U.S. NUCLEAR REGULATORY COMMISSION

REGION III

Report No. 50-282/306-OL/8601

Docket(s) No. 50-282; 50-306 License No(s). DPR 42; DPR 60

Licensee: Norhtern States Power Company
414 Nicollet Mall
Minneapolis, MN 55401

Facility Name: Prairie Island

Examination Administered At: Prairie Island

Examination Conducted: Senior Reactor Operator and Reactor Operator

Examiner(s): for T. M. Burdick 6/23/86
T. D. Reidinger Date

for T. M. Burdick 6/23/86
R. E. Schreiber Date

Approved By: T. M. Burdick 6/23/86
T. M. Burdick, Chief Date
Operator Licensing Section

Examination Summary

Examination administered on March 19-23, 1986 (Report No(s).50-282/306-OL/86001
Written and operating exams were administered to one reactor operator and five senior reactor operators.
Results: One reactor operator and four senior reactor operator candidates passed the examinations.

REPORTS DETAILS

1. Examiners

   T. D. Reidinger - NRC
   R. E. Schreiber - PNL

2. Examination Review Meeting

   N/A

3. Exit Meeting

   An exit meeting was held following the examinations with the examiners and facility representatives. The examiners expressed concerns in the areas of simulator initialization conditions, weakness in the candidates knowledge of electricity and electrical systems, certification of control switch alignment and surveillance documentation.

PRAIRIE ISLAND

Operator and Senior Operator Examination
Comments and Resolutions

Question 5.02

Part C - Revision 77 to Technical Specifications (attached) has revised limits for DNBR; 1.30 for Exxon fuel and 1.17 for Westinghouse fuel. Either answer should be acceptable.

Examiners Comment

The answer is acceptable. The examiner, however, notes that the Technical Specifications received with the examination reference material did not reflect this revision.

Question 5.06

Answer (C) should also be included as a correct response since above the point of adding heat, any change in moderator temperature also causes a change in fuel temperature which is part of the isothermal temperature coefficient. (This answer was included as a correct response on the March 26, 1985 Prairie Island exam.)

Examiners Comment

The answer is acceptable. The facility has since presented additional data after the examination to support their answer.

Question 5.10

A discussion that includes a reactor trip at 10% power due to power overshoot should also be an acceptable answer.

Examiners Comment

Answer is acceptable although no reference material or data was presented for the position.

Question 5.11

By the exam, the question is worth one point, yet the key states each of the four answers is worth .4 each. Each answer should be worth .25.

Examiners Comment

Notes concern and revised answer key points.

Question 5.15

Part a. of the question is worth .5 points on the key. Part b. is worth 1.0 point on the exam and 0.5 on the key.

Examiners Comment

Notes concern and revised answer key points.

Question 7.02

In addition to the two answers in the key, the Background Information for Status Trees (attached) provides additional cases for monitoring the status trees.

- Provide direct operator guidance in those rare events that go beyond the design basis of the Engineered Safeguards Systems and the E, ES and ECA series procedures.
- Periodic monitoring of the trees to evaluate Critical Safety Function Status during normal operation.

Examiners Comment

Will accept the answer presented in paragraph 1, but will not accept paragraph 2 answer. The data presented by the utility, however, for the second paragraph will be accepted.

- General surveillance under all sets of unusual or abnormal conditions that can lead to or result from initiation of reactor trip or safety injection.

The examiner notes the interpretative difference between the stated position of the utility and the data presented to support the answer.

Question 7.08

Part b - Since no reference was provided on this question, several other shutdown margins are also correct in references other that that listed in the key. Be Technical Specifications, in cold shutdown - 1%. By Technical Specification Figure 3-10 - 1% to 2%. Any of these responses should receive full credit.

Examiners Comment

The reference was stated in the question (Startup Procedure C1.2), which specifies 3% shutdown margin.

However, the examiner will accept the answer provided by the utility.

Question 7.10

Key defines adverse containment as 10E04 R/hr. Per the reference, this should be 1E04 R/hr.

Examiner Comment

The typographical error was corrected as it should have read 10*4 R/hr.

Question 7.16

Question asks for three actions required if criticality not achieved within ±750 μcm of the predicted rod position. Per the reference, rods should be inserted to bring the reactor subcritical, recompute the ECC, determine and correct the discrepancy, if discrepancy cannot be determined, insert control rods to the bottom of the core, borabe to the Xenon-free, hot shutdown boron concentration and contact Nuclear Engineer. Responses which include these steps should be given full credit.

Examiner Comment

Will accept the first half of answer. The second half of the answer is the key presented in the examination. The examiner notes that the utility was advised of the additional data that was inadvertently omitted from the examination key prior to the receipt of the utility comments.

Question 8.06

In addition to not being able to delegate recommendation of offsite protective actions, per F3-12 (attached), the Emergency Director cannot delegate authorizing excess radiation exposures. This response should be given full credit.

Examiner Comment

Accepted.

Question 6.04

Due to a recent design change, the "L" signed for 21 BAST has been changed from 10% to 4%. (Setpoint change request attached.) This response should also be acceptable.

Examiners Comment

Accepted.

Question 6.13

Per the reference, steam line isolation on an affected steam line will also occur due to high-high steam flow plus safety injection. This response should also be accepted.

Examiners Comment

Accepted.

Question 6.15

Part c. of the question asks for six conditions which will actuate the 20/ET backup solenoid. Per pages 9 and 10 of B23, in addition to the six conditions in the key, the 20/ET backup solenoid will actuate due to:

- Main transformer lockout relays tripped
- Auxiliary transformer lockout relays tripped
- Either main steam isolation valve closed
- Safety injection

These should be included as correct answers.

Examiners Comment

Accepted.

Question 6.05

Part b. of the question asks for two reasons for the valves being closed during cold shutdown. Per the key and the reference, there is only one reason, over-pressurization of the RCS. The additional two answers are methods of over-pressurization. Full credit should be given for over-pressurization.

Examiner Comment

The question asked for two reasons for the valves being closed during cold shutdown. The two reasons being over-pressurization of the RCS by valve leakage and over-pressurization of the RCS by the high discharge pressure of the SI pump. There are two possible sources of over-pressurization of the RCS, through the loop isolation valves and reactor vessel injection isolation valves.

However the examiner will accept the generic version of the answer key of "over-pressurization of the RCS."

Question 1.01

The reference quoted does not support this question. Several other factors not listed can also affect core reactivity, e.g., fuel enrichment, core loading pattern. If these are adequately explained credit should be given. The explanation for soluble boron control "prevents excessively negative MTC at BOL" is not a reason for why boron is used, it is an undesirable side effect. The explanation of gadolinium states it acts like a burnable poison which is said to flatten flux distribution and reduce boron needed. These are both true. However, question 1.07 states reason for mixing gadolinium in the fuel is to hold down excess reactivity. Any of these explanations should be valid for both questions.

Examiner Comment

The examiner notes the facility's concern.

Question 1.03

Key requires answer to be within ±5 steps. Smallest scale division for rod height is 40 steps, accuracy required should be ±20 steps (one-half scale division).

Examiner Comment

Not accepted.

Question 1.11

Key states one of reasons for rod insertion limits is to provide suitable axial flux distribution. Per the reference, the reason is to assure meeting power distribution limits (i.e., hot channel factors).

Examiner Comment

Accepted

Question 1.14

Key specifies an answer range that is less than one-half a scale division. Should accept a larger range of answer (e.g. 285-305°F).

Examiner Comment

Not accepted.

Question 2.02

Question specified listing of components. During exam, the proctor authorized circling items on drawing which should be acceptable.

Examiner Comment

Notes comment

Question 2.04

Question does not specify how many responses are required. Credit should be given for tracing back to an initiating signal, even though 10 inputs may not be indicated.

Examiner Comment

Not accepted.

Question 2.05

Part of a question asks for four sources of power to the Rod Control power cabinets. Per the reference, the answers provided are "control" power supplies. Acceptable answers should also include the 70 VDC and 120 VDC power supplies.

Examiner Comment

Disagree, no reference, answer will not be revised.

Question 2.11

Answer is correct in general terms. However, there are two cross-connect flowpaths upstream of the air dryers through MV-32318 and CP-40-7 (reference drawing B34-2) in addition to the downstream flow path through SA-12-18 and SA-12-19. These should be acceptable answers.

Examiners Comment

Accepted.

Question 2.13

Reducing general corrosion by reducing free oxygen is the function of hydrogen gas addition to VCT. Suppressing the formation of nitric acid is a by-product of this reaction. Maintaining 15 psig in VCT should not be required for either hydrogen or nitrogen since any gas could also serve this purpose.

Examiners Comment

Examiner notes concern.

Question 3.02

Answer key should also accept the "load rejection" signal which is necessary to arm steam dump, reference drawing B7-8.

Examiner Comment

Accepted.

Question 3.09

Question says to "identify" potential sources of inadvertent dilution. Listing of sources should be acceptable in addition to marking drawing. In addition, there are two separate paths for Reactor Makeup, through blender and through chem mix tank. Both paths should be acceptable. Also, a likely source of an inadvertent dilution is placing a new mixed bed demin in service that is not saturated.

Examiner Comment

Accepted.

Question 3.16a

Key should also accept control room hydrogen concentration indicator decreasing as a readout available to determine if recombiner is working.

Examiner Comment

Accepted.

Question 4.06

In addition to the answers in the key, the response of Tavg to an attempt to move the rod would distinguish RPI failure and stuck RCCA (reference C-6, p.8). From the key it appears the candidate must supply one response for a failed RPI and one response for stuck rod. Any two answers should be correct.

Examiner Comment

Accepted.

Master

U.S. NUCLEAR REGULATORY COMMISSION

REACTOR OPERATOR LICENSE EXAMINATION

Adjusted for facility comments.

Facility: Prairie Island 1,2

Reactor Type: Westinghouse-PWR

Date Administered: May 20, 1986

Examiner: R. E. Schreiber

Candidate: Answer Key

INSTRUCTIONS TO CANDIDATE:

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	Candidate's Score	% of Cat. Value	Category
25	25			1. Principles of Nuclear Power Plant Operation, Thermodynamics, Heat Transfer and Fluid Flow
25	25			2. Plant Design Including Safety and Emergency Systems
25	25			3. Instruments and Controls
25	25			4. Procedures - Normal, Abnormal, Emergency and Radiological Control
100				TOTALS

Final Grade _____ %

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

_____
Candidate's Signature

5:20 start

Points
Available

1.0 Principles of Nuclear Power Plant Operation, Thermodynamics, Heat Transfer and Fluid Flow (25.0)

QUESTION 1.01

List four (4) major means by which reactivity is controlled or altered in the core. Explain why each method is used or how it functions if not under direct operator control. (4.0)

ANSWER 1.01

1. Control rods. Allows large reactivity changes in short time periods. They are used to ensure enough negative reactivity can be inserted into the core to maintain minimum shutdown margin.

2. Soluble boron. Allows operation with minimum rod insertion to perturb axial flux distribution. Prevents excessively negative moderator temperature coefficient at the beginning of core life.

3. Coolant temperature. The negative Moderator Temperature Coefficient provides an inherent reactivity control.

4. Fuel temperature coefficient. Most effective at BOL and as protection against rapid reactivity insertion transients.

5. Burnable Poison rods. If in use, they not only aid in flattening radial flux distribution, they reduce the amount of soluble boron needed, thus keeping MTC sufficiently negative, especially at BOL.

6. Poisons. Xe and Sm buildup have strong negative effect on reactivity.

7. Gadolinium. Dispersed in fuel, it acts like BPs.

Any four (4) [+0.5] for each item and [+0.5] for each explanation, +4.0 maximum

Reference(s) 1.01

1. Prairie Island: Lesson Plan 8188L-001, Reactor Theory Review, pp. 36-39.

-Section 1.0 Continued on Next Page-

Points
Available

QUESTION 1.02

Describe how the following will respond to a gradual loss of Natural Circulation.

a. RCS Wide Range T-hot and T-cold (1.0)

b. Variation of T-cold and P-steam, or T_{sat}, with time (1.0)

ANSWER 1.02

a. T-hot increases [+0.5] (as boiling in the core refluxes into the hot leg) and T-cold remains fairly constant [+0.5] (gradual cooling to ambient, does not see core behavior because of downcomer).

b. T-cold does not follow P-steam (T_{sat}) [+0.5] (because the thermocouple is down stream of the RCP and its loop seal). P-steam will decrease [+0.5] (as boiloff occurs in S/Gs).

Reference(s) 1.02

1. Prairie Island: ES0.3, Background information for natural circulation cooldown.

2. Prairie Island: SGTR, Attachment A, Natural Circulation Conditions.

-Section 1.0 Continued on Next Page-

Points
Available

QUESTION 1.03

The reactor is subcritical with D-Bank at 72 steps. An ECP has just been run that shows 250 pcm are needed to reach criticality and be on an acceptable ramp toward 10^{-8} amps. Use the attached Rod Worth curve to determine the required bank position. Assume no change in boron concentration or xenon. (1.0)

ANSWER 1.03

At 72 steps the total pcm in the rods is 600 on the Integral curve. **[+0.4]** Subtracting 250 pcm gives 350 pcm **[+0.2]**. At this value, D-bank is at about 115 steps ±5 steps. **[+0.4]**

Reference(s) 1.03

1. Prairie Island: C1-A, Reactivity Calculations, Figure C1-4A, p. 1 of 2.

-Section 1.0 Continued on Next Page-

Points
Available

FIGURE C1-4A PAGE 1 OF 2

PRAIRIE ISLAND UNIT 1 CYCLE 10
DIFFERENTIAL AND INTEGRAL ROD BANK WORTHS
BOC–HOT ZERO POWER

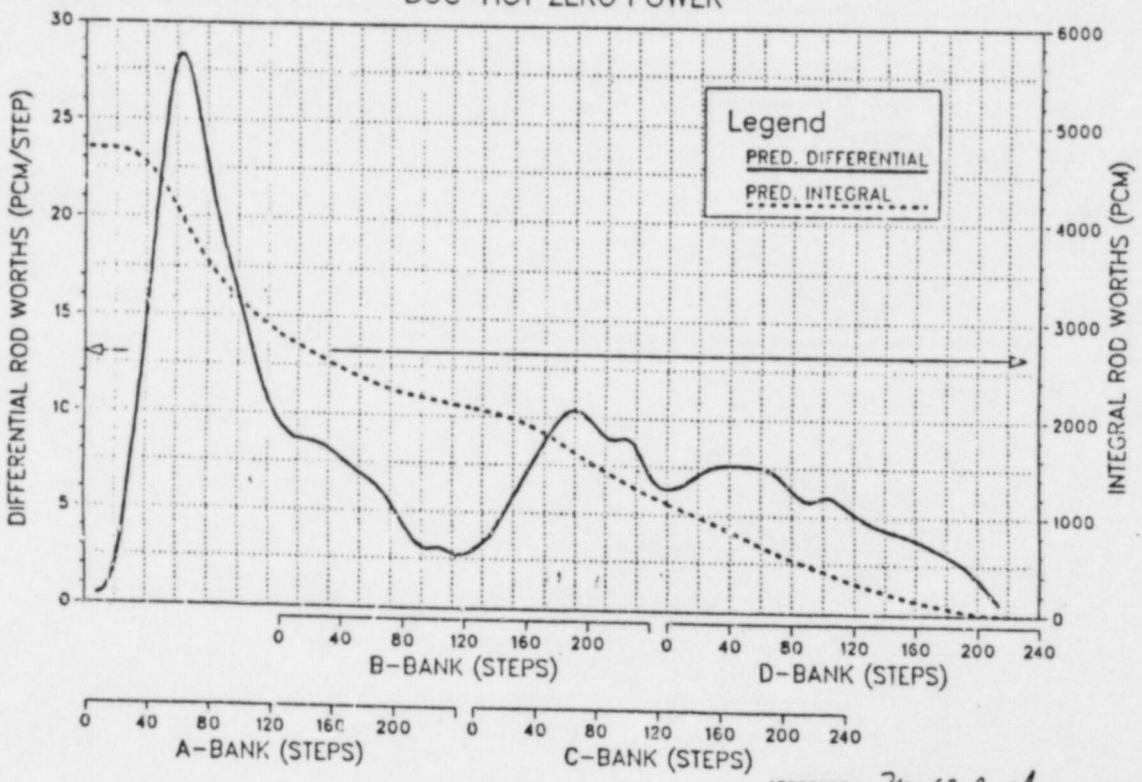

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Figure 1.03 (QUESTION)

-Section 1.0 Continued on Next Page-

Points
Available

QUESTION 1.04

Select the time values from column B that match the xenon concentration behavior given in column A. (2.0)

A	B
a. Time to reach equilibrium after startup.	1. 6 hours
b. Time to reach peak after trip from 100% power.	2. 10 hours
c. Time to reach starting value after trip from 100% power.	3. 17 hours
d. Time to reach essentially xenon free condition after trip from 100% power.	4. 24 hours
	5. 32 hours
	6. 40 hours
	7. 55 hours
	8. 70 hours

ANSWER 1.04

a. 6

b. 2

c. 4

d. 8

[+0.5] each

Reference(s) 1.04

1. Prairie Island: NET Notes, p. 39.

2. Prairie Island: C1A, Reactivity Calculations, Figure C1-6.

-Section 1.0 Continued on Next Page-

Points
Available

QUESTION 1.05

Use the attached figure to show how much Total Power Defect must be overcome in going from 30% power and 400 ppm boron to 95% power and 100 ppm boron. (1.0)

ANSWER 1.05

The transition is from -490 to -1690, the difference is -1200±15 pcm. **[+1.0]**

Reference(s) 1.05

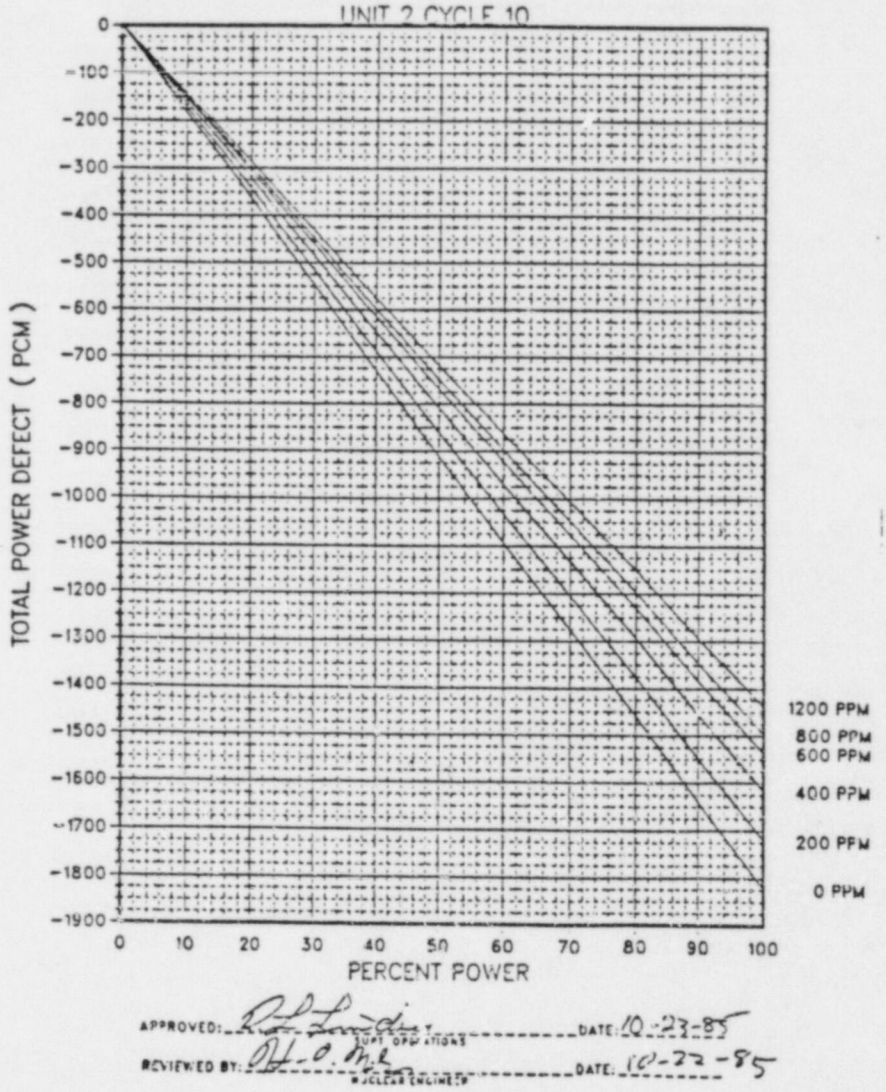
1. Prairie Island: NET Notes, p. 34.

-Section 1.0 Continued on Next Page-

FIGURE C1-7B

TOTAL POWER DEFECT
VS.
PERCENT POWER

UNIT 2 CYCLE 10



APPROVED: _____ DATE: 10-23-85
SUPT. OPERATIONS

REVIEWED BY: _____ DATE: 10-22-85
NUCLEAR ENGINEER

Figure 1.05 (QUESTION)

-Section 1.0 Continued on Next Page-

Points
Available

QUESTION 1.06

Given the reactor at the following conditions:

$k_{eff} = 0.98$

Count rate = 20 cps

Moderator temperature coefficient = -18.5 pcm/^{o}F (assume constant)

What would the expected count rate be after a temperature decrease of 50^{o}F? Show calculations. (2.0)

ANSWER 1.06

Reactivity, $rho_1 = \frac{k1 - 1}{k1} = \frac{-0.02}{0.98} = -0.02041 = -2041$ pcm

Temperature change, delta rho = (-18.5)(-50) = 925 pcm

Final reactivity, $rho_2 = -2041 + 925 = -1116$ pcm

Final k2 = $1/(1-rho_2) = 1/(1+0.01116) = 0.98896$

$CR2 = CR1\frac{(1-k1)}{(1-k2)} = 20\frac{(0.02)}{(0.01104)} = 36.23$ cps (accept range, 36-38)

[+2.0]

Reference(s) 1.06

1. Prairie Island: Lesson Plan 8188L-001, Reactor Theory Review, pp. 172-173.

-Section 1.0 Continued on Next Page-

Points
Available

QUESTION 1.07

What is the purpose of mixing Gadolinium in the fuel? (1.0)

ANSWER 1.07

This is a distributed burnable poison that serves the same purpose as using burnable poison rods to hold down excess reactivity early in core life. **[+1.0]**

Reference(s) 1.07

1. Prairie Island: NET Notes, p. 32.

-Section 1.0 Continued on Next Page-

Points
Available

QUESTION 1.08

The reactor is initially at 4×10^{-9} amps. Positive reactivity is introduced to put the reactor on a constant SUR of 0.25 DPM. The time it takes to reach 1.4×10^{-8} amps falls in the range: (Select one.) (1.0)

(a.) 10 to 25 seconds

(b.) 25 to 50 seconds

(c.) 50 to 100 seconds

(d.) 100 to 150 seconds

ANSWER 1.08

(d.) (about 130 seconds) **[+1.0]**

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

$$\frac{P}{P_o} = \frac{1.4 \times 10^{-8}}{0.4 \times 10^{-8}} = 3.5$$

$$\log_{10} 3.5 = (0.25)t, \; t = 2.18 \text{ min } (\sim 130 \text{ sec})$$

Reference(s) 1.08

1. Prairie Island: NET Notes, p. 28.

-Section 1.0 Continued on Next Page-

Points
Available

QUESTION 1.09

Will the insertion of a given amount of reactivity to a critical reactor at EOL produce a (LARGER, SMALLER, or THE SAME) startup rate than at BOL? Explain. (1.0)

ANSWER 1.09

LARGER. [+0.5] The value of the effective delayed neutron fraction is smaller at EOL. A smaller Beta-bar-effective results in a larger SUR for a given reactivity change. [+0.5]

Reference(s) 1.09

1. Prairie Island: NET Notes, p. 30.

2. Prairie Island: Plant Information Summary, p. 8.

QUESTION 1.10

Answer TRUE or FALSE.

Control rods are more effective neutron absorbers at low moderator temperatures than at high moderator temperatures. (0.5)

ANSWER 1.10

False. [+0.5] (The neutron migration area increases with temperature of the moderator. This means a larger volume of the reactor is affected by the presence of a rod at higher moderator temperatures than at low. "More effective neutron absorbers" means increased rod worth. The effect is about 20%.)

Reference(s) 1.10

1. Prairie Island: NET Notes, p. 33.

-Section 1.0 Continued on Next Page-

Points
Available

QUESTION 1.11

What are three (3) purposes of establishing Control Rod Insertion Limits? (1.5)

ANSWER 1.11

1. To minimize the consequences of a rod ejection accident.
2. To guarantee sufficient shutdown margin.
3. To provide suitable axial flux distribution. (Alt: Hot Channel Factors, or Peaking Factors)

[+0.5] each

Reference(s) 1.11

1. Prairie Island: Technical Specification Bases, 3.10-15.

-Section 1.0 Continued on Next Page-

Points
Available

QUESTION 1.12

Explain each of the following statements in regard to the Available Net Positive Suction Head to a centrifugal pump.

a. Raising the pump elevation to be closer to the surge tank that feeds it will decrease the NPSH available. (1.0)

b. Cooling the fluid upstream of the pump will increase the NPSH available. (1.0)

ANSWER 1.12

a. Available NPSH is the actual head (pressure) minus the vapor pressure of the fluid. Decreasing the distance between the tank and the pump decreases the actual head. [+1.0]

b. Cooling the fluid decreases the vapor pressure of the fluid, thereby increasing the difference between actual head and vapor pressure. [+1.0] A secondary effect is due to increase in density which increases both static head and dynamic head.

Reference(s) 1.12

1. Prairie Island: NET #4, Plant Performance, p. 6.5-1 to 5.

-Section 1.0 Continued on Next Page-

Points
Available

QUESTION 1.13

For the following changes in plant status, indicate whether the DNB Ratio will INCREASE, DECREASE, or REMAIN THE SAME. Consider each change separately and assume all other plant parameters are unchanged.

a. Increased reactor power (0.5)

b. Increased CVCS charging and letdown (0.5)

c. Increased PZR pressure (0.5)

d. Increased core inlet temperature, T_c (0.5)

ANSWER 1.13

a. Decrease

b. Remain the Same

c. Increase

d. Decrease

[+0.5] each

Reference(s) 1.13

1. Prairie Island: NET Notes, pp. 63-66.

-Section 1.0 Continued on Next Page-

Points
Available

QUESTION 1.14

a. Determine the Subcooling Margin, °F, using the following information:

The highest core outlet thermocouple reads 600°F.

The lowest primary system pressure reads 2185 psig.

It is not necessary to show work. (1.0)

b. What is the effect of Steam Generator tube plugging on P-stm at full power (INCREASE, DECREASE, REMAIN THE SAME)? Assume that RCS temperatures are unchanged. (0.5)

c. What is the temperature of the steam down stream of a slightly cracked open valve if the pressure upstream is 500 psia and the pressure downstream is one standard atmosphere. The steam upstream contains 2% moisture. It is not necessary to show work. (1.0)

ANSWER 1.14

a. 2185 psig (2200 psia) corresponds to a saturation temperature of 649.5°F, so the subcooling margin is 649.5 - 600 = 49.5°F. **[+1.0]**

b. Decrease. **[+0.5]** (Heat transfer area is reduced, but nothing else changes, so T_{sat} is reduced, and therefore P-stm is decreased.)

c. Between 290 and 300°F **[+1.0]** (Isenthalpic process. Steam is superheated.)

Reference(s) 1.14

1. Steam Tables for saturated conditions.

2. Prairie Island: NET Notes, p. 69.

3. Mollier Chart and superheated steam tables.

-Section 1.0 Continued on Next Page-

Points
Available

QUESTION 1.15

Explain how some Condensate Depression can be an advantage if the hotwell level is low in the Main Condenser, but that excessive condensate depression can be a hindrance to overall plant operation. (1.0)

ANSWER 1.15

Some CD compensates for the loss of the Available NPSH for the Condensate pump (thereby preventing cavitation), but too much (subcooling below saturation) reduces plant efficiency. [+1.0]

Reference(s) 1.15

1. Prairie Island: NET 4, Plant Performance, p. 5.3-2.

QUESTION 1.16

Does Pressurizer Thermal Shock to the Reactor Vessel become MORE or LESS of a danger as the vessel ages? (0.5)

ANSWER 1.16

More. [+0.5] (As the vessel ages, embrittlement due to fast neutron fluence increases. This raises the NDT temperature. As the NDT temperature increases, the vessel is susceptible to crack propagation at higher and higher temperatures. Because PTS adds stress to a relatively cool vessel, the danger of crack propagation is increased as the vessel ages.)

Reference(s) 1.16

1. Prairie Island: NET 4, Plant Performance, Unit 10.

-End of Section 1.0-

Points
Available

2.0 Plant Design Including Safety and Emergency Systems (25.0)

QUESTION 2.01

Answer the following questions about the Caustic Addition system for the Containment Spray:

a. What are the two (2) important reasons for adding caustic to Containment Spray? (1.0)

b. Describe the provisions for ensuring that the correct proportion of caustic solution from the Standpipe is added to the RWST water flowing through the Containment spray pump. (2.0)

ANSWER 2.01

a. Absorb iodine in the containment atmosphere after a LOCA **[+0.5]**, and make the spray solution basic (~10.5 pH) to reduce the corroding effects of boric acid on stainless steel **[+0.5]**.

b. The level in the standpipe is less than the RWST level to account for the denser caustic solution **[+1.0]**. Vacuum breakers allow the caustic to flow out of the standpipe (such that the level in the standpipe and RWST drop at the same rate) **[+1.0]**. (The breathers absorb CO_2 and moisture from the air and thus reduce corrosion inside the carbon steel standpipe. They do not primarily participate in the spray function. Excess caustic will react with aluminum and galvanized (zinc coated) steel in containment to release hydrogen.)

Reference(s) 2.01

1. Prairie Island: B-18D, Containment Spray System, pp. 9-11.

-Section 2.0 Continued on Next Page-

Points
Available

QUESTION 2.02

List the equipment still being served by the Component Cooling Water (CCW) system after the CCW system has received a Safeguards Actuation Signal to isolate equipment not essential for safe shutdown of the plant. Use the attached figure. Do not list the CCW HXs, CCW pumps, or CCW surge tank. Ignore unit 2 connections. (1.5)

ANSWER 2.02

Candidate should know that MV-32120 and 32121 are shut by the signal. This leaves the following equipment still receiving CCW:

RHR HXs [+0.2]

RHR pump coolers [+0.2]

Spent fuel pit HXs [+0.1]

RCPs [+0.4] Alternate: thermal barriers [+0.2] and oil coolers [+0.2]

S/G blowdown sample analysis panel [+0.1] and sample coolers [+0.1]

SI pump coolers [+0.2]

Containment spray pump coolers [+0.2]

Reference(s) 2.02

1. Prairie Island: B-14, CCW, pp. 5, 13 and Figure B 14-1.

-Section 2.0 Continued on Next Page-

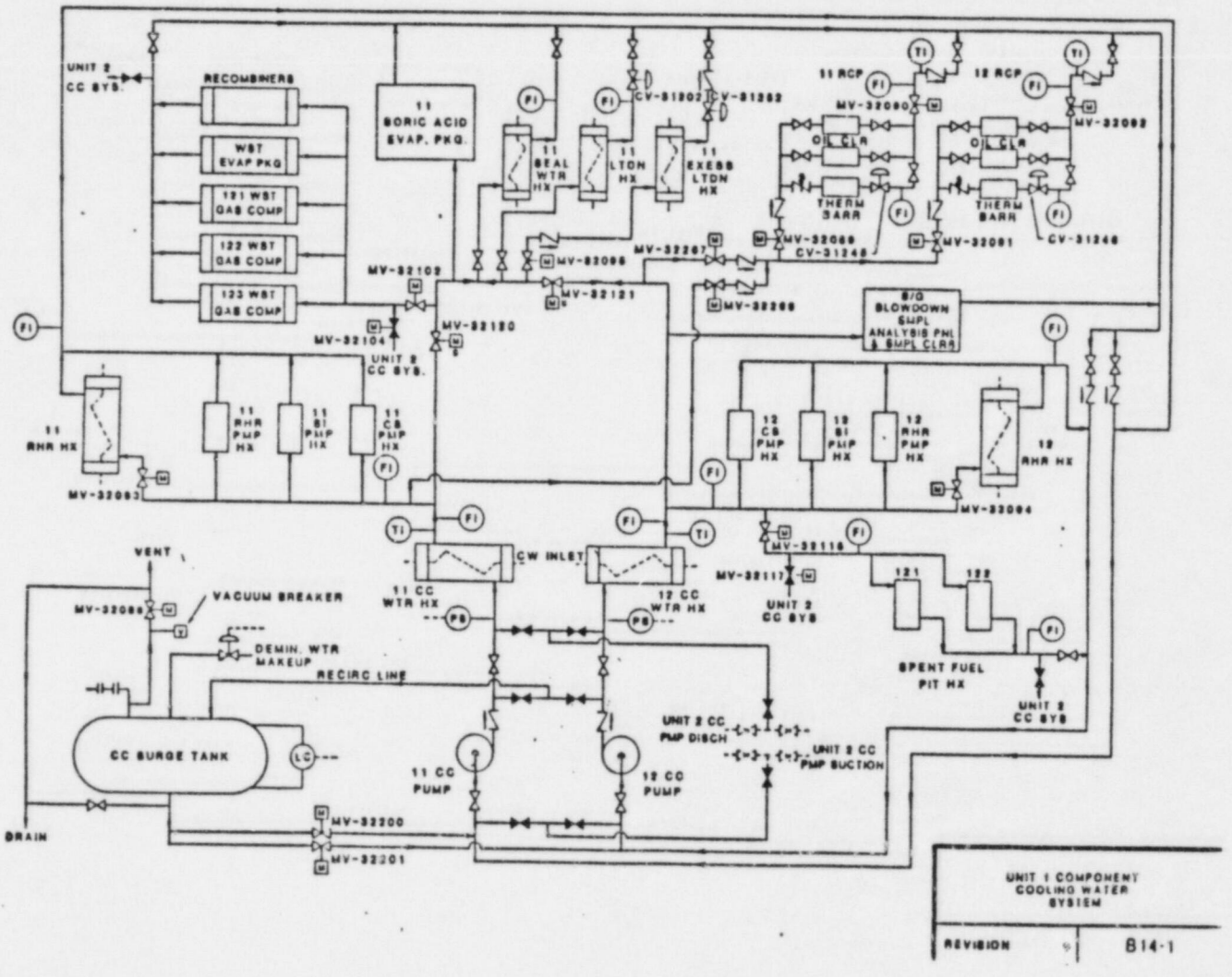


Figure 2.02 (QUESTION)

-Section 2.0 Continued on Next Page-

Points
Available

QUESTION 2.03

Select from the following list of trips, those that will cause an automatic trip of the Emergency Diesel Generator even though there is a SI signal present. (1.5)

1. Crank case pressure high at 2 inches water
2. Diesel overspeed at 1000 rpm
3. Generator reverse current
4. Ground fault on a safeguards bus feed
5. Jacket water pressure low at 9 psig
6. Jacket water temperature high at 205^{o}F
7. Lube oil pressure low at 16 psig
8. Phase differential on the generator

ANSWER 2.03

2, 4, 8. [+1.5]

Reference(s) 2.03

1. Prairie Island: B-38A, pg 12.

-Section 2.0 Continued on Next Page-

Points
Available

QUESTION 2.04

Trace a Containment Isolation Signal back to all possible sources in the top row of the attached Safeguards Logic Diagram. Ignore all reset loops and branches. (2.0)

ANSWER 2.04

The traces identified should be similar to the attached key. It is not sufficient to list Manual and SI; the training objective is that the candidate be able to trace a signal through the logic network (block diagram). **[+0.2] for each of 10 inputs**

Reference(s) 2.04

1. Prairie Island: Lesson Plan P8180L-006, Engineered Safeguards, p. 1 and Figure B-18C, Logic Diagram Safeguards Actuation Signals.

-Section 2.0 Continued on Next Page-

Prairie Island
May 20, 1986

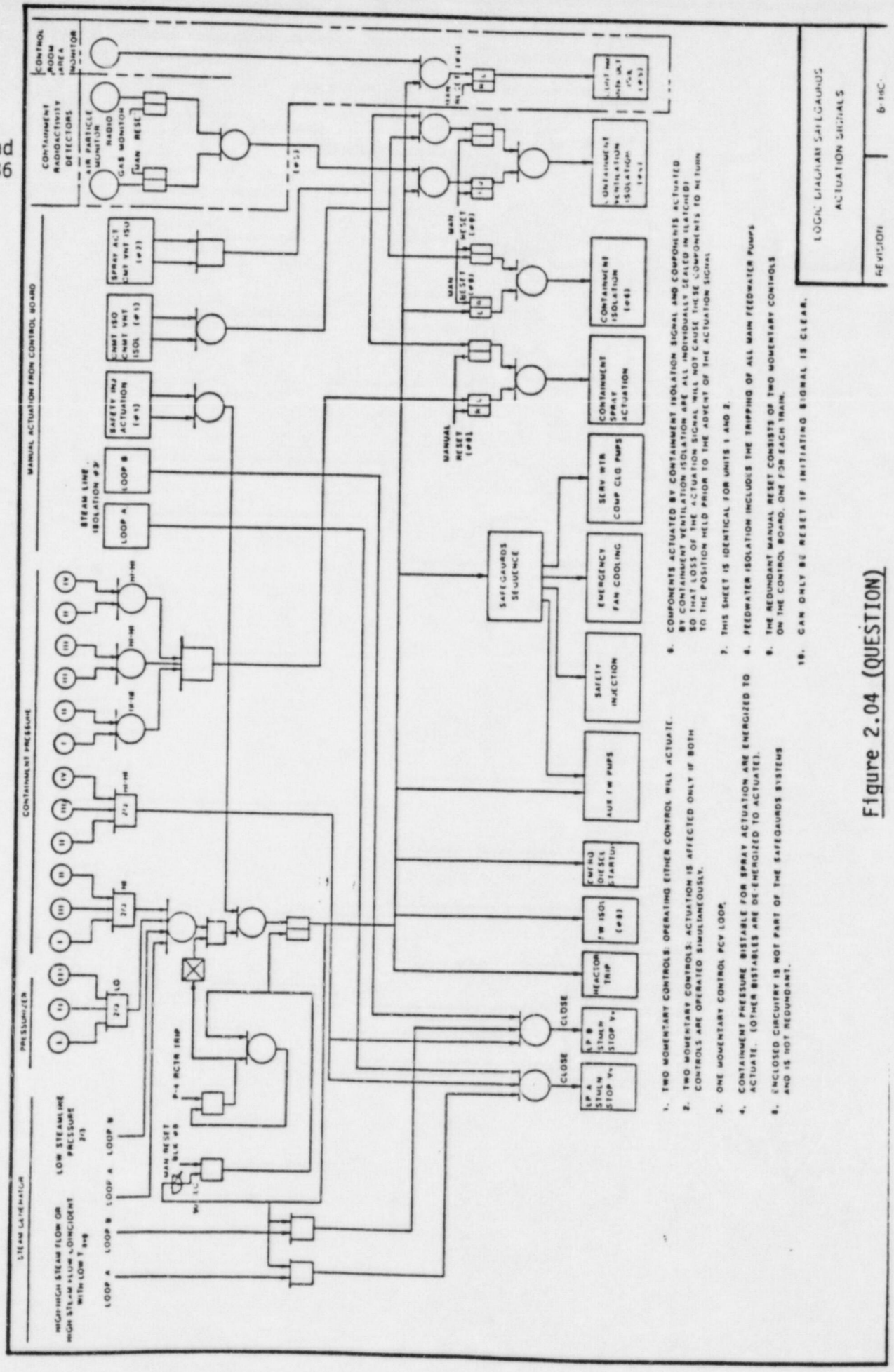
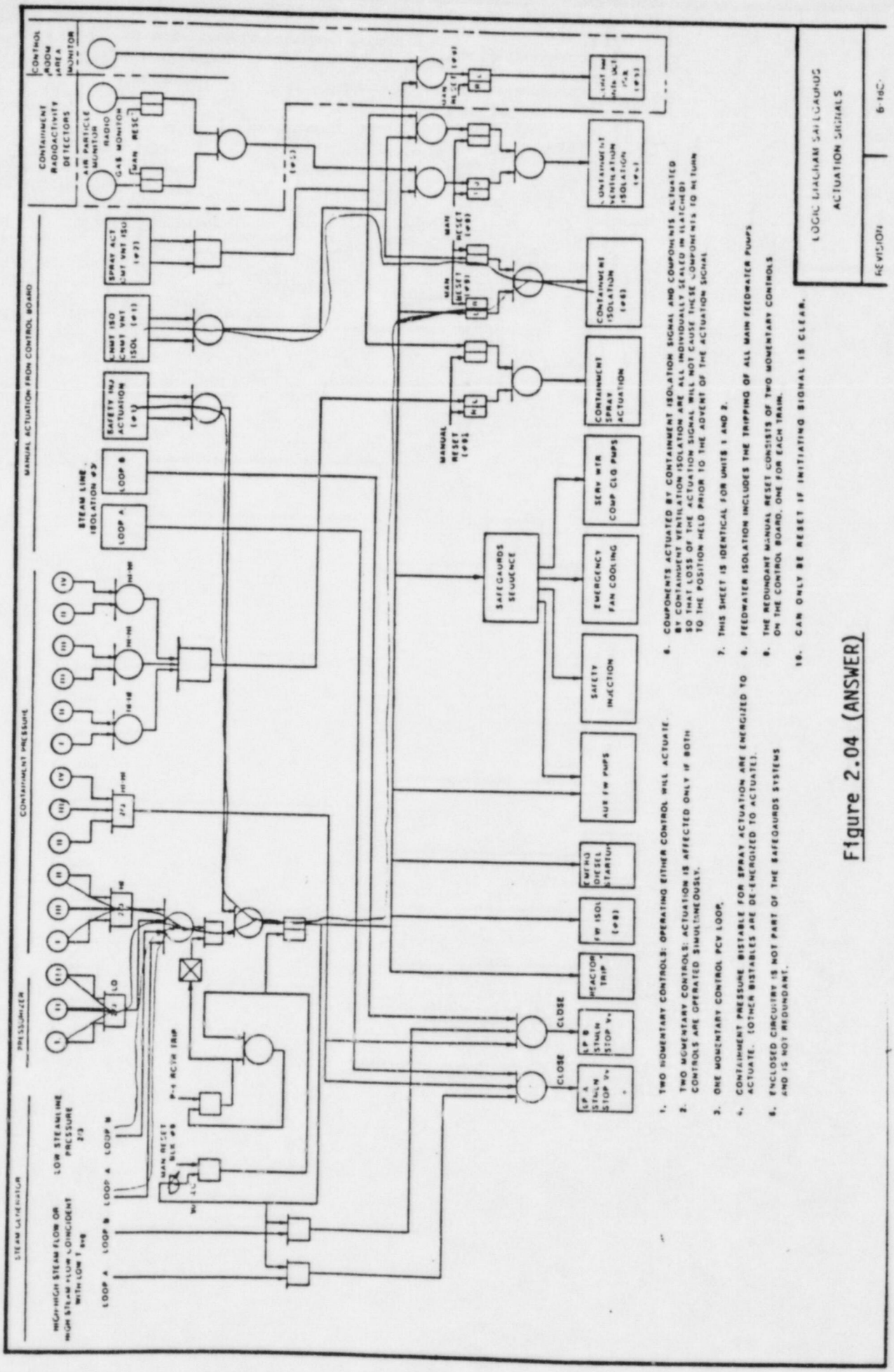


Figure 2.04 (QUESTION)

-Section 2.0 Continued on Next Page-

Prairie Island
May 20, 1986



1. TWO MOMENTARY CONTROLS: OPERATING EITHER CONTROL WILL ACTUATE.
2. TWO MOMENTARY CONTROLS: ACTUATION IS AFFECTED ONLY IF BOTH CONTROLS ARE OPERATED SIMULTANEOUSLY.
3. ONE MOMENTARY CONTROL PER LOOP.
4. CONTAINMENT PRESSURE BISTABLE FOR SPRAY ACTUATION ARE ENERGIZED TO ACTUATE. (OTHER BISTABLES ARE DE-ENERGIZED TO ACTUATE).
5. ENCLOSED CIRCUITRY IS NOT PART OF THE SAFEGUARDS SYSTEMS AND IS NOT REDUNDANT.
6. COMPONENTS ACTUATED BY CONTAINMENT ISOLATION SIGNAL AND COMPONENTS ACTUATED BY CONTAINMENT VENTILATION ISOLATION ARE ALL INDIVIDUALLY SEALED-IN (LATCHED) SO THAT LOSS OF THE ACTUATION SIGNAL WILL NOT CAUSE THESE COMPONENTS TO RETURN TO THE POSITION HELD PRIOR TO THE ADVENT OF THE ACTUATION SIGNAL
7. THIS SHEET IS IDENTICAL FOR UNITS 1 AND 2.
8. FEEDWATER ISOLATION INCLUDES THE TRIPPING OF ALL MAIN FEEDWATER PUMPS
9. THE REDUNDANT MANUAL RESET CONSISTS OF TWO MOMENTARY CONTROLS ON THE CONTROL BOARD, ONE FOR EACH TRAIN.
10. CAN ONLY BE RESET IF INITIATING SIGNAL IS CLEAR.

Figure 2.04 (ANSWER)

-Section 2.0 Continued on Next Page-

Points
Available

QUESTION 2.05

a. What are the four (4) sources of power to each Rod Control System Power Supply cabinet? (2.0)

b. What determines which power source is used by a cabinet? (1.0)

c. Answer TRUE or FALSE: An urgent failure in a power cabinet prevents movement of any individual rod bank. (0.5)

ANSWER 2.05

a. Two power supplies are from the M/G sets **[+1.0]** and two are from the safeguards 480 volt bus 110 **[+1.0]** (through MCC 1 AC bus 1, panel 117 and a step down transformer).

b. Auctioneered high voltage. **[+1.0]**

c. False. **[+0.5]** (Any rod bank that is not powered by the affected cabinet may be moved manually, even though auto rod motion of the whole system is inhibited by the urgent failure.)

Reference(s) 2.05

1. Prairie Island: B-5, Rod Control System, pp. 17-18.

-Section 2.0 Continued on Next Page-

Points
Available

QUESTION 2.06

What are the two (2) reasons for maintaining a small constant flow through the Pressurizer spray nozzle? (1.0)

ANSWER 2.06

Reduce thermal shock to the nozzle when full spray is turned on [+0.5] (alternate answer: prevent excessive cooling of the spray piping) and to mix (homogenize) the contents of the Pressurizer with the reactor coolant [+0.5].

Reference(s) 2.06

1. Prairie Island: B-4A, Reactor Coolant System, p. 15.

QUESTION 2.07

On the attached diagram, draw lines to show the Seal Injection Flow into and through the seal(s) and bearing(s) of the Reactor Coolant Pump. Label the inlet and outlet flows and show the connection to the Standpipe. (3.0)

ANSWER 2.07

On the attached diagram there are 8 line segments and 4 labels to be filled in. Scoring is [+0.25] each.

Reference(s) 2.07

1. Prairie Island: B-3, Reactor Coolant Pumps, pp. 11-13 and Figure B3-2.

-Section 2.0 Continued on Next Page-

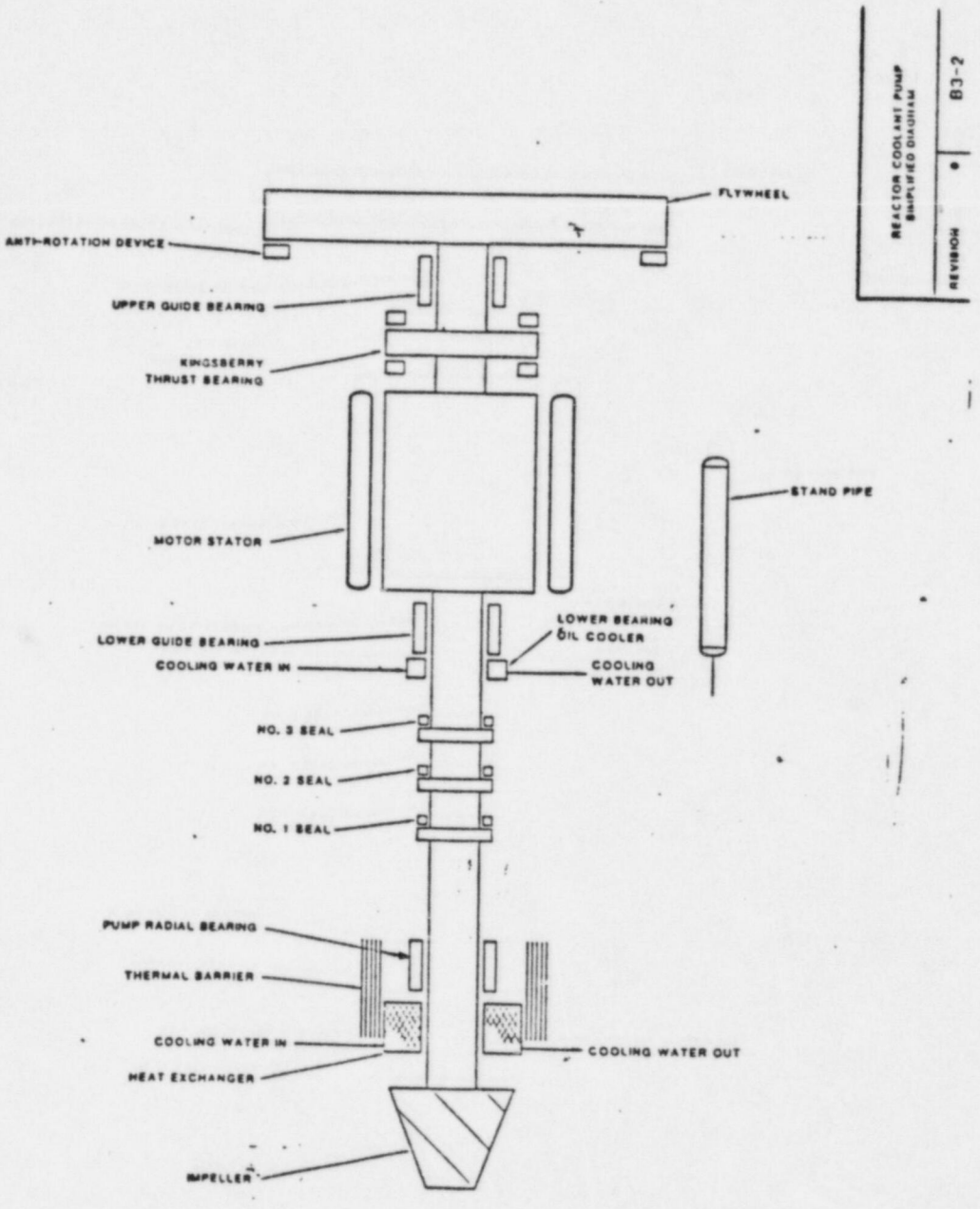


Figure 2.07 (QUESTION)

-Section 2.0 Continued on Next Page-

Points
Available

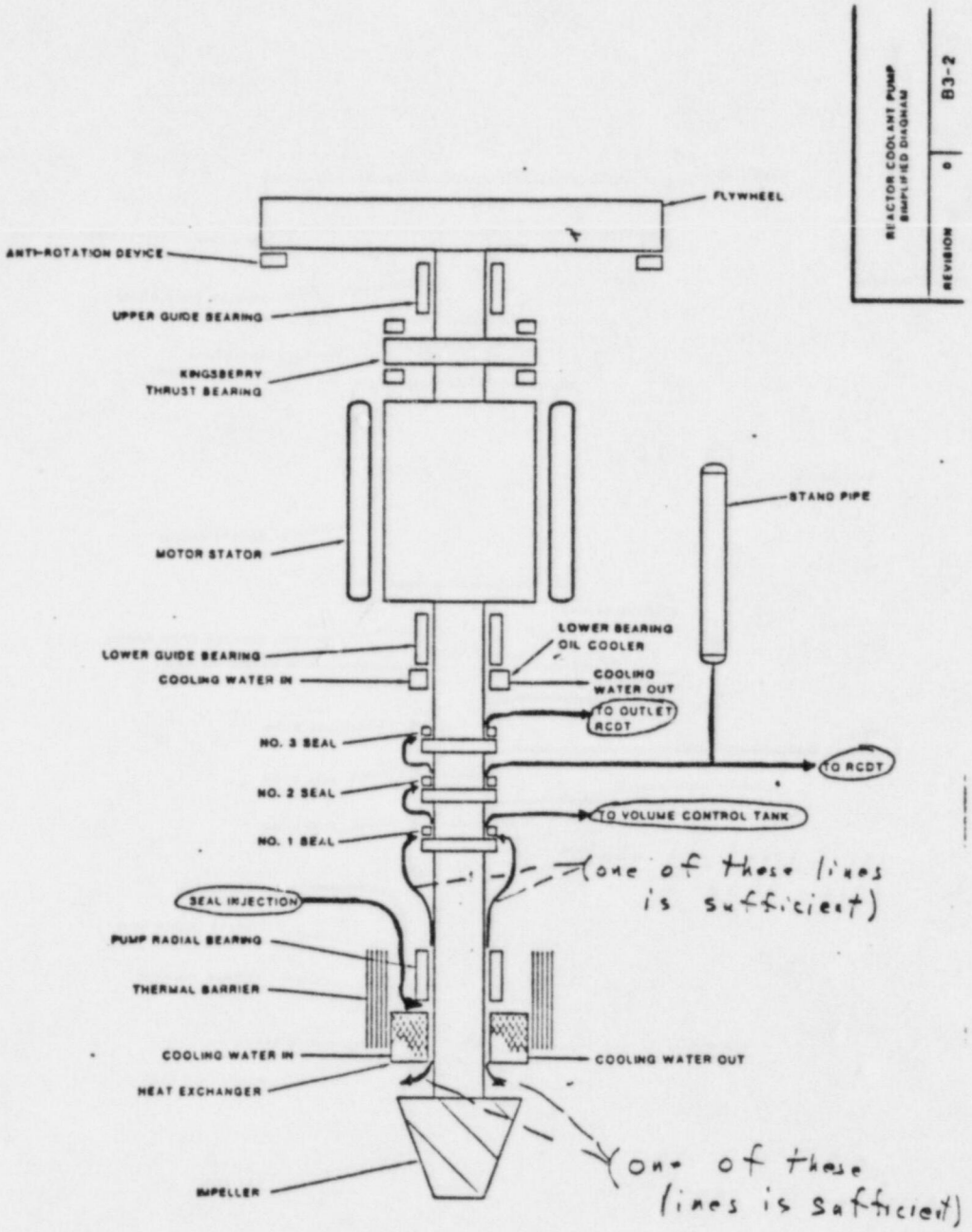


Figure 2.07 (ANSWER)

-Section 2.0 Continued on Next Page-

Points
Available

QUESTION 2.08

a. Which (by number) safeguards bus supplies power to each of the Residual Heat Removal pumps: (1.0)

Pump 11, bus ___
Pump 12, bus ___
Pump 21, bus ___
Pump 22, bus ___

b. Describe the feature of the RHR system that prevents overheating of the RHR pumps if the RCS pressure is greater than RHR pump shut-off head. (1.0)

ANSWER 2.08

a. bus 15, 16, 26, 25 **[+1.0]**

b. Flow from the pumps goes through HXs and then recirculates to the pump suctions. (Flow to the suction of the high head SI pumps, or the containment spray pumps, may be so aligned, but their function is not protection of the RHR pumps. CCW cooling of the RHR pump bearings is continuous, regardless of the pressure in the RCS. The RHR discharge relief valve only provides overpressure protection for train A during ECCS alignment.) **[+1.0]**

Reference(s) 2.08

1. Prairie Island: Lesson Plan P8180L-003, RHR System, p. 11.

2. Prairie Island: B-15, RHR Systems, Figure B-15-3.

-Section 2.0 Continued on Next Page-

Points
Available

QUESTION 2.09

a. What are the two (2) sources of Auxiliary Feedwater? (1.0)

b. Answer TRUE or FALSE. It is possible for any AFW pump to supply the emergency auxiliary feedwater needs of either Unit 1 or Unit 2. (0.5)

ANSWER 2.09

a. 1. Condensate Storage tanks (3 interconnected)

2. The Cooling Water system.

[+0.5] each

b. False. **[+0.5]** (The motor driven pumps are cross connected, but the Terry turbine driven pumps are not. In an emergency, it may be possible to block the return line to the CST, open the common return line to the motor driven pump, open the cross connect to the other unit. It is hard to show on the PIDs available.)

Reference(s) 2.09

1. Prairie Island: B-28B, Auxiliary Feedwater System, pp. 4, 3, Figure B28B-1, PID 39220, PID 39222.

-Section 2.0 Continued on Next Page-

Points
Available

QUESTION 2.10

Answer TRUE or FALSE.

The Instrument AC Distribution System is designed to be Non-Interruptable. (0.5)

ANSWER 2.10

False. **[+0.5]** (Because of redundancy, the system can tolerate brief interruptions. The Computer AC Distribution System is designed to be non-interruptable.)

Reference(s) 2.10

1. Prairie Island: B-20.8, Instrument AC and Computer AC Distribution System, p. 2.

QUESTION 2.11

Describe the two (2) flowpaths by which Station Air can be crosstied to Instrument Air. (1.0)

ANSWER 2.11

Either upstream or downstream of the Instrument Air Dryers. (Station air is of acceptable quality for the instrument air system because it has already passed through a dryer.) **[+1.0]**

Reference(s) 2.11

1. Prairie Island: B-34, Instrument and Station Air, p. 5.

Also, figure B 34-2

-Section 2.0 Continued on Next Page-

Points
Available

QUESTION 2.12

a. What are the two (2) streams of potentially radioactive liquid waste that are monitored prior to discharge? State their respective radiation monitor numbers. (1.0)

b. What automatic function is performed by the effluent monitors should high levels of activity be detected? (0.5)

ANSWER 2.12

a. Common discharge header for liquid wastes [+0.3] R-18 [+0.2] and steam generator blowdown header [+0.3] R-19 [+0.2].

b. The respective flow is shut off. [+0.5]

Reference(s) 2.12

1. Prairie Island: Lesson Plan P8182L-001, Radioactive Waste Liquid, p. 8.

-Section 2.0 Continued on Next Page-

Points
Available

QUESTION 2.13

Explain why the following materials are added to the Chemical and Volume Control System. Each material may have more than one purpose. (3.0)

1. Hydrogen peroxide
2. Hydrogen gas
3. Hydrazine
4. Lithium hydroxide
5. Nitrogen gas

ANSWER 2.13

1. Cause a crud burst in the RCS, (allowing system to be cleaned up prior to refueling.) [+0.5]
2. Reduce general corrosion by reducing free oxygen (produced by radiolysis of the water) [+0.5]. Suppress the formation of nitric acid. [+0.2] Used to maintain 15 psig in VCT whenever RCP is running. [+0.3]
3. Scavenges dissolved oxygen at low temperature (below 180^{o}F). [+0.5]
4. Added to raise pH (at EOL when boric acid concentration is low and production of Li from neutron boron reaction is low). [+0.5]
5. Added to assist in purging the RCS of hydrogen (prior to opening up the primary system; (also called "burping"). [+0.2] Used to maintain 15 psig in VCT whenever RCP is running [+0.3].

Reference(s) 2.13

1. Prairie Island: Lesson Plan P8172L-001A, CVCS, pp. 25-26.
2. Prairie Island: System Procedures C-12, CVCS, pp. 69-70.

-End of Section 2.0-

Points
Available

3.0 Instruments and Controls (25.0)

QUESTION 3.01

a. The Steam Generator Level Control System is said to be "level dominant." Explain what this means in terms of the input signals to the controller. (1.25)

b. The flow error of the S/G Level Control System is said to be "anticipatory". Explain what is being anticipated, and how response time is affected. (1.25)

ANSWER 3.01

a. A level error signal [+0.25] will overcome [+0.25] a flow error signal [+0.25] to maintain S/G level [+0.25] as close as possible to the program level [+0.25].

b. The flow error signal allows the system to respond rapidly [+0.5] to an anticipated level change [+0.5] due to a steam flow (i.e., power) change. [+0.25]

Reference(s) 3.01

1. Prairie Island: B-7, Reactor Control Systems, p. 40.

-Section 3.0 Continued on Next Page-

Points
Available

QUESTION 3.02

Give five (5) of the ~~six (6)~~ seven (7) interlocks or conditions that must be met if the Steam Dump System is to operate in the T_{avg}, load rejection, mode. (2.5)

ANSWER 3.02

1. The steam dump "Off/Reset-On-Bypass" interlock switches are in the ON position. **[+0.5]**

2. The steam dump "Mode Selector Control" switch is in the T_{avg} CONTROL position. **[+0.5]**

3. Reactor coolant loop temperatures are above the Low-Low T_{avg} setpoints (540°F). **[+0.5]**

4. No turbine trip (2/2 stop valves shut) exists. **[+0.5]**

5. Air pressure is available to the valves. **[+0.5]**

6. Condenser available, **[+0.5]** or
   a. One out of two circulating water pumps operating (breaker closed). **[+0.5]**
   b. Condenser vacuum greater than 15" Hg. in both condenser shells. **[+0.5]**

(+2.5 maximum)

7. Also, load rejection signal to arm dumps. [0.5]

Reference(s) 3.02

1. Prairie Island: B-7, Reactor Control Systems, p. 20.

-Section 3.0 Continued on Next Page-

Points
Available

QUESTION 3.03

Select the correct statement for the Pressurizer Level Control System. (1.0)

(a.) Heaters and sprays overlap to provide positive control.

(b.) At lo-lo level alarm, heaters and letdown are secured.

(c.) Reactor will trip at 2/3 hi-hi level when reactor is in ~~Mode 2~~. S/U, less 2 ~2 pwr

(d.) There is an alarm but no control action at high level.

ANSWER 3.03

(b.) **[+1.0]**

Reference(s) 3.03

1. Prairie Island: B-7, Reactor Control Systems, p. 37, and Figure B-7-23.

-Section 3.0 Continued on Next Page-

Points
Available

QUESTION 3.04

a. Against what phenomenon is the reactor protected by the Overtemperature Delta T reactor trip? (1.0)

b. Indicate whether the OTdeltaT setpoint will INCREASE, DECREASE, or REMAIN THE SAME for each of the following conditions:

1. A gradual increase in T_{avg} due to blockage of S/G tubes. (0.5)

2. A downward drift in RCS pressure due to heater failure. (0.5)

ANSWER 3.04

a. DNB **[+1.0]** (no credit for "overtemperature")

b. 1. Decrease **[+0.5]**

2. Decrease **[+0.5]**

Reference(s) 3.04

1. Prairie Island: B-8, RPS, p. 7.

-Section 3.0 Continued on Next Page-

Points
Available

QUESTION 3.05

Match the Accident Condition in column A with the Safety Injection Signals in column B. More than one choice is possible. (1.75)

A	B
1. Large LOCA	a. 2/3 PZR pressure <1815 psig
2. S/G Tube Rupture	b. 2/3 containment pressure >4 psig
3. Large Steam Line Break inside containment	c. 2/3 steamline pressure in either loop <500 psig
4. Loss of S/G Feedwater	

ANSWER 3.05

1. a, b
2. a
3. a, b, c, inside containment, only a, c outside
4. c

[+0.25] per choice

Reference(s) 3.05

1. Prairie Island: B-18A, SI and Accumulator Systems, p. 26.
2. Prairie Island: Updated FSAR, Section 14, Safety Analyses, 14.5-14, 14.5-20, 14.6-1, 14.8-4

-Section 3.0 Continued on Next Page-

Points
Available

QUESTION 3.06

Select the seven (7) correct Source Range functions from the following list. An item may apply to more than one (1) NIS range. (1.75)

1. Channel Comparator
2. Computer Input
3. Control Board Indication
4. Control Board Recording
5. Containment Evacuation Alarm
6. Delta I Indication
7. Delta I Recorder
8. Detector Current Comparator
9. High Flux at Shutdown alarm
10. High Level Trip
11. High Power Rod Stop
12. High Power Trip
13. Low Power Trip
14. Overpower Recorder
15. P-6
16. P-8
17. P-9
18. P-10
19. Rate comparator for positive and negative rate trips
20. RPS OT and OP Delta T Trips
21. Rod Control System
22. Startup Rate Circuit

ANSWER 3.06

2, 3, 4, 5, 9, 10, 22 **[+0.25] each, +1.75 maximum**

Reference(s) 3.06

1. Prairie Island: B-9, NIS, pp. 7 and 8.

-Section 3.0 Continued on Next Page-

Points
Available

QUESTION 3.07

Answer TRUE or FALSE. There are no interlocks to prevent the closing of any Letdown Orifice Isolation valve. (0.5)

ANSWER 3.07

TRUE. [+0.5]

Reference(s) 3.07

1. Prairie Island: B-12A, CVCS, p. 8.

QUESTION 3.08

During switchover from the VCT to the RWST, why does the outlet valve from the VCT remain open until the valve to the RWST is open? (1.0)

ANSWER 3.08

To be assured that there is always a supply of water to the suction of the charging pumps. [+1.0]

Reference(s) 3.08

1. Prairie Island: B-12A, CVCS, p. 19.

-Section 3.0 Continued on Next Page-

Points
Available

QUESTION 3.09

Identify the potential sources of inadvertent dilution of the RCS using the attached diagram, B-12A-2. Do not assume leaking heat exchangers. (2.0)

ANSWER 3.09

See Figure 3.09 (ANSWER).

Reference(s) 3.09

1. Prairie Island: B-12A, CVCS, Figure B-12A-2.

QUESTION 3.10

If an RTD fails open, will the apparent temperature be high or low? Explain. (1.5)

ANSWER 3.10

High. **[+0.5]** The resistance increases with temperature, an open circuit looks like a very high resistance. **[+1.0]**

Reference(s) 3.10

1. Prairie Island: Lesson Plan, 8184L-003, Reactor Process Instrumentation, p. 5.

-Section 3.0 Continued on Next Page-

Points
Available

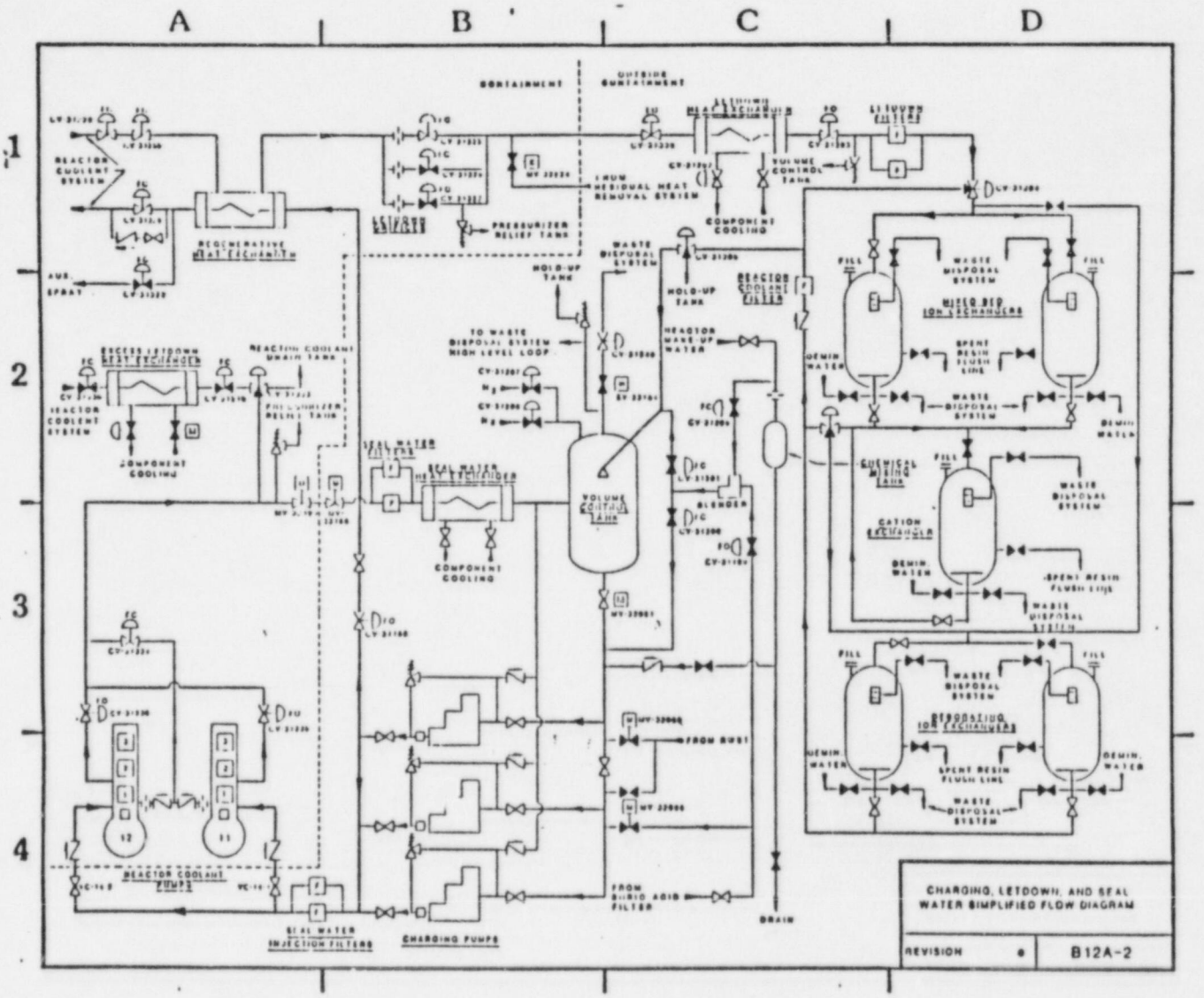


Figure 3.09 (QUESTION)

-Section 3.0 Continued on Next Page-

Points
Available

ANSWER 3.09

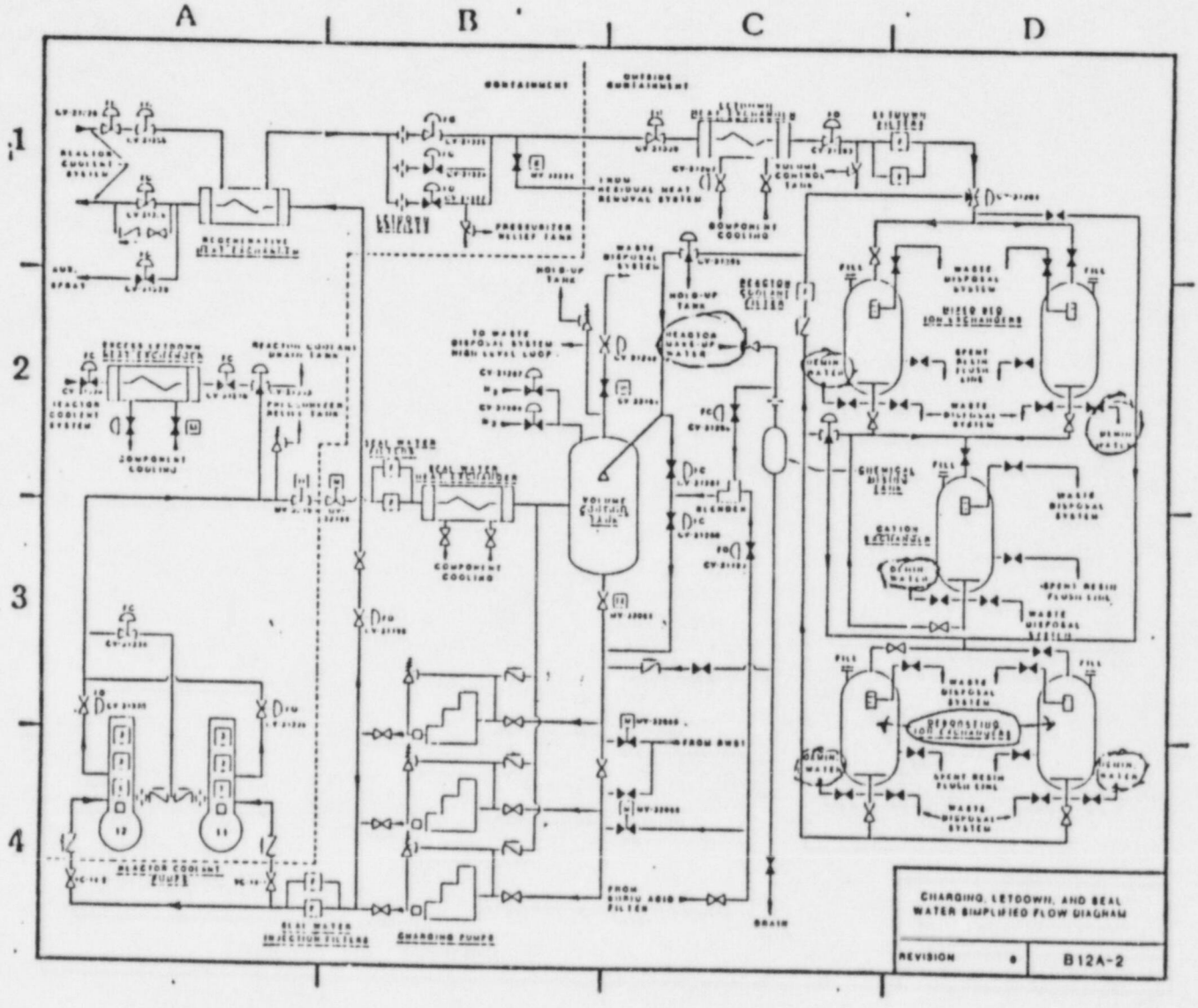


Figure 3.09 (ANSWER)

[+0.25] for each choice: M/u, 5 demin. water, 2 deborating ion exchangers

-Section 3.0 Continued on Next Page-

Points
Available

QUESTION 3.11

What is the function of the Air Ejector Monitor, R-15? (1.0)

ANSWER 3.11

To indicate primary to secondary leakage. **[+1.0]**

Reference(s) 3.11

1. Prairie Island: Lesson Plan, 8182L-002, p. 15.

QUESTION 3.12

How is Area Monitor R-7 likely to interact with incore flux mapping operations? (1.0)

ANSWER 3.12

R-7 is in the area of the seal table **[+0.5]**. Unless the fuses are pulled during mapping, the activation of the probes will trigger the monitor during withdrawal **[+0.5]**.

Reference(s) 3.12

1. Prairie Island: Lesson Plan 8182L-002, p. 22.

-Section 3.0 Continued on Next Page-

Points
Available

QUESTION 3.13

State the positions of the Selector Switch and the Control Switch for the Auxiliary Feedwater Pump if the auto start on main feedpump trip is to be blocked. Ignore any other means by which the MFP may be blocked. (1.0)

ANSWER 3.13

Selector switch in SHUTDOWN AUTO and control switch in NORMAL. (The control switch will always be in NORMAL because it is spring return from either START or STOP.) **[+1.0]**

Reference(s) 3.13

1. Prairie Island: B-28B, AFW System, p. 7.

QUESTION 3.14

What three (3) signals will cause a Control Room Ventilation Isolation? (1.5)

ANSWER 3.14

A Safety Injection signal, 1/2 high rad levels on R-23 or R-24, toxic gas monitor. **[+1.5]**

Reference(s) 3.14

1. Prairie Island: Lesson Plan 8180L-006, ESF, p. 12.

-Section 3.0 Continued on Next Page-

Points
Available

QUESTION 3.15

Which of the five (5) types of fire detectors used throughout the plant is most likely to react first to a developing fire in a general area? (1.0)

ANSWER 3.15

Ionization detector **[+1.0]**

Reference(s) 3.15

1. Prairie Island: Lesson Plan 8178L-003, pp. 3-4.

QUESTION 3.16

a. What six (6) Controls and Readouts are available to the operator to determine if the Electric Hydrogen Recombiner System is working properly? (1.5)

b. What is the minimum concentration of hydrogen in the containment that is flammable? (0.5)

ANSWER 3.16

a. 1. Wattmeter
2. Controller potentiometer
3. On/off switch
4. Power-available pilot light
5. Temperature readout
6. TC selector switch.

Also, Accept other direct indications of H conc. in CTMT.

[+0.25] each

b. 4% [+0.5]

Reference(s) 3.16

1. Prairie Island: Lesson Plan 8180L-008, pp. 6, 13-15.

-Section 3.0 Continued on Next Page-

Points
Available

QUESTION 3.17

Explain why it may be necessary to override an ESF Isolation signal that closes Sample Line valves from the PZR. (1.0)

ANSWER 3.17

After a severe accident it is necessary to monitor fuel failure and boron concentration by taking samples from the RCS. **[+1.0]**

Reference(s) 3.17

1. Prairie Island: B-39, Sampling System, p. 9.

-End of Section 3.0-

Points
Available

4.0 Procedures - Normal, Abnormal, Emergency and Radiological Control (25.0)

QUESTION 4.01

a. Unidentified leakage from the RCS is limited to _____ gpm, per TS 3.1-9. (0.5)

b. With regard to Instrumentation Surveillance, use the ideas expressed in the definitions of Channel Calibration and Channel Functional Test to show which is more comprehensive. (1.0)

ANSWER 4.01

a. 1 [+0.5]

b. Channel Calibration involves the entire channel, including the sensor. It is more comprehensive because it includes the Functional Test. [+1.0]

Reference(s) 4.01

1. Prairie Island: TS 3.1-9.

2. Prairie Island: TS 1.-3.

-Section 4.0 Continued on Next Page-

Points
Available

QUESTION 4.02

Give the five (5) Immediate Manual Actions contained in emergency procedure AB1, Loss of All Offsite Power. (2.5)

ANSWER 4.02

1. Inspect the reactor TRIP "First Out" annunciator panel for the first out trip and subsequent trips.

2. Verify that the reactor trip breakers are open.

3. Verify that all full-length control rods and shutdown rods are properly inserted by inspecting the rod position indications.

4. Verify that the power level is decreasing by inspection.

5. Verify emergency oil pump is on the turbine.

[+0.5] each

Reference(s) 4.02

1. Prairie Island: Procedure AB1, Loss of All Offsite Power, p. 4.

-Section 4.0 Continued on Next Page-

Points
Available

QUESTION 4.03

Complete the following table, Red Path Summary, for a Loss of Coolant Accident, procedure E-1. (2.5)

SUBCRITICALITY _____

CORE COOLING _____ or _____

HEAT SINK _____

INTEGRITY _____

CONTAINMENT _____

ANSWER 4.03

Subcriticality -- Nuclear power >5%

Core cooling -- Exit TCs >1200F or Exit TCs >700°F and RVLIS full range <37%, no RCPs

Heat Sink -- S/Gs WR level <60% and total feedflow <200 gpm

Integrity -- Cold leg temp decrease >100F/hr and RCS cold leg temp <230°F

Containment -- Pressure >46 psig

[+0.5] each

Reference(s) 4.03

1. Prairie Island: EOP E-1, information page opposite p. 3.

-Section 4.0 Continued on Next Page-

Points
Available

QUESTION 4.04

How many Nuclear Instrumentation detectors of each range must be in service prior to startup? (1.5)

ANSWER 4.04

2 SR

2 IR

4 PR

[+0.5] each

Reference(s) 4.04

1. Prairie Island: C1.2, S/U Administrative Control 3.3.1, p. 5.

QUESTION 4.05

You come on shift during RCS heatup and note in the log that the temperature an hour ago was 325°F. According to administrative limits, what is the highest temperature it is allowed to be now? (1.0)

ANSWER 4.05

385°F (60°F/hr max heatup rate) [+1.0]

Reference(s) 4.05

1. Prairie Island: C1.2, S/U Administrative Control 3.3.4, p. 5.

-Section 4.0 Continued on Next Page-

Points
Available

QUESTION 4.06

Give two (2) observations that would help you distinguish between a failed Rod Position Indicator and a stuck RCCA. (2.0)

ANSWER 4.06

Symptoms peculiar to a failed RPI: **[+1.0] for either**

a. Erratic behavior of RPI when bank not in motion OR

b. Sudden large indicated change in rod position without changes in nuclear power or motion of other rods.

c. Change in T_{avg} with rod motion, regardless of RPI indic.

Symptoms peculiar to stuck RCCA, simultaneous occurrence **[+1.0] for any one**

a. RPI/group step counter disagreement

b. Rod group movement shown by suspect step counter, but no RPI motion

c. Abnormal power distribution as shown by excore or incore NIs

Reference(s) 4.06

1. Prairie Island: C6, Rod Position Indicator System, pp. 6 and 7.

-Section 4.0 Continued on Next Page-

Points
Available

QUESTION 4.07

If a Pressurizer pressure transmitter has failed, should the Reactor trip and SI bistables associated with the failed channel be placed in the trip or bypass position? (0.5)

ANSWER 4.07

Trip for both [+0.5]

Reference(s) 4.07

1. Prairie Island: C7.2, Malfunction of the PZR Pressure Control System, p. 31.

-Section 4.0 Continued on Next Page-

Points
Available

QUESTION 4.08

Give four (4) examples or general statements of the kind of significant operations or actions that the Reactor Operator will enter in the Reactor Log. Omit data filled in on the stamped form at the beginning of each day. (2.0)

ANSWER 4.08

Group answers into these general categories:

1. All operations affecting the operation of the reactor or major unit equipment.

2. Changes in reactor coolant boron concentration.

3. Changes in reactor power level and generator output.

4. Performance of unit surveillance testing or special testing. Results of testing when applicable.

5. Instrumentation or equipment failures.

6. Occurrence of significant annunciator alarms.

7. REs, SOEs, suspected REs or SOEs. [CAF]

Any four (4) [+0.5] each, +2.0 maximum

Reference(s) 4.08

1. Prairie Island: SWI-0-4, p. 7.

-Section 4.0 Continued on Next Page-

Points
Available

QUESTION 4.09

Given a situation where the RCS activity becomes so high that Normal Letdown and Excess Letdown must be isolated, what are three (3) emergency letdown paths into containment? (3.0)

ANSWER 4.09

1. Reactor head vent to PRT
2. PZR PORVs to PRT
3. Excess letdown to RCDT
4. Stop an RCP, route seal return to PRT
5. RCP seal bypass to PRT
6. Pump RCS PZR solid and use safeties after gagging charging pump relief

Any three (3) [+1.0] each, +3.0 maximum

Reference(s) 4.09

1. Prairie Island: C12, CVCS S/U Procedure, p. 6.
2. Prairie Island: C1.9, Emergency S/D and Cooldown, pp. 2-4.

-Section 4.0 Continued on Next Page-

Points
Available

QUESTION 4.10

There are two (2) caution statements before step one and after step four of ES-0.2, SI Termination. Answer the following in regard to those cautions:

a. If offsite power is lost after SI reset, what must be done with regard to safeguards equipment? (1.0)

b. What must be done before SI will reinitiate automatically? (1.0)

ANSWER 4.10

a. It must be manually restarted. **[+1.0]**

b. Reactor trip breakers must be reset. **[+1.0]**

Reference(s) 4.10

1. Prairie Island: ES-0.2, SI Termination, p. 3.

-Section 4.0 Continued on Next Page-

Points
Available

QUESTION 4.11

a. What are your quarterly exposure limits, according to PI Radiation Protection rules? (1.5)

b. Under what conditions can you exceed quarterly whole body limits? (0.5)

ANSWER 4.11

a. 1.25 Rem/qtr for whole body **[+0.5]** (head and trunk, active blood forming organs, lens of eyes or gonads). Skin dose per quarter is 7.5 Rem. **[+0.5]** Extremities dose is 18.75 Rem/qtr. **[+0.5]**

b. Quarterly whole body dose can be increased to 3 Rem provided the individual's lifetime accumulated dose does not exceed 5(N-18) where N is age. **[+0.5]**

Reference(s) 4.11

1. Prairie Island: F2, Radiation Safety, pp. 11 and 12.

-Section 4.0 Continued on Next Page-

Points
Available

QUESTION 4.12

a. For a LOCA, procedure E-1, state the two (2) conditions for which the RCPs should be stopped in step 1. (2.0)

b. In step 3 of E-1, what is an acceptable Wide Range Level in the Intact S/Gs? (0.5)

ANSWER 4.12

a. 1. High-head SI pumps running, flow indicated **[+1.0]**

2. RCS pressure <1200 psig (1500 psig for adverse containment) **[+1.0]**

b. >60% (accept 60 to 64 as given in next step) **[+0.5]**

Reference(s) 4.12

1. Prairie Island: EOP E-1, p. 3.

QUESTION 4.13

From a security standpoint, what is your conduct toward visitors to the control room? (1.0)

ANSWER 4.13

Keep an eye on them to make sure they obey company rules **[+0.5]** and challenge them if their ID is not visible, or if otherwise appropriate. **[+0.5]**

Reference(s) 4.13

1. Prairie Island: SWI-O-13, Watchstanders Guide, p. 3.

-Section 4.0 Continued on Next Page-

Points
Available

QUESTION 4.14

After an accident in containment, what two (2) conditions are considered Adverse Containment, with regard to instrumentation readings that appear in Emergency Procedure E-0? (1.0)

ANSWER 4.14

5 psig [+0.5] and 10^4 R/hr [+0.5]

Reference(s) 4.14

1. Prairie Island: E-0, footnote on information page.

-End of Section 4.0-

-End of Exam-

EQUATION SHEET

Where $\dot{m}_1 = \dot{m}_2$

$(\text{density})_1(\text{velocity})_1(\text{area})_1 = (\text{density})_2(\text{velocity})_2(\text{area})_2$

$KE = \frac{mv^2}{2}$ $\quad PE = mgh$ $\quad PE_1 + KE_1 + P_1V_1 = PE_2 + KE_2 + P_2V_2$ where V = specific volume, P = Pressure

$Q = \dot{m}c_p(T_{out} - T_{in})$ $\quad Q = UA\,(T_{ave} - T_{stm})$ $\quad Q = \dot{m}(h_1 - h_2)$

$P = P_0 10^{(SUR)(t)}$ $\quad P = P_0 e^{t/T}$ $\quad SUR = \frac{26.06}{T}$ $\quad T = \frac{(B-p)t}{p}$

$\text{delta } K = (K_{eff} - 1)$ $\quad CR_1(1-K_{eff1}) = CR_2(1-K_{eff2})$ $\quad CR = S/(1-K_{eff})$

$M = \frac{(1-K_{eff1})}{(1-K_{eff2})}$ $\quad SDM = \frac{(1-K_{eff}) \times 100\%}{K_{eff}}$

$\text{decay constant} = \frac{\ln(2)}{t_{1/2}} = \frac{0.693}{t_{1/2}}$ $\quad A_1 = A_o e^{-(\text{decay constant}) \times (t)}$

Water Parameters

1 gallon = 8.345 lbs
1 gallon = 3.78 liters

1 ft^3 = 7.48 gallons

Density = 62.4 lbm/ft^3
Density = 1 gm/cm^3

Heat of Vaporization = 970 Btu/lbm
Heat of Fusion = 144 Btu/lbm
1 Atm = 14.7 psia = 29.9 in Hg

Miscellaneous Conversions

1 Curie = 3.7×10^{10} dps
1 kg = 2.21 lbs

1 hp = 2.54×10^3 Btu/hr

1 MW = 3.41×10^6 Btu/hr
1 Btu = 778 ft-lbf

Degrees F = (1.8 x Degrees C) + 32
1 inch = 2.54 $centimeters_2$
g = 32.174 ft-lbm/lbf-sec^2

START 0820

MASTER COPY

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

FACILITY: PRAIRIE ISLAND 1&2

REACTOR TYPE: PWR-WEC2

DATE ADMINISTERED: 86/05/19

EXAMINER: REIDINGER, T.

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

EQUATIONS

REACTOR THEORY

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

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

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

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

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

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

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

$$k_2 = k_1 + \delta k$$

$$\delta k = k - 1$$

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

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

$$\Sigma = N\sigma$$

$$\phi = nv$$

Defect = Coeff x Δ Parameter

RADIATION

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

$$A = \lambda N$$

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

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

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

$I_1 d_1^2 = I_2 d_2^2$ 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

$$y^a = b$$

$$\log_y b = a$$

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

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

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

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 $\alpha \sqrt{dp}$

head loss $= f\frac{L}{D}\frac{V^2}{2g_c}$ or head loss αV^2

head loss $\alpha \Delta p$

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

$F = pA$

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

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	0.016059	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	0.016069	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	1.9428	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	0.57700	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	2.0085	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	392.9	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	1.06961	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	296.36	296.38	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	1.8187	1.9624	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	1.3506	0.016172	251.38	251.38	79.98	1030.2	1110.2	0.1507	1.8021	1.9528	112.0
114.0	1.4299	0.016180	238.21	238.22	81.97	1029.1	1111.0	0.1542	1.7938	1.9480	114.0
116.0	1.5133	0.016188	225.84	225.85	83.97	1027.9	1111.9	0.1577	1.7856	1.9433	116.0
118.0	1.6009	0.016196	214.20	214.21	85.97	1026.8	1112.7	0.1611	1.7774	1.9386	118.0
120.0	1.6927	0.016204	203.25	203.26	87.97	1025.6	1113.6	0.1646	1.7693	1.9339	120.0
122.0	1.7891	0.016213	192.94	192.95	89.96	1024.5	1114.4	0.1680	1.7613	1.9293	122.0
124.0	1.8901	0.016221	183.23	183.24	91.96	1023.3	1115.3	0.1715	1.7533	1.9247	124.0
126.0	1.9958	0.016230	174.09	174.09	93.96	1022.2	1116.1	0.1749	1.7453	1.9202	126.0
128.0	2.1065	0.016238	165.47	165.47	95.96	1021.0	1117.0	0.1783	1.7374	1.9157	128.0
130.0	2.2222	0.016247	157.33	157.33	97.96	1019.8	1117.8	0.1817	1.7295	1.9112	130.0
132.0	2.3433	0.016256	149.64	149.66	99.95	1018.7	1118.6	0.1851	1.7217	1.9068	132.0
134.0	2.4700	0.016265	142.40	142.41	101.95	1017.5	1119.5	0.1884	1.7140	1.9024	134.0
136.0	2.6027	0.016274	135.55	135.57	103.95	1016.4	1120.3	0.1918	1.7063	1.8980	136.0
138.0	2.7418	0.016284	129.09	129.11	105.95	1015.2	1121.1	0.1951	1.6986	1.8937	138.0
140.0	2.8874	0.016293	122.98	123.00	107.95	1014.0	1122.0	0.1985	1.6910	1.8895	140.0
142.0	3.0398	0.016303	117.22	117.22	109.95	1012.9	1122.8	0.2018	1.6834	1.8852	142.0
144.0	3.1991	0.016312	111.74	111.76	111.95	1011.7	1123.6	0.2051	1.6759	1.8810	144.0
146.0	3.3655	0.016322	106.58	106.60	113.95	1010.5	1124.5	0.2084	1.6684	1.8769	146.0
148.0	3.5391	0.016332	101.72	101.74	115.95	1009.3	1125.3	0.2117	1.6610	1.8727	148.0
150.0	3.7202	0.016343	97.07	97.07	117.95	1008.2	1126.1	0.2150	1.6536	1.8686	150.0
152.0	3.9087	0.016353	92.68	92.68	119.95	1007.0	1126.9	0.2183	1.6463	1.8646	152.0
154.0	4.1050	0.016363	88.50	88.52	121.95	1005.8	1127.7	0.2216	1.6390	1.8606	154.0
156.0	4.3094	0.016374	84.56	84.57	123.95	1004.6	1128.6	0.2248	1.6318	1.8566	156.0
158.0	4.5219	0.016384	80.82	80.83	125.96	1003.4	1129.4	0.2281	1.6245	1.8526	158.0
160.0	4.7434	0.016395	77.27	77.29	127.96	1002.2	1130.2	0.2313	1.6174	1.8487	160.0
162.0	4.9732	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	5.4613	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	6.8687	0.016486	54.59	54.61	143.99	992.6	1136.6	0.2568	1.5616	1.8184	176.0
178.0	7.1840	0.016499	52.35	52.36	145.99	991.4	1137.4	0.2600	1.5549	1.8147	178.0

*Use steam tables for 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
388.0	7.5110	0.016510	96.21	96.22	148.00	990.2	1138.2	0.2631	1.5480	1.8111	388.0
392.0	7.850	0.016522	88.172	88.189	150.01	989.0	1139.0	0.2662	1.5413	1.8075	392.0
396.0	8.203	0.016534	86.232	86.249	152.01	987.8	1139.8	0.2694	1.5346	1.8040	396.0
400.0	8.568	0.016547	84.383	84.400	154.02	986.5	1140.5	0.2725	1.5279	1.8004	400.0
404.0	8.947	0.016559	82.621	82.638	156.03	985.3	1141.3	0.2756	1.5213	1.7969	404.0
408.0	9.340	0.016572	80.941	80.957	158.04	984.1	1142.1	0.2787	1.5148	1.7934	408.0
412.0	9.747	0.016585	79.337	79.354	160.05	982.8	1142.9	0.2818	1.5082	1.7900	412.0
416.0	10.168	0.016598	77.808	77.824	162.05	981.6	1143.7	0.2848	1.5017	1.7865	416.0
420.0	10.605	0.016611	76.348	76.364	164.06	980.4	1144.4	0.2879	1.4952	1.7831	420.0
424.0	11.058	0.016624	74.954	74.970	166.08	979.1	1145.2	0.2910	1.4888	1.7798	424.0
428.0	11.526	0.016637	73.622	73.639	168.09	977.9	1146.0	0.2940	1.4824	1.7764	428.0
432.0	12.012	0.016650	72.351	72.367	170.11	976.6	1146.8	0.2971	1.4760	1.7731	432.0
436.0	12.514	0.016663	71.135	71.151	172.11	975.4	1147.5	0.3001	1.4697	1.7698	436.0
440.0	13.034	0.016676	69.972	69.988	174.12	974.2	1148.3	0.3031	1.4634	1.7665	440.0
444.0	13.568	0.016691	68.862	68.878	176.14	972.8	1149.0	0.3061	1.4571	1.7632	444.0
448.0	14.119	0.016703	67.799	67.815	178.15	971.6	1149.8	0.3091	1.4509	1.7600	448.0
452.0	14.691	0.016719	66.782	66.799	180.17	970.3	1150.5	0.3121	1.4447	1.7568	452.0
456.0	15.281	0.016732	65.808	65.824	182.18	969.0	1151.2	0.3151	1.4385	1.7536	456.0
460.0	15.901	0.016747	64.878	64.894	184.20	967.8	1152.0	0.3181	1.4323	1.7505	460.0
464.0	16.540	0.016761	63.988	64.004	186.22	966.5	1152.7	0.3211	1.4262	1.7473	464.0
468.0	17.186	0.016775	63.131	63.148	188.23	965.2	1153.4	0.3241	1.4201	1.7442	468.0
472.0	17.856	0.016789	62.309	62.326	190.25	963.9	1154.2	0.3270	1.4140	1.7411	472.0
476.0	18.556	0.016805	61.529	61.545	192.27	962.6	1154.9	0.3300	1.4081	1.7380	476.0
480.0	19.215	0.016818	60.776	60.793	194.29	961.3	1155.6	0.3329	1.4021	1.7350	480.0
484.0	19.895	0.016834	60.056	60.073	196.31	960.0	1156.3	0.3359	1.3961	1.7320	484.0
488.0	20.595	0.016849	59.364	59.381	198.33	958.7	1157.0	0.3388	1.3902	1.7290	488.0
492.0	21.567	0.016864	58.701	58.718	200.35	957.4	1157.8	0.3417	1.3842	1.7260	492.0
496.0	23.216	0.016895	57.454	57.471	204.40	954.8	1159.2	0.3476	1.3725	1.7201	496.0
500.0	24.968	0.016926	56.304	56.321	208.45	952.1	1160.6	0.3533	1.3609	1.7142	500.0
504.0	26.826	0.016958	55.243	55.260	212.50	949.5	1162.0	0.3591	1.3494	1.7085	504.0
508.0	28.799	0.016990	54.264	54.281	216.56	946.8	1163.4	0.3649	1.3379	1.7028	508.0
512.0	30.883	0.017022	53.358	53.375	220.62	944.1	1164.7	0.3706	1.3266	1.6972	512.0
516.0	33.091	0.017056	52.520	52.538	224.69	941.4	1166.1	0.3763	1.3154	1.6917	516.0
520.0	35.427	0.017089	51.745	51.762	228.76	938.6	1167.4	0.3819	1.3043	1.6862	520.0
524.0	37.894	0.017123	51.025	51.042	232.83	935.9	1168.7	0.3876	1.2933	1.6808	524.0
528.0	40.500	0.017157	50.358	50.375	236.91	933.1	1170.0	0.3932	1.2823	1.6755	528.0
532.0	43.249	0.017193	49.738	49.755	240.99	930.3	1171.3	0.3987	1.2715	1.6702	532.0
536.0	46.147	0.017228	49.162	49.180	245.08	927.5	1172.5	0.4043	1.2607	1.6650	536.0
540.0	49.200	0.017264	48.627	48.644	249.17	924.6	1173.8	0.4098	1.2501	1.6599	540.0
544.0	52.414	0.01730	48.128	48.145	253.3	921.7	1175.0	0.4154	1.2395	1.6548	544.0
548.0	55.795	0.01734	47.663	47.680	257.4	918.8	1176.2	0.4208	1.2290	1.6498	548.0
552.0	59.350	0.01738	47.230	47.247	261.5	915.9	1177.4	0.4263	1.2186	1.6449	552.0
556.0	63.084	0.01741	46.826	46.843	265.6	913.0	1178.6	0.4317	1.2082	1.6400	556.0
560.0	67.005	0.01745	46.448	46.458	269.7	910.0	1179.7	0.4372	1.1979	1.6351	560.0
564.0	71.119	0.01749	46.095	46.130	273.8	907.0	1180.9	0.4426	1.1877	1.6303	564.0
568.0	75.433	0.01753	45.765	45.780	278.0	904.0	1182.0	0.4479	1.1776	1.6256	568.0
572.0	79.953	0.01757	45.456	45.472	282.1	901.0	1183.1	0.4533	1.1676	1.6209	572.0
576.0	84.688	0.01761	45.167	45.184	286.3	897.9	1184.1	0.4586	1.1576	1.6162	576.0
580.0	89.643	0.01766	44.896	44.913	290.4	894.8	1185.2	0.4640	1.1477	1.6116	580.0
584.0	94.826	0.01770	44.641	44.659	294.6	891.6	1186.2	0.4692	1.1378	1.6071	584.0
588.0	100.245	0.01774	44.400	44.418	298.7	888.5	1187.2	0.4745	1.1280	1.6025	588.0
592.0	105.907	0.01779	44.173	44.191	302.9	885.3	1188.2	0.4798	1.1183	1.5981	592.0
596.0	111.820	0.01783	43.958	43.976	307.1	882.1	1189.1	0.4850	1.1086	1.5936	596.0
600.0	117.992	0.01787	43.755	43.773	311.3	878.8	1190.1	0.4902	1.0990	1.5892	600.0
604.0	124.430	0.01792	43.563	43.581	315.5	875.5	1191.0	0.4954	1.0894	1.5849	604.0
608.0	131.142	0.01797	43.378	43.396	319.7	872.2	1191.1	0.5006	1.0799	1.5806	608.0
612.0	138.138	0.01801	43.203	43.221	323.9	868.9	1192.7	0.5058	1.0705	1.5763	612.0
616.0	145.424	0.01806	43.036	43.054	328.1	865.5	1193.6	0.5110	1.0611	1.5721	616.0
620.0	153.010	0.01811	42.877	42.895	332.3	862.1	1194.4	0.5161	1.0517	1.5678	620.0
624.0	160.903	0.01816	42.726	42.744	336.5	858.6	1195.2	0.5212	1.0424	1.5637	624.0
628.0	169.113	0.01821	42.581	42.599	340.8	855.1	1195.9	0.5263	1.0331	1.5594	628.0
632.0	177.648	0.01826	42.443	42.461	345.0	851.6	1196.7	0.5314	1.0240	1.5554	632.0
636.0	186.517	0.01831	42.312	42.330	349.3	848.1	1197.4	0.5365	1.0148	1.5513	636.0
640.0	195.729	0.01836	42.187	42.205	353.6	844.5	1198.0	0.5416	1.0057	1.5473	640.0
644.0	205.294	0.01842	42.069	42.087	357.9	840.8	1198.7	0.5466	0.9966	1.5432	644.0
648.0	215.220	0.01847	41.956	41.974	362.2	837.2	1199.3	0.5516	0.9876	1.5392	648.0
652.0	225.516	0.01853	41.849	41.867	366.5	833.4	1199.9	0.5567	0.9786	1.5352	652.0
656.0	236.193	0.01858	41.747	41.765	370.8	829.7	1200.4	0.5617	0.9695	1.5312	656.0
660.0	247.259	0.01864	41.649	41.667	375.1	825.9	1201.0	0.5667	0.9605	1.5272	660.0
664.0	258.725	0.01870	41.556	41.574	379.4	822.0	1201.5	0.5717	0.9516	1.5234	664.0
668.0	270.600	0.01875	41.467	41.486	383.8	818.2	1202.0	0.5766	0.9426	1.5195	668.0
672.0	282.894	0.01881	41.382	41.400	388.1	814.2	1202.4	0.5816	0.9336	1.5157	672.0
676.0	295.617	0.01887	41.302	41.320	392.5	810.2	1202.8	0.5866	0.9247	1.5118	676.0
680.0	308.780	0.01894	41.225	41.244	396.9	806.2	1203.1	0.5915	0.9158	1.5080	680.0
684.0	322.391	0.01900	41.152	41.171	401.3	802.2	1203.5	0.5964	0.9069	1.5042	684.0
688.0	336.463	0.01906	41.082	41.101	405.7	798.0	1203.7	0.6014	0.8980	1.5004	688.0
692.0	351.00	0.01913	41.016	41.035	410.1	793.9	1204.0	0.6063	0.8892	1.4966	692.0
696.0	366.03	0.01919	40.953	40.972	414.6	789.7	1204.2	0.6112	0.8803	1.4928	696.0
700.0	381.54	0.01926	40.893	40.912	419.0	785.4	1204.4	0.6161	0.8715	1.4890	700.0
704.0	397.56	0.01933	40.836	40.855	423.5	781.1	1204.6	0.6210	0.8627	1.4853	704.0
708.0	414.09	0.01940	40.782	40.801	428.0	776.7	1204.7	0.6259	0.8539	1.4815	708.0
712.0	431.14	0.01947	40.731	40.750	432.5	772.3	1204.8	0.6308	0.8451	1.4778	712.0
716.0	448.73	0.01954	40.682	40.702	437.0	767.8	1204.8	0.6356	0.8363	1.4741	716.0

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

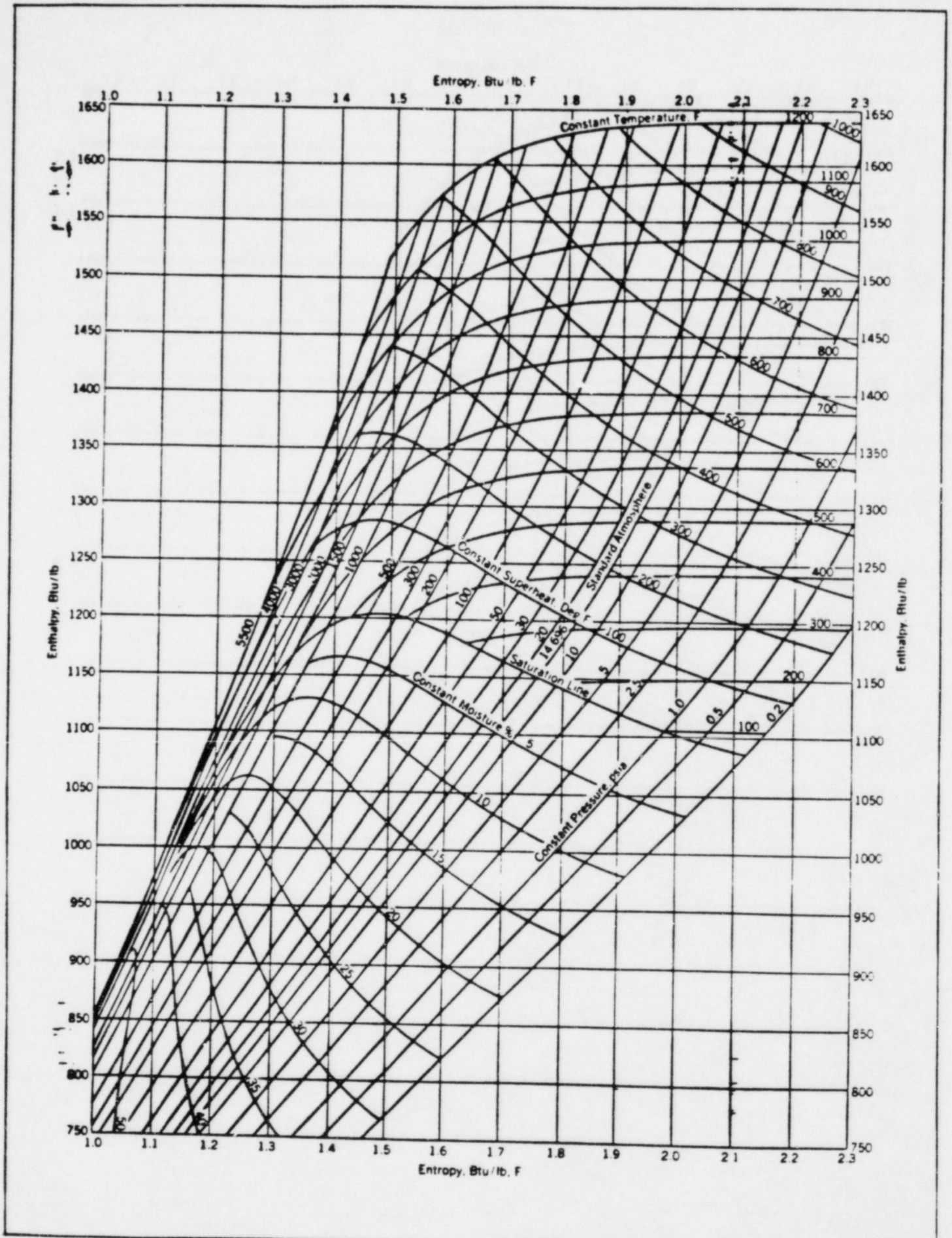
Temp Fahr t	Abs Press Lb per Sq In p	Specific Volume Sat Liquid v_f	Specific Volume Evap v_{fg}	Specific Volume Sat Vapor v_g	Enthalpy Sat Liquid h_f	Enthalpy Evap h_{fg}	Enthalpy Sat Vapor h_g	Entropy Sat Liquid s_f	Entropy Evap s_{fg}	Entropy Sat Vapor s_g	Temp Fahr t
460.0	466.87	0.01961	0.97463	0.99424	441.5	763.2	1204.8	0.6405	0.8299	1.4704	460.0
464.0	485.56	0.01969	0.93588	0.95557	446.1	758.6	1204.7	0.6454	0.8213	1.4667	464.0
468.0	504.83	0.01976	0.89885	0.91862	450.7	754.0	1204.6	0.6502	0.8127	1.4629	468.0
472.0	524.67	0.01984	0.86345	0.88329	455.2	749.3	1204.5	0.6551	0.8042	1.4592	472.0
476.0	545.11	0.01992	0.82958	0.84950	459.9	744.5	1204.3	0.6599	0.7956	1.4555	476.0
480.0	566.15	0.02000	0.79716	0.81717	464.5	739.6	1204.1	0.6648	0.7871	1.4518	480.0
484.0	587.81	0.02009	0.76613	0.78622	469.1	734.7	1203.8	0.6696	0.7785	1.4481	484.0
488.0	610.10	0.02017	0.73641	0.75658	473.8	729.7	1203.5	0.6745	0.7700	1.4444	488.0
492.0	633.03	0.02026	0.70794	0.72820	478.5	724.6	1203.1	0.6793	0.7614	1.4407	492.0
496.0	656.61	0.02034	0.68065	0.70100	483.2	719.5	1202.7	0.6842	0.7528	1.4370	496.0
500.0	680.86	0.02043	0.65448	0.67492	487.9	714.3	1202.2	0.6890	0.7443	1.4333	500.0
504.0	705.78	0.02053	0.62938	0.64991	492.7	709.0	1201.7	0.6939	0.7357	1.4296	504.0
508.0	731.40	0.02062	0.60530	0.62592	497.5	703.7	1201.1	0.6987	0.7271	1.4258	508.0
512.0	757.72	0.02072	0.58218	0.60289	502.3	698.2	1200.5	0.7036	0.7185	1.4221	512.0
516.0	784.76	0.02081	0.55997	0.58079	507.1	692.7	1199.8	0.7085	0.7099	1.4183	516.0
520.0	812.53	0.02091	0.53864	0.55956	512.0	687.0	1199.0	0.7133	0.7013	1.4146	520.0
524.0	841.04	0.02102	0.51814	0.53916	516.9	681.3	1198.2	0.7182	0.6926	1.4108	524.0
528.0	870.31	0.02112	0.49843	0.51955	521.8	675.5	1197.3	0.7231	0.6839	1.4070	528.0
532.0	900.34	0.02123	0.47947	0.50070	526.8	669.6	1196.4	0.7280	0.6752	1.4032	532.0
536.0	931.17	0.02134	0.46123	0.48257	531.7	663.6	1195.4	0.7329	0.6665	1.3993	536.0
540.0	962.79	0.02146	0.44367	0.46513	536.8	657.5	1194.3	0.7378	0.6577	1.3954	540.0
544.0	995.22	0.02157	0.42677	0.44834	541.8	651.3	1193.1	0.7427	0.6489	1.3915	544.0
548.0	1028.49	0.02169	0.41048	0.43217	546.9	645.0	1191.9	0.7476	0.6400	1.3876	548.0
552.0	1062.59	0.02182	0.39479	0.41660	552.0	638.5	1190.6	0.7525	0.6311	1.3837	552.0
556.0	1097.55	0.02194	0.37966	0.40160	557.2	632.0	1189.2	0.7575	0.6222	1.3797	556.0
560.0	1133.38	0.02207	0.36507	0.38714	562.4	625.3	1187.7	0.7625	0.6132	1.3757	560.0
564.0	1170.10	0.02221	0.35099	0.37320	567.6	618.5	1186.1	0.7674	0.6041	1.3716	564.0
568.0	1207.72	0.02235	0.33741	0.35975	572.9	611.5	1184.5	0.7725	0.5950	1.3675	568.0
572.0	1246.26	0.02249	0.32429	0.34678	578.3	604.5	1182.7	0.7775	0.5859	1.3634	572.0
576.0	1285.74	0.02264	0.31162	0.33426	583.7	597.2	1180.9	0.7825	0.5766	1.3592	576.0
580.0	1326.17	0.02279	0.29937	0.32216	589.1	589.9	1179.0	0.7876	0.5673	1.3550	580.0
584.0	1367.7	0.02295	0.28753	0.31048	594.6	582.4	1176.9	0.7927	0.5580	1.3507	584.0
588.0	1410.0	0.02311	0.27608	0.29919	600.1	574.7	1174.8	0.7978	0.5485	1.3464	588.0
592.0	1453.3	0.02328	0.26499	0.28827	605.7	566.8	1172.6	0.8030	0.5390	1.3420	592.0
596.0	1497.8	0.02345	0.25425	0.27770	611.4	558.8	1170.2	0.8082	0.5293	1.3375	596.0
600.0	1543.2	0.02364	0.24384	0.26747	617.1	550.6	1167.7	0.8134	0.5196	1.3330	600.0
604.0	1589.7	0.02382	0.23374	0.25757	622.9	542.2	1165.1	0.8187	0.5097	1.3284	604.0
608.0	1637.3	0.02400	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	0.17265	685.9	443.1	1129.0	0.8746	0.4015	1.2761	644.0
648.0	2178.1	0.02657	0.13876	0.16534	692.9	431.1	1124.0	0.8806	0.3893	1.2699	648.0
652.0	2239.2	0.02691	0.13124	0.15816	700.0	418.7	1118.7	0.8868	0.3767	1.2634	652.0
656.0	2301.7	0.02728	0.12387	0.15115	707.4	405.7	1113.1	0.8931	0.3637	1.2567	656.0
660.0	2365.7	0.02768	0.11663	0.14431	714.9	392.1	1107.0	0.8995	0.3502	1.2498	660.0
664.0	2431.1	0.02811	0.10947	0.13757	722.9	377.7	1100.6	0.9064	0.3361	1.2425	664.0
668.0	2498.1	0.02858	0.10229	0.13087	731.5	362.1	1093.5	0.9137	0.3210	1.2347	668.0
672.0	2566.6	0.02911	0.09514	0.12424	740.2	345.7	1085.9	0.9212	0.3054	1.2266	672.0
676.0	2636.8	0.02970	0.08799	0.11769	749.2	328.5	1077.6	0.9287	0.2892	1.2179	676.0
680.0	2708.6	0.03037	0.08080	0.11117	758.5	310.1	1068.5	0.9365	0.2720	1.2086	680.0
684.0	2782.1	0.03114	0.07349	0.10463	768.2	290.2	1058.4	0.9447	0.2537	1.1984	684.0
688.0	2857.4	0.03204	0.06595	0.09799	778.8	268.2	1047.0	0.9535	0.2337	1.1872	688.0
692.0	2934.5	0.03313	0.05797	0.09110	790.5	243.1	1033.6	0.9634	0.2110	1.1744	692.0
696.0	3013.4	0.03455	0.04916	0.08371	804.4	212.8	1017.2	0.9749	0.1841	1.1591	696.0
700.0	3094.3	0.03662	0.03857	0.07519	822.4	172.7	995.2	0.9901	0.1490	1.1390	700.0
702.0	3135.5	0.03824	0.03173	0.06997	835.0	144.7	979.7	1.0006	0.1246	1.1252	702.0
704.0	3177.2	0.04108	0.02192	0.06300	854.2	102.0	956.2	1.0169	0.0876	1.1046	704.0
705.0	3198.3	0.04427	0.01304	0.05730	873.0	61.4	934.4	1.0329	0.0527	1.0856	705.0
705.47*	3208.2	0.05078	0.00000	0.05078	906.0	0.0	906.0	1.0612	0.0000	1.0612	705.47*

*Critical temperature

Table 2: Saturated Steam: Pressure Table

Abs Press Lb/Sq In p	Temp Fahr t	Specific Volume 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	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	1.2167	1.6440	60.0
70.0	302.93	0.017482	6.1875	6.2050	272.7	907.8	1180.6	0.4411	1.1905	1.6316	70.0
80.0	312.04	0.017573	5.4536	5.4711	282.1	900.9	1183.1	0.4534	1.1675	1.6208	80.0
90.0	320.28	0.017659	4.8779	4.8953	290.7	894.6	1185.3	0.4643	1.1470	1.6113	90.0
100.0	327.82	0.017740	4.4133	4.4310	298.5	888.6	1187.2	0.4743	1.1284	1.6027	100.0
110.0	334.79	0.01782	4.0306	4.0484	305.8	883.1	1188.9	0.4834	1.1115	1.5950	110.0
120.0	341.27	0.01789	3.7097	3.7275	312.6	877.8	1190.4	0.4919	1.0960	1.5879	120.0
130.0	347.33	0.01796	3.4364	3.4544	319.0	872.8	1191.7	0.4998	1.0815	1.5813	130.0
140.0	353.04	0.01803	3.2010	3.2190	325.0	868.0	1193.0	0.5071	1.0681	1.5752	140.0
150.0	358.43	0.01809	2.9958	3.0139	330.6	863.4	1194.1	0.5141	1.0554	1.5695	150.0
160.0	363.55	0.01815	2.8155	2.8336	336.1	859.0	1195.1	0.5206	1.0435	1.5641	160.0
170.0	368.42	0.01821	2.6556	2.6738	341.2	854.8	1196.0	0.5269	1.0322	1.5591	170.0
180.0	373.08	0.01827	2.5129	2.5312	346.2	850.7	1196.9	0.5328	1.0215	1.5543	180.0
190.0	377.53	0.01833	2.3847	2.4030	350.9	846.7	1197.6	0.5384	1.0113	1.5498	190.0
200.0	381.80	0.01839	2.2689	2.2873	355.5	842.8	1198.3	0.5438	1.0016	1.5454	200.0
210.0	385.91	0.01844	2.16373	2.18217	359.9	839.1	1199.0	0.5490	0.9923	1.5413	210.0
220.0	389.88	0.01850	2.06779	2.08629	364.2	835.4	1199.6	0.5540	0.9834	1.5374	220.0
230.0	393.70	0.01855	1.97991	1.99846	368.3	831.8	1200.1	0.5588	0.9748	1.5336	230.0
240.0	397.39	0.01860	1.89909	1.91769	372.3	828.4	1200.6	0.5634	0.9665	1.5299	240.0
250.0	400.97	0.01865	1.82452	1.84317	376.1	825.0	1201.1	0.5679	0.9585	1.5264	250.0
260.0	404.44	0.01870	1.75548	1.77418	379.9	821.6	1201.5	0.5722	0.9508	1.5230	260.0
270.0	407.80	0.01875	1.69137	1.71013	383.6	818.3	1201.9	0.5764	0.9433	1.5197	270.0
280.0	411.07	0.01880	1.63169	1.65049	387.1	815.1	1202.3	0.5805	0.9361	1.5166	280.0
290.0	414.25	0.01885	1.57597	1.59482	390.6	812.0	1202.6	0.5844	0.9291	1.5135	290.0
300.0	417.35	0.01889	1.52384	1.54274	394.0	808.9	1202.9	0.5882	0.9223	1.5105	300.0
350.0	431.73	0.01912	1.30642	1.32554	409.8	794.2	1204.0	0.6059	0.8909	1.4968	350.0
400.0	444.60	0.01934	1.14162	1.16095	424.2	780.4	1204.6	0.6217	0.8630	1.4847	400.0
450.0	456.28	0.01954	1.01224	1.03179	437.3	767.5	1204.8	0.6360	0.8378	1.4738	450.0
500.0	467.01	0.01975	0.90787	0.92762	449.5	755.1	1204.7	0.6490	0.8148	1.4639	500.0
550.0	476.94	0.01994	0.82183	0.84177	460.9	743.3	1204.3	0.6611	0.7936	1.4547	550.0
600.0	486.20	0.02013	0.74962	0.76975	471.7	732.0	1203.7	0.6723	0.7738	1.4461	600.0
650.0	494.89	0.02032	0.68811	0.70843	481.9	720.9	1202.8	0.6828	0.7552	1.4381	650.0
700.0	503.08	0.02050	0.63505	0.65556	491.6	710.2	1201.8	0.6928	0.7377	1.4304	700.0
750.0	510.84	0.02069	0.58880	0.60949	500.9	699.8	1200.7	0.7022	0.7210	1.4232	750.0
800.0	518.21	0.02087	0.54809	0.56896	509.8	689.6	1199.4	0.7111	0.7051	1.4163	800.0
850.0	525.24	0.02105	0.51197	0.53302	518.4	679.5	1198.0	0.7197	0.6899	1.4096	850.0
900.0	531.95	0.02123	0.47968	0.50091	526.7	669.7	1196.4	0.7279	0.6753	1.4032	900.0
950.0	538.39	0.02141	0.45064	0.47205	534.7	660.0	1194.7	0.7358	0.6612	1.3970	950.0
1000.0	544.58	0.02159	0.42436	0.44596	542.6	650.4	1192.9	0.7434	0.6476	1.3910	1000.0
1050.0	550.53	0.02177	0.40047	0.42224	550.1	640.9	1191.0	0.7507	0.6344	1.3851	1050.0
1100.0	556.28	0.02195	0.37863	0.40058	557.5	631.5	1189.1	0.7578	0.6216	1.3794	1100.0
1150.0	561.82	0.02214	0.35859	0.38073	564.8	622.2	1187.0	0.7647	0.6091	1.3738	1150.0
1200.0	567.19	0.02232	0.34013	0.36245	571.9	613.0	1184.8	0.7714	0.5969	1.3683	1200.0
1250.0	572.38	0.02250	0.32306	0.34556	578.8	603.8	1182.6	0.7780	0.5850	1.3630	1250.0
1300.0	577.42	0.02269	0.30722	0.32991	585.6	594.6	1180.2	0.7843	0.5733	1.3577	1300.0
1350.0	582.32	0.02288	0.29250	0.31537	592.3	585.4	1177.8	0.7906	0.5620	1.3525	1350.0
1400.0	587.07	0.02307	0.27871	0.30178	598.8	576.5	1175.3	0.7966	0.5507	1.3474	1400.0
1450.0	591.70	0.02327	0.26584	0.28911	605.3	567.4	1172.8	0.8026	0.5397	1.3423	1450.0
1500.0	596.20	0.02346	0.25372	0.27719	611.7	558.4	1170.1	0.8085	0.5288	1.3373	1500.0
1550.0	600.59	0.02366	0.24235	0.26601	618.0	549.4	1167.4	0.8142	0.5182	1.3324	1550.0
1600.0	604.87	0.02387	0.23159	0.25545	624.2	540.3	1164.5	0.8199	0.5076	1.3274	1600.0
1650.0	609.05	0.02407	0.22143	0.24551	630.4	531.3	1161.6	0.8254	0.4971	1.3225	1650.0
1700.0	613.13	0.02428	0.21178	0.23607	636.5	522.2	1158.6	0.8309	0.4867	1.3176	1700.0
1750.0	617.12	0.02450	0.20263	0.22713	642.5	513.1	1155.6	0.8363	0.4765	1.3128	1750.0
1800.0	621.02	0.02472	0.19390	0.21861	648.5	503.8	1152.3	0.8417	0.4662	1.3079	1800.0
1850.0	624.83	0.02495	0.18558	0.21052	654.5	494.6	1149.0	0.8470	0.4561	1.3030	1850.0
1900.0	628.56	0.02517	0.17761	0.20278	660.4	485.2	1145.6	0.8522	0.4459	1.2981	1900.0
1950.0	632.22	0.02541	0.16999	0.19540	666.3	475.8	1142.0	0.8574	0.4358	1.2931	1950.0
2000.0	635.80	0.02565	0.16266	0.18831	672.1	466.2	1138.3	0.8625	0.4256	1.2881	2000.0
2100.0	642.76	0.02615	0.14885	0.17501	683.8	446.7	1130.5	0.8727	0.4053	1.2780	2100.0
2200.0	649.45	0.02669	0.13603	0.16272	695.5	426.7	1122.2	0.8828	0.3848	1.2676	2200.0
2300.0	655.89	0.02727	0.12406	0.15133	707.2	406.0	1113.2	0.8929	0.3640	1.2569	2300.0
2400.0	662.11	0.02790	0.11287	0.14076	719.0	384.8	1103.7	0.9031	0.3430	1.2460	2400.0
2500.0	668.11	0.02859	0.10209	0.13068	731.7	361.6	1093.3	0.9139	0.3206	1.2345	2500.0
2600.0	673.91	0.02938	0.09172	0.12110	744.5	337.6	1082.0	0.9247	0.2977	1.2225	2600.0
2700.0	679.53	0.03029	0.08165	0.11194	757.3	312.3	1069.7	0.9356	0.2741	1.2097	2700.0
2800.0	684.96	0.03134	0.07171	0.10305	770.7	285.1	1055.8	0.9468	0.2491	1.1958	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
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.

QUESTION 5.01 (2.50)

a. Explain the effect of rod position on the Moderator Temperature Coefficient (MTC). Consider only rods inserted or withdrawn at power and disregard any effects of changes in boron concentration. (1.5)

b. Explain how and why the magnitude of MTC will vary with RCS temperature. (1.0)

QUESTION 5.02 (3.00)

a. The heat flux at a particular position in a reactor is 4x10 5 BTU/HR.-SQ.FT. The DNBR is 3.2. Determine the Critical Heat Flux (CHF) at this location. (1.0)

b. How will the CHF vary with the following: (each increase separately)

1. Coolant flow rate ?
2. Reactor coolant pressure ?
3. Reactor coolant quality ? (1.2)

c. What is the limiting DNBR for the PI facility and why must it be operated at or above this limit ? (0.8)

QUESTION 5.03 (1.50)

The speed of a centrifugal pump is decreased to half its initial value. Given the following initial conditions, what are the final conditions.

1. Fluid Horsepower	25 HP
2. Flow	45 gpm
3. Head	250 psi

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

QUESTION 5.04 (3.00)

Assume that your plant has experienced a degraded electrical power condition and that you are monitoring the plant's cooldown on natural circulation. Explain WHY you agree or disagree with the following statements:

A. A slow downward trend in narrow range Tave is a good indication of well-established natural circulation flow. (1.0)

B. A difference between wide-range T h and wide-range T c of 65~F and slowly increasing indicates developing natural circulation flow. (1.0)

C. Natural circulation flow rate can be increased by increasing the steam flow rate. (1.0)

QUESTION 5.05 (.75)

Choose the CORRECT response. The Importance Factor at Prairie Island is _____ than one because delayed neutrons _____.

(a) less; are less likely to leak from the core.

(b) less; do not cause fast fission of U-238.

(c) greater; are less likely to leak from the core.

(d) greater; do not cause fast fission of U-238.

QUESTION 5.06 (.75)

Choose the CORRECT response. The isothermal temperature coefficient is the sum of the moderator temperature coefficient and the:

(a) fuel temperature coefficient when power is below the point of adding heat.

(b) power coefficient when power is below the point of adding heat.

(c) fuel temperature coefficient when power is above the point of adding heat.

(d) power coefficient when power is above the point of adding heat.

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

QUESTION 5.07 (.75)

Choose the CORRECT response. "Shutdown Margin" as used in Technical Specification 3.10 is the amount by which the reactor core would be sub-critical at hot shutdown conditions if all control rods were tripped, assuming:

(a) normal hot channel factors are maintained, and assuming no changes in xenon or boron concentrations.

(b) that the highest worth control rod assembly remained fully withdrawn, and assuming xenon-free conditions and no changes in boron concentrations.

(c) normal hot channel factors are maintained, and assuming xenon-free conditions and no changes in boron concentration.

(d) that the highest worth control rod assembly remained fully withdrawn, and assuming no changes in xenon or boron concentration.

QUESTION 5.08 (.75)

Choose the CORRECT response. In which of the following situations will the further insertion of control rods cause Delta I to become more positive?

(a) Buildup of Xenon in the top of the core with rods fully withdrawn.

(b) Positive MTC during a reactor startup.

(c) Bank D control rods inserted to the core midplane.

(d) Excessively negative MTC at EOL.

QUESTION 5.09 (.75)

With the plant operating at 85% steady state power and all the P.I. systems in their normal/automatic configuration, the operator borates 100 pcm. SHUTDOWN MARGIN will .....

1) increase
2) increase until rods move
3) decrease
4) decrease until rods move
5) remain unchanged, whether or not the rods move

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

QUESTION 5.10 (1.00)

The reactor is critical and leveled off at 10-8 amps. Both RCP's are operating and the steam dump system is maintaining Tave. The main condenser dump valve fails open.
At what power level, if at all, will the reactor level off?

QUESTION 5.11 (1.00)

Compare the estimated critical position (ECP) for a startup 15 hours after a trip to the actual critical rod position (ACP) for the following events or conditions. Consider each independently. Indicate whether the ACP will be higher than, lower than or the same as the ECP.

a. All steam generator levels are raised by 10% 5 minutes prior to startup.

b. The steam dump pressure setpoint is increased to a value just below the lowest code safety setpoint.

c. The startup is delayed two more hours.

d. Condenser vacuum is decreased by 2 inches of mercury.

QUESTION 5.12 (.75)

Choose the CORRECT response concerning pump shutoff head for a centrifugal pump.

(a) The excessive flow rate which exists at shutoff head will cause vibrations which may result in pump damage.

(b) Pump shutoff head is the pump head which exists at the onset of cavitation.

(c) Centrifugal pumps must not be started at shutoff head to avoid drawing starting current for an excessive amount of time.

(d) At pump shutoff head the resistance to flow is greater than the power which the pump can impart to the fluid.

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

QUESTION 5.13 (.75)

Choose the CORRECT response. Steam generator shrink occurs due to the:

(a) rapid increase in steam generator pressure when turbine power suddenly increases.

(b) rapid formation of bubbles forcing additional water into the moisture separators.

(c) rapid decrease in first stage pressure on a down-power transient causing a reduced steam generator level setpoint.

(d) rapid increase in steam generator pressure when turbine power suddenly decreases.

QUESTION 5.14 (3.00)

a. Power defect changes over core life. Of the coefficients that contribute to power defect, which contributes most to this change over core life? EXPLAIN (1.0)

b. Explain why power defect is desireable for reactor operation at power. (1.0)

c. Which of the reactivity coefficients that contribute to power defect act first to affect reactivity on a sudden power change due to rod movement? EXPLAIN WHY. (1.0)

QUESTION 5.15 (2.50)

a. Provide two conditions necessary for Brittle Fracture of a carbon steel pressure vessel to occur. (.50)

b. Define RT NDT (Nil-Ductility Reference Temperature). (1.0)

c. How does RT NDT change as the reactor vessel ages? Briefly EXPLAIN your answer. (1.0)

QUESTION 5.16 (1.50)

List three effects which would cause the Power Range indications to increase over core life. (NI's will be adjusted down)

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

QUESTION 5.17 (.75)

While conducting a plant startup, the operator planned a rod pull for a for a SUR of .75 dpm from 5*10 -8 amps but instead of withdrawning the rods he inserted the rods. Explain what the new startup rate will be?

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

QUESTION 6.01 (1.00)

On a decreasing pressure in the Fire Protection System state what events occur at the following pressures?
a) 120 psig
b) 105 psig
c) 95 psig
d) 90 psig

QUESTION 6.02 (2.00)

List the five conditions required for the emergency on site source breaker to close if the primary off site source and secondary off site source fail to restore the bus.

QUESTION 6.03 (1.00)

If LITE " SI PUMP NOT READY "was illuminated it would signify, (choose one)
a)the local/remote switch for the SI pump is in local position
b)a Safety Injection signal is present and the SI control room switch is in stop position
c)the SI pump switch in the control room is in " pull to lock " position
d)a Safety injection signal is present but there is a loss of safeguards bus power to the running SI pump

QUESTION 6.04 (2.00)

a) Include the setpoints and coincidences required for a "L" signal to be generated. (1.0)
b) List the two automatic equipment actions which occur when a "L" signal is generated. (1.0)

QUESTION 6.05 (2.00)

a)Why are the high head SI to reactor vessel nozzle supply valves "closed" when aligned for ECCS standby operation? (1.0)
b)List two reasons why the high head SI to reactor vessel isolation valves are "closed" during cold shutdown. (1.0)

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

QUESTION 6.06 (1.00)

What setpoints are required to manually initiate the recirculation phase for the containment spray system? (include coincidence if necessary)

QUESTION 6.07 (1.00)

Explain how the containment vessel has negative pressure protection during a containment isolation signal if the containment differential pressure is trending upwards greater than .4 psid.

QUESTION 6.08 (.50)

If left in automatic control, in what position should PCV-135 (letdown pressure control valve) be found two minutes after a safety injection initiation?

QUESTION 6.09 (1.00)

Why does the non running component cooling water pump start when the D.C. Transfer switch for the 4.16KV safeguards bus is transferred from its primary/alternate source?

QUESTION 6.10 (1.00)

What systems in the plant are available for determining containment hydrogen concentration? List two

QUESTION 6.11 (2.50)

a)Explain the one difference between Train A and Train B of the auxiliary building special ventilation system (ABSVZ) in their plant/control room indications when both are "started" by a safety injection signal.
b)Explain the response of each train of (ABSVZ) when "stopping" each train after they were started by the Safety injection signal. (1.

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

QUESTION 6.12 (1.00)

The steam flow signal sent to the RPS is density compensated but the steam flow signal sent to the ESF is not density compensated. Why does the Engineered Safeguards System use an uncompensated signal? (list one reason)

QUESTION 6.13 (.75)

List the signals required to initate a steam line isolation on an affected steam line.

QUESTION 6.14 (3.00)

A. Why do the Reactor Containment Fan Coolers (RCFC) automatically shift (or start) to slow speed following an SIS signal? (1.0)

B. How is RCFC affected on an SIS signal? (Include a description of the flow path.) (1.0)

C. List four signals that will cause Containment Ventilation isolation. (1.0)

QUESTION 6.15 (3.25)

a. With the Main Turbine Control System (MTC) selected to OPERATOR AUTO, state the signals used for the reference AND feedback when in:

1. IMP IN.
2. IMP OUT. (1.0)

b. List three conditions that will cause the MTC to switch to MANUAL. (0.75)

c. List six conditions that will actuate the 20/ET backup solenoid in the Emergency Trip Control Block circuit in the MTC. (1.5)

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

QUESTION 6.16 (2.00)

Describe the operation of a hydrogen recombiner unit. Include in the description how the hydrogen is drawn in, the process that takes place, and specifically how the hydrogen is removed. (2.0)

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

QUESTION 7.01 (1.00)

Prairie Island procedure on dampening Delta I oscillations on a large xenon transient is to react to the swing with rod movement.
Plot on part B the general trace you would expect on the C-panel stripchart when the rods are moved by procedure to dampen the xenon oscillations.
(see figure 7.1)

QUESTION 7.02 (.50)

List two cases in which the CSF status trees are required to be monitored per the ERG's.

QUESTION 7.03 (.50)

If a red terminus is encountered in a CSF status tree, list one action that must be taken by the operator(s)

QUESTION 7.04 (.50)

Choose the CORRECT response. With reactor power at 15%, penalty deviation outside the target band shall be accumulated on a time basis of _____.

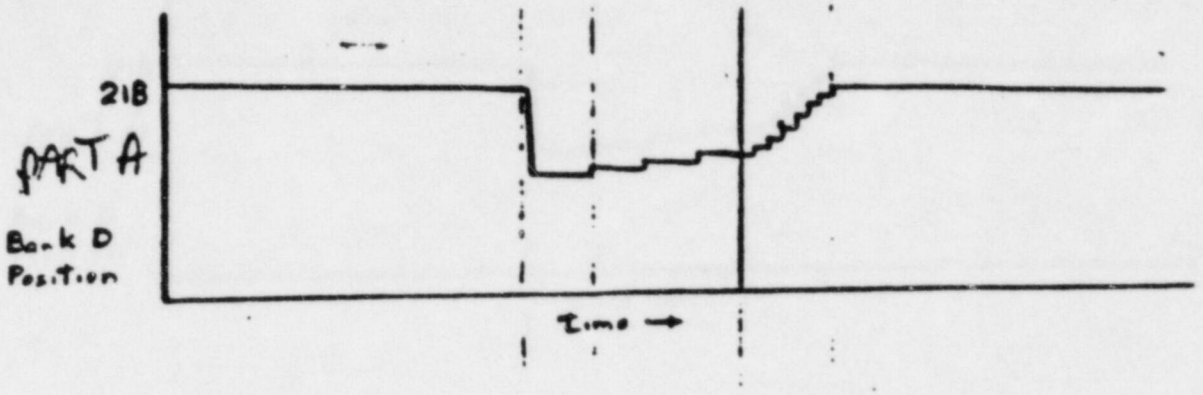
(a) one minute penalty for each one minute outside of the target band.

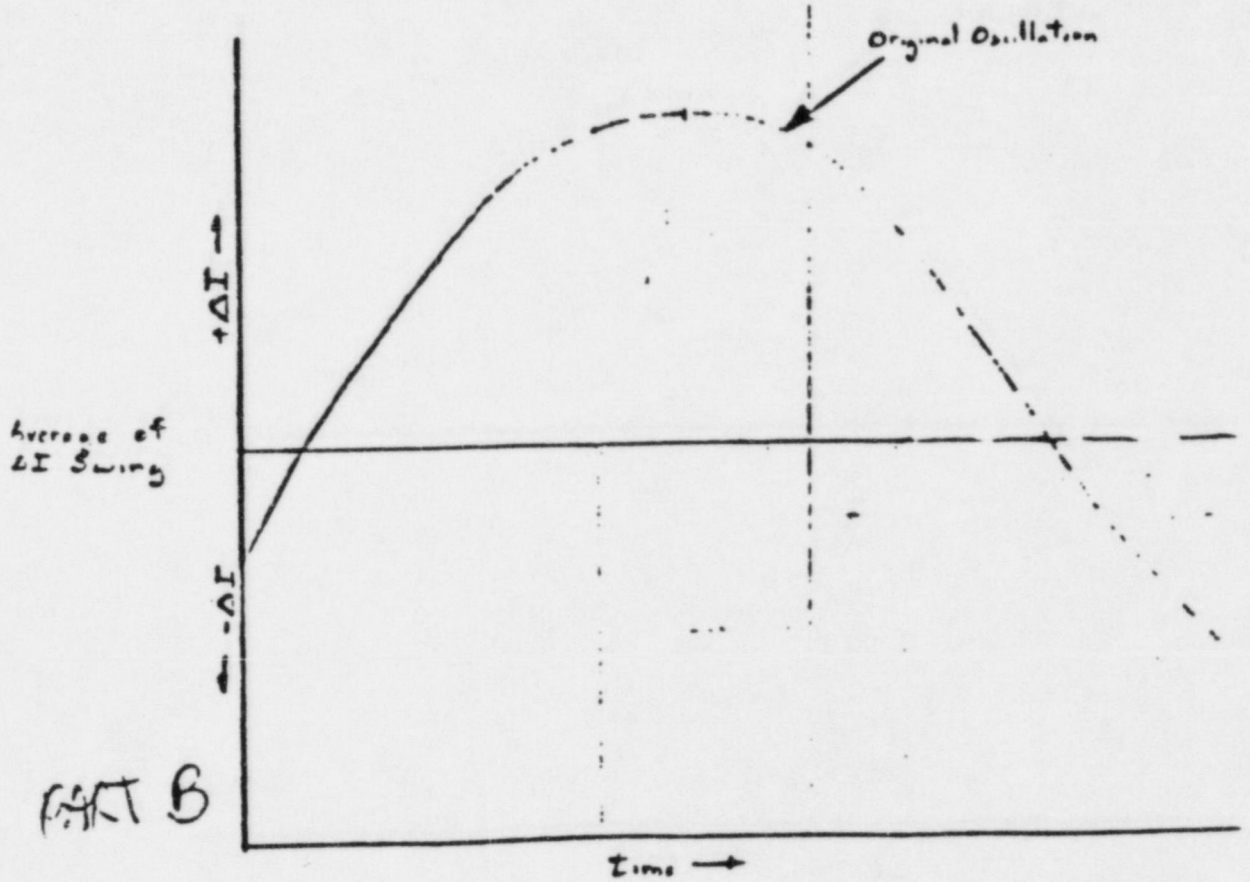
(b) one half minute penalty for each one minute outside of the target band.

(c) one minute penalty for each one half minute outside of the target band.

(d) zero minute penalty for time outside the target band.

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


21B
PART A
Bank D
Position
Time →


Original Oscillation
+ΔI →
Average of
ΔI Swing
← -ΔI
PART B
Time →

(P.91)

QUESTION 7.05 (.50)

Choose the CORRECT response. For a Quadrant Power Tilt Ratio (QPTR) of 1.09 Technical Specification 3.10 requires that the operator:

(a) reduce reactor power to less than 50%.

(b) reduce reactor power to rated power less 2% for every percent that the QPTR exceeds 1.0.

(c) bring the reactor to hot shutdown.

(d) reduce reactor power to less than 85%.

QUESTION 7.06 (3.00)

a. Several requirements that must be met in order to reset SI. Include all options, if any, in accordance with E-0.(list four) (2.0)

b. What two plant conditions require re-initiation of SI? (

c. If SI re-initiation (after being reset) is required will it be automatic? Explain. (0.5)

QUESTION 7.07 (2.25)

The following pertain to Shutdown Outside the Control Room (C1.8).

a. List four immediate duties of the Plant Equipment and Reactor Operator in an evacuation of the control room when conditions do not permit a reactor trip prior to leaving. (1.0)

b. As Xenon decays in the shutdown reactor, Boron must be added to maintain shutdown margin. State five basic steps that must be taken to borate the plant from outside the control room. (1.25)

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

QUESTION 7.08 (1.50)

a. Withdrawing the shutdown banks is administratively controlled in the startup procedure (C1.2). State the two plant conditions that may exempt the shutdown banks from being withdrawn? (2.0)

b. What is the minimum shutdown margin that must be maintained with all shutdown and control banks inserted? (0.5)

QUESTION 7.09 (2.00)

During the performance of C1.8 "Shutdown from outside the control room":

a. Under what circumstance is normal or excess letdown NOT to be established? (0.5)

b. List five alternate methods of establishing a letdown flowpath. (1.5)

QUESTION 7.10 (.50)

Part of the RCP trip criteria states that the RCP cannot be tripped unless RCS pressure if less than 1200 psig or 1500 psig for ADVERSE CONTAINMENT.

Define ADVERSE CONTAINMENT.

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

QUESTION 7.14 (.75)

For each location below, indicate the reactor coolant leakage criteria per the Technical Specification that would apply.

1. Unknown location
2. Through pressurizer code safety valves to the PRT
3. Total steam generator tube leakage

QUESTION 7.15 (1.00)

What procedure/s recommend that the CSF status trees should not be implemented but be monitored for information only?

QUESTION 7.16 (1.50)

List three actions required during a reactor startup if criticality has not been achieved within -/+ 750 pcm of the predicted rod position.

QUESTION 7.17 (1.50)

What are three major groups of operator actions employed to maintain the RCS cooling following a loss of heat sink event?

QUESTION 7.18 (1.00)

All FRG's take precedence over contingency guidelines. TRUE/FALSE

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

QUESTION 8.01 (1.00)

The control switch for no.#12 diesel cooling water pump was mistakenly left in manual for six hours.Unit 1 is at cold shutdown & Unit 2 at 100% power.

As a the SRO of the affected unit,you would (choose one)

a)apply tech/specs and demonstrate immediately that the other diesel generator and its cooling water pump are operable.
b)return the switch to auto for that mispositioned pump switch and the tech/specs that do apply allow for seven days for that pump.
c)return the switch for that diesel cooling water pump to auto and then demonstrate immediately that the pump is operable per tech/specs.
d)return the switch to auto for that pump,consider it operable and don't start the redundant pump and diesel because its not necessary or prudent per tech/specs.

QUESTION 8.02 (1.00)

While borating to a refueling shutdown boron concentration in a hot shutdown condition Prairie Island twice violated the technical specification concerning the boric acid tank level of 2000 gallons.After the second time the plant elected to allow the BAST level to remain below the technical specification of 2000 gallons.
What was the reasoning that the plant used to elect to stay below the technical specification level of the BAST level of 2000 gallons?

QUESTION 8.03 (1.00)

List two people whose responsibilties include ordering a HOLD card to be removed or installed.

QUESTION 8.04 (1.00)

Fire Brigade composition may be less than_____ for a period of time not to exceed_____ hours in order to accomodate unexpected absence of fire brigade members

QUESTION 8.05 (.50)

An open switch with a Secure card attached can be closed upon the direct order of a Power System/Operator. TRUE/FALSE

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

QUESTION 8.06 (1.00)

What responsibility of the Emergency Director cannot be delegated to another individual?

QUESTION 8.07 (.50)

Immediate first aid shall take precedence over contamination control in the event of a serious injury. true/false

QUESTION 8.08 (.75)

On a large radioactive spill emergency, the Shift Supervisor requires the emergency team members to wear protective clothing due to high airborne radioactivity.
List the two protective clothing required for the emergency team.

QUESTION 8.09 (1.00)

When does the Shift Supervisor review the Bypass Index to verify the accountability of all bypass jumpers,tags

QUESTION 8.10 (1.00)

The Shift Supervisor needs to authorize the removal of a bypass when it is removed in accordance with a standing procedure. true/false

QUESTION 8.11 (2.00)

If a limiting condition for operation has been exceeded and no time limit has been specified by Tech/Specs, what two actions should be taken? (assume 50% power)

QUESTION 8.12 (1.00)

An operator (aware of the ALARA concept) using a checklist in a radiation area can automatically alter the status of a device or component to meet the checklist. true/false

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

QUESTION 8.13 (1.50)

When the "System/Component Returned to Normal" slot is signed by the Shift Supervisor on the Work Request,it signifies that several requirements are satisfied.List three requirements.

QUESTION 8.14 (.50)

The position of a throttled (partially opened) valve can be independently verified by a second person opening or closing and then repositioning the valve. true/false

QUESTION 8.15 (.50)

What shall govern in the event of a conflict between the administrative control directives and the administrative work instruction?

QUESTION 8.16 (1.50)

10 CFR 20 and 10 CFR 50 designates 15 types of events that must be reported to the NRC at once (within one hour). List five separate events that require NRC notification within one hour. Note that listing more than one event that comes under the same heading or type will count as one.

QUESTION 8.17 (1.00)

According to SWI-0-4 (Records Management), what 2 cases will require the retention of specific portions of the Trend Typer output, as opposed to normal disposal? (1.0)

QUESTION 8.18 (1.50)

a. How is entry and exit to the containment by plant personnel required to be documented? (0.75)

b. How does the need for frequent containment entry affect the method of personnel documentation as sited in SWI-0-9 "Operation Section Containment Entry Instructions"? (0.75)

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

QUESTION 8.19 (1.75)

The following pertain to SWI-0-3 "Safeguards Hold Cards & Component Blocking or Locking".

a. How is a component identified as requiring a BLOCK or LOCK? (0.75)

b. Whose permission is required to remove a BLOCK or LOCK? (0.50)

c. True/False

When a block or lock device is removed it is returned to the plant maintenance foreman. (0.5)

QUESTION 8.20 (4.00)

According to PINGP, 5AWI 3.1.1 "Return to Power After Reactor Trip":

a. What three (3) people, by title, must agree that a restart is safe prior to returning the reactor to power? (1.5)

b. Who by job position/title can authorize the plant restart? (0.5)

c. The Operation Committee Review of Reactor Trips must take place if FOUR conditions cannot be agreed upon by certain plant staff, state the 4 conditions? (2.0)

QUESTION 8.21 (1.00)

a. What action must be taken immediately in accordance with Technical Specifications, if RCS pressure has just exceeded 2735 psig while at power? (0.5)

b. What organization authorizes unit restart following the exceeding of a Safety Limit? (0.5)

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

ANSWERS -- PRAIRIE ISLAND 1&2 -86/05/19-REIDINGER, T.

ANSWER 5.01 (2.50)

a. Withdrawing control rods tends to make the coefficient more positive. [0.5] Withdrawing rods effectively increases core size and less neutron leakage occurs. With less leakage any temperature change will result in a smaller reactivity change.[1.0] (1.5)
Will accept opposite affect if explanation of rod insertion.

b. At higher temperatures the rate of density change becomes larger, increasing the magnitude of MTC. (1.0)

REFERENCE
P.I. NUS NET MOD. 3, Chap. 9.2, p. 1-2

ANSWER 5.02 (3.00)

a. DNBR = CHF/Actual flux

CHF = DNBR x Actual flux [0.5]

= 3.2 x (4 x 10 5)

=1.28 x 10 6 BTU/HR. FT 2 [0.5] (1.0)

b. 1. Flow increase = CHF increase
2. Pressure increase = CHF increase
3. Quality increase = CHF decrease [0.4 each] (1.2)

c.1) 1.3 for exxon fuel, 1.17 for Westinghouse fuel [0.3] There is a small uncertainity associated with CHF experimental data so a DNBR > 1 is provided for conservatism. [0.5] Will accept a 95% surety that boiling (DNB) will not occur;i.e. prevent clad failure (0.
2)maintain the integrity of fuel cladding: or preventing fission product release;
(accept either answer)

REFERENCE
P.I. NUS NET MOD. 4, Chap. 8.2, p.1; Chap. 10.2, pp. 5-9,
Lesson Notes p. 82; General Physics Heat Transfer and Fluid Flow, p. 227
Tech/Specs p2.1-1

ANSWERS -- PRAIRIE ISLAND 1&2 -86/05/19-REIDINGER, T.

ANSWER 5.03 (1.50)

1. (25)(0.5)(0.5)(0.5) =3.125 HP

2. (45)(0.5) = 22.5 gpm

3. (250)(0.5)(0.5) = 62.5 psi [0.5 each] (1.5)

REFERENCE
P.I. NUS NET MOD. 4, Chap. 6.2, p.1; 6.4, p. 6

ANSWER 5.04 (3.00)

A. Disagree - Tave is a calculated indication and one parameter decreasing will cause Tave to decrease giving a false indication. Agree-If other indication is used in conjunction with Tave. (1.0)
Note: Will also accept disagree due to inaccurate flow through the bypass manifold during natural circulation.

B. Disagree - Natural Circulation is indicated by T h stabilizing then tends to decrease and the T c and T h dT tends to decrease as decay heat decreases. (1.0)

C. Agree - Lowering steam pressure will lower saturation temp which will increase heat transfer across the tubes. Will also accept disagree if mention that a rapid increase in steam flow may stop Natural Circulation. (1.0)

REFERENCE
WNTC Thermal and Hydraulic Principles, Chap. 14, p. 27
Training Module VIII -13,para 5.d;III para 1.B.3.4;RO requal exam 1-1.16

ANSWER 5.05 (.75)

(b)

REFERENCE
Lesson Notes for NUS NET Series, p 26

ANSWERS -- PRAIRIE ISLAND 1&2 -86/05/19-REIDINGER, T.

ANSWER 5.06 (.75)

(a)

REFERENCE
Westinghouse Reactor Theory Review Text, p I-5.22

ANSWER 5.07 (.75)

(d)

REFERENCE
TS 3.10-1

ANSWER 5.08 (.75)

(c)

REFERENCE
Lesson Notes for NUS NET Series, P-SOE-78-11

ANSWER 5.09 (.75)

increases

REFERENCE
Reactor Theory p.208

ANSWER 5.10 (1.00)

@7.5%

REFERENCE
PIE chap 1-14b,Reactor theory p211

ANSWERS -- PRAIRIE ISLAND 1&2 -86/05/19-REIDINGER, T.

ANSWER 5.11 (1.00)

a. ACP lower than ECP

b. ACP higher than ECP

c. ACP lower than ECP

d. ACP same as ECP

,25
[.~~25~~ each]

REFERENCE
SRO requal chap 5-5.6

ANSWER 5.12 (.75)

(d)

REFERENCE
Thermal-Hydraulic Principles and Applications to the PWR II, p 10-43
RO requal chap 1-1.12

ANSWER 5.13 (.75)

(d)

REFERENCE
Thermal-Hydraulic Principles and Applications to the PWR II, p 12-53
SRO exam Chap 5-5.12

ANSWERS -- PRAIRIE ISLAND 1&2 -86/05/19-REIDINGER, T.

ANSWER 5.14 (3.00)

a. Moderator Temperature Coefficient (MTC) [0.5] due to an increase (more negative) in MTC as boron concentration is reduced over core life [0.5]. (1.0)

b. Power defect has a stabilizing influence on reactor operation because it resists power changes. (As power increases, power defect adds negative reactivity and as power decreases, power defect adds positive reactivity). (1.0)

c. Doppler (FTC) [0.5]. Fuel temperature changes first [0.5]. (1.0)

REFERENCE
P.I. NUS NET MOD. 3, Chap. 9.3, pp. 3-4

ANSWER 5.15 (2.50)

a. - low temperature
- vessel stress
- pre-existing material flaw

(any two) .25 [0 ~~4~~ ea.] .5 ~~(1.2)~~

b. RT NDT is that temperature at which non-ductile failure will no longer occur. 1.0 ~~(0.5)~~

c. Increases [0.5] because of metal changes due to (fast) neutron irradiation [0.5]. (1.0)

REFERENCE
P.I. NUS NET MOD. 4, Chap. 10.1, pp. 1-13.

ANSWER 5.16 (1.50)

1.less boron at EOL,so more leakage
2.flux shift to outer edges of the core
3.increase in total flux due to fuel burnup

REFERENCE
Theory Review p76

ANSWERS -- PRAIRIE ISLAND 1&2 -86/05/19-REIDINGER, T.

ANSWER 5.17 (.75)

-.325 dpm SUR(.50) to the longest delayed neutron precursor decaying with a mean life of 80 seconds.(.25)

REFERENCE
PI Exam bank Chap 1-21f

ANSWERS -- PRAIRIE ISLAND 1&2 -86/05/19-REIDINGER, T.

ANSWER 6.01 (1.00)

a)jockey pump starts
b)screen wash pump starts
c)motor driven fire pump starts
d)diesel driven fire pump starts
(.25 pt each)

REFERENCE
Fire protection p3

ANSWER 6.02 (2.00)

1)bus undervoltage
2)bus lockout relays-reset
3)diesel gen bkrs c/s-auto
4)diesel gen-95% normal freq/voltage
5)all source breakers to bus are open
(.40 pt each)

REFERENCE
B-20.5 p13 para 3.6

ANSWER 6.03 (1.00)

c

REFERENCE
B-18 p10

ANSWER 6.04 (2.00)

a)lo-lo level <10% (.50),1/2 on two sets in the safeguards selected BAST
b)The SI pump RWST supply isolation valves open
The SI pump BA supply isolation valves close
(.50 pts each)

REFERENCE
B-18A,p13,18

ANSWERS -- PRAIRIE ISLAND 1&2 -86/05/19-REIDINGER, T.

ANSWER 6.05 (2.00)

a)Prevent unneccessary thermal shock(.50)to the reactor vessel in the event of a spurious SI actuation(.50)
a)Prevent overpressurization of the RCS by :
1) valve leakage
2) high discharge pressure of the SI pump
(.50 each)

REFERENCE
B-18A p21,p27;para 4.4

ANSWER 6.06 (1.00)

8%(.25)low low level RWST(.25) and containment pressure(.25)>10 psig(.25)

REFERENCE
B-18D p17

ANSWER 6.07 (1.00)

Psid >.4: the vaccuum breakers open in spite of the containment isolation for pressure protection

REFERENCE
B-19,p11

ANSWER 6.08 (.50)

closed

REFERENCE
CVCS lesson plans p13

ANSWER 6.09 (1.00)

The CCW pump starts from a false low pressure signal caused by the pressure switch and relay that was momentarily de-energized during the transfer operation.

'NSWERS -- PRAIRIE ISLAND 1&2 -86/05/19-REIDINGER, T.

REFERENCE
LER 85-007

ANSWER 6.10 (1.00)

1) Containment hydrogen detector-reads out on recorder in control room
2) Gas analyzer lined up Post Loca system & gas grab from the Post Loca system

REFERENCE
Cont.Hydrogen Control lesson plans p7

ANSWER 6.11 (2.50)

a)Train A fan and damper lights are green following actuation(.625), Train B equipment lights are all extinguished.(.625) either one
b)Upon stopping Train A,the components that were automatically shutdown remain shutdown(.625) upon stopping Train B all normal equipment that was operating restarts automatically.(.625) either one

REFERENCE
C 19.2 p15

ANSWER 6.12 (1.00)

1)Possibility of the steam line break occurring in a location that would bypass the steam pressure detectors.
2)Break location could result in the loss of the steam multiplier signal and the failure of the steam flow channel to zero. (accept either ans.)

REFERENCE
B-18C,p21

ANSWER 6.13 (.75)

1)low-low tavg,b)high steam flow,c)s-signal (.25 ea) and and OR hi-hi stm flow w/ hi-lo Tavg

REFERENCE
B-18C,p13 (.15 early)

ANSWERS -- PRAIRIE ISLAND 1&2 -86/05/19-REIDINGER, T.

ANSWER 6.14 (3.00)

A. Prevent overloading motors due to the high water content (denser atmosphere) during a LOCA. (1.0)
B. Shifts to accident operation, rerouting air flow through (the cooling coils, fan) the butterfly valves to the upper containment. Will accept "All CFCU's shift/start in slow and discharge dampens fail to the dome. (1.0)
C. SIS
High Radiation. from
Manual containment isolation.
Manual containment spray.
R-11 R-12, or R-22. [4 @ 0.25ea.] (1.0)
OR

REFERENCE
P.I. System Description, B-18, pp. 18, 67, 82.
B-18C p27,31

ANSWER 6.15 (3.25)

a. 1. IMP IN- Reference--Percent of Load (setter)
Feedback---Impulse Pressure

2. IMP OUT-Reference--Percent of valve position
Feedback---None [0.25 ea.] (1.0)

b. 1. Use Turbine Manual Pushbutton
2. Load reference channel failure (20% difference between demand and actual)
3. Speed reference is different from turbine speed by 30%
4. Turn the Maintenence Test key from TEST to OFF
[any 3 @ 0.25 ea.] (0.75)

c. 1. Generator lockout contacts (86) actuated
2. Both main feed pumps trip
3. Auto-stop Oil pressure <45 psig
4. Reactor trip -Train B
5. High Level in the Feed Water Heater 11, 12, or 13
6. Hi-Hi Steam Generator water level
2 main transformer lockout relays tripped
2 aux transformer lockout relays tripped [0.25 ea.] (1.5)
4 Safety injection on train B
1 either Main stm isol. valve shut

REFERENCE
P.I. System Description, B-23 pp. ~~6, 7, 28~~
19, 25

ANSWERS -- PRAIRIE ISLAND 1&2 -86/05/19-REIDINGER, T.

ANSWER 6.16 (2.00)

1. Hydrogen enters via natural convection with the containment air.
2. The air is preheated by the inlet preheater section .
3. Electric heaters raise the temperature of the air to where hydrogen and oxygen spontaneously recombine forming steam.
4. The steam passes into a mixing chamber, mixed with cool cntm. air and returned to containment.

[0.5 ea.] (2.0)

REFERENCE
containment Hyrogen Control p10-P8180L KA028/000,K6.01,2.6

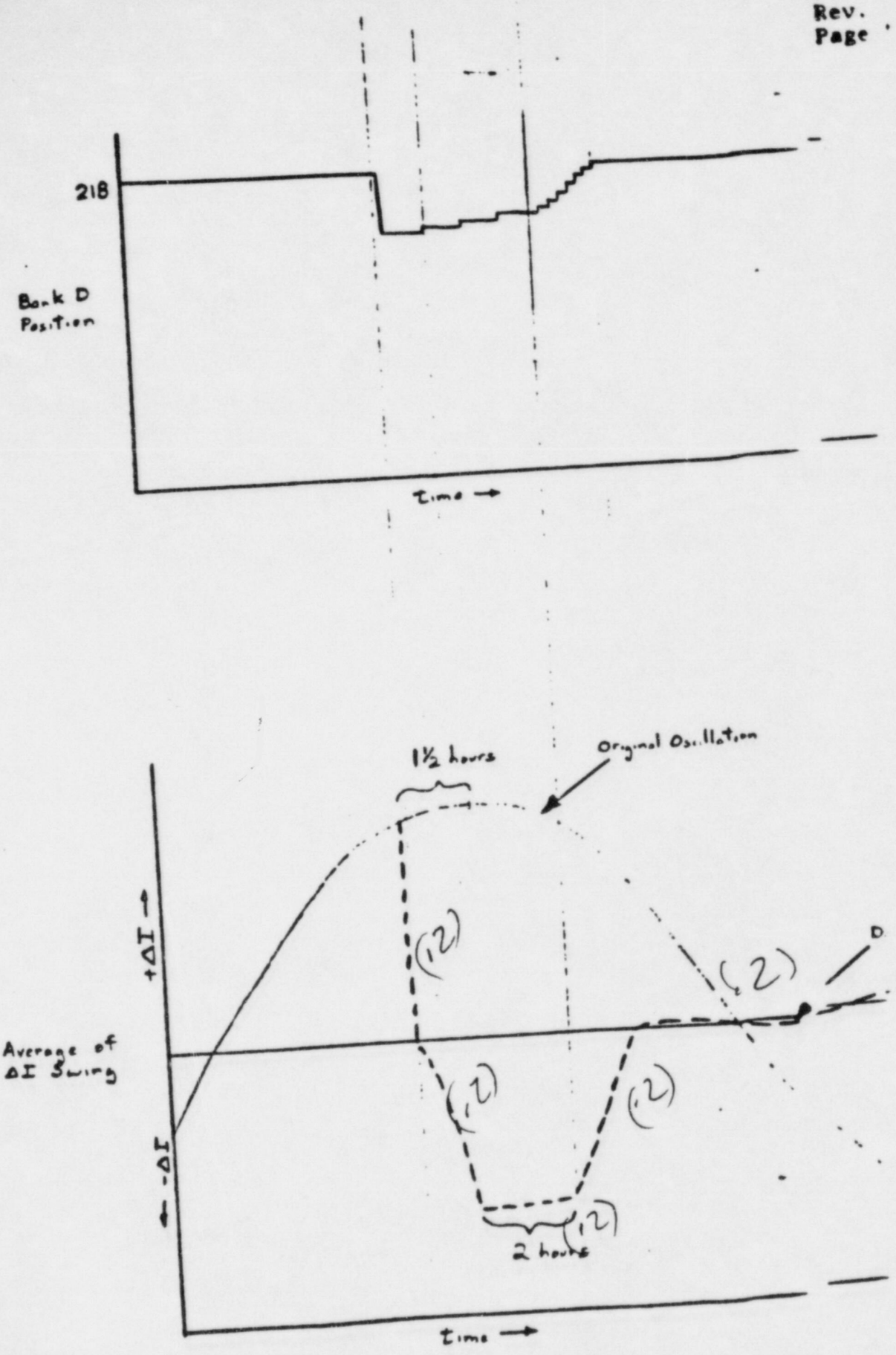

218
Bank D Position
time →
1½ hours
Original Oscillation
+ΔI →
- ΔI ←
Average of ΔI Swing
(12)
(12)
(12)
(12)
(12)
2 hours
D
time →

FIG 7.1

ANSWERS -- PRAIRIE ISLAND 1&2 -86/05/19-REIDINGER, T.

ANSWER 7.01 (1.00)

answer is illustrated by a figure attached.

REFERENCE
D-60,PI exam bank

ANSWER 7.02 (.50)

a. The operator is directed by an action step in E-0 to begin monitoring the status trees.
b. The operator transitions from E-0 to some other guidelines or enters ECA-0.0 on symptoms at which the CSF status trees should be monitored.
c. provide direct operator guidance in those rare events that go beyond the design basis of the engineered safeguards systems and the E, ES & ECA series procedures

REFERENCE
ERG's
d. periodic monitoring of the trees to evaluate critical safety function status during normal operation

ANSWER 7.03 (.50)

a. If any red terminus is encountered, the operator is required to immediately stop any optimal recovery guideline in progress, and to perform the functional restoration guideline required by the terminus.
b. If during the performance of any red-conditioned FRG, a red condition of higher priority arises, then the higher priority condition should be addressed first, and the lower priority red-frg suspended.
(accept either answer)

REFERENCE
ERG"s

ANSWER 7.04 (.50)

(b)

REFERENCE
TS 3.10-5

ANSWERS -- PRAIRIE ISLAND 1&2 -86/05/19-REIDINGER, T.

ANSWER 7.05 (.50)

(c)

REFERENCE
TS 3.10-5

ANSWER 7.06 (3.00)

a. 1. RCS subcooling >50 F (based on exit TC's). [0.4]
or adequate subcooling margin
2. Total feed flow to intact S/G's >200 gpm [0.4] OR Wide range level in one S/G >60%. [0.4] or adequate heat sink

3. RCS pressure >2000 psig and stable or increasing. [0.4]

4. Pressurizer level >10%.or adequate RCS inventory [0.4]

b. RCS subcooling (based on core exit TC's) <50 F. [0.25]
OR
Pressurizer level cannot be maintained >5%. [0.25] (0.5)

c. No, the Reactor Trip Breakers have not been cycled, thus, the automatic SI has not been reset (reinstated).
NOTE: May answer YES if assume RT breakers are cycled. (0.5)

REFERENCE
ES-0.2 p. 3; SI Logic diagram; E-0 p. 10

ANSWERS -- PRAIRIE ISLAND 1&2 -86/05/19-REIDINGER, T.

ANSWER 7.07 (2.25)

a. 1. Pick up the radio.

2. Manually trip the reactor at the reactor trip breakers.

3. Verify turbine trip at the pedestal.

4. Report to the remote S/D panel. [0.25 ea.] (1.0)

b. 1. (Use last known boron concentration in calculation).

2. Place Boric Acid Pump in "local".

3. Close RMW & Emergency Boration Isolation to Chg. Pump Suction valve (VC-11-58).

4. Open Emergency Boration to Chg. Pump Suction MOV (MV-32086) manually.

5. Start pump.

6. Open VC-11-58 as necessary.

7. (Observe flow). [0.25 ea.]

REFERENCE
P.I. Procedure C1.8, pp. 2, 5-6

ANSWER 7.08 (1.50)

a. RCS borated to at least the cold shutdown concentration (or greater) or borated to the hot xenon free concentration and is being maintained at (no-load average temperature.-2) (1.0 ea.)

b. 3% by procedure, T/S - cold shutdown 1% (0.5)
T/S Figure 3-10 1%-2%

REFERENCE
a) P.I. Procedure C1.2 pp 5,6,7
b) C1A para 5, p11

ANSWERS -- PRAIRIE ISLAND 1&2 -86/05/19-REIDINGER, T.

ANSWER 7.09 (2.00)

a. When RCS activity is extremely high (1 x 10-4 uci/cc - 10R/hr on R-9) (0.5)

b. 1. Head vents
2. RCP seals
3. Pressurizer PORV's
4. Excess letdown to RCDT
5. Letdown relief valve to PRT
6. Pressurizer safeties
7. Excess letdown to VCT [any 5 at 0.3 ea.] (1.5)

REFERENCE
OM C1.8 pg. 5, C.19 pg. 2-3

ANSWER 7.10 (.50)

Adverse containment - containment pressure greater than 5 psig or containment radiation level greater than ~~10 E 04~~ 10 * 04 R/hr. (0.6)

REFERENCE
Info. page for EO Series Procedures

ANSWER 7.11 (2.00)

a. 1. As a RCP is started the steam bubble will collapse and pressurizer level will decrease rapidly to fill the void. [0.5]

2. If a RCP cannot be started, a rapid cooldown will make the void larger displacing water in the RCS causing an insurge into the pressurizer. [0.5] (1.0)

b. If pressurizer is solid, pressure may be reduced rapidly as level is reduced. OR This pressure reduction may be less than saturation in the rest of the RCS and may result in system bulk boiling. Partial credit given for mentioning bubble in PZR not in the vessel head and establishing pressure control. (1.0)

REFERENCE
ES-0.5 background pg. 1

ANSWERS -- PRAIRIE ISLAND 1&2 -86/05/19-REIDINGER, T.

ANSWER 7.12 (2.50)

a. (I1D1)(I1D1) = (I2D2)(I2D2) [0.5]

1200(2)(2)/(5)(5)=192 mr/hr

(192 mr/hr)(2 hr.)= 384 mrem [0.75] (1.25)

b. 900 mrem + 384 mrem = 1284 mrem [0.25]

He exceeded normal 10CFR20 whole body limit of 1250 mrem.
If assume that NRC FORM 4 is complete, then limit of 3000 mrem is not exceeded. [1.0]
NOTE: Answer to "b" is dependent on answer to "a" and graded accordingly. (1.25)

REFERENCE
P.I. Question Bank, 5-16

ANSWER 7.13 (2.50)

a. The motor run for 20 minutes (prior to the third attempt) or it has been idle for 45 minutes. (1.0)

b. 1. Insure a steam bubble is formed in the pressurizer.

2. Cool the RCS below seal water temperature.

3. Restrict seal injection flow to the RCP to <10 minutes prior to pump start.

[0.5 ea.] (1.5)

REFERENCE
P.I. Procedure C3 p.11

ANSWER 7.14 (.75)

1. 1 gpm
2. 10 gpm
3. 1 gpm

[0.25 each]

ANSWERS -- PRAIRIE ISLAND 1&2 -86/05/19-REIDINGER, T.

REFERENCE
P.I. Technical Specifications 3.1-9

ANSWER 7.15 (1.00)

ECA 0.0

REFERENCE
ECA-0.0 p3

ANSWER 7.16 (1.50)

1. insert control rods to the bottom
2. borate to xenon free hot shutdown boron concentration
3. contact nuclear engineer

REFERENCE
C 1.2 p26

or 1) recompute ECC
2) determine + correct the discrepancy
3) rods should be inserted to bring reactor subcritical
(.25) (.25)

ANSWER 7.17 (1.50)

1. attempt restoration of feed flow to the steam generators
2. initiate RCS bleed and feed heat removal
3. restore and verify secondary heat sink
4. terminate RCS bleed and feed
(accept any three)

REFERENCE
PI-1FRH.1 p1-10

ANSWER 7.18 (1.00)

false

REFERENCE
ECA 2.1 p3 ,FRH.1

ANSWERS -- PRAIRIE ISLAND 1&2 -86/05/19-REIDINGER, T.

ANSWER 8.01 (1.00)

a

REFERENCE
T/S .3.7-1 ,LER 85-002

ANSWER 8.02 (1.00)

The reactor core was in a safer condition with boric acid in the RCS rather than in a BAST.The boric acid concentration is sufficient to mitigate the consequence of the postulated steampipe rupture accident.

REFERENCE
LER 85-001

ANSWER 8.03 (1.00)

ss,and power system dispatcher/operator

REFERENCE
5ACD 3.10 para 6.1.2

ANSWER 8.04 (1.00)

5,2hrs

REFERENCE
5ACD 3.13 para 6.5.2

ANSWERS -- PRAIRIE ISLAND 1&2 -86/05/19-REIDINGER, T.

ANSWER 8.05 (.50)

false

REFERENCE
5ACD 3.10 para 6.5.7

ANSWER 8.0 (1.00)

Authorize protective action recommendations excess radiation exposure

REFERENCE
F3.8 para 4.1 , F3-12

ANSWER 8.07 (.50)

true

REFERENCE
F4 para 1.15

ANSWER 8.08 (.75)

Wear plastic outer clothing and use a self contained breathing apparatus

REFERENCE
F2 para 14.2bf

ANSWER 8.09 (1.00)

Once a shift

REFERENCE
5ACD 3.9 para 6.5.1

ANSWERS -- PRAIRIE ISLAND 1&2 -86/05/19-REIDINGER, T.

ANSWER 8.10 (1.00)

false

REFERENCE
5ACD3.9 para 6.3.2.para f

ANSWER 8.11 (2.00)

1)Unit shutdown shall be initiated within 1 hour after a L.C.O. has been exceeded
2)Unit shall be in hot shutdown within 6 hours after S/D was initiated

REFERENCE
SWI-O-22 para 3.0

ANSWER 8.12 (1.00)

false

REFERENCE
SWI-O-10 para 3.3.2

ANSWER 8.13 (1.50)

1)system is ready for operation
2)no additional work or testing is required
3)all procedure sign-offs are complete
4)Responsibile individual review in Section VI of the WR is signed off.
(accept any three)

REFERENCE
5ACD 3.2 para 6.18.2 (c) note

ANSWER 8.14 (.50)

false

REFERENCE
5AWI 3.10.1 para 6.1.4

ANSWERS -- PRAIRIE ISLAND 1&2 -86/05/19-REIDINGER, T.

ANSWER 8.15 (.50)

Administrative control directives

REFERENCE
5ACD 1.1 para 6.2.4

ANSWER 8.16 (1.50)

1. Events defined by 10 CFR 20.403 involving:
   a. radiation exposure to personnel.
   b. radioactive releases.
   c. loss of facility operations
   d. damage to property

2. Events defined by 10 CFR 50.73 involving:
   a. declaration of emergency classes
   b. plant shutdown required by technical specifications
   c. deviations from technical specifications in an emergency as necessary to protect the public health and safety.
   d. any serious degradation of the nuclear plant including it's principal safety barriers.
   e. unanalyzed conditions that significantly compromise plant safety.
   f. a condition that is outside the design basis of the plant.
   g. conditions not covered by the plant's operating and emergency procedures.
   h. any natural phenomenon or other external condition that poses a threat to plant safety or significantyly hampers site personnel in the performance of duties necessary for safe plant operation.
   i. any event that results or should have resulted in ECCS discharge to the RCS as a result of a valid signal.
   j. any event that results in a loss of emergency assessment capability, offsite response capability, or communications capability.
   k. any event that poses an actual threat to the plant safety or significantly hampers site personnel in the performance of duties necessary for the safe operation of the plant including fire, toxic gas releases or radioactive releases.

REFERENCE: 10 CFR 20.403 AND 10 CFR 50.72 [5 @ .3 each]

ANSWERS -- PRAIRIE ISLAND 1&2 -86/05/19-REIDINGER, T.

ANSWER 8.20 (4.00)

a. 1. Shift supervisor
2. STA
3. Duty engineer or Plant Manager [0.4 each] (1.2)

b. Plant manager or designee. (0.3)

c. 1. Cause of trip is known.
2. Actions taken to correct trip initiation are satisfactory.
3. Plant response to trip was as expected.
4. It is safe to return to power. [0.5ea] (2.0)

REFERENCE
PINGP, Administrative Work Instructions, 5AWI 3.1.1 p. 3

ANSWER 8.21 (1.00)

a. Unit shutdown [0.25] and NRC notified [0.25] (0.5)

b. NRC (0.5)

REFERENCE
Technical Specifications, 6.4

ANSWERS -- PRAIRIE ISLAND 1&2 -86/05/19-REIDINGER, T.

ANSWER 8.17 (1.00)

a. 1. Following a reactor trip. (0.5)
2. When requested by an individual. (0.5)
NOTE: Surveilances are acceptable ie. Leaktest

REFERENCE
PINGP; Section Work Instructions, SWI-0-4, p. 3

ANSWER 8.18 (1.50)

a. Control room personnel should log each entry and exit and reason for entry. (0.75)

b. A guard will control and monitor entry and exit. (0.75)

REFERENCE
PING, SWI-0-9, Operation Section Containment Entry Instructions

ANSWER 8.19 (1.75)

a. Designated on the "Integrated Operations Checklist" (by the words BLOCK & TAG or LOCK & TAG in Status Column). (0.75)

b. Shift supervisor. (0.5)

c. False (0.5)

REFERENCE
PINGP; Section Work Instructions; SWI-0-3, p. 2