). [.25]
The temperature of any system containing boric acid is kept elevated to a temperature which keeps the acid in solution.[.5]
This is accomplished by heat tracing or in-tank heaters.
Systems which are not heat traced, but pass borated water, are flushed after use. [.75] (1.5)

REFERENCE
Millstone System Descriptions, topic 2, lesson 2, Pp 14, 19, 29-31.
Zion S.D. 5a, p.12, and 5b, p.13.

ANSWERS -- ZION 1&2 -85/09/30-HEMMING, W.

ANSWER 3.01 (2.50)

a. INTERMEDIATE and POWER
b. SOURCE, INTERMEDIATE and POWER
c. NONE
d. INTERMEDIATE and POWER
e. INTERMEDIATE and POWER [0.5 each] (2.5)

REFERENCE
Zion SD, 6a,6b,and 6c.

ANSWER 3.02 (2.00)

a. -one channel input for the high pressure reactor trip will be active.
-the high pressure annunciator will activate. (1.0)

b. No.[.25] Even though one PORV receives an input from the PID controller, the valve logic requires two inputs at 2335 to activate. The second input is not rate sensitive for either valve.[.75] (1.0)

REFERENCE
Zion SD; 3c-22 and 24

ANSWER 3.03 (2.00)

a. NO MOTION; Failure results in loop B Tavg decreasing. Rod Control [.25] uses Auctioneered High Tavg. [.25] (0.5)

b. RODS IN; Failed Pimp will generate a maximum rate change due to an [.5] instantaneous power mismatch [.5]. C-5 will activate which will prevent any outward auto rod motion [.25]. (1.25)

c. RODS IN; Failed NI channel will generate a maximum rate change due [.5] to an instaneous power mismatch [.5]. C-2 rod stop will activate preventing any auto or manual outward rod motion [.25] (1.25)

REFERENCE
Zion SD; 8a-11 through 13

ANSWERS -- ZION 1&2 -85/09/30-HEMMING, W.

ANSWER 3.04 (3.00)

- Low Pressurizer Pressure [.25], P-11 [.25].
- High Steam Flow with Low Steam Pressure or Lo-Lo Tavg [.25], P-12 [.25].
- High Steamline Differential Pressure [.25], R.C. Loop Isolation Valve Permissive [.25].
- High Containment Pressure [.25], No Permissive [.25]. (2.0)

manual reperm issive

REFERENCE
Zion SD: 12b-31 and 32

ANSWER 3.05 (3.00)

a. HIGH PZR LEVEL: [.5] Failure causes charging flow to go to minimum which allows pzr. level to decrease. Low pzr. level will isolate letdown causing pzr. level to rise until a high level trip occurs [1.0]. (1.5)

b. LOW PZR PRESSURE: [.5] High Loop/Auctioneered Tavg causes rods to insert. Decreasing Tave will cause pzr pressure and level to decrease and trip the reactor on low pressure. [1.0] (1.5)

REFERENCE
Zion SD: Chapter 9

ANSWER 3.06 (2.50)

a. Steam pressure is used to compensate the steam flow signal for density variations in the steam caused by pressure changes as power is altered. (1.0)

b. Indicated steam flow will be higher than actual steam flow [.5] due to the over-compensating signal from the steam pressure channel. 50% steam pressure is higher than 100% steam pressure and will create a compensating signal that is greater than needed [1.0]. (1.5)

REFERENCE
Millstone System Descriptions, topic 6, lesson 9, p 18.
Zinn S.D. 25b, p.14.

ANSWERS -- ZION 1&2 -85/09/30-HEMMING, W.

ANSWER 3.07 (3.00)

a. Coincidence is the number of input channels required to initiate a protective action as compared to the total number of input channels. (1.0)

b. Minimum is one more channel than is required to initiate the protective action. (1.0)

c. High-high containment pressure,[.5] to prevent inadvertant initiation of containment spray if power is lost. [.5] (1.0)

REFERENCE
Millstone Systems Descriptions, topic 7, lesson 1,2, and 3, Pp 8-11, 73 and topic 8, lesson 4, p 6.
Zion S.D. 9, p.13, S.D. 12b, p.3.

ANSWER 3.08 (3.00)

a. 1,3
b. 4
c. 2
d. 1,3
e. 1,2
f. 5
g. 5
h. 1,3 [.25 each response] (3.0)

REFERENCE
VCS Plant System Descriptions, IC-1, pp 19-23
Zion S.D. 21c.

ANSWER 3.09 (1.00)

b.

REFERENCE
VCS Plant System Descriptions, IC-2, p. 10
Zion S.D.25b, Pp. 2-3.

ANSWERS -- ZION 1&2 -85/09/30-HEMMING, W.

ANSWER 3.10 (1.00)

X. d

REFERENCE
VCS Plant System Descriptions, IC-3, p. 9
Zion S.D.3c, p.23.

ANSWER 3.11 (1.00)

b.

REFERENCE
VCS Plant System Descriptions, IC-9, p. 47
Zion S.D.9, P.22.

ANSWER 3.12 (1.00)

c.

REFERENCE
VCS Plant System Descriptions, IC-6, p. 25
Zion S.D.9, p.23 and T.S. Section 1.1, p.9-10.

ANSWERS -- ZION 1&2 -85/09/30-HEMMING, W.

ANSWER 4.01 (2.50)

a. - Common blowdown valve shuts.
   - Individual sample valves shut. (1.0)

b. Surge tank vent valve shuts. ('No action' is acceptable if it is assumed that the valve is blocked open.) (0.5)

c. Fire sump pumps discharge shuts. (0.5)

d. No action. (0.5)

REFERENCE
Zion SD; 13a-7, 13a-37 and 38

ANSWER 4.02 (2.50)

a. 100 (0.5)
b. 320 (0.5)
c. 200 (185 accepted for partial credit) (0.5)
d.1) 50 [0.5]
  2) 200 [0.5] (1.0)

REFERENCE
Zion GOP-1; pp 7 through 10

ANSWER 4.03 (2.50)

a. - Emergency borate (100 ppm)
   - Reinsert all control banks
   - Recalculate ECC (and adjust boron if necessary) [0.33 each] (1.0)

b. - Insure adequate SDM
   - Insure ejected rod reactivity limits maintained
   - Insure acceptable core power distribution limits [0.5 each] (1.5)

REFERENCE
Zion GOP-2; pp 7 and 13

ANSWERS -- ZION 1&2 -85/09/30-HEMMING, W.

ANSWER 4.04 (1.50)

a. INADVERTENT TRIP: A reactor trip that results from personnel error or from minor equipment malfunction and that can be demonstrated to be unrelated with a reactor plant transient or any valid protective system actuation. (.75)

b. DEGREE OF REDUNDANCY: The degree of redundancy is the difference between the number of operable channels and the minimum number of these channels which, when tripped, will cause an automatic trip. (.75)

REFERENCE
Zion T.S.; p 2 and 5

ANSWER 4.05 (1.00)

c.

REFERENCE
10 CFR 20.3

ANSWER 4.06 (1.00)

b.

REFERENCE
10 CFR 20.101.

ANSWER 4.07 (2.50)

a. -Pzr. pressure drops below 1815 psig.
-Pzr. level drops below 10%.
-RCS subcooling drops below 35 F. [.5 ea.] (1.5)

b. The P-4 (reactor tripped) input into the SI reset logic blocks the automatic initiation signals from activating the SI logic until the P-4 signal is removed if even momentarily. (1.0)

ANSWERS -- ZION 1&2 -85/09/30-HEMMING, W.

REFERENCE
Zion EOP-0, Pp. 10-11 and figure 12b-II-C5.

ANSWER 4.08 (1.50)

Hot leg RTD's pegged high, or 5 or more core exit thermocouples above 1200 F. AND

No ECCS flow is being delivered to the RCS. AND

No auxiliary feedwater being delivered to the intact S/G's. [.5 ea] (1.5)

REFERENCE
Zion EOP-11, p.2.

ANSWER 4.09 (2.00)

1. Through MOV-VC 8104.
2. Through FCV-VC 110A and 110B.
3. Through VC 8439.
4. Through the BIT. NOT PREFERRED. [.5 ea] (2.0)

REFERENCE
Zion EOP-5, p.4.

ANSWER 4.10 (2.50)

a. If pressurizer level cannot be maintained.[.5] You are directed to proceed according to EOP-0. [.5] (1.0)

b. May be closed when RCS pressure is BELOW 2000 psig. [.5] Must be reopened when RCS pressure increases to 2000 psig. [.5] Reopened to insure adequate flow through the CCP's. The higher the RCS pressure the lower the flow through the pumps into the system. [.5] (1.5)

ANSWERS -- ZION 1&2 -85/09/30-HEMMING, W.

REFERENCE
Zion AOP-19, p.3 and S.D. 5a, p.6.

ANSWER 4.11 (3.00)

a. One hour. [.5]
No operationsare allowed that would cause dilution and core outlet temperature must be maintained at least 10 F below saturation temperature. [.75] (1.25)

b. 1. Trip running RHR pump(s).
Determine reason for closure.
Reopen valve.
Start a RHR pump.

2. Verify adequate RHR flow.
Throttle HCV which is still operable as required to maintain RHR cooling.
[.25 ea.] (1.75)

REFERENCE
Zion T.S. 3.3.1.A.3, p.73a and AOP-20, p.2.

ANSWER 4.12 (2.50)

5 minute delay. (0.5)

The affected: 1) D/G starts.
4) D/G output breaker closes.
2) main feed breaker to 4 KV ESF bus opens.
3) reserve feed breaker to 4 KV ESF bus opens. [.25 ea] (1.0)

~~Within 30~~ seconds: 1) CCW auto-starts.
2) Service Water auto-starts.
4) RCFC's auto-start.
3) Auxiliary Feedwater auto-starts. (148/149 only)
[.25 ea] (1.0)

REFERENCE
Zion AOP-21, p.3.

Master

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

FACILITY: ZION 1&2

REACTOR TYPE: PWR-WEC4

DATE ADMINISTERED: 85/09/30

EXAMINER: HIGGINS, R.

APPLICANT: _____

INSTRUCTIONS TO APPLICANT:

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

CATEGORY VALUE	% OF TOTAL	APPLICANT'S SCORE	% OF CATEGORY VALUE	CATEGORY
25.00	25.00			5. THEORY OF NUCLEAR POWER PLANT OPERATION, FLUIDS, AND THERMODYNAMICS
25.00	25.00			6. PLANT SYSTEMS DESIGN, CONTROL, AND INSTRUMENTATION
25.00	25.00			7. PROCEDURES - NORMAL, ABNORMAL, EMERGENCY AND RADIOLOGICAL CONTROL
25.00	25.00			8. ADMINISTRATIVE PROCEDURES, CONDITIONS, AND LIMITATIONS
100.00	100.00			TOTALS

FINAL GRADE _____%

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

_____
APPLICANT'S SIGNATURE

QUESTION 5.01 (2.50)

Compare the CALCULATED Estimated Critical Position (ECP) for a startup to be performed 4 hours after a trip from 100% power, to the ACTUAL control rod position if the following events/conditions occurred. Consider each indeperdently. Limit your answer to HIGHER than, LOWER than, or SAME as the ECP.

a. One reactor coolant pump is stopped two minutes prior to criticality. (0.5)

b. The startup is delayed until 8 hours after the trip. (0.5)

c. The steam dump pressure setpoint is increased to a value just below the Steam Generator PORV setpoint. (0.5)

d. Condenser vacuum is reduced by 4 inches of Mercury. (0.5)

e. All Steam Generator levels are being raised by 5% as the ECP is reached. (0.5)

QUESTION 5.02 (2.00)

A. Does Beta bar effective Increase, Decrease, or Remain the Same, from BOL to EOL? (Briefly explain your choice.) (1.0)

B. For equivalent positive reactivity additions to a critical reactor, will the SUR be the Same, Larger, or Smaller at EOL compared to BOL? (no explanation necessary) (1.0)

QUESTION 5.03 (1.50)

Two identical reactors are taken critical using continous rod withdrawal. Reactor A has a rod speed of 48 steps per minute and reactor B has a rod speed of 24 steps per minute.

a. Which reactor will obtain criticality first? (0.5)

b. Which reactor will have the highert source range counts at criticality? (0.5)

c. How will 10-8 critical rod heights compare in the two reactors? (0.5)

(***** CATEGORY 05 CONTINUED ON NEXT PAGE *****)

QUESTION 5.04 (.50)

TRUE or FALSE?

At EOL, the Doppler Temperature Coefficient is more negative due to an increase in the quantity of Pu-240 in the fuel.

QUESTION 5.05 (.50)

TRUE or FALSE?

With all rods out, and a constant boron concentration (ppm), the MTC becomes more negative as RCS temperature (Tavg) increases.

QUESTION 5.06 (2.00)

a. Provide TWO reasons for Xenon contributing more negative reactivity at full power than Samarium. (1.0)

b. Explain why you agree or disagree with the following statement: 'Equilibrium Samarium concentration at 50% power is approximately half its concentration at 100% power.' (1.0)

QUESTION 5.07 (1.00)

At BOL, the components of the power defect in an INCREASING order of significance (reactivity value) are:

a. Void, Doppler, MTC

b. Void, MTC, Doppler

c. MTC, Void, Doppler

d. MTC, Doppler, Void

(***** CATEGORY 05 CONTINUED ON NEXT PAGE *****)

QUESTION 5.08 (1.00)

Which of the following statements concerning the power defect is correct?

a. The power defect is the difference between the measured power coefficient and the predicted power coefficient.

b. The power defect increases the rod worth requirements necessary to maintain the desired shutdown margin following a reactor trip.

c. Because of the higher boron concentration, the power defect is more negative at beginning of core life.

d. The power defect necessitates the use of a ramped Tavg program to maintain an adequate Reactor Coolant System subcooling margin.

QUESTION 5.09 (1.00)

During fuel loading, which of the following will have NO effect on the shape of a 1/M plot?

a. Location of the neutron source in the core.

b. Strength of the neutron source in the core.

c. Location of the neutron detectors around the core.

d. Order of placement of fuel assemblies in the core.

QUESTION 5.10 (1.00)

The reactor is critical at 10,000 cps when a S/G PORV fails open. Assuming BOL conditions, no rod motion, and no reactor trip, choose the answer below that best describes the values of Tavg and nuclear power for the resulting new steady state. (POAH = point of adding heat)

a. Final Tavg greater than initial Tavg, Final power above POAH.

b. Final Tavg greater than initial Tavg, Final power at POAH.

c. Final Tavg less than initial Tavg, Final power at POAH.

d. Final Tavg less than initial Tavg, Final power above POAH.

(***** CATEGORY 05 CONTINUED ON NEXT PAGE *****)

QUESTION 5.11 (1.00)

The Moderator Temperature Coefficient (MTC) varies with certain plant conditions. Concerning these variations, which of the following is correct?

a. The MTC becomes more negative as boron concentration is increased.

b. The MTC causes axial flux distribution to be tilted towards the top of the core at BOL.

c. The MTC varies as temperature changes because of the non-linear density changes of water as temperature changes.

d. The MTC is not permitted by Technical Specifications to be positive in any plant operating modes.

QUESTION 5.12 (1.50)

a. At what axial location in a PWR core is the critical heat flux at the MAXIMUM? (Limit your answer to top, middle, or bottom.) (0.5)

b. How does the MINIMUM critical heat flux change (increase, decrease not change) as the following parameters are INCREASED? Consider each separately. (1.0)

1. Tave
2. RCS pressure
3. RCS flow

QUESTION 5.13 (2.50)

a. If steam goes through a throttling process, specifically as in a leak from the high pressure main steam header, indicate whether the following parameters will INCREASE, DECREASE, or REMAIN THE SAME. (2.0)

1. Enthalpy
2. Pressure
3. Entropy
4. Temperature

b. Will the steam become subcooled, saturated or superheated as it leaks out? (0.5)

(***** CATEGORY 05 CONTINUED ON NEXT PAGE *****)

QUESTION 5.14 (1.00)

When the flow rate through a centrifugal pump is increased by opening the discharge valve, the required NPSH _____, and the available NPSH _____.

(a) increases; increases

(b) increases; decreases

(c) decreases; increases

(d) decreases; decreases

QUESTION 5.15 (1.50)

TRUE or FALSE?

a. The faster a centrifugal pump rotates, the greater the NPSH required to prevent cavitation. (0.5)

b. One of the pump laws for centrifugal pumps states that the volumetric flow rate is inversely proportional to the speed of the pump. (0.5)

c. Pump runout is the term used to describe the condition of a centrifugal pump running with no volumetric flow rate. (0.5)

QUESTION 5.16 (1.00)

In order to maintain a 200 F subcooling margin in the RCS when reducing RCS pressure to 1600 psig, steam generator pressure must be reduced to approximately:

a. 245 psig

b. 445 psig

c. 645 psig

d. 845 psig

(***** CATEGORY 05 CONTINUED ON NEXT PAGE *****)

QUESTION 5.17 (1.00)

The reactor is operating at 30% power when one RCP trips. Assuming NO reactor trip or turbine load change occur, which of the following parameters will DECREASE?

a. Flow in operating reactor coolant loops

b. Core delta T

c. Reactor vessel delta P

d. Steam generator pressure in affected loop

QUESTION 5.18 (1.00)

The main condenser must remove more heat energy to condense ...

a. One pound of steam at 0 psia.

b. One pound of steam at 300 psia.

c. Two pounds of steam at 600 psia.

d. Two pounds of steam at 1200 psia.

QUESTION 5.19 (1.50)

a. With the plant operating at 85% power and all systems in a normal/automatic configuration, the operator borates 100 PCM. Shutdown Margin will: (1.0)

1. Increase
2. Increases until rods move
3. Decrease
4. Decreases until rods move
5. Remain unchanged, whether or not rods move

b. The Shutdown Margin required by Technical Specifications for Cold Shutdown condition is _____% DeltaK/K. (0.5)

(***** END OF CATEGORY 05 *****)

QUESTION 6.01 (1.50)

Indicate which, OT delta-T, OP delta-T, or BOTH (OT delta-T and OP delta-T) protection instruments, apply to each of the following statements.

a. Backup for the high neutron flux trip. (0.5)

b. Circuitry dynamically compensates for piping delays to the loop temperature detectors. (0.5)

c. Requires RCS pressure within the high and low reactor trip setpoints in order to be valid. (0.5)

QUESTION 6.02 (2.00)

a. Describe the instrument LOGIC and SETPOINTS necessary to ~~activate~~ enable the Reactor Coolant 1 and 2 loop low flow trips in the protection system. (1.5)

b. What core protection is provided by the undervoltage and underfrequency low flow reactor trips. (0.5)

QUESTION 6.03 (3.00)

Answer the following concerning the Spent Fuel Pool (SFP):

a. Why is SFP level maintained between +/- 3° of normal? (1.0)

b. List 4 normal and alternate sources of makeup water for the SFP. (1.0)

c. How is boron concentration normally maintained in the SFP? (1.0)

QUESTION 6.04 (3.00)

The following Questions concern the Component Cooling Water System.

a. Name THREE CCW system alarms that could indicate a RCS to CCW leak. (1.5)

b. Describe, in detail, how the CCW system is protected against an overpressure condition if a RCS to CCW rupture occurred in the RCP Thermal Barrier. (1.5)

(xxxxx CATEGORY 06 CONTINUED ON NEXT PAGE xxxxx)

QUESTION 6.05 (2.50)

The following concern the CVCS at Zion.

a. What are the TWO functions (purposes) of the Letdown Pressure Flow Control Valve (PCV-131)? (1.0)

b. If left in automatic control, what position should PCV-131 be found in two minutes after a safety injection initiation? (0.5)

c. Why is letdown flow limited to 120 gpm? (0.5)

d. With only the PD pump operating at power, which valve(s) is/are utilized to vary RCP seal injection flow? (Either noun name or numbers acceptable.) (0.5)

QUESTION 6.06 (2.00)

a. State the INITIAL direction of rod motion for the following events. Briefly explain.

1. First stage pressure fails high at 50% power.

2. Feed regulating valve fails open at 90% power. (1.0)

b. Briefly explain the reason for including the following inputs into the Rod Control System.

1. Tavg

2. Neutron Flux. (1.0)

(***** CATEGORY 06 CONTINUED ON NEXT PAGE *****)

QUESTION 6.07 (3.00)

a. If while operating at 100% power, the pressure compensation signal to the SGWLC system fails high:

1. Explain the immediate response of feedwater flow. (1.0)

2. What would be the long term effect on steam generator level? Assume no operator action or trip actuation. (0.5)

b. What input signal(s) is/are used as the reference signal for the feedwater pump speed control system programmed Delta P? (0.5)

c. List the FOUR Protective features derived from monitored Steam Generator parameters (Setpoints and coincidence not required). (1.0)

QUESTION 6.08 (4.00)

a. List the automatic start signals for:

1. STEAM DRIVEN auxiliary feed pumps.

2. MOTOR DRIVEN auxiliary feed pumps. (3.5)

b. What valves are automatically shut with any of the auto start signals in 'a' above? (0.5)

QUESTION 6.09 (2.00)

If the available Feedwater Pump NPSH decreases to 275 psig, an alarm sounds. What other FOUR actions automatically occur when a low FWP suction pressure condition exists? (2.0)

(***** CATEGORY 06 CONTINUED ON NEXT PAGE *****)

QUESTION 6.10 (2.00)

Indicate which of the Excore Nuclear Instrumentation Ranges (SOURCE, INTERMEDIATE, or POWER), will correctly match with the following statements. More than one may apply to each.

a. Provides a direct input to the Rod Control System.

b. Has a reactor trip function that is blocked at some time between startup and full power operation.

c. Utilizes a Boron-10 coating in it's detectors.

d. Operates in the 'Ion Chamber' region of the 'Gas Filled Detector Characteristic Curve'. (2.0)

(***** END OF CATEGORY 06 *****)

QUESTION 7.01 (2.50)

Document 10 CFR 20 provides regulations for radiation exposure at the Zion facility. Answer the following questions in accordance with 10 CFR 20.

a. The whole body exposure limit provided is 1.25 Rem/Quarter. Under what THREE non-emergency conditions/criteria may this limit be exceeded? (1.5)

b. Personnel monitoring (film badge, dosimeter, etc.) is required in three situations. Provide TWO of these situations. (1.0)

QUESTION 7.02 (4.00)

a. What THREE indications 'identify' a specific ruptured steam generator (S/G) according to EOP-10, 'Steam Generator Tube Rupture'(SGTR) procedure? (1.5)

b. After the ruptured S/G has been identified, the MSIV is required to be shut. What THREE other actions/verifications are required by EOP-10 to isolate the ruptured S/G? (1.5)

c. What specific actions are required to initiate RCS cooldown if the ruptured S/G MSIV will not shut? (1.0)

QUESTION 7.03 (3.00)

During refueling operations, RT-AR03 alarms indicating high radiation in the Fuel Building Pool Area.

a. What automatic actions take place? (1.0)

b. What are the Fuel Handling Supervisors immediate responsibilities as stated in FOP-6 (Fuel Handling Emergency)? (1.0)

c. If Health Physics reports there is a high level of tritium in the area, what protective measures must be taken prior to entry into this area? (1.0)

(***** CATEGORY 07 CONTINUED ON NEXT PAGE *****)

QUESTION 7.04 (2.00)

a. List FOUR parameters used to verify adequate ~~subcooling during~~ natural circulation~~, conditions~~. (1.0)

b. During natural circulation cooldown, a steam bubble may form in the reactor vessel head area.

1. What is the primary indication of this bubble formation? (0.5)

2. Why is the bubble expected to occur in this area first? (0.5)

QUESTION 7.05 (3.50)

FILL IN THE BLANKS for GOP-1 precautions.

a. The RCS oxygen concentration must be less than _____ ppm prior to raising RCS temperature above _____ degrees F.

b. All three pressurizer safety valves must be operable any time RCS temperature exceeds _____ degrees F.

c. A minimum of one Source Range channel shall be in operation with _____ and _____ indication anytime the reactor is shutdown.

d. If any RCP's seal leakoff flow does not increase by at least ____ gpm after ther RCS is pressurized to approximately _____ psig and the seal leakoff valve is open, do not start the RCP. (3.5)

(***** CATEGORY 07 CONTINUED ON NEXT PAGE *****)

QUESTION 7.06 (2.00)

Answer the following according to GOP-2.

a. The shutdown banks do not need to be withdrawn prior to dilution if what condition is met? (0.5)

b. Which SI must be unblocked prior to diluting below the required cold shutdown boron concentration? (0.5)

c. Why must the startup of Main Feedwater Pump B or C be done only when ready to go off Auxiliary Feedwater? (0.5)

d. Why is it required that the Main Turbine bearing lift pump control switch be placed in the AUTO (after-start) position at the end of the turbine oil pump interlock checks? (0.5)

(xxxxx CATEGORY 07 CONTINUED ON NEXT PAGE xxxxx)

QUESTION 7.07 (3.00)

POWER HISTORY

8/1 -- 0800 hrs. the reactor is at 1% power after a refueling shut-down with all physics testing complete. Power was raised to 22% max. at 1800 hrs on 8/1.

8/7 -- 1300 hrs. power ramp commenced to 50% when at 1430 hrs a trip occured at 32% power from a feed pump failure.

8/11 -- 0030 hrs. the reactor is at POAH. At 0830 50% power is achieved.

8/15 -- 0800 hrs commenced raising power to 90% power, which is obtained at 1200 hrs. on 8/16.

8/16 -- power is held at 90% until 1735 hrs. on 8/18 when the reactor is tripped due to an instrument tech. error.

a. Describe any fuel conditioning limit violations. (2.0)

b. ASSUME: Control rods for bank D were at 220 steps prior to the trip from 90% power.
The NORMAL power rate of change is 20% per hour unless special limits apply.
ALL POWER CHANGE IS TO BE CONSIDERED WITH RODS ONLY, NEGLECT BORON CHANGE REQUIREMENTS.

What would be the minimum time required to achieve 100% power with rods at 220 steps, from the time of reaching 1% power on the recovery from 90%?

QUESTION 7.08 (2.50)

a. According to EOP-0 what are the RCP termination criteria. (1.5)

b. What additional action must be done as a result of the RCP termination and WHY? (1.0)

(***** CATEGORY 07 CONTINUED ON NEXT PAGE *****)

QUESTION 7.09 (2.50)

a. Describe the immediate action steps to determine which instrument bus is lost according to AOP-15, 'Loss of Instrument Bus'. (1.5)

b. How is power restored to the bus? (1.0)

(***** END OF CATEGORY 07 *****)

QUESTION 8.01 (1.50)

List THREE reasons/bases why control rods must be maintained above the Tech. Spec. minimum insertion limit during power operation.

QUESTION 8.02 (3.00)

The concentration of the boric acid solution in the Boron Injection Tank (BIT) shall be verified once a week in accordance with Technical Specification 4.1.8 E. The chemist sampled the BIT on the following schedule. (All samples taken at 1200 hours).

Aug 1 --- Aug 8 ---Aug 16 --- Aug 24 --- AUG 31

a. EXPLAIN why surveillance time interval requirements were or were not exceeded on AUG 16. (1.5)

b. EXPLAIN why surveillance time interval requirements were or were not exceeded on Aug 24. (1.5)

QUESTION 8.03 (2.00)

What are the THREE provisions that must be met before a temporary change can be made to an approved operating procedure, according to Technical Specifications?

QUESTION 8.04 (1.00)

According to Technical Specifications, if a safety limit is exceeded the NRC Operations Center shall be notified within _____.

a. 15 minutes

b. 1 hour

c. 4 hours

d. 24 hours

(***** CATEGORY 08 CONTINUED ON NEXT PAGE *****)

QUESTION 8.05 (1.00)

Which of the following statements concerning the AFD requirements is correct?

a. Above 90%, within 30 minutes of going outside the target band, either restore indicated AFD to within the target band or reduce power to less than 90%.

b. If the axial flux difference alarms are out of service, the AFD shall shall be logged every hour for the first 24 hours and half-hourly thereafter until the alarms are returned to operable.

c. Below 50% power, penalty points are accumulated at one point for every minute outside the target band.

d. Power level shall not be increased above 50% unless the AFD is within the target band.

QUESTION 8.06 (1.00)

Which of the following statements concerning Shutdown Margin (SDM) considerations is correct?

a. With Tavg less than 200 degrees, the SDM requirements are increased because of the possibility of a positive MTC.

b. The most restrictive condition for SDM requirements occur at EOL, with Tavg at no load temperature, and is associated with a rod ejection accident.

c. When in Mode 2 with keff less than 1.0, adequate SDM is ensured by verifying the predicted critical rod position is above the rod insertion limits.

d. If one rod is known to be partially inserted and untrippable an increased allowance for the entire rod worth shall be made to the SDM requirements.

(***** CATEGORY 08 CONTINUED ON NEXT PAGE *****)

QUESTION 8.07 (3.00)

The following concern the Plant Emergency Procedures.

a. State the title of the person who is responsible for the initiation of the INITIAL emergency action. Who is responsible if this person is unavailable or incapacitated? (1.0)

b. A Site Evacuation of non-essential personnel has been determined necessary.

1. Where is the main assembly area? (0.5)

2. Provide THREE conditions that would preclude evacuation of personnel, assume personnel accountability complete. (1.5)

QUESTION 8.08 (1.00)

Which of the following is a function/responsibility of the Shift Engineer according to ZAP-0-1, Admitting and Control of Westinghouse Trainees?

a. Authorizing more than five trainees per Westinghouse Instructor.

b. Verify instructors are on the approved list.

c. Advise the instructor as to the status of the plant.

d. Inform Control Room personnel the areas in which observations/training will be performed.

(***** CATEGORY 08 CONTINUED ON NEXT PAGE *****)

QUESTION 8.09 (3.00)

Indicate whether the following is a primary function of the Shift Engineer OR Shift Foreman(licensed), according to ZAP 1-151-1, Station Organization.

a. Authorize Surveillance.

b. Act as Fire Chief.

c. Submit work requests and coordinate operations/maintanence activities.

d. Placing equipment in or out of service.

e. Review Unit logs.

f. Ensure unqualified operating personnel perform evolutions in the presence of qualified personnel.

QUESTION 8.10 (1.50)

What is the bases/reason for the Technical Specification requirement to reduce Tavg to less [illegible]00 degrees when specific activity limits are exceeded?

QUESTION 8.11 (2.00)

Provide TWO of the four Shift Engineer responsibilities concerning "High Radiation Area Access Control", ZAP 5-51-15.

QUESTION 8.12 (2.40)

What are FOUR of the five means of protection taken to prevent a low temperature over pressurization accident when RCS temperature is below 250-F and the vessel head is installed, in accordance with Technical Specifications?

(***** CATEGORY 08 CONTINUED ON NEXT PAGE *****)

QUESTION 8.13 (2.60)

Primary to secondary leakage through the steam generator tubes has two Technical Specification leakage rate criteria.

1. What are the allowable leakage rates? (1.0)
2. What is the bases for each of the leakage rates? (1.6)

(***** END OF CATEGORY 08 *****)
(*************** END OF EXAMINATION ***************)

EQUATIONS

REACTOR THEORY

$$P = P_o e^{t/\tau} = P_o 10^{SUR \cdot t}$$

$$\tau = \frac{\bar{l}_g}{\rho} + \frac{\beta - \rho}{\lambda\rho} \quad \text{or} \quad \tau = \frac{\beta - \rho}{\lambda\rho}$$

$$\rho = \frac{k - 1}{k} \qquad \frac{k_2 - k_1}{k_2 k_1} = \Delta\rho$$

$$\frac{cps_2}{cps_1} = \frac{1 - k_1}{1 - k_2} \qquad k < 1$$

$$\frac{1}{M} = 1 - k$$

$$\frac{1}{M} = \frac{cps_o}{cps_n}$$

$$\rho_{net} = \Delta(\rho_{doppler} + \rho_{mod} + \rho_{void} + \rho_{Xe} + \rho_{Sm} + \rho_{Pu} + \rho_{Boron} + \rho_{rod} + \rho_{fuel} + \rho_{Poisons})$$

$$k_2 = k_1 + \delta k$$

$$\delta k = k - 1$$

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

$$P = \frac{\Sigma\phi V}{3.1 \times 10^{10}}$$

$$\Sigma = N\sigma$$

$$\phi = nv$$

Defect = Coeff x Δ Parameter

RADIATION

$$N = N_o e^{-\lambda t}$$

$$A = \lambda N$$

$$I = I_o e^{-\mu x} = I_o 10^{-x/TVT}$$

$$\lambda T_{\frac{1}{2}} = 0.693$$

$$R/hr \text{ @ } d \text{ feet} = \frac{6CE}{d^2}$$

$$I_1 d_1^2 = I_2 d_2^2 \qquad \text{point source}$$

$$I_1 d_1 = I_2 d_2 \quad \text{- line source}$$

R/hr x time = R

Rad x QF = Rem

$$T_{\frac{1}{2}eff} = \frac{T_{\frac{1}{2}Bio} \times T_{\frac{1}{2}Rad}}{T_{\frac{1}{2}Bio} + T_{\frac{1}{2}Rad}}$$

MATH

$$y^a = b$$

$$\log_{y_c} b = a$$

$$\log x^c = c \log x$$

$$\log \frac{x}{y} = \log x - \log y$$

$$\log xy = \log x + \log y$$

FLUIDS/THERMO/HEAT TRANSFER

$$\dot{m} = A_1\rho_1 V_1 = A_2\rho_2 V_2$$

$$Q = A_1 V_1 = A_2 V_2$$

$$E_{in} = E_{out} + \Delta E_{stored}$$

$$E = KE + PE + U + pV + Q + W$$

$$PE = \frac{mg}{g_c} Z$$

$$KE = \tfrac{1}{2} m \frac{V^2}{g_c}$$

reduced for - turbine, SG pump, nozzle, orifice, condenser, pipe, Rx

flow $\alpha \sqrt{dp}$

$$\text{head loss} = f\frac{L}{D}\frac{V^2}{2g_c} \quad \text{or head loss } \alpha\ V^2 \text{ head loss } \alpha\ \Delta p$$

$$p = h + p_{ambient} \qquad = k\frac{V^2}{2g_c}$$

$$F = pA$$

$$\Delta P_{2\,phase} = \Delta P_{1\,phase} \times K$$

k = f(quality & Pressure)

Pump laws speed α flow

(speed)$^2\alpha$ pressure

(speed)$^3\alpha$ power

$$Q = kA\Delta T = hA\Delta T = UA\Delta T$$

$$Q = mc_p\Delta T$$

$$Q = m\Delta h$$

$$Q = \varepsilon\sigma T$$

$$\Delta H = mc_p\Delta T$$

$$\Delta U = mc_v\Delta T$$

$$H = U + pV$$

$$\Delta S = \frac{\Delta Q}{T}$$

$$pV = nRT$$

$$\frac{p_1V_1}{T_1} = \frac{p_2V_2}{T_2}$$

$$C_1V_1 + C_2V_2 = C_3(V_1 + V_2)$$

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	0.31626	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	2.0359	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	527.5	527.5	54.026	1045.0	1099.0	0.1043	1.9151	2.0193	86.0
88.0	0.65553	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	296.18	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	1.3509	0.016173	251.37	251.38	79.98	1030.2	1110.2	0.1507	1.8021	1.9528	112.0
114.0	1.4309	0.016180	238.21	238.22	81.97	1029.1	1111.0	0.1542	1.7938	1.9480	114.0
116.0	1.5151	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	1.6834	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 metastable

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

Temp Fahr t	Abs Press Lb per Sq in p	Specific Volume Sat Liquid v_f	Evap v_{fg}	Sat Vapor v_g	Enthalpy Sat Liquid h_f	Evap h_{fg}	Sat Vapor h_g	Entropy Sat Liquid s_f	Evap s_{fg}	Sat Vapor s_g	Temp Fahr t
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	48.189	150.01	989.0	1139.0	0.2662	1.5413	1.8075	182.0
184.0	8.203	0.016534	46.237	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	24.876	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	15.243	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	1.6157	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	1.30766	1.32679	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	1.19763	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*

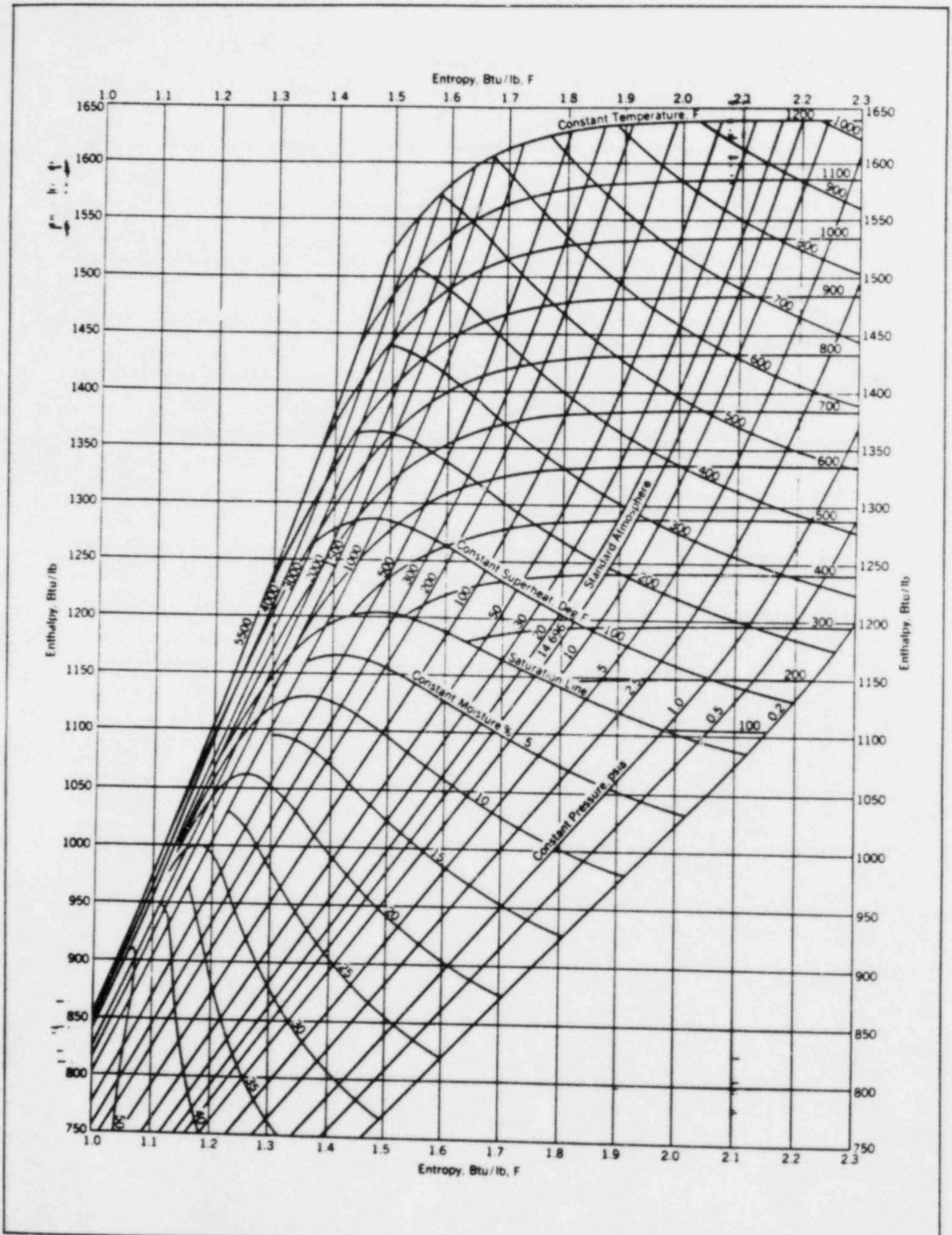
Temp Fahr t	Abs Press Lb per Sq in p	Specific Volume Sat Liquid v_f	Evap v_{fg}	Sat Vapor v_g	Enthalpy Sat Liquid h_f	Evap h_{fg}	Sat Vapor h_g	Entropy Sat Liquid s_f	Evap s_{fg}	Sat Vapor s_g	Temp Fahr t
460.0	466.87	0.01961	0.97463	0.99424	441.5	763.2	1204.8	0.6405	0.8299	1.4704	460.0
464.0	485.56	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	0.6507	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	1176.5	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	0.13878	0.16534	692.9	431.1	1124.0	0.8806	0.3893	1.2699	648.0
652.0	2239.2	0.02691	0.13174	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	0.03874	0.03173	0.06957	835.0	144.7	979.7	1.0006	0.1246	1.1257	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 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	Abs Press Lb/Sq in p
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	1.2187	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	1.91765	372.3	828.4	1200.6	0.5634	0.9665	1.5299	240.0
250.0	400.97	0.01865	1.82457	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	821.8	1201.5	0.5722	0.9508	1.5230	260.0
270.0	407.80	0.01875	1.69137	1.71013	383.6	818.5	1201.9	0.5764	0.9433	1.5197	270.0
280.0	411.07	0.01880	1.63169	1.65049	387.1	815.3	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	0.6056	0.8909	1.4965	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	494.85	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	538.35	0.0214	0.45064	0.47205	534.7	660.0	1194.7	0.7358	0.6612	1.3970	950.0
1000.0	544.58	0.02159	0.47436	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	0.6218	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	0.10239	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	2800.0
2900.0	690.22	0.03262	0.06158	0.09470	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	1.0612	3208.2*

*Critical pressure



Mollier diagram (*h-s*) for steam.

Master

5. THEORY OF NUCLEAR POWER PLANT OPERATION, FLUIDS, AND THERMODYNAMICS

ANSWERS -- ZION 1&2 -85/09/30-HIGGINS, R.

ANSWER 5.01 (2.50)

a. SAME

b. HIGHER

c. HIGHER

d. SAME

e. LOWER [0.5 each] (2.5)

REFERENCE
SHNPP RT-LP-3.13, p 10-15 and RT-TP-262.
NUS Nuclear Energy Training (NET), 12.5-1.

ANSWER 5.02 (2.00)

a. Decreases [0.25] Pu 239 concentration increases (while U 235 concentration decreases) [0.75]. (1.0)

b. Larger SUR. (1.0)

REFERENCE
SHNPP RT-LP-1.6, p 23,24.
NUS-NET, 5.3-1 to-3.

ANSWER 5.03 (1.50)

a. A
b. B
c. Same rod height [0.5 each]

REFERENCE
SHNPP RT-LP-1.6, p39-46.
NUS-NET, 12.4-2.

ANSWERS -- ZION 1&2 -85/09/30-HIGGINS, R.

ANSWER 5.04 (.50)

True.

REFERENCE
SHNPP RT-LP-1.9, p 19.
NUS-NET, 13.4-3 and A.9-1.

ANSWER 5.05 (.50)

True. [1.0]

REFERENCE
SHNPP RT-LP-1.10, p 11-16,20-22.
NUS-NET, 9.2-1 to-4.

ANSWER 5.06 (2.00)

a. 1. Higher fission yield.
2. Larger (thermal) absorbtion cross section (1.0)

b. Disagree [0.4] Equilibrium Sm concentration is not power dependent.[0.6] (1.0)

REFERENCE
SHNPP RT-LP-1.11, p 9-21.
NUS-NET, 10.5-1,-2.

ANSWER 5.07 (1.00)

b

REFERENCE
Westinghouse Reactor Physics, pp. I-5.12, 25, and 27
SHNPP RT-LP-1.10, p 14,15.
NUS-NET, 8.2,4,5,6,-1 and 9.6-1.

ANSWERS -- ZION 1&2 -85/09/30-HIGGINS, R.

ANSWER 5.08 (1.00)

b

REFERENCE
Westinghouse Reactor Physics, pp. I-5.26 & 27
SHNPP RT-LP-1.10, p 13-15.
NUS-NET, 8.6-1.

ANSWER 5.09 (1.00)

b

REFERENCE
Westinghouse Reactor Physics, pp. I-4.19 - 24.
SHNPP RT-LP-1.7.
NUS-NET, 12.3-1 to-5.

ANSWER 5.10 (1.00)

d

REFERENCE
Westinghouse Reactor Physics, Section I-5, MTC and Power Defect
SHNPP RT-LP-1.6, p 36-41.
NUS-NET, 13.5-2.

ANSWER 5.11 (1.00)

c

REFERENCE
Westinghouse Reactor Physics, pp. I-5.2 - 16
SHNPP RT-LP-1.10, p 9-12.
NUS-NET, 8.3-1; 9.2-1 to-4.

ANSWERS -- ZION 1&2 -85/09/30-HIGGINS, R.

ANSWER 5.12 (1.50)

a. Bottom of the core. (0.5)

b. 1. Decrease
2. Increase
3. Increase [0.33 each] (1.0)

REFERENCE
GPNT Vol III, Ch. 2, Sect E, p. 2-164 thru 167.
SHNPP HT-LP-1.2, p 10-14.
Westinghouse Thermal-Hydraulic Principles and Applications to the PWR.(WTH) 13-19,-24,-34.

ANSWER 5.13 (2.50)

a. 1. REMAIN THE SAME
2. DECREASE
3. INCREASE
4. DECREASE

b. Superheated. [0.5 each]

REFERENCE
Steam Tables
SHNPP FF-LP-1.1, p 32-34.
WTH, 10-67 to-73.

ANSWER 5.14 (1.00)

b

REFERENCE
FF-LP-1.1, p 27-30.
WTH, 10-53 to-56.

ANSWERS -- ZION 1&2 -85/09/30-HIGGINS, R.

ANSWER 5.15 (1.50)

a. True

b. False

c. False [0.5 each]

REFERENCE
Westinghouse Thermal Science, Chapter 10, Pp. 41-49
SHNPP FF-LP-1.1, p 21-23, 27-30.
WTH, 10-35 to-49.

ANSWER 5.16 (1.00)

a.

REFERENCE
SHNPP Thermo-LP-1.1 and steam tables KA002/000,K5.01,3.1
Cook-Westinghouse Thermal Science,Chapter 2,Pp 63-70,79. /020,K5.06,3.4
Steam Tables.

ANSWER 5.17 (1.00)

c

REFERENCE
General Physics, HTFF - Fluid Flow Applications for Systems and Components.
SHNPP T&AA-LP-1.19.
WTH, 12-15 to-18.

ANSWER 5.18 (1.00)

c

REFERENCE
Steam Tables

ANSWERS -- ZION 1&2 -85/09/30-HIGGINS, R.

ANSWER 5.19 (1.50)

a. 1 (Increase) [1.0]

b. 1 [0.5]

REFERENCE
SHNPP Technical Specifications 3.1.1.1; RT-LP-3.13, p 7-9.
ZION TS, p 39,65,66.

ANSWERS -- ZION 1&2 -85/09/30-HIGGINS, R.

ANSWER 6.01 (1.50)

1. OP Delta-T
2. ~~BOTH~~ OPΔT
3. OT Delta-T [0.5 each]

REFERENCE
Millstone 3, Vol. 3, Topic 6, Lesson 8, Pages 7-14.
ZION System Descriptions, Chapter 9, pp 22-23 and Functional Dia. 617F767

ANSWER 6.02 (2.00)

a. Single loop loss of flow: when 2/4 power ranges > 60%. (0.5)

Two loop loss of flow: when 2/4 power ranges > 10% OR
1/2 impulse pressures > 10% [0.5 each] (1.0)

b. DNB protection. (0.5)

REFERENCE
ZION System Description Chapter 9, pp 19, 23-24 and Table 9-II-C1

ANSWER 6.03 (3.00)

a. Maintain radiation levels below 2.5 MREM/HR at the Spent Fuel Pool (SFP) surface, during fuel movement. OR (1.0)

b. Refueling Water Storage Tank (RWST) or Boron Recycle System or Demineralized Flushing Water System or Service Water System. [0.25 each] (1.0)

c. Makeup is via the Boric Acid Blender by a temporary line or RWST normal makeup. [0.5 each] (1.0)

REFERENCE
a. HO-SF-24
b. HO-SF-25
c. HO-SF-25
ZION System Descriptions, Chapter 16, p. 2

ANSWERS -- ZION 1&2 -85/09/30-HIGGINS, R.

ANSWER 6.04 (3.00)

a. 1. CCW surge tank high level.

2. CCW RMS alarm.

3. RCP Thermal Barrier outlet low flow alarm

4. RCP Thermal Barrier Return ~~High Differential~~ Cooling Water High Flow ~~alarm~~

[0.5 each, 3 required] (1.5)

b. 1. ~~Inlet/outlet flow mismatch closes return isolation valve.~~ high flow of 190 gpm closes return isolation valve FCV-685

2. Check valve isolates on reverse flow.

3. Relief valve (~2500 psig) protects from overpressure. (1.5)

REFERENCE
WB FSAR; 9.2.2-11
WB PID; 47W611-70-3
WB Instrument Tabulation, XA-55-27B & XA-55-27B-A.
ZION System Descriptions Chapter 15, pp 8-9, P&ID M-66 and M-67

ANSWER 6.05 (2.50)

a. - Maintain backpressure on orifices to prevent flashing.
- Maintain RCS pressure when solid. [0.5 each] (1.0)

b. SHUT (0.5)

c. Prevent (resin channeling due to) excess flow through demin resin. (0.5)

d. HCV-312 (Charging flow control valve). (0.5)

REFERENCE
WBLP; CVCS, pages 11 and 16
ZION System Descriptions Chapter 5, pp 5-6, 39 and Fig. 5a-I-C1

ANSWERS -- ZION 1&2 -85/09/30-HIGGINS, R.

ANSWER 6.06 (2.00)

a. 1. Rods drive out-- because of the sudden reactor/turbine mismatch.

2. Out--Tavg decreases. (1.0)

b. 1. Provides 1/2 of the temperature error signial required for the Tavg-Tref siganl.

2. Acts as an anticipatory signal and modifies rod speed accordingly. (1.0)

REFERENCE
Connecticut Yankee Plant Information Book (PIB)--Rod Control pp. 13,22
ZION System Descriptions, Chapter 8, pp 1-30

ANSWER 6.07 (3.00)

a. 1. Increase [0.5] steam flow signal would increase [0.25] causing an immediate SF-FF mismatch [0.25]. (1.0)

2. The steam generator level would level out at a higher than normal level. (0.5)

b. Total steam flow. (0.5)

c. 1. Low steam line pressure (SI) or Lo Tave w. High Stm flow
2. ~~Negative steam pressure rate (steamline isolation).~~ stm line ΔP SI
3. Low-Low S/G level (Reactor trip and AFW actuation).
4. Hi-Hi S/G level (P-14) (turbine trip and feedwater isolation).
5. S/G Low level with SF/FF mismatch Reactor trip [0.25 each] (1.0)

REFERENCE
Plant System Book 3, SNPT-223, Chapter 6, pp 6-7 to 6-21 GLJ 19
ZION System Descriptions, Chapter 21a, pp 30-35
ZION Logic Diagrams, 5653D30, 617F767

ANSWERS -- ZION 1&2 -85/09/30-HIGGINS, R.

ANSWER 6.08 (4.00)

a.1. Low-low level in TWO S/G
2/4 reactor coolant pump bus voltage low
SI signal
Blackout signal [0.5 each] (2.0)

2. Low-low level in ~~TWO~~ One S/G
Blackout signal
SI signal [0.5 each] (1.5)

b. ~~S/G blowdown valves~~
S/G sampling valves [0~~.25~~ .5 ~~each~~] (0.5)

REFERENCE
CPSES System Information Manual; VIII-8.7 and 8.8
ZION System Descriptions, Chapter 12c, pp 1-2 and 19

ANSWER 6.09 (2.00)

- Gland seal condenser bypass valves trip open
- Standby Cond./Cond. Booster Pump starts
- Cond. Booster Pump recirc valves trip shut
- Heater Drain Level Control overrides (to allow full HDTP flow to go to the FWP). [0.5 each] (2.0)

REFERENCE
Zion System Descriptions, Chapter 25a, p. 44

ANSWER 6.10 (2.00)

a. INTERMEDIATE and POWER
b. SOURCE, INTERMEDIATE and POWER
c. INTERMEDIATE and POWER
d. INTERMEDIATE and POWER [0.5 each] (2.0)

REFERENCE
Zion SD, 6a,6b,and 6c.
SHNP NIS-LP-1.0, pp 8-19

ANSWERS -- ZION 1&2 -85/09/30-HIGGINS, R.

ANSWER 7.01 (2.50)

a. -3 Rem/Quarter is NOT exceeded. [0.5]
-Total accumulated dose does not exceed 5(N-18). [0.5]
-Accumulated exposure on record (NRC-4). [0.5] (1.5)

b. -When the individual entering a resticted area receives or is likely to receive 25% of his quarterly exposure limit.
-When an individual 18 years or younger receives or is likely to receive 5% of the adult quarterly exposure limit.
-Anyone entering a high radiation area. [0.5 each, two required] (1.0)

REFERENCE
ZNPT-211, Radiation Protection and Safety, A-13, pp 8,11,12 of 33 BLS 42

ANSWER 7.02 (4.00)

a. 1. Unexpected rise in S/G level.
2. High radiation from S/G blowdown sample.
3. High radiation from S/G steamline. [0.5 each] (1.5)

b. 1. Secure all feedwater flow to the faulted S/G (F-S/G).
2. Verify F-S/G Blowdown valves closed.
3. Close steam supply to TDAFW pump (if A or D S/G). [0.5 each] (1.5)

c. 1. Close non-ruptured (N/R) S/G MSIV's and bypass valves.
2. Use N/R S/G PORV's for steam dumps.
3. Terminate steam dump to the condenser. [0.33 each] (1.0)

REFERENCE
ZION EOP-10, pp 3-6.

ANSWERS -- ZION 1&2 -85/09/30-HIGGINS, R.

ANSWER 7.03 (3.00)

a. 1. Fuel building ventilation diverts through the charcoal filters.
2. Charcoal booster fans auto start. (1.0)

b. 1. All personnel accesses to the affected area are closed.
2. All personnel have evacuated the affected area (1.0)

c. 1. Shield against injestion.
2. Air feed respirators.
3. Use of a plastic or rubber suit. [0.33 each] (1.0)

REFERENCE
EOP-8 p.4,5 & Rad Con Considerations

ANSWER 7.04 (2.00)

a. Tc from S/G pressure.
Th from average Incore T/Cs
Core delta T < 60 F
S/G pressure following RCS Hot Leg temperature. [0.25 each] (1.0)

b. 1) Erratic pressurizer level indication. (0.5)
2) Low RCS flow results in significant cooling reduction in the head area. (0.5)

REFERENCE
ZION EOP-7, Appendix A, p. 31

ANSWER 7.05 (3.50)

a. 0.1, 250
b. 200
c. visual, audible
d. 0.2, 400 [0.5 each] (3.5)

REFERENCE
ZION GOP-1, precautions, pp 7-9

ANSWERS -- ZION 1&2 -85/09/30-HIGGINS, R.

ANSWER 7.06 (2.00)

a. Minimum S/D margin is not violated.

b. HI STEAM FLOW.

c. Prolonged idling may damage the turbine due to high moisture content in the steam at low powers.

d. Auto stop of the pump at ~ 600 RPM.

[0.5 each] (2.0)

REFERENCE
ZION GOP-2, pp 9, 10, 22, 26

ANSWER 7.07 (3.00)

a. YES [0.5], power increase to 32% power exceeded the 3%/hr rate on 8/7 [0.75]. And on 8/11 the rate to 50% exceeded 3%/hr and the one hour soak at 25% power [0.75]. (2.0)

b. 27.25 hrs +/- 0.5 hrs. if not already preconditioned to 50% (1.0)
19.1 hrs if already preconditioned to 50%

REFERENCE
ZION GOP-3, p. 6

ANSWER 7.08 (2.50)

a. One CCP or SI pump running AND
Wide Range RCS pressure drops below 1200 psig. [0.75 each] (1.5)

b. Transfer Steam dumps to steam pressure mode. (0.5)
REASON: When pumps are secured the dump looses a valid Tavg input from the bypass instrument loop. (0.5)

REFERENCE
ZION EOP-0, p. 7

one CCP or SI pump running and RCS press < 1200 psig (1520 psig for diverse containment) OR
5 min after loosing CCW to the RCP's

ANSWERS -- ZION 1&2 -85/09/30-HIGGINS, R.

ANSWER 7.09 (2.50)

a. 1. Check AC amps and/or output voltage on inverter.
2. Check 'power supply' lights on the RPS or Safeguards status lights.
3. Check any common 4 channel indication. [0.5 each] (1.5)

b. 1. Open the inverter feed breaker.
2. Close dirty power feed breaker. [0.5 each] (1.0)

REFERENCE
ZION AOP-15

ANSWERS -- ZION 1&2 -85/09/30-HIGGINS, R.

ANSWER 8.01 (1.50)

1. Maintain acceptable power distribution limits.(nuclear peaking factors)
2. Maintain adequate SDM.
3. Limit affects of rod ejection accident. [0.5 each]

REFERENCE
SHNPP TS, B 3/4 1-3.
ZION TS, p 65.

ANSWER 8.02 (3.00)

a. Interval requirement not exceeded [0.5]. Eight days does not exceed 1.25 times the specified interval [1.0]. (1.5)

b. Interval requirement exceeded [0.5]. The last 3 consecutive intervals exceed 3.25 times the specified interval [1.0]. (1.5)

REFERENCE
SHNPP TS, p. 3/4 0-2, 5-10.
ZION TS, p 27a.

ANSWER 8.03 (2.00)

1. The intent of the procedure is not altered [0.5].
2. The change is approved by two members of the plant management staff, at least one holds a SRO license [1.0].
3. The change is documented, reviewed, and approved within 14 days of implementation by the Station Superintendent [0.5]. (2.0)

REFERENCE
SHNPP TS, p 6-17.
ZION TS, p308.

ANSWER 8.04 (1.00)

x b

REFERENCE
SHNPP TS p 6-16.
ZION TS, p320.

ANSWERS -- ZION 1&2 -85/09/30-HIGGINS, R.

ANSWER 8.05 (1.00)

b

REFERENCE
SHNPP, TS 3/4 2.1
ZION TS, p 46a-47.

ANSWER 8.06 (1.00)

c

REFERENCE
SHNPP, TS, pp. 3/4 1-1 and B 3/4 1-1.
ZION TS, pp. 39-42 and 64,65.

ANSWER 8.07 (3.00)

a. Shift Engineer [0.5]
Shift Foreman [0.5] (1.0)

b. 1. Service building machine shop area. (0.5)

2. -Severe weather
-Radiological hazard
-Security threat
-Similiar condition that would adversly affect personnel in the Station Director's opinion. [3 required, 0.5 each] (1.5)

REFERENCE
SHNPP PEP 101 p 4-6; 103 p 6; 2.3-2.5 p 1.
ZION EPIP 110-1, p 2; 360-1, p 2.

ANSWER 8.08 (1.00)

c

REFERENCE
ZION ZAP-0-1, p 2,3.

ANSWERS -- ZION 1&2 -85/09/30-HIGGINS, R.

ANSWER 8.09 (3.00)

a. Shift Engineer
b. Shift Foreman
c. Shift Foreman
d. Shift Engineer
e. Shift Foreman
f. Shift Engineer [0.5 each] (3.0)

REFERENCE
ZION ZAP 1-151-1, p 4-6.

ANSWER 8.10 (1.50)

Prevents a release of activity in event of a SGTR (saturation pressure less than atmospheric steam relief valve setpoint).

REFERENCE
ZION TS, p 125.

ANSWER 8.11 (2.00)

1. Controls "R" keys (issued thru his office)
2. Maintain logbook/clipboard for each "R" key issued (and non issued keys)
3. Accounts for each "R" key at the end of shift.
4. Forward filled out log sheets to the office supervisor.

Ensure high rad areas are locked or guarded [Two required, 1.0 each] (2.0)

REFERENCE
ZION ZAP 5-51-15, p 3.

ANSWER 8.12 (2.40)

1. Two PORV's operable (or one PORV shall be open, or PZR level <25% and pressure <100 psig)
2. Only ONE charging pump operable.
3. No SI pumps.
4. No accumulators operable.
5. The first RCP not started with associated S/G temp >50-F above RCS temp. [Four required, 0.6 each] (2.4)

ANSWERS -- ZION 1&2 -85/09/30-HIGGINS, R.

REFERENCE
ZION TS, p 82,83.

ANSWER 8.13 (2.60)

1. 1 gpm total leakage for all S/G's.
   500 gpd per S/G. [0.5 each] (1.0)

2. 1 gpm--ensures the dosage contribution from the tube leakage will be limited to a small fraction of the Part 100 limits in event of a SGTR or SLB. (0.8)

   500 gpd--ensures that S/G tube integrity is maintained in the event of a steam line rupture as under LOCA conditions. (0.8)

REFERENCE
ZION TS, p 98a.