U.S. NUCLEAR REGULATORY COMMISSION

REGION III

Report No. 85-01

Docket No. 50-331 License No. DPR-49

Licensee: Iowa Electric Light and Power Company
P. O. Box 351
Cedar Rapids, IA 52406

Facility Name: Duane Arnold Energy Center

Examination Administered At: Duane Arnold Energy Center

Examination Conducted: Duane Arnold Energy Center

Examiner(s): J. I. McMillen for David Graves, RIV — 4/24/85 Date

Eldon Plettner
Eldon Plettner, RIII — 4/24/85 Date

Approved By: J. I. McMillen
J. I. McMillen, Chief
Operating Licensing Section — 4/24/85 Date

Examination Summary

Examination administered on March 12, 13 and 14, 1985 (Report No. 85-01) to four reactor operator candidates and two senior reactor operator candidates. Results: One reactor operator candidate failed.

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REPORT DETAILS

1. Examiners

   D. N. Graves, Chief Examiner, RIV
   E. Plettner, Observer, RIII

2. Examination Review Meeting

   Review of the written examinations was conducted after the examination was administered. Personnel present during this review were: C. Mick, P. Roy, G. Van Middlesworth and R. Schlesinger, representing Iowa Electric, and D. Graves and E. Plettner representing the NRC.

   Facility comments and resolution of those comments are as follows:

   Comments

2.9	First the drain valve to the lower heater opens fully IE-3A, then the DUMP opens to the condenser. Also, there are no extraction steam bypass valves at DAEC.
	Ref.: P&ID M-105, sh. 2
Resolution:	Agree. Key modified.
3.2	Steam flow is used for RWM.
	Ref.: System Description I-10, pg. 8
Resolution:	Agree. Key modified.
3.3.6	15 seconds, not required for full credit.
Resolution:	Agree.
3.6	None of the answers is correct.
	Ref.: E-109, sh-2
Resolution:	Agree. Questions deleted.

   Section 4 has only 24.5 points. Cover sheet shows 25.

Resolution:	Noted.
4.6	Another low vacuum alarm occurs at 25.5" Mg
	Ref.: System Descriptions D-4, pgs. 16-17
Resolution:	Agree. Key modified.

4.4/7.9	Accept in addition to answer key answers:

1. Control rods
2. EMC/pressure set

Accept any three

Ref.: IPOI VI, D.1, pg. 15
D.2, pg. 16
E, pg. 17

Resolution: Accepted control rods. Did not accept EMC/pressure set after review of procedure in question. Key modified. Also added CRD cooling water flow adjustment as an acceptable answer.

5.5.a Runout can also lead to conditions which can lead to pump damage.

Resolution: Agree. Added to key as acceptable answer.

5.11 Add: Does not change during normal operation, i.e., equilibrium value is independent of power.

Resolution: Agree. Added to key.

6.1 Other possible answers:

1. Thermal limit calculations assume a specific bundle orientation. If this orientation is different than that assumed in the calculation, you may end up with non-conservative thermal limit (MCPR) calculations.
2. Assure proper bypass flow. If oriented wrong, the bypass flow would not be in the correct location for instrument cooling.

Resolution: Agree. Key modified.

6.3 Consider accepting start permissives: 35 psig, Rx pressure and inboard MSIVs shut.

Resolution: Agree. Key modified.

6.6.c Answer will be half-scram if corresponding IRM is upscale or inop. I-3, pg. 34.

Ref.: System Description I-2, Figure 12

6.6.e	Answer will be half-scram if corresponding APRM is downscale.
	Ref.: System Description I-2, Figure 12
Resolution:	Agree if candidate specifies the additional condition.
7.2	1. Also accept Plant Superintendent
	2. Also accept Assistant Plant Superintendent (any of 3)
	Ref.: Chief Engineer and Assistant Chief Engineer are old terminology and not all procedures reflect this relatively recent change.
Resolution:	Agree. Key modified.
7.3	2. "Bypass Offgas" should be in acceptable answers.
Resolution:	Agree. Will accept.
7.7/4.8	Well water and GSW should be considered as independent answers as should Condensate Service Water and demineralized water for purpose of providing six different sources of water as alternate sources.
	Ref.: P&IDs, M-111, M-144, M-109, M-146
Resolution:	Agree. Key modified.
8.2	SSE will now be the OSS.
Resolution:	Agree. Key modified.
8.7	1. Accept either of the <u>or</u> answers as a complete answer.
	2. OSSs do not approve RWPs, they just get a copy of the RWP, no signature is required by the OSS. Therefore, consider throwing out the question as not required knowledge of the OSS.
Resolution:	1. Not accepted. If title only was given, full credit was awarded.
	2. Disagree. Considered pertinent knowledge for a Senior Reactor Operator.

3. Exit Meeting

At the conclusion of the site visit, the examiner met with utility representatives to discuss results of the examination. The following personnel were present:

NRC	Utility	
D. Graves	R. Hannen	D. Mineck
J. Wiebe	E. Mick	P. Roy
	W. Miller	R. Schlesinger

Mr. Graves started the meeting by detailing preliminary results of the oral operating examination with one of the four reactor operator candidates being a "not clear pass" as of that time. It was explained to those present that a "not clear pass" is not a definite failure.

One general candidate weakness was identified to the facility. It was noted by the examiner that the candidates were weak in abnormal procedure immediate operator actions.

The utility asked if any particularly strong areas were noted and when results could be expected. Examiner responded that no particularly strong area was noted in all candidates and that results would be given upon completion of the examination grading and subsequent reviews per Region III's policies.

The meeting concluded with the examiner thanking the staff for their cooperation during the examination.

MASTER CO[illegible]

U. S. NUCLEAR REGULATORY COMMISSION
REACTOR OPERATOR LICENSE EXAMINATION

FACILITY: Duane Arnold Energy Center

REACTOR TYPE: BWR

DATE ADMINISTERED: March 12, 1985

EXAMINER: Dave Graves

APPLICANT: ____________________

INSTRUCTIONS TO APPLICANT:

Use separate paper for the answers. Write answers on one side only. Staple question sheet on top of the answer sheets. Points for each question are indicated in parentheses after the question. The passing grade requires at least 70% in each category and a final grade of at least 80%.

Category Value	% of Total	Applicant's Score	% of Category Value	
25	25	_____	_____	1. Principles of Nuclear Power Plant Operations, 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 exam is my own, I have neither given nor received aid.

____

Applicant's Signature

1. Principles of Nuclear Power Plant Operations, Thermodynamics, Heat Transfer and Fluid Flow

1.1 In your reactor theory lesson plans the following formula is given:
$\sigma_a = \sigma_c + \sigma_f$ Explain the meaning of this formula. (1.0)

1.2 A moderator is necessary to slow neutrons down to thermal energies. Which of the following is the most correct reason for operating with thermal instead of fast neutrons? (1.0)

a. Increased neutron efficiency since thermal neutrons are less likely to leak out of the core than fast neutrons.

b. Reactors operating primarily on fast neutrons are inherently unstable and have a higher risk of going prompt critical.

c. The fission cross section of the fuel is much higher for thermal neutrons than for fast neutrons.

d. Doppler and moderator temperature coefficients become positive as neutron energy increases.

1.3 As core exposure increases, plutonium-239 (Pu-239) concentration increases:

a. Briefly explain the processes by which this buildup occurs. (Note: a reaction-decay chain equation may be used.) (0.75)

b. Explain the effect on reactor behavior caused by the Pu-239 buildup. (1.75)

1.4 Which of the following is NOT a characteristic of subcritical multiplications? (1.0)

a. If the reactor is shutdown long enough, the source range instruments will lose their ability to determine the subcritical multiplication level even though the core may still be at MOL.

b. Doubling the indicated count rate by reactivity additions will reduce the margin to critical by approximately one half.

c. For equal reactivity additions, it takes longer for the equilibrium subcritical multiplication level to be reached as K eff approaches unity.

d. If two notches of rod withdrawal increases the subcritical multiplication level by 10 CPS, 4 notches of rod withdrawal will increase the subcritical multiplication level by approximately 20 cps.

1.5 What interlocks ensure that the NPSH requirements are met for the reactor recirculation and jet pumps? (1.0)

1.6 See attached figure 32-11 "Pressure - Steam Flow Relationship". Why does the reactor pressure increase so much more from 0→100% steam flow than the turbine throttle pressure does? (1.0)

1.7 Which of the following statements is most nearly accurate regarding control rod worth? (1.0)

a. It is proportional to reactor power

b. It is proportional to rod speed.

c. It is higher in regions of higher relative neutron flux.

d. It is about the same for all rods in the core.

1.8 T-S diagrams of real plant cycles show a small amount of "condensate depression"(subcooling) in the condenser.

a. How would cycle efficiency be affected if subcooling is decreased? Why? (1.5)

b. How could the operator increase the amount of subcooling? (.5)

1.9 For each of the events listed below, state WHICH reactivity coefficient will respond first, WHY it responds, and if it ADDS positive or negative reactivity.

a. SRV opening at 100% power. (1.0)

b. Rod drop at 100% power. (1.0)

c. Isolation of a feed heater string. (1.0)

1.10 Which of the following statements is NOT correct concerning decay heat? (1.0)

a. Is the heat produced by the energy released from the radioactive decay of fission products.

b. Can be determined by the reading of the SRM's when the reactor is shutdown.

c. Is approximately 6% of the total energy released from fission.

d. Is still a significant contributor to the energy in the reactor core for approximately two hours after the reactor has been shutdown.

1.11 Following an auto initiation of RCIC at a reactor pressure of 800 psig, reactor pressure decreases to 400 psig. Assume the RCIC is operating as designed, which of the following statements best describe the parameter changes in the RCIC. (1.0)

a. As the RCIC flow to the reactor increases, RCIC pump discharge head remains constant and RCIC turbine speed increases.

b. As the RCIC flow to the reactor remains constant, RCIC pump discharge head decreases and the RCIC turbine speed decreases.

c. As the RCIC flow to the ractor remains constant, RCIC pump discharge head remains constant and RCIC turbine speed remains constant.

d. As the RCIC flow to the reactor decreases, RCIC pump discharge head increases and the turbine speed remains constant.

1.12 A motor driven centrifugal pump is operating at rated flow. You start closing down the discharge valve. Which of the following statements best describes the parameter changes that will occur with this action? (1.0)

a. Flow remains constant, discharge pressure remains constant, motor amps increase, net positive suction head increases.

b. Flow decreases, discharge pressure increases, motor amps increase, net positive suction head increases.

c. Flow decreases, discharge pressure increases, motor amps decrease, net positive suction head decreases.

d. Flow decreases, discharge pressure increases, motor amps decrease; net positive suction head increases.

1.13 If the recirculation pump speed remains constant, which of the following statements best describe why core flow will change if power is reduced below 100% by control rod insertion. (1.0)

a. Flow will increase because less 2 phase resistance.

b. Flow will increase because of higher differential pressure across the core and higher feedwater density.

c. Flow will decrease because the control rods are inserted thus reducing the total flow area.

d. Flow will decrease because more voids are formed thus less volume available for water in the core.

1.14 Explain the effects of increasing the following core parameters on steady state critical power.

a. Core flow (1.5)

b. Inlet subcooling (1.5)

c. Reactor pressure when above 800 psig. (1.5)

1.15 Boiling water reactors are designed to have "under moderated cores". Which statement best describes under moderated? (1.0)

a. The ratio of moderator to fuel is such that the temperature and void coefficient will both be the same (both positive or both negative).

b. The ratio of moderator/fuel is such that increasing moderator density increases K eff.

c. The ratio of moderator to fuel is such that the amount of under moderation increases during core life.

d. The ratio of fuel to moderator is such that increasing moderator density will decrease K eff.

1.16 Which of the following is NOT one of the four contributors or factors that establish equilibrium xenon? (1.0)

a. Direct production from fission.

b. Decay of Iodine.

c. Decay of Xenon to Sm.

d. Decay of Xenon to Cs.

1.17 The HPCI barometric condenser receives steam from gland seals, drain pot and leak offs. Explain how this condenser works to condense this steam. (1.0)

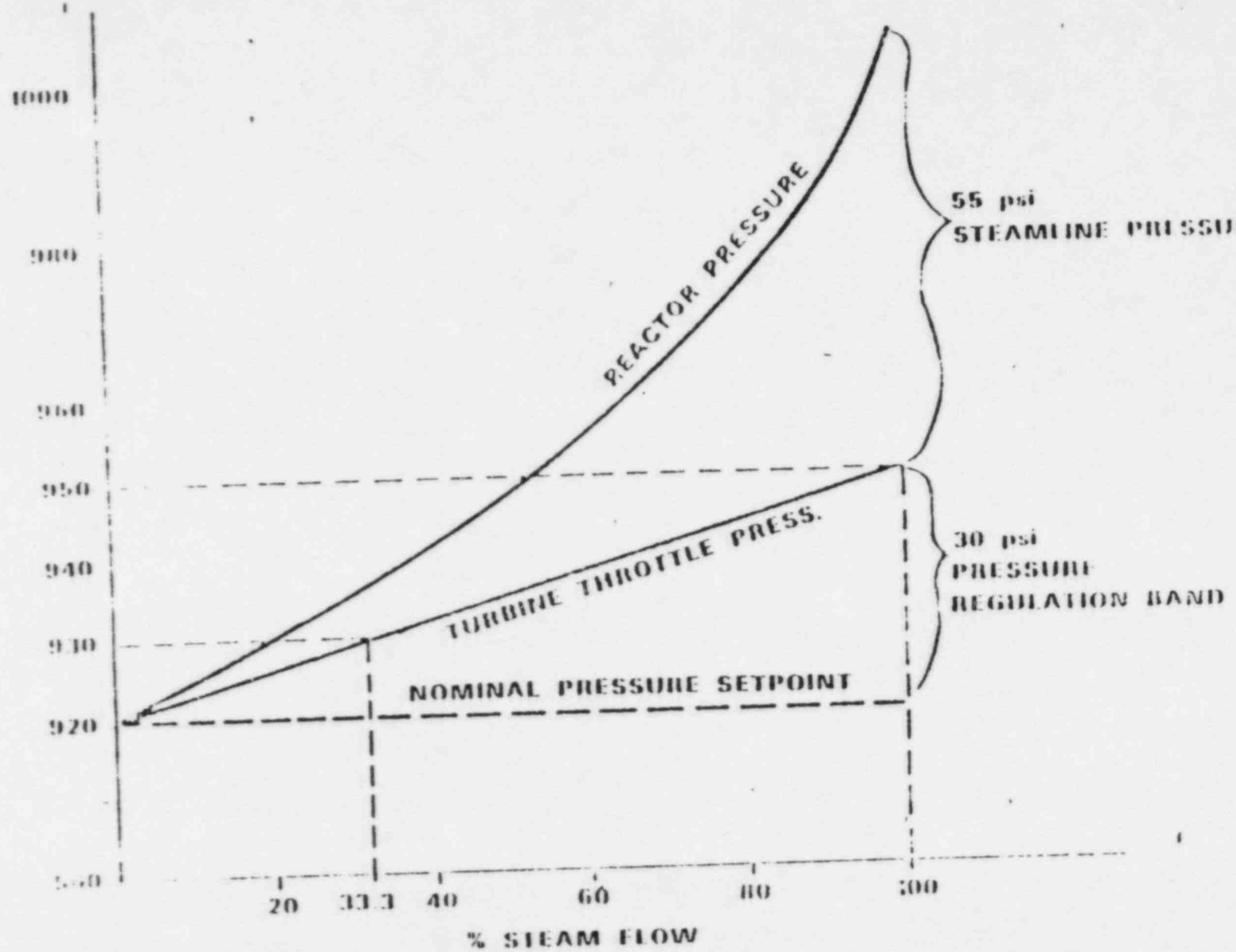

Figure 32-11 Pressure-Steam Flow Relationship

2. Plant Design Including Safety and Emergency Systems

2.1 What are ten (10) different indications available to you in the control room that could be used to determine that a reactor coolant leak was occurring in the drywell? (2.5)

2.2 How does the CRO system interface with the following systems?

a. Condensate system. (1.0)
b. Reactor recirculation system. (1.0)
c. Liquid radwaste system (1.0)
d. Reactor building cooling water system (.5)

2.3 In addition to the main turbine, the bypass, safety and safety relief valves, what are six (6) other steam loads (systems) off of the main steam system? Do not list two similar components (i.e., such as "A' and "B") as separate loads. (2.0)

2.4 RHR is being used in the suppression pool cooling mode to cool off the torus. "B" loop is lined up for cooling using the "B" RHR pump and "B" + "D": RHR service water pumps. Explain what will happen (if anything) to any of the equipment being used for suppression pool cooling flow and the flow path if a LPCI initiation and injection signal were to occur. (3.5)

2.5 The standby gas treatment system can take a suction from all of the following <u>except</u>: (1.0)

a. Condenser vacuum pump
b. Fuel pool exhaust
c. HPCI turbine vacuum pump
d. Radwaste building evaporator vent

2.6 In the hydrogen seal oil system the main seal oil pump normally supplies oil to the shaft seals. If the main seal oil pump were to fail, what are the two backups that would supply oil to the shaft seals? (1.0)

2.7 What automatic interlocks must be satisfied prior to using the MSIV-LCS? Include setpoints if appropriate (1.25)

What is the purpose of the heater in the system? (.5)

2.8 Your primary containment has vacuum breakers that connect the suppression chamber and the drywell. If these vacuum breakers were to fail what would be the consequences under the following conditions. Treat each condition as a separate occurrance.

a. If a LOCA occurred with the torus drywell vacuum breakers failed closed? (2.0)

b. If a LOCA occurred with any of the torus drywell vacuum breakers failed open? (2.0)

2.9 What will happen to the inlet and outlet flow paths for the shell side of the IE-4A feedwater heater on an increasing level condition in 1E-4A heater? Assume level continues to increse to the trip point. (2.5)

2.10 There are two pressure switches that tap off the discharge of each core spray pump prior to the discharge check valves. These switches are set to operate at 145 psig. What is the purpose of these two switches? (1.25)

2.11 SBLC pumps have a common suction header and discharge to a common discharge header. During system operation only one pump is running at a time. What prevents backflow through the non-running pump? (1.0)

2.12 Main turbine stop valve position less than 90% open is utilized for two trip functions. What are those two trip functions? (1.0)

3. Instruments and Controls

3.1 When the handswitch is turned to "start" for the circulating water pump (1P-4A or 1P-4B), what four (4) conditions must be satisfied for the pump to start? Assume power is available to the pump and control circuit. (2.0)

3.2 The main steam line flow restrictors are also used to determine the steam flow in the main steam lines. What are three (3) uses of this main steam line flow signal? (1.5)

3.3 What will cause the RWCU system differential flow high annunciator to alarm? (Be specific as to inputs) (1.5)

What automatic actions occur when this alarm annunciates? (1.0)

3.4 Below are listed the five signals (A-E) that will cause the recirc M-G set scoop tube to lock up. What of these signals will also cause a drive motor trip? (1.)

a. Low lube oil pressure (less than 30 psig with 6 sec time delay)

b. High lube oil temp (210°F)

c. Speed control signal failure

d. Loss of power to scoop tube position

e. Manual

3.5 Pick the correct answer in regards to an auto initiation of SGTS. (1.0)

a. The train in auto will start on the first signal and the standby train will then be in readiness to start on any subsequent signal.

b. Both trains will start and the standby train will trip on low flow.

c. The train in auto will start and after the low flow alarm has cleared the standby train will start.

d. Both trains will start immediately and run until some manual action is taken.

3.6 Pick the correct answer concerning the reactor feed pump circuity (1.0)

a. A second feed pump can be started with only one condensate pump running as long as suction pressure remains greater than the low pressure trip point.

b. With both feed pumps running, a trip of only one condensate pump will cause both feed pumps to trip.

c. The reactor feed pump low lube oil pressure trip is automoatically bypassed for 10 seconds on a pump start to allow the shaft driven oil pump to build up pressure.

d. If the suction pressure of a running feed pump drops to less than the low pressure trip point, the feed pump will trip immediately.

3.7 The following levels (A-E) are setpoints at which alarms or trips occur. For each of the following actions that occur (1-8), match the action up with the level at which it occurs. (2.0)

Level
A 195" high level alarm
B 186" low level alarm
C 170" low level trip
D 119.5" low-low level trip
E. 46.5" low-low-low-level trip

Action
1. LPCI loop select
2. HPCI initiation
3. LPCI initiation
4. PCIS Group 3 isolate
5. PCIS Group 1 isolate
6. Recirculation pump runback if <2 RFP's in operation)
7. Recirculation pump ATWS trip
8. Start standby diesel generator

3.8 What are two (2) indications that you could use to determine which particular safety or safety/relief valve had opened? (1.5)

3.9 Concerning the low low set feature of the safety/relief valves.

A. How many valves are actuated by this system? (.5)
B. What signals are required to arm this system? (1.5)
C. How is opening/closing of the SRV's changed when LLS is armed? (1.0)
D. How is LLS reset after it is armed? (.5)

3.10 Refer to the attached Figure 10, Reactor Recirculation System Simplified Diagram. On this diagram some instrumentation is shown that feed into other systems. For the instrumentation A-D, state: (1) What system(s) the instrumentation feeds into, and (2) What the signal is used for in that system. (4.0)

3.11 What conditions can cause an APRM channel to be either physically inoperative or to be considered inoperative? (2.5)

3.12 a. During movement of a control rod drive, what is the flow path for the exhaust water flow? Be specific and include flow path into the reactor vessel. (2.0)

For b. below, pick the correct answer:

b. Which of the following flows is <u>not</u> indicated in the control room? (.5)

1. Hydraulic supply header flow
2. Charging header flow
3. Drive header flow
4. Cooling header flow

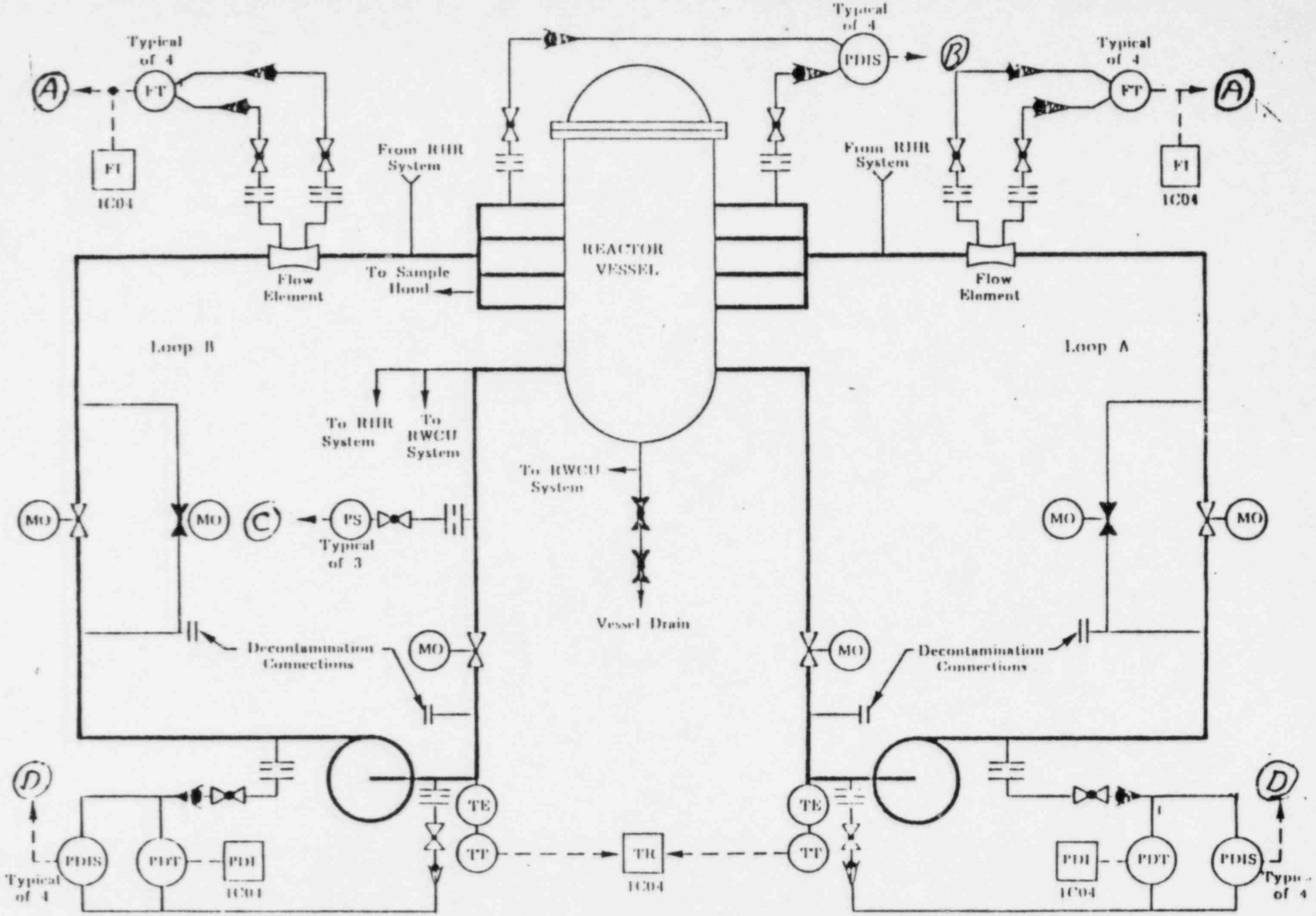

Figure 10
Reactor Recirculation System
Simplified Diagram

4. Procedures, Normal, Abnormal, Emergency and Radiological Control

4.1 Which of the following would not necessarily be a symptom of unidentified leakage in the drywell of 5 GPM or higher? (1.0)

a. Excessively increasing drywell floor drain sump total flow at F.Q. 3707 on Panel 1C19.

b. DRYWELL HIGH TEMPERATURE alarm on Panel 1C04-C

c. DRYWELL FLOOR DRAIN SUMP HI-HI-LEVEL on panel 1C04-C

d. DRYWELL FLOOR DRAIN SUMP HI LEAK on panel 1C04-C

4.2 The reactor is operating at 90% power when condenser vacuum suddenly starts to decrease:

a. WHAT are FOUR (4) AUTOMATIC ACTIONS that occur on a LOSS of CONDENSER VACUUM? Include any applicable setpoints. (2.0)

b. In accordance with IPOI 6-4.0, Loss of Condendser Vacuum, WHAT are FIVE (5) Immediate Operator actions, OTHER THAN acknowledgement of annunciators and announcement of the condition? (2.5)

4.3 Under what conditions during a startup must rod pulls be continued using notch withdrawal only? (1.0)

4.4 When in the hot standby condition and with the reactor crictical, what are the 3 systems or sets of systems that may be used to control reactor pressure? Which of these is the perferred method? (2.0)

4.5 Chose the correct answer concerning when during a startup the IRM detectors should be withdrawn? (1.0)

a. After switching the mode switch to the RUN mode.
b. After all of the APRM downscales have cleared.
c. After the proper overlap has been verified between the IRM's and APRM's.
d. After the turbine roll is completed.

4.6 When in the shutdown cooling mode of RHR, your precautions tell you to insure that RHR flow is equal to or greater than 4000 gpm. What is the reason for requiring flow to be this high? (1.0)

4.7 According to your shutdown procedure, prior to steam flow dropping to the Rod Worth Minimizer Low Power Alarm Point (LPAP 35% reactor power), the existing control rod pattern must be checked. What three things must the control rod pattern be checked for? (3.0)

4.8 What are the six systems that are considered to be alternate injection subsystems by your emergency procedures? (3.0)

4.9 What are the entry conditions for EOP-2, PRIMARY CONTAINMENT CONTROL? Include setpoints. 5 Conditions Required. (5.0)

4.10 At the beginning of a shift, it may be your duty to fill out the log. At the beginning of each shift what are the plant status items that must be logged? 4 Items Required. (2.0)

4.11 According to your Hold Off Procedure, what is the differences in the purpose of a hold card and a warning tag? (1.0)

EQUATION SHEET

$f = ma$ $v = s/t$

Cycle efficiency = (Network out)/(Energy in)

$w = mg$ $s = V_o t + 1/2\ at^2$

$E = mc^2$

$KE = 1/2\ mv^2$ $a = (V_f - V_o)/t$ $A = \lambda N$ $A = A_o e^{-\lambda t}$

$PE = mgh$

$V_f = V_o + at$ $w = \theta/t$ $\lambda = \ln 2/t_{1/2} = 0.693/t_{1/2}$

$NPSH = P_{in} - P_{sat}$

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

$\dot{m} = \rho AV$

$\Delta E = 931\ \Delta m$

$I = I_o e^{-Ex}$

$Q = \dot{m}Cp\Delta t$

$Q = UA\Delta h$ $I = I_o e^{-\mu x}$

$Pwr = W_f \Delta h$ $I = I_o\ 10^{-x/TVL}$

$TVL = 1.3/\mu$

$P = P_o 10^{sur(t)}$ $HVL = -0.693/\mu$

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

$SUR = 26.06/T$ $SCR = S/(1 - K_{eff})$

$CR_x = S/(1 - K_{effx})$

$SUR = 26\rho/\ell^* + (\beta - \rho)T$ $CR_1(1 - K_{eff1}) = CR_2(1 - k_{eff2})$

$T = (\ell^*/\rho) + [(\bar{\beta} - \rho)/\lambda\rho]$ $M = 1/(1 - K_{eff}) = CR_1/CR_o$

$T = \ell/(\rho - \beta)$ $M = (1 - K_{effo})/(1 - K_{eff1})$

$T = (\beta - \rho)/(\lambda\rho)$ $SDM = (1 - K_{eff})/K_{eff}$

$\rho = (K_{eff}-1)/K_{eff} = \Delta K_{eff}/K_{eff}$ $\ell^* = 10^{-5}$ seconds

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

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

$I_1 d_1 = I_2 d_2$

$P = (\Sigma\phi V)/(3 \times 10^{10})$ $I_1 d_1{}^2 = I_2 d_2{}^2$

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

$NPSH$ = Static head $- h_L - P_{sat}$ $R/hr = 6\ CE/d^2$ (feet)

Water Parameters

1 gal. = 8.345 lbm.
1 gal. = 3.78 liters
1 ft^3 = 7.48 gal.
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 psi = 29.9 in. Hg.

Miscellaneous Conversions

1 curie = 3.7×10^{10} dps
1 kg = 2.21 lbm
1 hp = 2.54×10^3 Btu/hr
1 mw = 3.41×10^6 Btu/hr
1 in = 2.54 cm
°F = 9/5°C + 32
°C = 5/9 (°F-32)

Table 1. Saturated Steam: Temperature Table

Temp Fahr t	Abs Press Lb per Sq In. p	Specific Volume Sat. Liquid v_f	Specific Volume Evap v_{fg}	Specific Volume Sat. Vapor v_g	Enthalpy Sat. Liquid h_f	Enthalpy Evap h_{fg}	Enthalpy Sat. Vapor h_g	Entropy Sat. Liquid s_f	Entropy Evap s_{fg}	Entropy Sat. Vapor s_g	Temp Fahr t
32.0*	0.08859	0.016022	3304.7	3304.7	-0.0179	1075.5	1075.5	0.0000	2.1873	2.1873	32.0*
34.0	0.09600	0.016021	3061.9	3061.9	1.996	1074.4	1076.4	0.0041	2.1762	2.1802	34.0
36.0	0.10395	0.016020	2839.0	2839.0	4.008	1073.2	1077.2	0.0081	2.1651	2.1732	36.0
38.0	0.11249	0.016019	2634.1	2634.2	6.018	1072.1	1078.1	0.0122	2.1541	2.1663	38.0
40.0	0.12163	0.016019	2445.8	2445.8	8.027	1071.0	1079.0	0.0162	2.1432	2.1594	40.0
42.0	0.13143	0.016019	2272.4	2272.4	10.035	1069.8	1079.9	0.0202	2.1325	2.1527	42.0
44.0	0.14192	0.016019	2112.8	2112.8	12.041	1068.7	1080.7	0.0242	2.1217	2.1459	44.0
46.0	0.15314	0.016020	1965.7	1965.7	14.047	1067.6	1081.6	0.0282	2.1111	2.1393	46.0
48.0	0.16514	0.016021	1830.0	1830.0	16.051	1066.4	1082.5	0.0321	2.1006	2.1327	48.0
50.0	0.17796	0.016023	1704.8	1704.8	18.054	1065.3	1083.4	0.0361	2.0901	2.1262	50.0
52.0	0.19165	0.016024	1589.2	1589.2	20.057	1064.2	1084.2	0.0400	2.0798	2.1197	52.0
54.0	0.20625	0.016026	1482.4	1482.4	22.058	1063.1	1085.1	0.0439	2.0695	2.1134	54.0
56.0	0.22183	0.016028	1383.6	1383.6	24.059	1061.9	1086.0	0.0478	2.0593	2.1070	56.0
58.0	0.23843	0.016031	1292.2	1292.2	26.060	1060.8	1086.9	0.0516	2.0491	2.1008	58.0
60.0	0.25611	0.016033	1207.6	1207.6	28.060	1059.7	1087.7	0.0555	2.0391	2.0946	60.0
62.0	0.27494	0.016036	1129.2	1129.2	30.059	1058.5	1088.6	0.0593	2.0291	2.0885	62.0
64.0	0.29497	0.016039	1056.5	1056.5	32.058	1057.4	1089.5	0.0632	2.0192	2.0824	64.0
66.0	0.31626	0.016043	989.0	989.1	34.056	1056.3	1090.4	0.0670	2.0094	2.0764	66.0
68.0	0.33889	0.016046	926.5	926.5	36.054	1055.2	1091.2	0.0708	1.9996	2.0704	68.0
70.0	0.36292	0.016050	868.3	868.4	38.052	1054.0	1092.1	0.0745	1.9900	2.0645	70.0
72.0	0.38844	0.016054	814.3	814.3	40.049	1052.9	1093.0	0.0783	1.9804	2.0587	72.0
74.0	0.41550	0.016058	764.1	764.1	42.046	1051.8	1093.8	0.0821	1.9708	2.0529	74.0
76.0	0.44420	0.016063	717.4	717.4	44.043	1050.7	1094.7	0.0858	1.9614	2.0472	76.0
78.0	0.47461	0.016067	673.8	673.9	46.040	1049.5	1095.6	0.0895	1.9520	2.0415	78.0
80.0	0.50683	0.016072	633.3	633.3	48.037	1048.4	1096.4	0.0932	1.9426	2.0359	80.0
82.0	0.54093	0.016077	595.5	595.5	50.033	1047.3	1097.3	0.0969	1.9334	2.0303	82.0
84.0	0.57702	0.016082	560.3	560.3	52.029	1046.1	1098.2	0.1006	1.9242	2.0248	84.0
86.0	0.61518	0.016087	527.5	527.5	54.026	1045.0	1099.0	0.1043	1.9151	2.0193	86.0
88.0	0.65551	0.016093	496.8	496.8	56.022	1043.9	1099.9	0.1079	1.9060	2.0139	88.0
90.0	0.69813	0.016099	468.1	468.1	58.018	1042.7	1100.8	0.1115	1.8970	2.0086	90.0
92.0	0.74313	0.016105	441.3	441.3	60.014	1041.6	1101.6	0.1152	1.8881	2.0033	92.0
94.0	0.79062	0.016111	416.3	416.3	62.010	1040.5	1102.5	0.1188	1.8792	1.9980	94.0
96.0	0.84072	0.016117	392.8	392.9	64.006	1039.3	1103.3	0.1224	1.8704	1.9928	96.0
98.0	0.89356	0.016123	370.9	370.9	66.003	1038.2	1104.2	0.1260	1.8617	1.9876	98.0
100.0	0.94924	0.016130	350.4	350.4	67.999	1037.1	1105.1	0.1295	1.8530	1.9825	100.0
102.0	1.00789	0.016137	331.1	331.1	69.995	1035.9	1105.9	0.1331	1.8444	1.9775	102.0
104.0	1.06965	0.016144	313.1	313.1	71.992	1034.8	1106.8	0.1366	1.8358	1.9725	104.0
106.0	1.1347	0.016151	296.16	296.18	73.99	1033.6	1107.6	0.1402	1.8273	1.9675	106.0
108.0	1.2030	0.016158	280.28	280.30	75.98	1032.5	1108.5	0.1437	1.8188	1.9626	108.0
110.0	1.2750	0.016165	265.37	265.39	77.98	1031.4	1109.3	0.1472	1.8105	1.9577	110.0
112.0	1.3505	0.016173	251.37	251.38	79.98	1030.2	1110.2	0.1507	1.8021	1.9528	112.0
114.0	1.4299	0.016180	238.21	238.22	81.97	1029.1	1111.0	0.1542	1.7938	1.9480	114.0
116.0	1.5133	0.016188	225.84	225.85	83.97	1027.9	1111.9	0.1577	1.7856	1.9433	116.0
118.0	1.6009	0.016196	214.20	214.21	85.97	1026.8	1112.7	0.1611	1.7774	1.9386	118.0
120.0	1.6927	0.016204	203.25	203.26	87.97	1025.6	1113.6	0.1646	1.7693	1.9339	120.0
122.0	1.7891	0.016213	192.94	192.95	89.96	1024.5	1114.4	0.1680	1.7613	1.9293	122.0
124.0	1.8901	0.016221	183.23	183.24	91.96	1023.3	1115.3	0.1715	1.7533	1.9247	124.0
126.0	1.9959	0.016229	174.08	174.09	93.96	1022.2	1116.1	0.1749	1.7453	1.9202	126.0
128.0	2.1068	0.016238	165.45	165.47	95.96	1021.0	1117.0	0.1783	1.7374	1.9157	128.0
130.0	2.2230	0.016247	157.32	157.33	97.96	1019.8	1117.8	0.1817	1.7295	1.9112	130.0
132.0	2.3445	0.016256	149.64	149.66	99.95	1018.7	1118.6	0.1851	1.7217	1.9068	132.0
134.0	2.4717	0.016265	142.40	142.41	101.95	1017.5	1119.5	0.1884	1.7140	1.9024	134.0
136.0	2.6047	0.016274	135.55	135.57	103.95	1016.4	1120.3	0.1918	1.7063	1.8980	136.0
138.0	2.7438	0.016284	129.09	129.11	105.95	1015.2	1121.1	0.1951	1.6986	1.8937	138.0
140.0	2.8892	0.016293	122.98	123.00	107.95	1014.0	1122.0	0.1985	1.6910	1.8895	140.0
142.0	3.0411	0.016303	117.21	117.22	109.95	1012.9	1122.8	0.2018	1.6834	1.8852	142.0
144.0	3.1997	0.016312	111.74	111.76	111.95	1011.7	1123.6	0.2051	1.6759	1.8810	144.0
146.0	3.3653	0.016322	106.58	106.59	113.95	1010.5	1124.5	0.2084	1.6684	1.8769	146.0
148.0	3.5381	0.016332	101.68	101.70	115.95	1009.3	1125.3	0.2117	1.6610	1.8727	148.0
150.0	3.7184	0.016343	97.05	97.07	117.95	1008.2	1126.1	0.2150	1.6536	1.8686	150.0
152.0	3.9065	0.016353	92.66	92.68	119.95	1007.0	1126.9	0.2183	1.6463	1.8646	152.0
154.0	4.1025	0.016363	88.50	88.52	121.95	1005.8	1127.7	0.2216	1.6390	1.8606	154.0
156.0	4.3068	0.016374	84.56	84.57	123.95	1004.6	1128.6	0.2248	1.6318	1.8566	156.0
158.0	4.5197	0.016384	80.82	80.83	125.96	1003.4	1129.4	0.2281	1.6245	1.8526	158.0
160.0	4.7414	0.016395	77.27	77.29	127.96	1002.2	1130.2	0.2313	1.6174	1.8487	160.0
162.0	4.9722	0.016406	73.90	73.92	129.96	1001.0	1131.0	0.2345	1.6103	1.8448	162.0
164.0	5.2124	0.016417	70.70	70.72	131.96	999.8	1131.8	0.2377	1.6032	1.8409	164.0
166.0	5.4623	0.016428	67.67	67.68	133.97	998.6	1132.6	0.2409	1.5961	1.8371	166.0
168.0	5.7223	0.016440	64.78	64.80	135.97	997.4	1133.4	0.2441	1.5892	1.8333	168.0
170.0	5.9926	0.016451	62.04	62.06	137.97	996.2	1134.2	0.2473	1.5822	1.8295	170.0
172.0	6.2736	0.016463	59.43	59.45	139.98	995.0	1135.0	0.2505	1.5753	1.8258	172.0
174.0	6.5656	0.016474	56.95	56.97	141.98	993.8	1135.8	0.2537	1.5684	1.8221	174.0
176.0	6.8690	0.016486	54.59	54.61	143.99	992.6	1136.6	0.2568	1.5616	1.8184	176.0
178.0	7.1840	0.016498	52.35	52.36	145.99	991.4	1137.4	0.2600	1.5548	1.8147	178.0

*The states shown are metastable

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

Temp Fahr t	Abs Press Lb per Sq In p	Specific Volume Sat Liquid v_f	Specific Volume Evap v_{fg}	Specific Volume Sat Vapor v_g	Enthalpy Sat Liquid h_f	Enthalpy Evap h_{fg}	Enthalpy Sat Vapor h_g	Entropy Sat Liquid s_f	Entropy Evap s_{fg}	Entropy Sat Vapor s_g	Temp Fahr t
180.0	7.5110	0.016510	50.21	50.22	148.00	990.2	1138.2	0.2631	1.5480	1.8111	180.0
182.0	7.850	0.016522	48.172	48.189	150.01	989.0	1139.0	0.2662	1.5413	1.8075	182.0
184.0	8.203	0.016534	46.232	46.249	152.01	987.8	1139.8	0.2694	1.5346	1.8040	184.0
186.0	8.568	0.016547	44.383	44.400	154.02	986.5	1140.5	0.2725	1.5279	1.8004	186.0
188.0	8.947	0.016559	42.621	42.638	156.03	985.3	1141.3	0.2756	1.5213	1.7969	188.0
190.0	9.340	0.016572	40.941	40.957	158.04	984.1	1142.1	0.2787	1.5148	1.7934	190.0
192.0	9.747	0.016585	39.337	39.354	160.05	982.8	1142.9	0.2818	1.5082	1.7900	192.0
194.0	10.168	0.016598	37.808	37.824	162.05	981.6	1143.7	0.2848	1.5017	1.7865	194.0
196.0	10.605	0.016611	36.348	36.364	164.06	980.4	1144.4	0.2879	1.4952	1.7831	196.0
198.0	11.058	0.016624	34.954	34.970	166.08	979.1	1145.2	0.2910	1.4888	1.7798	198.0
200.0	11.526	0.016637	33.622	33.639	168.09	977.9	1146.0	0.2940	1.4824	1.7764	200.0
204.0	12.512	0.016664	31.135	31.151	172.11	975.4	1147.5	0.3001	1.4697	1.7698	204.0
208.0	13.568	0.016691	28.862	28.878	176.14	972.8	1149.0	0.3061	1.4571	1.7632	208.0
212.0	14.696	0.016719	26.782	26.799	180.17	970.3	1150.5	0.3121	1.4447	1.7568	212.0
216.0	15.901	0.016747	24.878	24.894	184.20	967.8	1152.0	0.3181	1.4323	1.7505	216.0
220.0	17.186	0.016775	23.131	23.148	188.23	965.2	1153.4	0.3241	1.4201	1.7442	220.0
224.0	18.556	0.016805	21.529	21.545	192.27	962.6	1154.9	0.3300	1.4081	1.7380	224.0
228.0	20.015	0.016834	20.056	20.073	196.31	960.0	1156.3	0.3359	1.3961	1.7320	228.0
232.0	21.567	0.016864	18.701	18.718	200.35	957.4	1157.8	0.3417	1.3842	1.7260	232.0
236.0	23.216	0.016895	17.454	17.471	204.40	954.8	1159.2	0.3476	1.3725	1.7201	236.0
240.0	24.968	0.016926	16.304	16.321	208.45	952.1	1160.6	0.3533	1.3609	1.7142	240.0
244.0	26.826	0.016958	15.243	15.260	212.50	949.5	1162.0	0.3591	1.3494	1.7085	244.0
248.0	28.796	0.016990	14.264	14.281	216.56	946.8	1163.4	0.3649	1.3379	1.7028	248.0
252.0	30.883	0.017022	13.358	13.375	220.62	944.1	1164.7	0.3706	1.3266	1.6972	252.0
256.0	33.091	0.017055	12.520	12.538	224.69	941.4	1166.1	0.3763	1.3154	1.6917	256.0
260.0	35.427	0.017089	11.745	11.762	228.76	938.6	1167.4	0.3819	1.3043	1.6862	260.0
264.0	37.894	0.017123	11.025	11.042	232.83	935.9	1168.7	0.3876	1.2933	1.6808	264.0
268.0	40.500	0.017157	10.358	10.375	236.91	933.1	1170.0	0.3932	1.2823	1.6755	268.0
272.0	43.249	0.017193	9.738	9.755	240.99	930.3	1171.3	0.3987	1.2715	1.6702	272.0
276.0	46.147	0.017228	9.162	9.180	245.08	927.5	1172.5	0.4043	1.2607	1.6650	276.0
280.0	49.200	0.017264	8.627	8.644	249.17	924.6	1173.8	0.4098	1.2501	1.6599	280.0
284.0	52.414	0.01730	8.1280	8.1453	253.3	921.7	1175.0	0.4154	1.2395	1.6548	284.0
288.0	55.795	0.01734	7.6634	7.6807	257.4	918.8	1176.2	0.4208	1.2290	1.6498	288.0
292.0	59.350	0.01738	7.2301	7.2475	261.5	915.9	1177.4	0.4263	1.2186	1.6449	292.0
296.0	63.084	0.01741	6.8259	6.8433	265.6	913.0	1178.6	0.4317	1.2082	1.6400	296.0
300.0	67.005	0.01745	6.4483	6.4658	269.7	910.0	1179.7	0.4372	1.1979	1.6351	300.0
304.0	71.119	0.01749	6.0955	6.1130	273.8	907.0	1180.9	0.4426	1.1877	1.6303	304.0
308.0	75.433	0.01753	5.7655	5.7830	278.0	904.0	1182.0	0.4479	1.1776	1.6256	308.0
312.0	79.953	0.01757	5.4566	5.4742	282.1	901.0	1183.1	0.4533	1.1676	1.6209	312.0
316.0	84.688	0.01761	5.1673	5.1849	286.3	897.9	1184.1	0.4586	1.1576	1.6162	316.0
320.0	89.643	0.01766	4.8961	4.9138	290.4	894.8	1185.2	0.4640	1.1477	1.6116	320.0
324.0	94.826	0.01770	4.6418	4.6595	294.6	891.6	1186.2	0.4692	1.1378	1.6071	324.0
328.0	100.245	0.01774	4.4030	4.4208	298.7	888.5	1187.2	0.4745	1.1280	1.6025	328.0
332.0	105.907	0.01779	4.1788	4.1966	302.9	885.3	1188.2	0.4798	1.1183	1.5981	332.0
336.0	111.820	0.01783	3.9681	3.9859	307.1	882.1	1189.1	0.4850	1.1086	1.5936	336.0
340.0	117.992	0.01787	3.7699	3.7878	311.3	878.8	1190.1	0.4902	1.0990	1.5892	340.0
344.0	124.430	0.01792	3.5834	3.6013	315.5	875.5	1191.0	0.4954	1.0894	1.5849	344.0
348.0	131.142	0.01797	3.4078	3.4258	319.7	872.2	1191.1	0.5006	1.0799	1.5806	348.0
352.0	138.138	0.01801	3.2423	3.2603	323.9	868.9	1192.7	0.5058	1.0705	1.5763	352.0
356.0	145.424	0.01806	3.0863	3.1044	328.1	865.5	1193.6	0.5110	1.0611	1.5721	356.0
360.0	153.010	0.01811	2.9392	2.9573	332.3	862.1	1194.4	0.5161	1.0517	1.5678	360.0
364.0	160.903	0.01816	2.8002	2.8184	336.5	858.6	1195.2	0.5212	1.0424	1.5637	364.0
368.0	169.113	0.01821	2.6691	2.6873	340.8	855.1	1195.9	0.5263	1.0332	1.5595	368.0
372.0	177.648	0.01826	2.5451	2.5633	345.0	851.6	1196.7	0.5314	1.0240	1.5554	372.0
376.0	186.517	0.01831	2.4279	2.4462	349.3	848.1	1197.4	0.5365	1.0148	1.5513	376.0
380.0	195.729	0.01836	2.3170	2.3353	353.6	844.5	1198.0	0.5416	1.0057	1.5473	380.0
384.0	205.294	0.01842	2.2120	2.2304	357.9	840.8	1198.7	0.5466	0.9966	1.5432	384.0
388.0	215.220	0.01847	2.1126	2.1311	362.2	837.2	1199.3	0.5516	0.9876	1.5392	388.0
392.0	225.516	0.01853	2.0184	2.0369	366.5	833.4	1199.9	0.5567	0.9786	1.5352	392.0
396.0	236.193	0.01858	1.9291	1.9477	370.8	829.7	1200.4	0.5617	0.9696	1.5313	396.0
400.0	247.259	0.01864	1.8444	1.8630	375.1	825.9	1201.0	0.5667	0.9607	1.5274	400.0
404.0	258.725	0.01870	1.7640	1.7827	379.4	822.0	1201.5	0.5717	0.9518	1.5234	404.0
408.0	270.600	0.01875	1.6877	1.7064	383.8	818.2	1201.9	0.5766	0.9429	1.5195	408.0
412.0	282.894	0.01881	1.6152	1.6340	388.1	814.2	1202.4	0.5816	0.9341	1.5157	412.0
416.0	295.617	0.01887	1.5463	1.5651	392.5	810.2	1202.8	0.5866	0.9253	1.5118	416.0
420.0	308.780	0.01894	1.4808	1.4997	396.9	806.2	1203.1	0.5915	0.9165	1.5080	420.0
424.0	322.391	0.01900	1.4184	1.4374	401.3	802.2	1203.5	0.5964	0.9077	1.5042	424.0
428.0	336.463	0.01906	1.3591	1.3782	405.7	798.0	1203.7	0.6014	0.8990	1.5004	428.0
432.0	351.00	0.01913	1.30266	1.32179	410.1	793.9	1204.0	0.6063	0.8903	1.4966	432.0
436.0	366.03	0.01919	1.24887	1.26806	414.6	789.7	1204.2	0.6112	0.8816	1.4928	436.0
440.0	381.54	0.01926	1.19761	1.21687	419.0	785.4	1204.4	0.6161	0.8729	1.4890	440.0
444.0	397.56	0.01933	1.14874	1.16806	423.5	781.1	1204.6	0.6210	0.8643	1.4853	444.0
448.0	414.09	0.01940	1.10212	1.12152	428.0	776.7	1204.7	0.6259	0.8557	1.4815	448.0
452.0	431.14	0.01947	1.05764	1.07711	432.5	772.3	1204.8	0.6308	0.8471	1.4778	452.0
456.0	448.73	0.01954	1.01518	1.03472	437.0	767.8	1204.8	0.6356	0.8385	1.4741	456.0

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

Temp Fahr 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	0.7771	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	1.3076	548.0
552.0	1062.59	0.02182	0.39479	0.41660	552.0	638.5	1190.6	0.7525	0.6311	1.3837	552.0
556.0	1097.55	0.02194	0.37966	0.40160	557.2	632.0	1189.2	0.7575	0.6222	1.3797	556.0
560.0	1133.38	0.02207	0.36507	0.38714	562.4	625.3	1187.7	0.7625	0.6132	1.3757	560.0
564.0	1170.10	0.02221	0.35099	0.37320	567.6	618.5	1186.1	0.7674	0.6041	1.3716	564.0
568.0	1207.72	0.02235	0.33741	0.35975	572.9	611.5	1184.5	0.7725	0.5950	1.3675	568.0
572.0	1246.26	0.02249	0.32429	0.34678	578.3	604.5	1182.7	0.7775	0.5859	1.3634	572.0
576.0	1285.74	0.02264	0.31162	0.33426	583.7	597.2	1180.9	0.7825	0.5766	1.3592	576.0
580.0	1326.17	0.02279	0.29937	0.32216	589.1	589.9	1179.0	0.7876	0.5673	1.3550	580.0
584.0	1367.7	0.02295	0.28753	0.31048	594.6	582.4	1176.9	0.7927	0.5580	1.3507	584.0
588.0	1410.0	0.02311	0.27608	0.29919	600.1	574.7	1174.8	0.7978	0.5485	1.3464	588.0
592.0	1453.3	0.02328	0.26499	0.28827	605.7	566.8	1172.6	0.8030	0.5390	1.3420	592.0
596.0	1497.8	0.02345	0.25425	0.27770	611.4	558.8	1170.2	0.8082	0.5293	1.3375	596.0
600.0	1543.2	0.02364	0.24384	0.26747	617.1	550.6	1167.7	0.8134	0.5196	1.3330	600.0
604.0	1589.7	0.02382	0.23374	0.25757	622.9	542.2	1165.1	0.8187	0.5097	1.3284	604.0
608.0	1637.3	0.02402	0.22394	0.24796	628.8	533.6	1162.4	0.8240	0.4997	1.3236	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	0.02485	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	0.8629	0.4251	1.2875	636.0
640.0	2059.9	0.02595	0.15427	0.18021	679.1	454.6	1133.7	0.8686	0.4134	1.2821	640.0
644.0	2118.3	0.02625	0.14644	0.17269	685.9	443.1	1129.0	0.8746	0.4015	1.2761	644.0
648.0	2178.1	0.02657	0.13876	0.16534	692.9	431.1	1124.0	0.8806	0.3893	1.2699	648.0
652.0	2239.2	0.02691	0.13124	0.15816	700.0	418.7	1118.7	0.8868	0.3767	1.2634	652.0
656.0	2301.7	0.02728	0.12387	0.15115	707.4	405.7	1113.1	0.8931	0.3637	1.2567	656.0
660.0	2365.7	0.02768	0.11663	0.14431	714.9	392.1	1107.0	0.8995	0.3502	1.2498	660.0
664.0	2431.1	0.02811	0.10947	0.13757	722.9	377.7	1100.6	0.9064	0.3361	1.2425	664.0
668.0	2498.1	0.02858	0.10229	0.13087	731.5	362.1	1093.5	0.9137	0.3210	1.2347	668.0
672.0	2566.6	0.02911	0.09514	0.12424	740.2	345.7	1085.9	0.9212	0.3054	1.2266	672.0
676.0	2636.8	0.02970	0.08799	0.11769	749.2	328.5	1077.6	0.9287	0.2892	1.2179	676.0
680.0	2708.6	0.03037	0.08080	0.11117	758.5	310.1	1068.5	0.9365	0.2720	1.2086	680.0
684.0	2782.1	0.03114	0.07349	0.10463	768.2	290.2	1058.4	0.9447	0.2537	1.1984	684.0
688.0	2857.4	0.03204	0.06595	0.09799	778.8	268.2	1047.0	0.9535	0.2337	1.1872	688.0
692.0	2934.5	0.03313	0.05797	0.09110	790.5	243.1	1033.6	0.9634	0.2110	1.1744	692.0
696.0	3013.4	0.03455	0.04916	0.08371	804.4	212.8	1017.2	0.9749	0.1841	1.1591	696.0
700.0	3094.3	0.03662	0.03857	0.07519	822.4	172.7	995.2	0.9901	0.1490	1.1390	700.0
702.0	3135.5	0.03824	0.03173	0.06997	835.0	144.7	979.7	1.0006	0.1246	1.1252	702.0
704.0	3177.2	0.04108	0.02192	0.06300	854.2	102.0	956.2	1.0169	0.0876	1.1046	704.0
705.0	3198.3	0.04427	0.01304	0.05730	873.0	61.4	934.4	1.0329	0.0527	1.0856	705.0
705.47*	3208.2	0.05078	0.00000	0.05078	906.0	0.0	906.0	1.0612	0.0000	1.0612	705.47*

*Critical temperature

DUANE ARNOLD R.O. - MAR 12, 1985

1. Answers

1.1 The absorption microscopic cross section is the sum of the capture microscopic cross section and the fission microscopic cross section. (Any answer that explains the adequately is acceptable) (1.0)

REFERENCE: Reactor Theory Lesson Plan Page 3-4

1.2 c (1.0)

REFERENCE: Rector Theory Page 8-7

1.3 a. Pu-239 is builtup by a sequence of neutron absorption by U-238 and two subsequent b- decays to Pu-239.

-OR-

U-283 + ON1 ---->U-239 ---(B-)--->Np-239 ---(B-)--->Pu-239 (0.75)

b. Pu-239 is a fissile material and buildsup to rather significant levels so that it accounts for approximately 35% of the fissions at EOL (0.5). The delayed neutron fraction for Pu-239 is 0.0021. This coupled with its significant fission fraction causes the effective delayed neutron fraction for the core to decrease substantially over core life (0.5). As the fraction of delayed neutrons drops the effective generation time tends toward the prompt neutron lifetime so that the period resulting from a given reactivity insertion is shorter near EOL. (0.75) (1.75)

REFERENCE: Reactor Theory Chapter 19

1.4 d

REFERENCE: Reactor Theory Chapter 17

1.5 The interlocks that prevent increasing recirculation pump speed above minimum unless feedwater flow is greater than 20%, or the discharge valve is not fully open.

REFERENCE: Lesson Plan A-2 Page 36

1.6 As steam flow increases, the DP losses due to friction increase and so a larger DP is needed at higher flows (1.0)

REFERENCE: Figure 32-11 and standard thermodynamic principles.

1.7 c

REFERENCE: Standard nuclear theory.

1.8. a. Cycle efficiency would be increased by a decrease in subcooling (0.5). As less heat is rejected to the condenser, the returning condensate requires less reactor heat to produce steam (1.0). Therefore cycle efficiency will increase.

b. By controlling the temp and flow of the cooling water to the condenser, the operator can directly affect the overall cycle efficiency (0.5).

REFERENCE: Standard thermodynamic principles.

1.9 a. Void coef. Decreased pressure caused by the SRV opening causes an increase in voids and adds negative reactivity (1.0)

b. Fuel temp coef. The rapid addition of positive reactivity due to the rod drop (removal) causes power to increase, therefore fuel temperature increases, adding negative reactivity. (1.0)

c. Moderator temp coef. Removal of feed heating causes a decrease in feed water temp, adding positive reactivity. (1.0)

REFERENCE: Reactor theory, chapters 23, 24, and 26.

1.10 b

REFERENCE: Standard nuclear theory.

1.11 b

REFERENCE: Standard thermodynamic theory.

1.12 d

REFERENCE: Standard thermodynamic theory.

1.13 a.

REFERENCE: Standard thermodynamic theory.

1.14 a. As flow increases, critical power increases, at higher flow rate cooling improves and thus a greater power input is required to raise the coolant enthalpy to saturation conditions and change water to steam. (1.5)

b. CP increases as inlet subcooling increases. Greater enthalpy rise is required to bring the coolant to saturation conditions thus higher bundle powers are required before boiling begins. (1.5)

c. An increase in pressure will cause a decrease in CP. The enthalpy of saturated steam decreases as pressure increases. e.g., enthalpy at 1000 psi = 1192.9; enthalpy at 1100 psi = 1189.1 (1.5)

The drop in enthalpy means a given pound of coolant must acquire less energy in traveling through a bundle to reach transition boiling. Thus, CP decreases.

REFERENCE: Standard thermodynamic theory.

1.15 b

RERERENCE: Standard nuclear theory.

1.16 c

REFERENCE: Standard nuclear theory.

1.17 Cool water from the booster pump discharge is sprayed into the barometric condenser through spray nozzles to condense the steam. (1.0)

REFERENCE: Lesson plan C-3, page 4.

2. Plant Design Including Safety and Emergency Systems ANSWERS

2.1 There are numerous indications that could be used and any reasonable answer will be given credit. The list below may not be all inclusive and reasonable indications or alarms may be acceptable. (Any 10 at .25 each)

Drywell sump flow and timers
Primary Containment pressure
Primary containment atmosphere temperature
Primary containment humidity
Primary containment radioactivity
Drywell vent coolers Delta T
Drywell level
Torus level
Reactor level
Reactor pressure
Steam flow/feed flow mismatch
Steam line pressure decrease
Torus water temperature

REFERENCE: Lesson Plan B-3, page 4-10.

2.2 1. CRD pumps take suction from the condensate reject line to CST (1.0)
2. CRD system supplies seal purge water to recirc pumps (1.0)
3. Scram discharge and instrument volumes drain to radwaste. Also vents from the drive water filters go to liquid radwaste. (1.0)
4. CRD gear box, pump bearings and seals are cooled by RBCCW. It is sufficient to say pump is cooled. (.5)

REFERENCE: Lesson plan A-1, pages 55-57.

2.3 RCIC pump turbine
HPCI pump turbine
SJAE's
Mositure separator/reheaters
Gland seals
Turbine building sampling system
Off gas preheater (any 6 at .33 each)
Offgas Jet Compressor
REFERENCE: Lesson plan A-6, pages 9-10

2.4 "B" RHR pump will continue running (.5)
"B" and "D" service water pumps will stop and heat exchanger throttle valve close. (1.0)
RHR heat exchanger bypass valve (MO-1940) opens (.5)
Suppression pool spray valve (1932) closes (.5)
LPCI to suppression pool test line valve (1934) closes. "B" RHR pump will continue to take a suction from the suppression pool but the discharge will now bypass the heat exchanger and go through the injection valves rather than through the test valves to the torus. (.5)

REFERENCE: Lesson plan C-1 and F-6.

2.5 a

REFERENCE: Lesson plan E-11, page 2

2.6 1. Emergency seal oil pump
2. Bearing oil header

REFERENCE: Lesson plan D-12, page 3.

2.7 a. Pressure in reactor vessel <35#. (.75)
The inboard MSIV in the associated line is closed. (.5)

b. Boil off any condensate that collects in the line. (.5)

REFERENCE: Lesson plan A-6, page 42.

2.8 a. As the steam condenses, pressure will decrease in the drywell. With the vacuum breakers failed shut, pressure cannot be equalized. The pressure in the drywell would decrease and the negative pressure (vacuum) limit would be exceeded and failure would probably result. (2.0)

b. Steam flows from the drywell to the torus through the vacuum breaker equalizing the pressure. The steam is not forced through the downcomers and up through the water (which would condense the steam and limit pressure rise), but instead is dumped on the surface of the water in the torus. As a result of this both torus and drywell pressure will probably exceed design pressure and fail. (2.0)

REFERENCE: Lesson plan E-6, page 11.

2.9 As level starts to increase in the 1E-4A heater the drain valve (emergency spill) to the condenser will start to open and open fully as level increases. As level increases further the high-high trip will be reached. ~~At this point the extraction steam bypass valve to condenser will open~~, the drain from the 1E-5A heater will close and the drain (emergency spill) from the 5A heater to the condenser will open. (1.0) (.5) (.5) (.5)

Drain valve to lower heater opens fully (1E-3A). Then the dump to the condenser opens fully

no extraction steam BPV

REFERENCE: Lesson plan D-15, pages 2, 6, 16-17.
P&ID M-105 sh 2

2.10 These switches provide a verification signal to the ADS system that a core spray pump has started. This is part of the ADS initiation permissive. (1.25)

REFERENCE: Lesson plan C-2, page 10.

2.11 Check valves located on the discharge side of the pump. (1.0)

REFERENCE: Lesson plan C-4, page 4.

2.12 1. Reactor scram signal (.5)
2. Recirculation pump trip signal (.5)

REFERENCE: Lesson plan D-9, page 29.

3. Instruments and Controls ANSWERS

3.1 1. Discharge valve 100% closed (.5)
2. Vent valve 100% open (.5)
3. Wet pit water level is normal (above 18" low level alarm) (.5)
4. Condenser discharge valves (MO 4208-4209) are 100% open (.5)

REFERENCE: Lesson plan D-3, page 7.

3.2 1. Inpute to PCIS (MSIV closure, group I)
2. Input to feedwater control system
3. Control room indication.
4. RWM input

REFERENCE: Lesson plan A-6, page 48.
System Description I-13 pg 8

3.3 a. An imbalance of flow (> setpoint) between inlet flow from the reactor and the sum of blowdown flow and return flow to the reactor. (1.5)

b. A (fifteen second) timer starts and if imbalance still exists after timer times out, isolation valves isolate. (1.0)

REFERENCE: Lesson plan B-4, page 7.

3.4 A&B (1.0)

REFERENCE: Lesson plan A-2, pages 39-40.

3.5 D (1.0)

REFERENCE: Lesson plan E-11, page 3.

3.6 B None of the answers are actually correct. Training material misleading (1.0)

REFERENCE: Lesson plan D-15, page 14-15.
Print B-109 Ch 2

3.7 1-D
2-D
3-E
4-C (.25 each)
5-E
6-B
7-D
8-E

REFERENCE: Lesson plan A-5, page 34.

3.8 Temperature elements monitoring the discharge piping temperature pressure switches in discharge piping.
Computer alarm (any 2 at .75 ea)

REFRENCE: Lesson plan A-6, page 26-46.

3.9 A Two valves (.5)

B A reactor high pressure scram signal and a safety/relief - valve opened as sensed by tailpipe pressure switches. (1.5)

C. After arming the LLS opening setpoints are dropped to 1020 psig (PSV 4401) and 1025 psig (PSV 4407). The closing setpoints are 120 PSI less (Other valves setpoints stay the same). (1.0)

D. Reset button on IC03. (.5)

REFERENCE: Lesson plan A-6, pages 36-38.

3.10 A. 1. Neutron monitoring system. 2. Used in flow biased trip units (Rod block and scram). (1.0)

B. 1. RHR system. 2. Used in LPCI loop selection logic to determine if there is a broken loop. (1.0)

C. 1. RHR system. 2. Used to determine pressure for RHR shutdown cooling permissive. (1.0)

D. 1. RHR system. 2. Used to determine if recirc pumps are running for LPCI loop selection logic. (1.0)

REFERENCE: Lesson plans A-2, page 24, C-1, pages 13-14, A-5, pages 32 and P&ID's 116, 119, and 120.

3.11 APRM channel mode switch not in operate. (.5)
APRM module (circuit card) removed. (.5)
LPRM input count circuit indicates too few LPRMs are being averaged. (.5)
Less than two inputs are available from any LPRM level in the core. (1.0)

REFERENCE: Lesson plan I&C 3, 4, page 21-22.

3.12 a. Water flows through the exhaust valve (insert or withdraw) into the exhaust header. Then into the other HCU's through the insert exhaust valves (SV-1854) and into the reactor through the CRD mechanism (drive withdraw line). (2.0)

b. B 2 (.5)

REFERENCE: Lesson plan A-1, pages 32-33, and 45-46.

4. Procedures - Normal, Abnormal, Emergency and Radiological Control ANSWERS

4.1 B (1.0)

REFERENCE: IPOI volume C-20, page II.B.2.

4.2 a. 1. Turbine Trip @ 19"
2. MSIV closures @ 10"
3. BPV's shut @ 7"
4. Reactor scram
5. Low vacuum alarm @ 24" and 25.5"
(4 required at .5 each)

b. Verify automatic actions have occurred.
If turbine trip has occurred, carryout turbine trip actions.
If reactor scram occurred, carryout scram actions.
If reactor has not scrammed, rapidly reduce reactor power using recirc pumps.
Place standby SJAE unit in service.
Place Mechanical Vacuum Pump in service.
(5 required at .5 each)

REFERENCE: IPOI C-40, Section O, Page O-2-3.
System Description D-4, pg 16,17

4.3. When any SRM has increased by a factor of ten or after group 2. (1.0

REFERENCE: IPOI Section II.C, page II 8A.

4.4 RCIC system - perferred (1.0)
HPCI system (.5)
RHR/RCIC system (.5)
control rods; CRDH cooling water flow rod, instrument

REFERENCE: IPOI Section II.C.20, page II 17.
IPOI VI D1 pg 15
D.2 pg 16

4.5 A (1.0)

REFERENCE: IPOI, Section II.C.3, page II-20.

4.6 To insure proper mixing of reactor vessel water (Prevent stagnation) (1.0)

REFERENCE: Section V.B, Page V-2.

4.7 Check that the existing control rod pattern:

1. Is in accordance with the RWM sequence latched. (1.0)
2. Has all rods in each group within one notch position of each other. (1.0)
3. Corresponds to required rod sequence control system group. (1.0)

REFERENCE: Section V.C., page V-3.

4.8 1. RHR service water crosstie.
2. Fire system
3. SBLC
4. Well water/GSW
5. ESW
6. Condensate/Demin service water

(.5 each)

REFERENCE: EOP 1, RC/L, Page 9

4.9 Torus water temperature above 95°F (1.0)
Drywell temperature above 150°F (1.0)
Drywell pressure above 2.0 psig (1.0)
Torus water level above 60% (1.0)
Torus water level below the minimum level allowed by DP (1.0)

REFERENCE: EOP-2, PCC, page 1.

4.10 Plant mode (.5)
Power level (MW_t and MW_e) (.5)
Electrical 4160V lineup (.5)
Major components out of service including limiting conditions of operation. (.5)

REFERENCE: 1410.3, page 4.

4.11 The hold card is used to safeguard human life and the warning tag is used to safeguard equipment, service or other operational reasons. (1.0)

REFERENCE: 1410.5, page 1.

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

FACILITY: Duane Arnold Energy Center
REACTOR TYPE: BWR
DATE ADMINISTERED: March 12, 1985
EXAMINER: Dave Graves
APPLICANT: ______________________

INSTRUCTIONS TO APPLICANT:

Use separate paper for the answers. Write answers on one side only. Staple question sheet on top of the answer sheets. Points for each question are indicated in parentheses after the question. The passing grade requires at least 70% in each category and a final grade of at least 80%.

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

Final Grade ______%

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

____
Applicant's Signature

Section 5 - Theory of Nuclear Power Plant Operation, Fluids and Thermodynamics

5.1 a. Explain the term "Prompt Critical." (1.0)

b. Explain why the amount of reactivity required to achieve prompt criticality varies with core life. (1.0)

5.2 In the main condenser, circulating water flow rate is approximately 20 times that of the steam flow rate. Why are these flow rates different? (Primary heat transfer rate equals circulating water heat transfer rate.) (Consider thermodynamic principles in your answer.) (1.5)

5.3 HOW and WHY does the MAGNITUDE (reactivity added per change in degree F) of the FUEL TEMPERATURE COEFFICIENT (DOPPLER) change, given the following changes in core conditions:

a. Core age (BOL to EOL). (1.0)

b. A significant increase in fuel temperature. (1.0)

c. A significant increase in core void fraction. (1.0)

5.4 a. After making a rod notch withdrawal with the reactor critical, you notice a 100 second period. How much reactivity was added by the rod notch? (assume BOL) (1.0)

b. After a reactor scram from power the shortest stable period possible is -80 seconds. Explain this statement. (1.0)

c. Is the initial period immediately following the scram shorter than -80 seconds? Explain your answer. (1.0)

5.5 a. What is "pump runout" and why is it an undesirable condition? (1.0)

b. Consider a real plant system (Non-IDEAL) with two identical pumps in parallel, one of which is running. The second pump is started. (Choose the correct answer and explain your choice. Both pumps are operating at 1800 RPM.) The new flow rate will be: (1.5)

(1) Double the original flow
(2) Less than double the original flow
(3) Greater than double the original flow
(4) Same as original flow, only discharge head changes

5.6 APLHGR limits have been set to assure that peak cladding temperature of 2200°F are not exceeded following a postulated LOCA.

a. following a LOCA, which rods (center, edge, corner) would be more likely to exceed this 2200°F limit. Explain your answer. (2.0)

b. Are these the same rods with the highest local peaking factors during normal operation? Explain. (1.5)

5.7 Following an auto initiation of HPCI at a reactor pressure of 800 psig, reactor pressure decreases to 400 psig. How are the following parameters affected (increases, decreases, remains constant) by the change in reactor pressure? Briefly explain your choice. Assume HPCI system is operating as designed.

a. HPCI flow to the reactor (1.0)

b. HPCI pump discharge head (assuming NPSH remains constant) (1.0)

c. HPCI turbine RPM (1.0)

5.8 For each of the events listed below, state which reactivity coefficient will respond first, why it responds first and whether it adds positive or negative reactivity.

a. SRV opening at 100% power. (1.0)

b. Rod drop from 100% power. (1.0)

5.9 Assume the reactor is at 100% power and flow. Explain what happens to core flow and why, with a reduction in power by driving rods. Assume recirculation pump speed remains constant. (1.0)

5.10 a. What is decay heat and how it is produced? (1.0)

b. After a reactor trip, thermal output of the reactor is a significant percentage for over two hours. Why isn't this power visible on the nuclear instrumentation? (1.0)

5.11 Give three (3) reasons why samarium is not considered a problem during reactor operations. (1.5)

Section 6 - Plant Systems Design, Control, and Instrumentation

6.1 When fuel is placed in the reactor, it is very important that fuel bundle orientation is correct. What are two reasons why the orientation must be correct? (2.0)

6.2 Concerning the feedwater control system in three element control:

a. What signals feed into the system? (1.0)

b. How many detectors are there for each signal? (1.0)

c. Where are these detectors located in their respective systems (if applicable)? (i.e., where in their flow path?) (1.0)

6.3 The MSIV-LCS is designed to take leakage from the MSIV's following a LOCA and discharge to the standby gas treatment system. What automatic features of this system will prevent continuously discharging excessive amounts of fission products to the SGTS if the MSIV's don't seal properly? (Include setpoints if appropriate) (3.0)

6.4 On certain recirculation system trips the generator field breaker will trip open immediately. On other trips the generator field breaker will remain closed until it trips due to exciter undervoltage. Why doesn't the field breaker just trip open on all recirc system trips? (2.0)

6.5 a. When a select error occurs on the RWM, can the operator still move the rod? (RWM is NOT bypassed and no rod blocks existed prior to selecting the rod.) ANSWER YES OR NO. (0.5)

b. If so, how far, and why? If not, why not? Explain your answer fully. Consider both an attempted insert and withdraw action. (2.5)

c. List the inputs supplied to the RWM from other plant systems. (1.0)

NOTE: Limit answers in "a" and "b" to RWM ONLY.

6.6 For EACH of the following conditions, STATE whether a SCRAM, HALF-SCRAM, ROD BLOCK, OR NO ACTION, is directly generated. For conditions that could produce more than one action, STATE the more limiting action (e.g. half-scram is more limiting than a rod block.) (2.5)

a. Loss of one RPS MG set

b. Turbine trip at 20% power

c. APRM B downscale, Mode switch in RUN

d. Scram discharge volume level is at 50 gallons

e. IRM A fails upscale, Mode switch in RUN

6.7 It may be necessary, under certain conditions, to vent the drywell when an isolation condition exists. What are 3 of the 4 signals or interlocks that must be bypassed or reset in order to vent the drywell under an isolation condition? (3.0)

6.8 RHR is being used in the suppression pool cooling mode to cool off the torus. "B" loop is lined up for cooling using the "B" RHR pump and the "B" + "D" RHR service water pumps. Explain what will happen (if anything) to any of the equipment being used for suppression pool cooling flow and the flow path if a LPCI initiation and injection signal were to occur. (3.5)

6.9 During movement of a control rod drive, what is the flow path for the exhaust water flow? Be specific and include flow path into the reactor vessel. (2.0)

0

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

7.1 What does the term ALARA stand for and what is the purpose of this concept? (2.0)

7.2 What three people (by title) can authorize entry into the Drywell when reactor pressure is greater than 400 psig? (1.5)

7.3 The vacuum pump should not be run at power levels >10%. What are the two reasons for this? (1.0)

7.4 EOP-2 states that torus water level must be below 13 ft. prior to initiating drywell sprays and torus level must be below 23.4 ft before initiating torus sprays. What are the reasons for requiring those levels prior to actuating sprays? (2.5)

7.5 The plant is at 80% of rated power. An explosion of unknown sources forces an evacuation of all personnel from the control room before any operator actions can take place.

a. In accordance with IPOI-H "Shutdown from Outside the Control Room", BRIEFLY EXPLAIN the PRIMARY AND BACKUP means of scramming the reactor. (2.0)

b. IDENTIFY TWO (2) visual observations that should be made by the operator to verify that the reactor has scrammed. (Include locations) (2.0)

7.6 According to your shutdown procedure, prior to steam flow dropping to the Rod Worth Minimizer Low Power Alarm Point (LPAP 35% reactor power), the existing control rod pattern must be checked. With three things must the control rod pattern be checked for? (3.0)

7.7 What are the six systems that are considered to be alternate injection subsystems by your emergency procedures? (3.0)

7.8 Which of the following would NOT necessarily be a symptom of unidentifiable leakage in the drywell of 5 GPM or higher? (1.0)

a. Excessively increasing drywell floor drain sump total flow at FQ 3707 on Panel 1C19.

b. DRYWELL HIGH TEMPERATURE alarm on Panel 1C04-C.

c. DRYWELL FLOOR DRAIN SUMP HI-HI LEVEL on Panel 1C04-C.

d. DRYWELL FLOOR DRAIN SUMP HI LEVEL on Panel 1C04-C.

7.9 When in the hot standby condition and with the reactor critical, what are the 3 systems or sets of system that may be used to control reactor pressure? Which of these is the preferred method? (2.0)

7.10 What operator actions are required if the "ROD OVERTRAVEL" annunicator alarms? (3.0)

7.11 During refueling, a functional and subcritical check of every control rod shall be made before the final shutdown margin test can be started. How is a "functional and subcritical check" performed and what is checked? (2.0)

Section 8 - Administrative Procedures, Conditions, and Limitations

8.1 Prestart Master Checklist need not be prepared for restarts following reactor critical operation that is terminated by an intentional non-mandatory shutdown of what two types? (1.5)

8.2 a. Prior to startup, independent manual valve position verification is required. Who must complete this verification and how is it completed? (2.0)

b. If a system lineup is to remain in an abnormal lineup (due to Hold Off Clearance, etc), how is this situation taken care of? (1.0)

8.3 How must changes to the control rod withdrawal sequence be documented and who must approve them? (2.0)

8.4 Prior to starting up the main turbine, there is a caution that says significant bypass steam flow has to have existed for at least 10 minutes before turbine startup. What is the purpose for this caution? (1.0)

8.5 According to Technical Specifications, what are the only five scrams that need to be operable when subcritical and water temperature <212°? (2.5)

8.6 Below are Technical Specification definitions for some of your thermal parameters. For each definition, give the correct thermal parameter.

a. The ratio of the linear heat generation rate (LHGR) existing at a given location to the design LHGR for that bundle type. (0.5)

b. The heat output per unit length of fuel pin. (0.5)

c. The ratio of local LHGR for any specific location on a fuel rod divided by the core average LHGR associated with the fuel bundles of the same type operating at the core average bundle power. (0.5)

d. The ratio of that fuel bundle power which would produce boiling transition to the actual fuel bundle power. (0.5)

8.7 Who can approve the following RWP's? (2.0)

a. Jobs with a collective dose estimate of less than one man-rem.

b. Jobs with a collective dose estimate of more than one man-rem.

c. Extended RWP's.

d. Standing RWP's.

8.8 According to EPIP-1.1, Determination of the Emergency Action Level, what are the responsibilities of the operations shift supervisor? (3.0)

8.9 Per your Technical Specifications, in order for the fire suppression system to be considered operable three (3) conditions must be met. What are these conditions? (3.0)

8.10 The Technical Specifications talk about operating with "Limiting Control Rod Patterns."

a. What is a limiting control rod pattern? (0.5)

b. What three (3) conditions must be met when operating with a limiting control rod pattern? (3.0)

8.11 Your Technical Specifications have limits of 5 gpm unidentified leakage and total leakage of 25 gpm in the primary containment. When are these limits in effect? (1.5)

EQUATION SHEET

$f = ma$

$w = mg$

$E = mc^2$

$KE = 1/2\ mv^2$

$PE = mgh$

$V_f = V_o + at$

$NPSH = P_{in} - P_{sat}$

$\dot{m} \alpha \rho AV$

$\Delta E = 931\ \Delta m$

$Q = \dot{m}Cp\Delta t$

$Q = UA\Delta h$

$Pwr = W_f\Delta h$

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

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

$SUR = 26.06/T$

$SUR = 26\rho/\ell^* + (\beta - \rho)T$

$T = (\ell^*/\rho) + [(\beta - \rho)/\lambda\rho]$

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

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

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

$\rho = [(\ell^*/(T\ K_{eff})] + [\beta_{eff}/(1 + \lambda T)]$

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

$\Sigma = \sigma N$

$NPSH = \text{Static head} - h_L - P_{sat}$

$v = s/t$

$s = V_o t + 1/2\ at^2$

$a = (V_f - V_o)/t$

$w = \theta/t$

Cycle efficiency = (Network out)/(Energy in)

$A = \lambda N$ $\quad A = A_o e^{-\lambda t}$

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

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

$I = I_o e^{-Ex}$

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

$I = I_o\ 10^{-x/TVL}$

$TVL = 1.3/\mu$

$HVL = -0.693/\mu$

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

$CR_x = S/(1 - K_{effx})$

$CR_1(1 - K_{eff1}) = CR_2(1 - k_{eff2})$

$M = 1/(1 - K_{eff}) = CR_1/CR_o$

$M = (1 - K_{effo})/(1 - K_{eff1})$

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

$\ell^* = 10^{-5}$ seconds

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

$I_1 d_1 = I_2 d_2$

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

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

$R/hr = 6\ CE/d^2$ (feet).

<u>Water Parameters</u>

1 gal. = 8.345 lbm.
1 gal. = 3.78 liters
1 ft^3 = 7.48 gal.
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 psi = 29.9 in. Hg

<u>Miscellaneous Conversions</u>

1 curie = 3.7×10^{10} dps
1 kg = 2.21 lbm
1 hp = 2.54×10^3 Btu/hr
1 mw = 3.41×10^6 Btu/hr
1 in = 2.54 cm
°F = 9/5°C + 32
°C = 5/9 (°F-32)

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	0.20675	0.016026	1482.4	1482.4	22.058	1063.1	1085.1	0.0439	2.0695	2.1134	54.0
56.0	0.22183	0.016028	1383.6	1383.6	24.059	1061.9	1086.0	0.0478	2.0593	2.1070	56.0
58.0	0.23843	0.016031	1292.2	1292.2	26.060	1060.8	1086.9	0.0516	2.0491	2.1008	58.0
60.0	0.25611	0.016033	1207.6	1207.6	28.060	1059.7	1087.7	0.0555	2.0391	2.0946	60.0
62.0	0.27494	0.016036	1129.2	1129.2	30.059	1058.5	1088.6	0.0593	2.0291	2.0885	62.0
64.0	0.29497	0.016039	1056.5	1056.5	32.058	1057.4	1089.5	0.0632	2.0192	2.0824	64.0
66.0	0.31626	0.016043	989.0	989.1	34.056	1056.3	1090.4	0.0670	2.0094	2.0764	66.0
68.0	0.33889	0.016046	926.5	926.5	36.054	1055.2	1091.2	0.0708	1.9996	2.0704	68.0
70.0	0.36292	0.016050	868.3	868.4	38.052	1054.0	1092.1	0.0745	1.9900	2.0645	70.0
72.0	0.38844	0.016054	814.3	814.3	40.049	1052.9	1093.0	0.0783	1.9804	2.0587	72.0
74.0	0.41550	0.016058	764.1	764.1	42.046	1051.8	1093.8	0.0821	1.9708	2.0529	74.0
76.0	0.44420	0.016063	717.4	717.4	44.043	1050.7	1094.7	0.0858	1.9614	2.0472	76.0
78.0	0.47461	0.016067	673.8	673.9	46.040	1049.5	1095.6	0.0895	1.9520	2.0415	78.0
80.0	0.50683	0.016072	633.3	633.3	48.037	1048.4	1096.4	0.0932	1.9426	2.0359	80.0
82.0	0.54093	0.016077	595.5	595.5	50.033	1047.3	1097.3	0.0969	1.9334	2.0303	82.0
84.0	0.57702	0.016082	560.3	560.3	52.029	1046.1	1098.2	0.1006	1.9242	2.0248	84.0
86.0	0.61518	0.016087	527.5	527.5	54.026	1045.0	1099.0	0.1043	1.9151	2.0193	86.0
88.0	0.65551	0.016093	496.8	496.8	56.022	1043.9	1099.9	0.1079	1.9060	2.0139	88.0
90.0	0.69813	0.016099	468.1	468.1	58.018	1042.7	1100.8	0.1115	1.8970	2.0086	90.0
92.0	0.74313	0.016105	441.3	441.3	60.014	1041.6	1101.6	0.1152	1.8881	2.0033	92.0
94.0	0.79062	0.016111	416.3	416.3	62.010	1040.5	1102.5	0.1188	1.8792	1.9980	94.0
96.0	0.84072	0.016117	392.8	392.9	64.006	1039.3	1103.3	0.1224	1.8704	1.9928	96.0
98.0	0.89356	0.016123	370.9	370.9	66.003	1038.2	1104.2	0.1260	1.8617	1.9876	98.0
100.0	0.94924	0.016130	350.4	350.4	67.999	1037.1	1105.1	0.1295	1.8530	1.9825	100.0
102.0	1.00789	0.016137	331.1	331.1	69.995	1035.9	1105.9	0.1331	1.8444	1.9775	102.0
104.0	1.06965	0.016144	313.1	313.1	71.992	1034.8	1106.8	0.1366	1.8358	1.9725	104.0
106.0	1.1347	0.016151	296.16	296.18	73.99	1033.6	1107.6	0.1402	1.8273	1.9675	106.0
108.0	1.2030	0.016158	280.28	280.30	75.98	1032.5	1108.5	0.1437	1.8188	1.9626	108.0
110.0	1.2750	0.016165	265.37	265.39	77.98	1031.4	1109.3	0.1472	1.8105	1.9577	110.0
112.0	1.3505	0.016173	251.37	251.38	79.98	1030.2	1110.2	0.1507	1.8021	1.9528	112.0
114.0	1.4299	0.016180	238.21	238.22	81.97	1029.1	1111.0	0.1542	1.7938	1.9480	114.0
116.0	1.5133	0.016188	225.84	225.85	83.97	1027.9	1111.9	0.1577	1.7856	1.9433	116.0
118.0	1.6009	0.016196	214.20	214.21	85.97	1026.8	1112.7	0.1611	1.7774	1.9386	118.0
120.0	1.6927	0.016204	203.25	203.26	87.97	1025.6	1113.6	0.1646	1.7693	1.9339	120.0
122.0	1.7891	0.016213	192.94	192.95	89.96	1024.5	1114.4	0.1680	1.7613	1.9293	122.0
124.0	1.8901	0.016221	183.23	183.24	91.96	1023.3	1115.3	0.1715	1.7533	1.9247	124.0
126.0	1.9959	0.016229	174.08	174.09	93.96	1022.2	1116.1	0.1749	1.7453	1.9202	126.0
128.0	2.1068	0.016238	165.45	165.47	95.96	1021.0	1117.0	0.1783	1.7374	1.9157	128.0
130.0	2.2230	0.016247	157.32	157.33	97.96	1019.8	1117.8	0.1817	1.7295	1.9112	130.0
132.0	2.3445	0.016256	149.64	149.66	99.95	1018.7	1118.6	0.1851	1.7217	1.9068	132.0
134.0	2.4717	0.016265	142.40	142.41	101.95	1017.5	1119.5	0.1884	1.7140	1.9024	134.0
136.0	2.6047	0.016274	135.55	135.57	103.95	1016.4	1120.3	0.1918	1.7063	1.8980	136.0
138.0	2.7438	0.016284	129.09	129.11	105.95	1015.2	1121.1	0.1951	1.6986	1.8937	138.0
140.0	2.8892	0.016293	122.98	123.00	107.95	1014.0	1122.0	0.1985	1.6910	1.8895	140.0
142.0	3.0411	0.016303	117.21	117.22	109.95	1012.9	1122.8	0.2018	1.6834	1.8852	142.0
144.0	3.1997	0.016312	111.74	111.76	111.95	1011.7	1123.6	0.2051	1.6759	1.8810	144.0
146.0	3.3653	0.016322	106.58	106.59	113.95	1010.5	1124.5	0.2084	1.6684	1.8769	146.0
148.0	3.5381	0.016332	101.68	101.70	115.95	1009.3	1125.3	0.2117	1.6610	1.8727	148.0
150.0	3.7184	0.016343	97.05	97.07	117.95	1008.2	1126.1	0.2150	1.6536	1.8686	150.0
152.0	3.9065	0.016353	92.66	92.68	119.95	1007.0	1126.9	0.2183	1.6463	1.8646	152.0
154.0	4.1025	0.016363	88.50	88.52	121.95	1005.8	1127.7	0.2216	1.6390	1.8606	154.0
156.0	4.3068	0.016374	84.56	84.57	123.95	1004.6	1128.6	0.2248	1.6318	1.8566	156.0
158.0	4.5197	0.016384	80.82	80.83	125.96	1003.4	1129.4	0.2281	1.6245	1.8526	158.0
160.0	4.7414	0.016395	77.27	77.29	127.96	1002.2	1130.2	0.2313	1.6174	1.8487	160.0
162.0	4.9722	0.016406	73.90	73.92	129.96	1001.0	1131.0	0.2345	1.6103	1.8448	162.0
164.0	5.2124	0.016417	70.70	70.72	131.96	999.8	1131.8	0.2377	1.6032	1.8409	164.0
166.0	5.4623	0.016428	67.67	67.68	133.97	998.6	1132.6	0.2409	1.5961	1.8371	166.0
168.0	5.7223	0.016440	64.78	64.80	135.97	997.4	1133.4	0.2441	1.5892	1.8333	168.0
170.0	5.9926	0.016451	62.04	62.06	137.97	996.2	1134.2	0.2473	1.5822	1.8295	170.0
172.0	6.2736	0.016463	59.43	59.45	139.98	995.0	1135.0	0.2505	1.5753	1.8258	172.0
174.0	6.5656	0.016474	56.95	56.97	141.98	993.8	1135.8	0.2537	1.5684	1.8221	174.0
176.0	6.8690	0.016486	54.59	54.61	143.99	992.6	1136.6	0.2568	1.5616	1.8184	176.0
178.0	7.1840	0.016498	52.35	52.36	145.99	991.4	1137.4	0.2600	1.5548	1.8147	178.0

*The states shown are meta stable

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

Temp Fahr t	Abs Press Lb per Sq In p	Specific Volume Sat Liquid v_f	Specific Volume Evap v_{fg}	Specific Volume Sat Vapor v_g	Enthalpy Sat Liquid h_f	Enthalpy Evap h_{fg}	Enthalpy Sat Vapor h_g	Entropy Sat Liquid s_f	Entropy Evap s_{fg}	Entropy Sat Vapor s_g	Temp Fahr t
180.0	7.5110	0.016510	50.21	50.22	148.00	990.2	1138.2	0.2631	1.5480	1.8111	180.0
182.0	7.850	0.016522	48.172	48.189	150.01	989.0	1139.0	0.2662	1.5413	1.8075	182.0
184.0	8.203	0.016534	46.232	46.249	152.01	987.8	1139.8	0.2694	1.5346	1.8040	184.0
186.0	8.568	0.016547	44.383	44.400	154.02	986.5	1140.5	0.2725	1.5279	1.8004	186.0
188.0	8.947	0.016559	42.621	42.638	156.03	985.3	1141.3	0.2756	1.5213	1.7969	188.0
190.0	9.340	0.016572	40.941	40.957	158.04	984.1	1142.1	0.2787	1.5148	1.7934	190.0
192.0	9.747	0.016585	39.337	39.354	160.05	982.8	1142.9	0.2818	1.5082	1.7900	192.0
194.0	10.168	0.016598	37.808	37.824	162.05	981.6	1143.7	0.2848	1.5017	1.7865	194.0
196.0	10.605	0.016611	36.348	36.364	164.06	980.4	1144.4	0.2879	1.4952	1.7831	196.0
198.0	11.058	0.016624	34.954	34.970	166.08	979.1	1145.2	0.2910	1.4888	1.7798	198.0
200.0	11.526	0.016637	33.622	33.639	168.09	977.9	1146.0	0.2940	1.4824	1.7764	200.0
204.0	12.512	0.016664	31.135	31.151	172.11	975.4	1147.5	0.3001	1.4697	1.7698	204.0
208.0	13.568	0.016691	28.862	28.878	176.14	972.8	1149.0	0.3061	1.4571	1.7632	208.0
212.0	14.696	0.016719	26.782	26.799	180.17	970.3	1150.5	0.3121	1.4447	1.7568	212.0
216.0	15.901	0.016747	24.878	24.894	184.20	967.8	1152.0	0.3181	1.4323	1.7505	216.0
220.0	17.186	0.016775	23.131	23.148	188.23	965.2	1153.4	0.3241	1.4201	1.7442	220.0
224.0	18.556	0.016805	21.529	21.545	192.27	962.6	1154.9	0.3300	1.4081	1.7380	224.0
228.0	20.015	0.016834	20.056	20.073	196.31	960.0	1156.3	0.3359	1.3961	1.7320	228.0
232.0	21.567	0.016864	18.701	18.718	200.35	957.4	1157.8	0.3417	1.3842	1.7260	232.0
236.0	23.216	0.016895	17.454	17.471	204.40	954.8	1159.2	0.3476	1.3725	1.7201	236.0
240.0	24.968	0.016926	16.304	16.321	208.45	952.1	1160.6	0.3533	1.3609	1.7142	240.0
244.0	26.826	0.016958	15.243	15.260	212.50	949.5	1162.0	0.3591	1.3494	1.7085	244.0
248.0	28.796	0.016990	14.264	14.281	216.56	946.8	1163.4	0.3649	1.3379	1.7028	248.0
252.0	30.883	0.017022	13.358	13.375	220.62	944.1	1164.7	0.3706	1.3266	1.6972	252.0
256.0	33.091	0.017055	12.520	12.538	224.69	941.4	1166.1	0.3763	1.3154	1.6917	256.0
260.0	35.427	0.017089	11.745	11.762	228.76	938.6	1167.4	0.3819	1.3043	1.6862	260.0
264.0	37.894	0.017123	11.025	11.042	232.83	935.9	1168.7	0.3876	1.2933	1.6808	264.0
268.0	40.500	0.017157	10.358	10.375	236.91	933.1	1170.0	0.3932	1.2823	1.6755	268.0
272.0	43.249	0.017193	9.738	9.755	240.99	930.3	1171.3	0.3987	1.2715	1.6702	272.0
276.0	46.147	0.017228	9.162	9.180	245.08	927.5	1172.5	0.4043	1.2607	1.6650	276.0
280.0	49.200	0.017264	8.627	8.644	249.17	924.6	1173.8	0.4098	1.2501	1.6599	280.0
284.0	52.414	0.01730	8.1280	8.1453	253.3	921.7	1175.0	0.4154	1.2395	1.6548	284.0
288.0	55.795	0.01734	7.6634	7.6807	257.4	918.8	1176.2	0.4208	1.2290	1.6498	288.0
292.0	59.350	0.01738	7.2301	7.2475	261.5	915.9	1177.4	0.4263	1.2186	1.6449	292.0
296.0	63.084	0.01741	6.8259	6.8433	265.6	913.0	1178.6	0.4317	1.2082	1.6400	296.0
300.0	67.005	0.01745	6.4483	6.4658	269.7	910.0	1179.7	0.4372	1.1979	1.6351	300.0
304.0	71.119	0.01749	6.0955	6.1130	273.8	907.0	1180.9	0.4426	1.1877	1.6303	304.0
308.0	75.433	0.01753	5.7655	5.7830	278.0	904.0	1182.0	0.4479	1.1776	1.6256	308.0
312.0	79.953	0.01757	5.4566	5.4742	282.1	901.0	1183.1	0.4533	1.1676	1.6209	312.0
316.0	84.688	0.01761	5.1673	5.1849	286.3	897.9	1184.1	0.4586	1.1576	1.6162	316.0
320.0	89.643	0.01766	4.8961	4.9138	290.4	894.8	1185.2	0.4640	1.1477	1.6116	320.0
324.0	94.826	0.01770	4.6418	4.6595	294.6	891.6	1186.2	0.4692	1.1378	1.6071	324.0
328.0	100.245	0.01774	4.4030	4.4208	298.7	888.5	1187.2	0.4745	1.1280	1.6025	328.0
332.0	105.907	0.01779	4.1788	4.1966	302.9	885.3	1188.2	0.4798	1.1183	1.5981	332.0
336.0	111.820	0.01783	3.9681	3.9859	307.1	882.1	1189.1	0.4850	1.1086	1.5936	336.0
340.0	117.992	0.01787	3.7699	3.7878	311.3	878.8	1190.1	0.4902	1.0990	1.5892	340.0
344.0	124.430	0.01792	3.5834	3.6013	315.5	875.5	1191.0	0.4954	1.0894	1.5849	344.0
348.0	131.142	0.01797	3.4078	3.4258	319.7	872.2	1191.1	0.5006	1.0799	1.5806	348.0
352.6	138.138	0.01801	3.2423	3.2603	323.9	868.9	1192.7	0.5058	1.0705	1.5763	352.6
356.0	145.424	0.01806	3.0863	3.1044	328.1	865.5	1193.6	0.5110	1.0611	1.5721	356.0
360.0	153.010	0.01811	2.9392	2.9573	332.3	862.1	1194.4	0.5161	1.0517	1.5678	360.0
364.0	160.903	0.01816	2.8002	2.8184	336.5	858.6	1195.2	0.5212	1.0424	1.5637	364.0
368.0	169.113	0.01821	2.6691	2.6873	340.8	855.1	1195.9	0.5263	1.0332	1.5595	368.0
372.0	177.648	0.01826	2.5451	2.5633	345.0	851.6	1196.7	0.5314	1.0240	1.5554	372.0
376.0	186.517	0.01831	2.4279	2.4462	349.3	848.1	1197.4	0.5365	1.0148	1.5513	376.0
380.0	195.729	0.01836	2.3170	2.3353	353.6	844.5	1198.0	0.5416	1.0057	1.5473	380.0
384.0	205.294	0.01842	2.2120	2.2304	357.9	840.8	1198.7	0.5466	0.9966	1.5432	384.0
388.0	215.270	0.01847	2.1126	2.1311	362.2	837.2	1199.3	0.5516	0.9876	1.5392	388.0
392.0	225.516	0.01853	2.0184	2.0369	366.5	833.4	1199.9	0.5567	0.9786	1.5352	392.0
396.0	236.193	0.01858	1.9291	1.9477	370.8	829.7	1200.4	0.5617	0.9696	1.5313	396.0
400.0	247.259	0.01864	1.8444	1.8630	375.1	825.9	1201.0	0.5667	0.9607	1.5274	400.0
404.0	258.725	0.01870	1.7640	1.7827	379.4	822.0	1201.5	0.5717	0.9518	1.5234	404.0
408.0	270.600	0.01875	1.6877	1.7064	383.8	818.2	1201.9	0.5766	0.9429	1.5195	408.0
412.0	282.894	0.01881	1.6152	1.6340	388.1	814.2	1202.4	0.5816	0.9341	1.5157	412.0
416.0	295.617	0.01887	1.5463	1.5651	392.5	810.2	1202.8	0.5866	0.9253	1.5118	416.0
420.0	308.780	0.01894	1.4808	1.4997	396.9	806.2	1203.1	0.5915	0.9165	1.5080	420.0
424.0	322.391	0.01900	1.4184	1.4374	401.3	802.2	1203.5	0.5964	0.9077	1.5042	424.0
428.0	336.463	0.01906	1.3591	1.3782	405.7	798.0	1203.7	0.6014	0.8990	1.5004	428.0
432.0	351.00	0.01913	1.30266	1.32179	410.1	793.9	1204.0	0.6063	0.8903	1.4966	432.0
436.0	366.03	0.01919	1.24887	1.26806	414.6	789.7	1204.2	0.6112	0.8816	1.4928	436.0
440.0	381.54	0.01926	1.19761	1.21687	419.0	785.4	1204.4	0.6161	0.8729	1.4890	440.0
444.0	397.56	0.01933	1.14874	1.16806	423.5	781.1	1204.6	0.6210	0.8643	1.4853	444.0
448.0	414.09	0.01940	1.10212	1.12152	428.0	776.7	1204.7	0.6259	0.8557	1.4815	448.0
452.0	431.14	0.01947	1.05764	1.07711	432.5	772.3	1204.8	0.6308	0.8471	1.4778	452.0
456.0	448.73	0.01954	1.01518	1.03472	437.0	767.8	1204.8	0.6356	0.8385	1.4741	456.0

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

Temp Fahr t	Abs Press Lb per Sq In p	Specific Volume Sat Liquid v_f	Specific Volume Evap v_{fg}	Specific Volume Sat Vapor v_g	Enthalpy Sat Liquid h_f	Enthalpy Evap h_{fg}	Enthalpy Sat Vapor h_g	Entropy Sat Liquid s_f	Entropy Evap s_{fg}	Entropy Sat Vapor s_g	Temp Fahr t
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	[illegible]	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	0.7771	1.4258	508.0
512.0	757.72	0.02072	0.58218	0.60289	502.3	698.2	1200.5	0.7036	0.7185	1.4221	512.0
516.0	784.76	0.02081	0.55997	0.58079	507.1	692.7	1199.8	0.7085	0.7099	1.4183	516.0
520.0	812.53	0.02091	0.53864	0.55956	512.0	687.0	1199.0	0.7133	0.7013	1.4146	520.0
524.0	841.04	0.02102	0.51814	0.53916	516.9	681.3	1198.2	0.7182	0.6926	1.4108	524.0
528.0	870.31	0.02112	0.49843	0.51955	521.8	675.5	1197.3	0.7231	0.6839	1.4070	528.0
532.0	900.34	0.02123	0.47947	0.50070	526.8	669.6	1196.4	0.7280	0.6752	1.4032	532.0
536.0	931.17	0.02134	0.46123	0.48257	531.7	663.6	1195.4	0.7329	0.6665	1.3993	536.0
540.0	962.79	0.02146	0.44367	0.46513	536.8	657.5	1194.3	0.7378	0.6577	1.3954	540.0
544.0	995.22	0.02157	0.42677	0.44834	541.8	651.3	1193.1	0.7427	0.6489	1.3915	544.0
548.0	1028.49	0.02169	0.41048	0.43217	546.9	645.0	1191.9	0.7476	0.6400	1.3876	548.0
552.0	1062.59	0.02182	0.39479	0.41660	552.0	638.5	1190.6	0.7525	0.6311	1.3837	552.0
556.0	1097.55	0.02194	0.37966	0.40160	557.2	632.0	1189.2	0.7575	0.6222	1.3797	556.0
560.0	1133.38	0.02207	0.36507	0.38714	562.4	625.3	1187.7	0.7625	0.6132	1.3757	560.0
564.0	1170.10	0.02221	0.35099	0.37320	567.6	618.5	1186.1	0.7674	0.6041	1.3716	564.0
568.0	1207.72	0.02235	0.33741	0.35975	572.9	611.5	1184.5	0.7725	0.5950	1.3675	568.0
572.0	1246.26	0.02249	0.32429	0.34678	578.3	604.5	1182.7	0.7775	0.5859	1.3634	572.0
576.0	1285.74	0.02264	0.31162	0.33426	583.7	597.2	1180.9	0.7825	0.5766	1.3592	576.0
580.0	1326.17	0.02279	0.29937	0.32216	589.1	589.9	1179.0	0.7876	0.5673	1.3550	580.0
584.0	1367.7	0.02295	0.28753	0.31048	594.6	582.4	1176.9	0.7927	0.5580	1.3507	584.0
588.0	1410.0	0.02311	0.27608	0.29919	600.1	574.7	1174.8	0.7978	0.5485	1.3464	588.0
592.0	1453.3	0.02328	0.26499	0.28827	605.7	566.8	1172.6	0.8030	0.5390	1.3420	592.0
596.0	1497.8	0.02345	0.25425	0.27770	611.4	558.8	1170.2	0.8082	0.5293	1.3375	596.0
600.0	1543.2	0.02364	0.24384	0.26747	617.1	550.6	1167.7	0.8134	0.5196	1.3330	600.0
604.0	1589.7	0.02382	0.23374	0.25757	622.9	542.2	1165.1	0.8187	0.5097	1.3284	604.0
608.0	1637.3	0.02402	0.22394	0.24796	628.8	533.6	1162.4	0.8240	0.4997	1.3238	608.0
612.0	1686.1	0.02422	0.21442	0.23865	634.8	524.7	1159.5	0.8294	0.4896	1.3190	612.0
616.0	1735.9	0.02444	0.20516	0.22960	640.8	515.6	1156.4	0.8348	0.4794	1.3141	616.0
620.0	1786.9	0.02466	0.19615	0.22081	646.9	506.3	1153.2	0.8403	0.4689	1.3092	620.0
624.0	1839.0	0.02489	0.18737	0.21226	653.1	496.6	1149.8	0.8458	0.4583	1.3041	624.0
628.0	1892.4	0.02514	0.17880	0.20394	659.5	486.7	1146.1	0.8514	0.4474	1.2988	628.0
632.0	1947.0	0.02539	0.17044	0.19583	665.9	476.4	1142.2	0.8571	0.4364	1.2934	632.0
636.0	2002.8	0.02566	0.16226	0.18792	672.4	465.7	1138.1	0.8628	0.4251	1.2879	636.0
640.0	2059.9	0.02595	0.15427	0.18021	679.1	454.6	1133.7	0.8686	0.4134	1.2821	640.0
644.0	2118.3	0.02625	0.14644	0.17269	685.9	443.1	1129.0	0.8746	0.4015	1.2761	644.0
648.0	2178.1	0.02657	0.13876	0.16534	692.9	431.1	1124.0	0.8806	0.3893	1.2699	648.0
652.0	2239.2	0.02691	0.13124	0.15816	700.0	418.7	1118.7	0.8868	0.3767	1.2634	652.0
656.0	2301.7	0.02728	0.12387	0.15115	707.4	405.7	1113.1	0.8931	0.3637	1.2567	656.0
660.0	2365.7	0.02768	0.11663	0.14431	714.9	392.1	1107.0	0.8995	0.3502	1.2498	660.0
664.0	2431.1	0.02811	0.10947	0.13757	722.9	377.7	1100.6	0.9064	0.3361	1.2425	664.0
668.0	2498.1	0.02858	0.10229	0.13087	731.5	362.1	1093.5	0.9137	0.3210	1.2347	668.0
672.0	2566.6	0.02911	0.09514	0.12424	740.2	345.7	1085.9	0.9212	0.3054	1.2266	672.0
676.0	2636.8	0.02970	0.08799	0.11769	749.2	328.5	1077.6	0.9287	0.2892	1.2179	676.0
680.0	2708.6	0.03037	0.08080	0.11117	758.5	310.1	1068.5	0.9365	0.2720	1.2086	680.0
684.0	2782.1	0.03114	0.07349	0.10463	768.2	290.2	1058.4	0.9447	0.2537	1.1984	684.0
688.0	2857.4	0.03204	0.06595	0.09799	778.8	268.2	1047.0	0.9535	0.2337	1.1872	688.0
692.0	2934.5	0.03313	0.05797	0.09110	790.5	243.1	1033.6	0.9634	0.2110	1.1744	692.0
696.0	3013.4	0.03455	0.04916	0.08371	804.4	212.8	1017.2	0.9749	0.1841	1.1591	696.0
700.0	3094.3	0.03662	0.03857	0.07519	822.4	172.7	995.2	0.9901	0.1490	1.1390	700.0
702.0	3135.5	0.03824	0.03173	0.06997	835.0	144.7	979.7	1.0006	0.1246	1.1252	702.0
704.0	3177.2	0.04108	0.02192	0.06300	854.2	102.0	956.2	1.0169	0.0876	1.1046	704.0
705.0	3198.3	0.04427	0.01304	0.05730	873.0	61.4	934.4	1.0329	0.0527	1.0856	705.0
705.47*	3208.2	0.05078	0.00000	0.05078	906.0	0.0	906.0	1.0612	0.0000	1.0612	705.47*

*Critical temperature

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Section 5 Answers

5.1 a. RX is said to be prompt critical when the reactivity addition exceeds the delayed neutron fraction Beta and is thus critical on prompt neutrons alone.

b. Beta decreases with the buildup of Pu-239.

Ref.: Standard nuclear theory

5.2 Circulating water is maintained subcooled while the steam undergoes a change in phase. The heat removal required to condense the steam (i.e., latent heat of condensation) accounts for the large difference in flow rates. (1.5)

Ref.: Standard thermodynamics

5.3 a. INCREASES or becomes more negative (0.25) due to the buildup of resonance absorption materials, such as Pu-240 and fission products not present at BOL (0.75). (1.0)

b. DECREASES or becomes less negative (0.25) due to a smaller fractional change in the neutrons being resonantly captured (0.75). (1.0)

c. INCREASES or becomes more negative (0.25) due to an increase in neutron slowing down length, causing neutrons to spend more time in the resonance energy spectrum (0.75). (1.0)

Ref.: Standard nuclear theory

5.4 a. $T=B-p/\lambda p$ so $p=B/\lambda T + 1$ λ = Lambda (1.0)
assume $B = .0072$ (BOL) and $\lambda = .1$
$p = .0072/(100)(0.1) + 1 = 6.545 \times 10E-4$ delta k/k

b. After the initial prompt drop, power cannot decrease faster than the longest lived delayed neutron appears. (1.0)

c. Yes. The initial drop in power will only be due to the prompt neutrons. (1.0)

5.5 a. Increase in flow due to loss of backpressure (0.5). The increased flow causes the motor to draw more current and possibly damage the motor windings (0.5). or can lead to cavitation which may cause pump damage.

b. 2 (0.5) When delivering water into a piping system that offers frictional resistance two pumps operating in parallel will encounter greater resistance to flow. The resistance lowers the total flow to less than twice the original flow (1.0).

Ref.: Standard fluid flow

5.6 a. The central rods are more likely to exceed the 2200°F limit. (0.5)

In the event of a LOCA, the fuel would dry out rather quickly and the primary heat transfer mechanism prior to rewetting would be thermal radiation. The edge rods can radiate heat away from the bundle, while the central rods radiate much of their heat to other central rods. (1.5)

b. No. The edge rods, and the corner rods in particular, have higher local peaking factors. This is due to the water gaps. (1.5)

Ref.: Heat transfer and fluid flow page 15-2 and standard nuclear theory

5.7 a. Remains constant (0.25). Flow is controlled by flow controller which will attempt to maintain a constant output flow regardless of reactor pressure (0.75).

b. Decreases (0.25). The flow controller functions to maintain a constant flow, thus pump discharge pressure is decreased along with the decreasing reactor pressure to maintain constant flow; or since flow controller maintains a constant flow to the reactor, as reactor pressure decreases, the pump discharge head must decrease to maintain a constant flow (constant NPSH) (0.75).

c. Decreases (0.25). Since pump discharge head is decreasing to maintain a constant flow, turbine RPM must also decrease (0.75).

5.8 a. The decrease in pressure will cause increased voids (0.5). Void coefficient (0.25) would add negative reactivity first (0.25).

b. The addition of positive reactivity by the rod removal causes power to increase and thus fuel temperature increases (0.5). The fuel temperature coefficient (0.25) would respond first by adding negative reactivity (0.25).

Ref.: BWR technology

5.9 Core flow would increase (0.5) due to reduction in two phase flow conditions (0.5). (Less resistance)

Ref.: Standard thermodynamic theory

5.10 a. Decay heat is the heat produced from that part of the fission energy released at some time after the fission event by radioactive decay of the fission products. (1.0)

b. The thermal output after a reactor trip is from Decay of Fission fragments and activated vessel structures by $Beta^-$ and Gamma decay. (1.0)

The IRM and SRM are compensated to discriminate for gammas.

Ref.: Standard reactor theory

5.11 1. Relatively low cross-section for absorption (0.5)

2. Low fission yield (0.5)

3. Long half-life (0.5)

4. Does not change during normal operation, its equilibrium value is independent of power

Ref.: Standard reactor theory

Section 6 Answers

6.1 1. If the fuel assemblies are not orientated properly, the control rod blade could bind and not operate smoothly, if at all. (1.0)

2. The fuel enrichment is based on the water gaps and misorientated fuel would cause undesirable flux distribution and burnup. (1.0)

3. Thermal limit calculation assumes specific bundle orientation. Could end up with non-conservative thermal limit calculations

Ref.: Lesson plan A-4, page 14, 21, 22 and fig. 9

4. Assure proper bypass flow for instrument cooling

6.2 a. Feed flow, steam flow, and reactor level (1.0)

b. 2-feed flow, 4-steam flow and 2-reactor level (only 1 reactor level is in circuit at a time) (1.0)

c. Feed flow is sensed downstream of H.P. heaters. Steam flow is sensed at steamline flow restrictors. (1.0)

Ref.: Lesson plans D-16, page 37-2, A-5, page 38, A-6, page 48 and P&ID M-107

6.3 1. If the main steamline pressure is not below 5 psig after one and a half minutes (1½ min.) of blowdown, the valves will close. (1.5)

2. During the bleed off mode of operation, if inboard MSIV leakage is greater than 90 SCFH after 1 min. of bleed off operation (3 min. total from system initiation), the valves will close. (1.5)

Also accept start permissives: <35 psig Rx pressure and inbd MSIV's closed

Ref.: Lesson plan A-6, page 42 & 43

6.4 The inertia of the M-G set components will help provide a slow coastdown following a loss of power to the drive motor. This allows for a cooling flow to the core to be maintained for a short period of time during the loss of flow transient. The generator field breaker only needs to be tripped if a possibility of generator or pump motor damage exists. (2.0)

Ref.: Lesson plan A-2, page 31

6.5 a. Yes (0.5)

b. It can be moved out one notch (0.5) before a withdraw error will block further movement (0.5). If the rod was inserted, it will move as far as the operator wants (0.5) as long as it is not the third insert error (0.5). If it were the third insert error, it would only go one notch (0.5). (2.5)

c. 1. Steam flow for LPAP and steam flow and feed flow for LPSP (0.25) (1.0)

2. Rod position from RPIS (0.25)

3. Rod select from RMCS (0.25)

4. Rod sequence from process computer (0.25)

Ref.: Lesson plan I&C-10-RWM, pages 7 & 8

6.6 a. Half-scram (0.5 ea)

b. No action

c. Rod block

d. Rod block

e. No action

Ref.: DAEC lesson plans I&C-2, IRM, pg. 25; I&C-3, APRM, pg. 30; I&C-7, RPS

6.7 Any 3 at 1.0 each

1. Atmosphere control key locked hand switch (Torus, Normal, Drywell) must be placed to Drywell.

2. The isolation signal(s) present must be bypassed using the key locked switch(es). (A-H)

3. Isolation valve reset pushbuttons must be pressed.

4. The valve to be opened must be placed in OVERRIDE to open.

Ref.: Lesson plan E-13, page 15 and EOP-2, page 19

6.8 "B" RHR pump will continue running. (0.5)

"B" and "D" RHR service water pumps will stop and heat exchanger throttle valve close. (1.0)

RHR heat exchanger bypass valve (MO-1940) opens. (0.5)

Suppression pool spray valve (1932) closes. (0.5)

LPCl to suppression pool test line valve (1934) closes. (0.5)

"B" RHR pump will continue to take a suction from the suppression pool but the discharge will now bypass the heat exchanger and go through the injection valves rather than through the test valves to the torus. (0.5)

Ref.: Lesson plan C-1 & F-6

6.9 Water flows through the exhaust valve (insert or withdraw) into the exhaust header. Then into the other HCU's, through the insert exhaust valves (SV-1854) and into the reactor through the CRD mechanism (drive withdraw line). (2.0)

Ref.: Lesson plan A-1, pages 32 & 33, and 45 & 46

Section 7 Answers

7.1 ALARA - as low as reasonably achievable. (0.5)

ALARA is a program to maintain the radiation exposure and the release of radioactive materials to unrestricted areas as low as reasonable achievable. (.75) (.75)

7.2 1. Chief Engineer or Plant Superintendent (0.5)

2. Assistant Chief Engineer - Asst Plant Superintendent (0.5)

3. Operations Supervisor (0.5)

Ref.: IPOI, Section II.C.2, page II.16

7.3 1. Possibility of hydrogen explosion (0.5)

2. Untreated release of activity (0.5)

Ref.: IPOI, Section II.C.2, page II.16

7.4 13 ft. is the level of the drywell to torus vacuum breakers and spraying the drywell could cause the negative internal pressure of the drywell to exceed limits. (1.5)

23.4 ft. is the level of the torus sprays. They would be ineffective if they were under water. (1.0)

Ref.: EOP-2, pages 12 & 14

7.5 a. Primary - Trip the Power Range Neutron Monitor System Bus A and Bus B at the RPS Distribution panel in the Essential Switchgear Room. (1.0)

Backup - Place the Main Turbine Trip Switch in the 'Trip' position at the Main Turbine Front Standard. (1.0)

b. 1. Accumulator low pressure/High level red lights are on at CRD Accumulator Local Panels 1C54 and 1C72. (1.0)

2. Check position of scram valves in control rod drive area on first floor (757'6"). (1.0)

Ref.: IPOI-H, Shutdown Outside Control Room, Rev. 9, page 6 & 7

7.6 Check that the existing control rod pattern:

1. is in accordance with the RWM sequence latched (1.0)

2. has all rods in each group within one notch position of each other (1.0)

3. corresponds to required Rod Sequence Control System groups (1.0)

Ref.: V.C., Page V-3

7.7 1. RHR service water crosstie (0.5 ea)

2. Fire system

3. SBLC

4. Well water/~~GSW~~

5. ESW

6. Condensate~~/Demin~~. service water

7. GSW 8. Demin water

Ref.: EOP-1, RC/L, page 9

7.8 B

Ref.: IPOI, Volume C-2.0, page II.B.2

7.9 RCIC system - preferred

HPIC system

RHR/RCIC system

Control rods, or CRD cooling water flow adjustment

Ref.: IPOI, Section II.C.2.a, page II.17

IPOI VI 0.1 pg 15, 0.L pg 16

7.10 1. Observe full core display and identify rod by red drift light. (1.0)

2. Normal corrective action is to attempt to recouple the rod. (1.0)

3. If cannot be recoupled, insert to 0 and disarm. (1.0)

Ref.: Annunciator procedure 1C05-B

7.11 A functional and subcritical check consists of notching the control rod to the fully withdrawn position, verifying subcriticality, verifying coupling of the CRD by attempting to dive to the overtravel position, and then measuring the time required for the rod to drive to the fully inserted position. (2.0)

Ref.: FRCHP #5, page 9

Section 8 Answers

8.1 1. The reactor is driven subcritical, without rods being fully inserted, to bring the steam plant from power operation to hot standby. (.75)

2. All rods have been fully inserted for less than four hours. (.75)

Ref.: IPOI, Section II.C, page II.5

8.2 a. A second qualified person(s), other than the person(s) performing initial lineup, will record the "as-found" position on the appropriate system Prestartup Manually Operated Valve Lineup Verification List by attempting to turn the appropriate valve in the "CLOSED" direction ½ turn. (This verification list is a separate list from the lineup list.) (2.0)

b. The ~~SSE~~ OSS will initial the CLEARED blank and explain on the backside of the system checklist. (1.0)

Ref.: IPOI, Section II.C, page II.6 & 7

8.3 Concurrence of the Reactor Engineer and the Operations Shift Supervisor. Must be legibly recorded on form II.C.1.2 (Control Rod Withdrawal Sequence form) at the time of the change. (2.0)

Ref.: IPOI, Section II.C, page II.9

8.4 Provide reasonable assurance that no water will enter the turbine. (1.0)

Ref.: IPOI, Section II.C.3, page II.20

8.5 1. Mode switch in shutdown (0.5)

2. Manual scram (0.5)

3. High flux IRM (0.5)

4. Scram discharge volume high level (0.5)

5. APRM 15% flux (0.5)

Ref.: DAEC Technical Specification

8.6 a. Fraction of Limiting Power Density (FLPD) (0.5)

b. Linear Heat generation rate (LHGR) (0.5)

c. Total Peaking Factor (TPF) (0.5)

d. Critical Power Ratio (CPR) (0.5)

8.7 a. Any Health Physics technician previously approved by Health Physics supervisor (0.5)

b. Health Physics foreman or designated alternate (0.5)

c. Health Physics Supervisor or foreman (0.5)

d. Radiation Protection Supervisor (0.5)

8.8 1. Evaluate plant condition to determine if an EAL has been reached. (1.0)

2. Initiate the notification requirements and initiate evacuation of the plant for events classified as an Alert or greater. (1.0)

3. Function as the Emergency Coordinator until relieved. (1.0)

Ref.: EPIP-1.1, page 1

8.9 1. The river water supply system operable. (1.0)

2. Two (2) fire pumps operable and aligned to the fire suppression yard header. (1.0)

3. Automatic initiation logic for each fire pump. (1.0)

Ref.: Tech Specs, page 3.13-3

8.10 a. A pattern which results in the core being on a thermal hydraulic limit. (0.5)

b. 1. Both RBM channels shall be operable. (1.0)

2. Control rod withdrawal shall be blocked. (1.0)

3. The operating power level shall be limited so that the MCPR will remain above safety limit assuming a single error that results in complete withdrawal of any single operable control rod. (1.0)

Ref.: Tech Specs, pages 3.3-5 & 17

8.11 Any time irradiated fuel is in the vessel and reactor coolant temperature is above 212°F. (1.5)

Ref.: Tech Specs, page 3.6-5