U.S. NUCLEAR REGULATORY COMMISSION

REGION III

Report No(s). 50-440/OL-85-01

Docket No(s). 50-440 License No(s). CPPR-148

Licensee: Cleveland Electric Illuminating
Company
Post Office Box 5000
Cleveland, OH 44101

Facility Name: Perry Nuclear Power Station

Examination Administered At: Perry Nuclear Power Station

Examination Conducted: The Weeks of March 26 and April 2, 1985

Examiner(s): T. Lang — 5-29-85 Date

J. McMillen — 5/30/85 Date

L. Dimmock — 5/30/85 Date

G. Sly — 5/30/85 Date

D. Hill — 5/30/85 Date

W. Cliff — 5/30/85 Date

Approved By: J. McMillen, Chief
Operating License Section — 5/30/85 Date

Examination Summary

Examination administered the weeks of March 26 and May 20, 1985 (Report No(s). 50-440/OL-85-01)
The written examination was administered to eight Reactor Operators and eighteen Senior Reactor Operators. Four candidates did not take simulator examinations since they passed them previously.
Results: Of the eighteen Senior and eight Reactor Operator examinations given, 15 passed the examination.

REPORT DETAILS

1. Examiners

   T. Lang, J. McMillen, L. Dimmock, G. Sly, W. Cliff, D. Hill

2. Examination Review Meeting

   The examinations were reviewed by the following personnel with all changes incorporated into the exam:

   S. Garchow, M. Morrow, T. Silakoski, F. Kearny, M. Haskins

3. Exit Meeting

   T. Lang and L. Dimmock held a short exit meeting and told Mr. Silakoski who clearly passed the oral and simulator portions of the exam.

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

FACILITY: PERRY 1

REACTOR TYPE: BWR-GE6

DATE ADMINISTERED: 85/03/26

EXAMINER: LANG,T.

APPLICANT: _____

INSTRUCTIONS TO APPLICANT:

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

CATEGORY VALUE	% OF TOTAL	APPLICANT'S SCORE	% OF CATEGORY VALUE	CATEGORY
25.00	25.25			1. PRINCIPLES OF NUCLEAR POWER PLANT OPERATION, THERMODYNAMICS, HEAT TRANSFER AND FLUID FLOW
24.50	24.75			2. PLANT DESIGN INCLUDING SAFETY AND EMERGENCY SYSTEMS
24.50	24.75			3. INSTRUMENTS AND CONTROLS
25.00	25.25			4. PROCEDURES - NORMAL, ABNORMAL, EMERGENCY AND RADIOLOGICAL CONTROL
99.00	100.00			TOTALS

FINAL GRADE _____%

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

_____
APPLICANT'S SIGNATURE

QUESTION 1.01 (3.00)

Briefly explain or define the following terms:

a. Thermal Neutron. (1.0)

b. Intrinsic Neutron Source. (1.0)

c. Reactivity (if equation is used in your answer, explain the equation.) (1.0)

QUESTION 1.02 (2.00)

More control rods must be withdrawn to go critical when the reactor is hot than when it is cold. Is the above statement TRUE or FALSE? (Note: Justify your answer with respect to control rod worth.)

QUESTION 1.03 (1.00)

a. Define 'Condensate Depression'. (0.5)

b. Is it necessary for plants to operate with 'condensate depression'? Explain your answer. (0.5)

QUESTION 1.04 (2.00)

A centrifugal pump is operating at 3600 RPM with a pump head of 160 FT. Pump speed is then reduced so that pump head is 100 FT. What is the new pump speed? Show all work.

QUESTION 1.05 (3.50)

a. List the three reactivity coefficients in a BWR at power and give approximate values for each. (1.5)

b. What effect (increase, decrease, or no effect) do each of the three coefficients have on total core reactivity following a saftey/relief valve failing open? Briefly explain why the dominant coefficient effects reactivity in the manner you indicate. (2.0)

QUESTION 1.06 (1.00)

Define or explain the following terms:

a. Convective heat transfer. (0.5)

b. Critical Power Ratio (0.5)

QUESTION 1.07 (1.50)

Does a recirculation pump have more NPSH at 100% power or at 10% power? Explain your answer. Include the sources of NPSH in your answer.

QUESTION 1.08 (3.00)

In your reactor you produce and remove Xenon during normal operation.

a. How is Xenon produced and removed in your core? (1.0)

b. Where physically in your core is Xenon found. I could answer this at high pwr locations (1.0)

c. Does Shutdown Margin Change when Xenon concentration changes? Explain your answer. (1.0)

QUESTION 1.09 (3.00)

The following statement relate to rod worth. For each of the following state whether it is TRUE or FALSE and explain the reason for your answer.

a. Control Rod Worth is greater at the center of the core than at anywhere else. I this assumes throughout core life (1.0)

b. As moderator temperature increases rod worth increases. (1.0)

c. As voids increase rod worth increases. (1.0)

QUESTION 1.10 (2.00)

a. Beta for U235 is 0.0065. Why is Beta effective approximately 0.007? (1.0)

b. How does the above affect reactor period? (1.0)

QUESTION 1.11 (3.00)

Reactor power is being increased on a 50 second period.

a. How long does it take to increase power from 2kw to 1mw? (1.0)

b. What reactivity is associated with the 50 second period? (1.0)

c. What is the Keff during the power increase? (1.0)

QUESTION 2.01 (2.00)

Following the automatic start of a Diesel Generator six (6) conditions must be satisfied in order for the Diesel Output breaker to close. What are four (4) of the six (6) conditions? (0.5 each)

QUESTION 2.02 (2.00)

For each of the RCIC system component failures listed below, state weather or not RCIC will auto inject into the reactor vessel.
-If it will inject, provide one potential adverse effect or consequence.
--If it will not inject, breifly explain why.
Asiume no operator actions, and the component is in the failed or misaligned condition at the time RCIC receives an auto initiation signal.

a. The turbine exhaust valve (F068) is misaligned closed, and the RCIC system receives an auto initiation. (1.0)

b. The minimum flow valve fails to auto open (stays shut) when the system conditions require it to be open. (1.0)

QUESTION 2.03 (2.00)

In regards to the CRD system:
a.How does the on-line flow control valve respond following a scram? (1.0)

b.Breifly explain the operational consequences of the scram inlet valve sticking shut on a scram. Consider the following two situations and the effect(s) on a single CRD HCU mechanism. (1.0

1.At 200 psig. Reactor Pressure. 2
2.At 800 psig. Reactor Pressure. 2 ONI Ctl-1 says MAY NOT

QUESTION 2.04 (2.00)

a.What is a Stator Cooling Run-Back? Be specific in your answer include all appropriate set points. 2 operators may use 75% and 25% rated amps in thier answer (1.0)

b.What signal(s) will initiate a Stator Cooling Run-Back? (1.0)

2 question does not ask for setpoints

QUESTION 2.05 (3.00)

For the following components in the Off-Gas system signify if they are BEFORE or AFTER the DESICANT DRYER in the Off-Gas flow path.

a. Water Seperator.
b. Off-Gas Condenser.
c. After Filter.
d. Cooler Condenser.
e. Gas Cooler.
f. Moisture Seperator.

QUESTION 2.06 (2.00)

According to your lesson plan on extraction steam, there are two reasons or purposes of the Positive Assist Non-Return check valve. What are these two purposes? ? part 1

QUESTION 2.07 (2.50)

What are five indications you could check to verify Standby Liquid Control initiation? (0.5 each)

QUESTION 2.08 (3.00)

There are five instruments ranges used at your plant for level.
a. What are these five ranges and to what are they referenced? (2.5)

b. Why are most of the reference leg piping run outside the drywell into the containment? (0.5)

QUESTION 2.09 (2.50)

a. Why does the Control Rod Drive Hydraulic (CRDH) system supply water to the Reactor Recirculation system? (0.75)

b. Why does the Nuclear Closed Cooling Water system supply water to the CRDH system? SDM CII - LO CLR P&ID 307-871 307-872 SDM p43 - Seals & Brgs (0.75)

c. Why is a continuous bypass flow maintained from the CRDH drive water pump discharge to the condensate storage tank? (1.0)

QUESTION 2.10 (1.50)

a. Following WHAT MAJOR ACCIDENT would the Emergency Closed Cooling (ECC) System be used to supply the Fuel Pool Cooling and Cleanup System heat exchangers? WHY? (1.0)

b. Which ECC loop can be operated from the Remote Shutdown Panel? (0.5)

QUESTION 2.11 (2.00)

In regards to the Perry Fire Protection System:

a. What two methods are used to maintain the WATER Fire Protection system static pressure greater than 80 psig? (1.0)

b. How do each of following CO2 Fire Protection system valves fail upon loss of electrical power?

1) Master Control Valves (0.5)
2) Selector Valves (0.5)

could mean using the Normal or Reserve charger

Nob - Div I, II chargers are NORM - Equalize

Div III - FLOAT - Equalize

QUESTION 3.01 (3.00)

In regards to the 125VDC system:

a. What are the two methods of charging the batteries, and when would each method be used? (2.0)

b. It is estimated that it will take 24 hours to recharge the batteries following a capacity test. It is suggested that the charging time can be reduced to 12 hours if both chargers are placed in parallel. Would you permit this operation, explain your answer. (1.0)

QUESTION 3.02 (2.00)

The SRV's have two modes of operation. One of which is the Pneumatic Actuating Mode.

a. What are three ways in which the pneumatic mode of operation can be initiated? only need 1 RPV press switch to energize either sol (1.5)

b. Pneumatic actuating is one of the two methods of SRV actuation. What is the other mode? ? can also be called SAFETY MODE (0.5)

QUESTION 3.03 (4.00)

Regarding the RPS system:

a. Indicate weather the solenoids associated with the following valves are energized or de-energized. Assume a SCRAM signal is present.
   1. Pilot Scram Valves. (0.5)
   2. Back Up Scram Valves. (0.5)
   3. Scram Discharge Vent and Drain Valves. (0.5)

b. Within the RPS trip system the pilot scram valves solenoids are devided into 4 groups (8 total). What indication is avalable to the operator that power is available and each group of solenoids is energized? Panel P680 (0.5)

c. What alarms and/or trips are associated with the Scram Dischage water level? Set points required for full credit. (1.5)

d. Specificly, where is (are) the sensor(s) located for the variable "W" in the APRM Scram Set Point formula .66W +50. (0.5)
   Flow ELBOWS in Reactor system

QUESTION 3.04 (2.00)

List the trip functions and trip actions with normal set points that are associated with the intermediate range monitors.(IRM's). Four required for full credit.

go

QUESTION 3.05 (4.00)

The Recirculation system (recirculation pumps, jet pumps, and FCV) needs protection from two conditions which can produce cavitation.

a. What are these two conditions? (2.0) Do you need setpoints, Flow may be in % => 22.8%

b. How is protection against cavitation accomplished if the two conditions in part (a.) were to occur? (2.0)

QUESTION 3.06 (1.50)

In regards to the Feedwater Control System:

good a. Why is 'Level Programing' necessary? (0.75)

b. Is 'Level Programing' continuously done through out a power increase to full power? Explain. (0.75)

QUESTION 3.07 (2.50)

Answer the following in regards to the Turbine Generator and Control System:

a. Explain the operation of the Intercept Valves on a Turbine Overspeed. (1.0)

b. What is the purpose of the Max. Combined Flow Limiter? (1.0)

c. The following speeds can be selected for the turbine, 100, 800, 1500, and 1800 RPM. In which speed(s) is the wobbulator circuit in effect? (0.5)

Not @ 1800 SDM => speeds > 1000 but < Rated => 1500 only.

QUESTION 3.08 (2.00)

You over hear an operator candidate telling a second operator candidate of his superior performance in the NRC simulator exam.

"They gave me a loss of seal water to the circ. pumps and then failed the automatic circ. pump trip on me. It was easy to tell because I had to manually trip the circ. pump. Also, latter on I re-started if even with the low flow seal water alarm up, and you shouldn't be able to do that!" answer Key Typo Circ Water Pumps instead of Recirc pump.

What if anything did you find he did correctly or incorrectly? Two answers required for full credit. False assumptions he made will count as answers as well as correct or incorrect actions.

QUESTION 3.09 (2.00)

If the following alarm were to annunciate:

```
xxxxxxxxxxxxxxxxxxx
x  ISO PHASE BUS  x
x    HYDROGEN     x
x    TROUBLE      x
xxxxxxxxxxxxxxxxxxx
```

a. What would be your immediate actions if it were not an instrument failure? (1.5)

b. What would be the cause of the alarm annunciating? Assume that it was not an instrument failure. (0.5)

QUESTION 3.10 (1.50)

What are the three temperature interlocks associated with the following alarm?

```
xxxxxxxxxxxxxxxxxxx
x Recirc Pump B   x
x    Temp         x
x  Interlock      x
xxxxxxxxxxxxxxxxxxx
```

(1.5)

QUESTION 4.01 (1.50)

In regards to the Fire Protection System:

a. What is the difference between a deluge and a wet pipe system? (0.75)

b. How does a preaction system function? (0.75)

QUESTION 4.02 (2.00)

While withdrawing control rods for startup you inadvertantly acheive a sustained short period. What action would you take if the sustained period were:

a. 20 seconds. (1.0)

b. 4 seconds (1.0)

QUESTION 4.03 (2.50)

In regards to a Loss Of Feedwater Heating:

a. The immediate action for a Loss of Feedwater Heating is to: "Reduce recirculation flow such that thermal power is at least 20% below the level prior to the reduction in feedwater heating."

If you complete the above action would you expect a scram? (Assume you were at full power prior to the lose of feedwater heating) If your answer is yes than what caused the scram and what could you have done to prevent it? (2.0)

b. Why is there a limit on the megawatt output of the generator when you lose feedwater heating? (0.5)

QUESTION 4.04 (2.00)

In regard to Uncoupled control rods:

a. Assuming the Rod Pattern Controller will permit it, how can re-coupling be performed? (0.5)

b. How do you verify that re-coupling was successful? (1.5)

QUESTION 4.05 (2.00)

Define Hot Standby and Hot Shutdown. (2.0)

QUESTION 4.06 (2.00)

At 8% Reactor power, and prior to transfering the mode switch to 'Run' the operator is required to verify six (6) conditions exist. What are four (4) of these conditions?

QUESTION 4.07 (1.50)

In accordance with the startup procedure a normal reactor shutdown should commence if the operator notes that he does not have a 'proper SRM/IRM overlap.'

a. What is SRM/IRM overlap? (0.5)

b. What is required in order for it to be 'proper'? (1.0)

QUESTION 4.08 (2.00)

During a Reactor Cold Startup the operator is cautioned to use extreme caution whenever the continuous withdrawal mode on rod movement is performed. What are the restrictions for use of 'Continuous Withdrawal'?

QUESTION 4.09 (3.00)

If a control room evacuation were required according to ONI-C61 'Evacuation of the Control Room' the reactor operator must perform six (6) things be for he leaves. What are these six (6) things?

QUESTION 4.10 (2.00)

Prior to securing a safety system once initiated the operator must ensure himself that certain conditions are met. What are these conditions?

also PEI's tests (approved procedure

QUESTION 4.11 (2.00)

Your reactor is in cold shutdown with all rods full in. Maintenance has just finished working on MSL low pressure interlocks. They ask you to go into 'Run' to verify correct operation of the interlock. Assuming there is no other work in progress, what Tech. Spec. restrictions apply to the mode switch change?

QUESTION 4.12 (2.50)

According to your Turbine and/or Generator Trip procedure your immediate actions require you to PERFORM one action and verify that five (5) others occur.

a. What is the first action the operator is required to PERFORM? (0.5)

b. The operator is required to verify five automatic actions occur; one of which is to verify that the Control, Main Stop, and Intermediate valves shut. What are the other four (4) actions? (2.0)

EQUATIONS/DATA SHEET

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

$1Ci = 3.7 \times 10^{10} Bq$

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

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

$\alpha_t = -4.5 \times 10^{-4} \frac{\Delta K/\%°F}{K}$

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

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

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

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

$Q = MCp\ \Delta t$

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

$f = 64/Re$

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

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

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

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

$M = 1/(1-k)$

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

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

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

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

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

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

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

$v = v_f + xv_{fg}$

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

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

1 in = 2.54 cm

1 gal. = 3.785 liters = 8.33 lb.

1 kg = 2.205 lb

$N = \rho A_o/A$

17.58 watts = 1 BTU/min
1psi = 6.895 Pa
1psi = 2.036 " H_g (@ 0C)
1psi = 27.68 " H_2O (@ 4C)

$\bar{\beta} = .0071$

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

Table 1. Saturated Steam: Temperature Table

Temp Fahr t	Abs Press Lb per Sq in p	Specific Volume Sat Liquid v_f	Evap v_{fg}	Sat Vapor v_g	Enthalpy Sat Liquid h_f	Evap h_{fg}	Sat Vapor h_g	Entropy Sat Liquid s_f	Evap s_{fg}	Sat Vapor s_g	Temp Fahr t
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	2.0492	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	2.0763	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	1.9709	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	633.2	633.3	48.037	1048.4	1096.4	0.0932	1.9426	2.0358	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	2.0084	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	1.13467	0.016151	296.18	296.18	73.99	1033.6	1107.6	0.1402	1.8273	1.9675	106.0
108.0	1.20308	0.016158	280.28	280.30	75.98	1032.5	1108.5	0.1437	1.8188	1.9626	108.0
110.0	1.27500	0.016165	265.35	265.35	77.98	1031.4	1109.3	0.1472	1.8105	1.9577	110.0
112.0	1.35056	0.016173	251.37	251.38	79.98	1030.2	1110.2	0.1507	1.8021	1.9528	112.0
114.0	1.42994	0.016180	238.31	238.32	81.97	1029.1	1111.0	0.1542	1.7938	1.9480	114.0
116.0	1.51333	0.016188	226.14	226.15	83.97	1027.9	1111.9	0.1577	1.7856	1.9433	116.0
118.0	1.60096	0.016196	214.79	214.81	85.97	1026.8	1112.7	0.1611	1.7774	1.9385	118.0
120.0	1.69271	0.016204	203.26	203.26	87.97	1025.6	1113.6	0.1646	1.7693	1.9339	120.0
122.0	1.78911	0.016213	192.52	192.55	89.96	1024.5	1114.4	0.1681	1.7613	1.9293	122.0
124.0	1.89001	0.016221	182.53	182.54	91.96	1023.3	1115.3	0.1715	1.7533	1.9247	124.0
126.0	1.99559	0.016229	173.28	173.29	93.96	1022.2	1116.1	0.1749	1.7453	1.9202	126.0
128.0	2.10608	0.016238	164.45	164.47	95.96	1021.0	1117.0	0.1783	1.7374	1.9157	128.0
130.0	2.22130	0.016247	156.32	156.33	97.96	1019.8	1117.8	0.1817	1.7295	1.9112	130.0
132.0	2.34145	0.016256	148.64	148.66	99.95	1018.7	1118.6	0.1851	1.7217	1.9068	132.0
134.0	2.46677	0.016265	141.40	141.41	101.95	1017.5	1119.5	0.1884	1.7140	1.9024	134.0
136.0	2.59747	0.016274	134.57	134.59	103.95	1016.4	1120.3	0.1918	1.7063	1.8980	136.0
138.0	2.73378	0.016284	128.09	128.11	105.94	1015.2	1121.1	0.1951	1.6986	1.8937	138.0
140.0	2.87597	0.016293	121.98	121.99	107.94	1014.0	1121.9	0.1985	1.6910	1.8895	140.0
142.0	3.02411	0.016303	116.21	116.22	109.94	1012.9	1122.8	0.2018	1.6834	1.8852	142.0
144.0	3.17843	0.016312	110.76	110.78	111.93	1011.7	1123.6	0.2051	1.6759	1.8810	144.0	
146.0	3.33917	0.016322	105.58	105.60	113.93	1010.5	1124.5	0.2084	1.6683	1.8769	146.0
148.0	3.50661	0.016332	100.68	100.70	115.93	1009.3	1125.3	0.2117	1.6610	1.8727	148.0
150.0	3.68084	0.016343	96.04	96.05	117.93	1008.0	1126.1	0.2150	1.6536	1.8686	150.0
152.0	3.86213	0.016353	91.64	91.66	119.93	1006.8	1126.9	0.2183	1.6463	1.8646	152.0
154.0	4.05056	0.016363	87.50	87.52	121.93	1005.6	1127.7	0.2216	1.6390	1.8606	154.0
156.0	4.24648	0.016374	83.56	83.57	123.93	1004.4	1128.4	0.2248	1.6318	1.8566	156.0
158.0	4.45007	0.016384	79.82	79.83	125.93	1003.1	1129.1	0.2281	1.6245	1.8526	158.0
160.0	4.66144	0.016395	76.27	76.29	127.93	1001.9	1129.9	0.2313	1.6174	1.8487	160.0
162.0	4.88077	0.016406	72.90	72.92	129.93	1000.6	1130.6	0.2345	1.6103	1.8448	162.0
164.0	5.10824	0.016417	69.70	69.72	131.94	999.4	1131.3	0.2377	1.6032	1.8409	164.0
166.0	5.34403	0.016428	66.67	66.69	133.94	998.1	1132.0	0.2409	1.5961	1.8371	166.0
168.0	5.58833	0.016440	63.79	63.81	135.94	996.8	1132.8	0.2441	1.5892	1.8333	168.0
170.0	5.84076	0.016451	61.06	61.08	137.94	995.5	1133.5	0.2473	1.5822	1.8295	170.0
172.0	6.10236	0.016463	58.47	58.49	139.94	994.2	1134.2	0.2505	1.5753	1.8258	172.0
174.0	6.37314	0.016474	56.01	56.03	141.94	993.0	1134.9	0.2537	1.5684	1.8221	174.0
176.0	6.65320	0.016486	53.68	53.70	143.95	991.7	1135.6	0.2568	1.5616	1.8184	176.0
178.0	6.94270	0.016498	51.46	51.48	145.95	990.4	1136.4	0.2600	1.5548	1.8147	178.0

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

Temp °F t	Abs Press Lb per Sq In p	Specific Volume Sat Liquid v_f	Evap v_{fg}	Sat Vapor v_g	Enthalpy Sat Liquid h_f	Evap h_{fg}	Sat Vapor h_g	Entropy Sat Liquid s_f	Evap s_{fg}	Sat Vapor s_g	Temp °F t
180.0	7.5110	0.016510	50.21	50.22	148.00	990.2	1138.2	0.2631	1.5490	1.8121	180.0
182.0	7.8650	0.016527	48.172	48.189	150.01	989.0	1139.0	0.2669	1.5413	1.8082	182.0
184.0	8.2031	0.016548	46.232	46.249	152.01	987.8	1139.8	0.2694	1.5336	1.8030	184.0
186.0	8.568	0.016567	44.383	44.400	154.02	986.5	1140.5	0.2725	1.5276	1.8001	186.0
188.0	8.947	0.016589	42.621	42.638	156.03	985.3	1141.3	0.2756	1.5213	1.7969	188.0
190.0	9.340	0.016612	40.941	40.957	158.03	984.1	1142.1	0.2787	1.5149	1.7936	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	10.169	0.016598	37.808	37.824	162.05	981.6	1143.7	0.2849	1.5017	1.7865	194.0
196.0	10.605	0.016611	36.348	36.364	164.06	980.4	1144.4	0.2879	1.4953	1.7831	196.0
198.0	11.056	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	33.627	33.639	168.09	977.9	1146.0	0.2940	1.4825	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	13.564	0.016691	28.842	28.858	176.14	972.8	1148.9	0.3061	1.4571	1.7632	208.0
212.0	14.696	0.016719	26.787	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	23.113	23.129	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	1.7381	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	15.242	15.260	212.50	949.5	1162.0	0.3591	1.3494	1.7084	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	13.366	13.375	220.62	944.1	1164.7	0.3706	1.3265	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	11.755	11.767	228.76	938.6	1167.4	0.3819	1.3043	1.6862	260.0
264.0	37.894	0.017123	11.035	11.047	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	0.3931	1.2823	1.6755	268.0
272.0	43.249	0.017193	9.718	9.735	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	8.637	8.655	249.17	924.6	1173.8	0.4098	1.2501	1.6599	280.0
284.0	52.414	0.017301	8.143	8.161	253.3	921.7	1175.0	0.4154	1.2395	1.6548	284.0
288.0	55.795	0.017338	7.678	7.695	257.4	918.8	1176.2	0.4209	1.2290	1.6498	288.0
292.0	59.350	0.017376	7.239	7.2476	261.5	915.9	1177.4	0.4263	1.2186	1.6449	292.0
296.0	63.084	0.01741	6.8759	6.8433	265.6	913.0	1178.6	0.4317	1.2082	1.6400	296.0
300.0	67.005	0.017453	6.4893	6.4938	269.7	910.0	1179.7	0.4372	1.1979	1.6351	300.0
304.0	71.119	0.017494	6.1255	6.1130	273.8	907.0	1180.9	0.4426	1.1877	1.6303	304.0
308.0	75.433	0.017535	5.7855	5.7810	278.0	904.0	1182.0	0.4479	1.1776	1.6256	308.0
312.0	79.953	0.017577	5.4666	5.4742	282.1	901.0	1183.1	0.4533	1.1676	1.6209	312.0
316.0	84.689	0.017621	5.1673	5.1849	286.3	897.9	1184.2	0.4586	1.1576	1.6162	316.0
320.0	89.643	0.017666	4.8864	4.9031	290.4	894.8	1185.2	0.4640	1.1477	1.6117	320.0
324.0	94.824	0.017710	4.6218	4.6395	294.6	891.6	1186.2	0.4693	1.1378	1.6071	324.0
328.0	100.24	0.017756	4.3730	4.3906	298.7	888.5	1187.2	0.4746	1.1280	1.6026	328.0
332.0	105.91	0.017804	4.1388	4.1568	302.9	885.3	1188.2	0.4798	1.1183	1.5982	332.0
336.0	111.82	0.017853	3.9187	3.9373	307.1	882.1	1189.1	0.4850	1.1086	1.5936	336.0
340.0	117.99	0.017903	3.7119	3.7298	311.3	878.8	1190.1	0.4902	1.0990	1.5892	340.0
344.0	124.43	0.017954	3.5178	3.5357	315.5	875.5	1191.0	0.4954	1.0894	1.5849	344.0
348.0	131.14	0.018007	3.3358	3.3538	319.7	872.2	1191.9	0.5006	1.0799	1.5804	348.0
352.0	138.13	0.018061	3.1653	3.1833	323.9	868.9	1192.7	0.5058	1.0705	1.5763	352.0
356.0	145.42	0.018116	3.0053	3.1044	328.1	865.5	1193.6	0.5110	1.0611	1.5721	356.0
360.0	153.01	0.018173	2.8550	2.8732	332.3	862.1	1194.4	0.5161	1.0517	1.5678	360.0
364.0	160.91	0.018231	2.7142	2.7325	336.5	858.6	1195.2	0.5212	1.0424	1.5637	364.0
368.0	169.13	0.018291	2.5819	2.6002	340.8	855.1	1195.9	0.5263	1.0332	1.5595	368.0
372.0	177.68	0.018353	2.4579	2.4763	345.0	851.6	1196.7	0.5314	1.0240	1.5554	372.0
376.0	186.57	0.018417	2.3415	2.3602	349.3	848.1	1197.4	0.5365	1.0148	1.5513	376.0
380.0	195.79	0.018482	2.2323	2.2508	353.6	844.5	1198.0	0.5416	1.0057	1.5473	380.0
384.0	205.36	0.018549	2.1298	2.1483	357.9	840.8	1198.7	0.5466	0.9966	1.5432	384.0
388.0	215.28	0.018617	2.0334	2.0521	362.2	837.2	1199.3	0.5516	0.9876	1.5392	388.0
392.0	225.56	0.018688	1.9429	1.9616	366.5	833.4	1199.9	0.5566	0.9786	1.5352	392.0
396.0	236.23	0.018759	1.8577	1.8764	370.8	829.7	1200.4	0.5616	0.9696	1.5313	396.0
400.0	247.28	0.018832	1.7776	1.7965	375.1	825.9	1201.0	0.5666	0.9607	1.5273	400.0
404.0	258.73	0.018907	1.7022	1.7213	379.5	822.0	1201.5	0.5715	0.9518	1.5234	404.0
408.0	270.60	0.018983	1.6313	1.6503	383.8	818.2	1202.0	0.5765	0.9430	1.5195	408.0
412.0	282.89	0.019061	1.5647	1.5837	388.2	814.2	1202.4	0.5814	0.9342	1.5156	412.0
416.0	295.61	0.019141	1.5021	1.5212	392.5	810.2	1202.8	0.5863	0.9254	1.5117	416.0
420.0	308.76	0.019222	1.4432	1.4624	396.9	806.2	1203.1	0.5912	0.9167	1.5079	420.0
424.0	322.35	0.019305	1.3878	1.4069	401.3	802.1	1203.4	0.5961	0.9080	1.5041	424.0
428.0	336.39	0.019390	1.3356	1.3546	405.8	798.0	1203.8	0.6010	0.8993	1.5003	428.0
432.0	350.88	0.019476	1.2864	1.3059	410.2	793.8	1204.0	0.6059	0.8907	1.4966	432.0
436.0	365.83	0.019564	1.2401	1.2596	414.6	789.6	1204.2	0.6107	0.8821	1.4928	436.0
440.0	381.25	0.019654	1.1965	1.2161	419.1	785.4	1204.4	0.6156	0.8735	1.4891	440.0
444.0	397.14	0.019745	1.1554	1.1751	423.6	781.1	1204.6	0.6204	0.8650	1.4853	444.0
448.0	413.51	0.019838	1.1167	1.1365	428.0	776.8	1204.8	0.6253	0.8565	1.4817	448.0
452.0	430.36	0.019933	1.0802	1.1001	432.5	772.4	1204.8	0.6301	0.8480	1.4781	452.0
456.0	447.73	0.020029	1.0457	1.0657	437.0	768.0	1205.0	0.6350	0.8396	1.4745	456.0

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

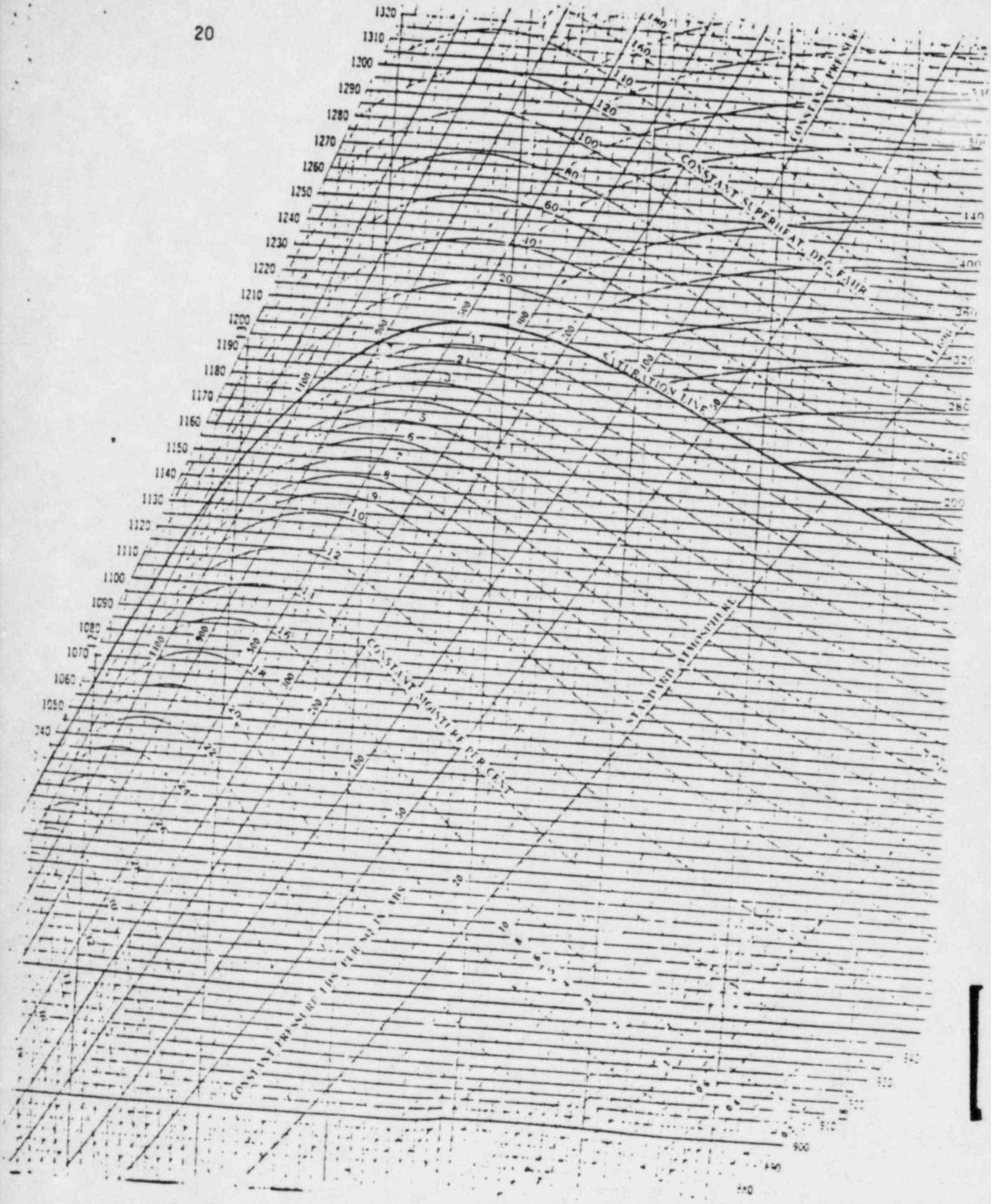
Temp - Fahr t	Abs Press Lb per Sq In p	Specific Volume Sat Liquid v_f	Evap v_{fg}	Sat Vapor v_g	Enthalpy Sat Liquid h_f	Evap h_{fg}	Sat Vapor h_g	Entropy Sat Liquid s_f	Evap s_{fg}	Sat Vapor s_g	Temp Fahr t
460.0	456.87	0.01961	0.97463	0.99424	441.5	763.2	1204.8	0.6405	0.8255	1.4700	460.0
464.0	485.56	0.01969	0.93588	0.95557	445.1	758.6	1203.7	0.6454	0.8213	1.4667	464.0
468.0	504.83	0.01976	0.89885	0.91862	448.7	754.0	1202.6	0.6502	0.8172	1.4635	468.0
472.0	524.67	0.01984	0.86345	0.88329	452.2	749.3	1201.5	0.6551	0.8132	1.4603	472.0
476.0	545.11	0.01992	0.82958	0.84950	455.9	744.5	1200.3	0.6599	0.7956	1.4555	476.0
480.0	566.15	0.02000	0.79716	0.81717	459.5	739.6	1199.1	0.6648	0.7871	1.4519	480.0
484.0	587.81	0.02009	0.76613	0.78622	463.1	734.7	1197.8	0.6696	0.7785	1.4481	484.0
488.0	610.10	0.02017	0.73641	0.75658	466.8	729.7	1196.5	0.6745	0.7700	1.4445	488.0
492.0	633.03	0.02026	0.70794	0.72820	470.5	724.6	1195.1	0.6793	0.7614	1.4407	492.0
496.0	656.61	0.02034	0.68065	0.70100	474.2	719.5	1193.7	0.6842	0.7528	1.4370	496.0
500.0	680.86	0.02043	0.65448	0.67492	477.9	714.3	1192.2	0.6890	0.7443	1.4333	500.0
504.0	705.78	0.02053	0.62938	0.64991	481.7	709.0	1190.7	0.6939	0.7357	1.4296	504.0
508.0	731.40	0.02062	0.60530	0.62592	485.5	703.7	1189.1	0.6987	0.7271	1.4258	508.0
512.0	757.72	0.02072	0.58218	0.60290	489.3	698.2	1187.5	0.7036	0.7185	1.4221	512.0
516.0	784.76	0.02081	0.55997	0.58079	493.1	692.7	1185.8	0.7085	0.7099	1.4183	516.0
520.0	812.53	0.02091	0.53864	0.55956	497.0	687.0	1184.0	0.7133	0.7013	1.4146	520.0
524.0	841.04	0.02102	0.51814	0.53916	500.9	681.3	1182.2	0.7182	0.6926	1.4108	524.0
528.0	870.31	0.02112	0.49843	0.51955	504.8	675.5	1180.3	0.7231	0.6839	1.4070	528.0
532.0	900.34	0.02123	0.47947	0.50070	508.8	669.6	1178.4	0.7280	0.6752	1.4032	532.0
536.0	931.17	0.02134	0.46123	0.48257	512.7	663.6	1176.4	0.7329	0.6665	1.3993	536.0
540.0	962.79	0.02146	0.44367	0.46513	516.8	657.5	1174.3	0.7378	0.6577	1.3954	540.0
544.0	995.23	0.02157	0.42677	0.44834	520.8	651.3	1172.1	0.7427	0.6489	1.3915	544.0
548.0	1028.49	0.02169	0.41048	0.43217	524.9	645.0	1169.9	0.7476	0.6400	1.3876	548.0
552.0	1062.59	0.02181	0.39479	0.41660	529.0	638.5	1167.5	0.7525	0.6311	1.3837	552.0
556.0	1097.55	0.02194	0.37966	0.40160	533.2	632.0	1165.2	0.7575	0.6222	1.3797	556.0
560.0	1133.38	0.02207	0.36507	0.38714	537.4	625.3	1162.7	0.7625	0.6132	1.3756	560.0
564.0	1170.10	0.02220	0.35099	0.37320	541.6	618.5	1160.1	0.7674	0.6041	1.3714	564.0
568.0	1207.72	0.02235	0.33741	0.35976	545.9	611.5	1157.5	0.7725	0.5950	1.3675	568.0
572.0	1246.26	0.02249	0.32429	0.34678	550.3	604.5	1154.7	0.7775	0.5859	1.3634	572.0
576.0	1285.74	0.02264	0.31162	0.33426	554.7	597.2	1151.9	0.7825	0.5766	1.3591	576.0
580.0	1326.17	0.02279	0.29937	0.32216	559.1	589.9	1149.0	0.7876	0.5673	1.3550	580.0
584.0	1367.7	0.02295	0.28753	0.31048	563.6	582.4	1146.0	0.7927	0.5580	1.3507	584.0
588.0	1410.0	0.02311	0.27608	0.29919	568.1	574.7	1142.8	0.7979	0.5485	1.3464	588.0
592.0	1453.3	0.02328	0.26499	0.28827	572.7	566.8	1139.6	0.8030	0.5390	1.3420	592.0
596.0	1497.8	0.02345	0.25425	0.27770	577.4	558.8	1136.2	0.8082	0.5293	1.3375	596.0
600.0	1543.7	0.02364	0.24384	0.26747	582.1	550.6	1132.7	0.8134	0.5196	1.3330	600.0
604.0	1590.7	0.02383	0.23376	0.25759	586.9	542.2	1129.1	0.8187	0.5097	1.3284	604.0
608.0	1639.3	0.02402	0.22396	0.24798	591.8	533.6	1125.4	0.8240	0.4997	1.3236	608.0
612.0	1688.1	0.02422	0.21442	0.23865	596.8	524.7	1121.5	0.8294	0.4894	1.3190	612.0
616.0	1739.9	0.02444	0.20516	0.22960	601.8	515.6	1117.4	0.8348	0.4794	1.3141	616.0
620.0	1792.6	0.02466	0.19615	0.22081	606.9	506.2	1113.2	0.8403	0.4693	1.3092	620.0
624.0	1846.0	0.02489	0.18737	0.21226	612.1	496.6	1108.8	0.8458	0.4591	1.3041	624.0
628.0	1901.0	0.02513	0.17882	0.20395	617.5	486.7	1104.2	0.8514	0.4488	1.2988	628.0
632.0	1957.0	0.02539	0.17044	0.19583	622.9	476.4	1099.3	0.8571	0.4384	1.2934	632.0
636.0	2013.8	0.02566	0.16226	0.18792	628.4	465.7	1094.1	0.8628	0.4281	1.2879	636.0
640.0	2072.5	0.02595	0.15427	0.18021	634.1	454.6	1088.7	0.8686	0.4176	1.2821	640.0
644.0	2132.1	0.02625	0.14644	0.17269	639.9	443.1	1083.0	0.8746	0.4070	1.2761	644.0
648.0	2192.6	0.02657	0.13876	0.16534	645.9	431.1	1077.0	0.8806	0.3963	1.2699	648.0
652.0	2254.2	0.02691	0.13124	0.15816	652.0	418.7	1070.7	0.8868	0.3854	1.2634	652.0
656.0	2316.7	0.02728	0.12387	0.15115	658.4	405.7	1064.1	0.8931	0.3743	1.2567	656.0
660.0	2380.3	0.02768	0.11663	0.14431	664.9	392.1	1057.0	0.8995	0.3630	1.2496	660.0
664.0	2444.8	0.02811	0.10947	0.13757	671.7	377.9	1049.6	0.9062	0.3514	1.2425	664.0
668.0	2510.4	0.02856	0.10229	0.13085	678.7	363.1	1041.9	0.9131	0.3395	1.2347	668.0
672.0	2577.0	0.02907	0.09514	0.12421	686.0	347.7	1033.7	0.9202	0.3274	1.2266	672.0
676.0	2644.8	0.02960	0.08799	0.11760	693.5	331.5	1025.0	0.9276	0.3150	1.2179	676.0
680.0	2713.6	0.03017	0.08080	0.11097	701.5	314.5	1016.0	0.9353	0.3022	1.2085	680.0
684.0	2783.7	0.03078	0.07349	0.10427	709.8	296.6	1006.4	0.9434	0.2891	1.1984	684.0
688.0	2854.8	0.03142	0.06599	0.09741	718.6	277.8	996.4	0.9519	0.2755	1.1873	688.0
692.0	2926.9	0.03213	0.05826	0.09039	727.9	257.9	985.8	0.9610	0.2613	1.1753	692.0
696.0	3000.1	0.03291	0.05016	0.08307	737.8	236.8	974.7	0.9709	0.2463	1.1621	696.0
700.0	3074.3	0.03381	0.04157	0.07538	748.6	214.2	962.8	0.9821	0.2302	1.1476	700.0
702.0	3113.5	0.03434	0.03713	0.07147	754.2	202.4	956.6	0.9882	0.2216	1.1398	702.0
704.0	3152.8	0.03494	0.03247	0.06741	760.1	190.0	950.1	0.9947	0.2124	1.1317	704.0
706.0	3192.3	0.03562	0.02753	0.06315	766.3	176.8	943.1	1.0019	0.2025	1.1224	706.0
705.47*	3208.2	0.05078	0.00000	0.05078	904.0	0.0	904.0	1.0627	0.0000	1.0627	705.47*

*Critical temperature

Table 2: Saturated Steam: Pressure Table

Abs Press Lb/Sq In p	Temp Fahr t	Specific Volume Sat Liquid v_f	Specific Volume Evap v_{fg}	Specific Volume Sat Vapor v_g	Enthalpy Sat Liquid h_f	Enthalpy Evap h_{fg}	Enthalpy Sat Vapor h_g	Entropy Sat Liquid s_f	Entropy Evap s_{fg}	Entropy Sat Vapor s_g	Abs Press Lb Sq In p
0.08865	32.018	0.016022	3302.4	3302.4	0.0003	1075.5	1075.5	0.0000	2.1872	2.1872	0.08865
0.25	59.323	0.016032	1235.5	1235.5	27.382	1060.1	1087.4	0.0542	2.0480	2.1022	0.25
0.50	79.586	0.016071	641.5	641.5	47.623	1048.6	1096.3	0.0925	1.9436	2.0360	0.50
1.0	101.74	0.016136	333.59	333.60	69.73	1036.1	1105.8	0.1326	1.8355	1.9681	1.0
5.0	162.24	0.016407	73.515	73.532	130.20	1000.9	1131.1	0.2349	1.6094	1.8443	5.0
10.0	193.21	0.016592	38.404	38.420	161.25	982.1	1143.3	0.2836	1.5033	1.7869	10.0
14.696	212.00	0.016719	26.782	26.799	180.17	970.3	1150.5	0.3121	1.4447	1.7568	14.696
15.0	213.03	0.016726	26.274	26.290	181.21	969.7	1150.9	0.3137	1.4415	1.7551	15.0
20.0	227.96	0.016834	20.070	20.087	196.27	960.1	1156.3	0.3358	1.3962	1.7320	20.0
30.0	250.34	0.017009	13.7266	13.7436	218.9	945.2	1164.1	0.3682	1.3313	1.6995	30.0
40.0	267.25	0.017151	10.4794	10.4965	236.1	933.6	1169.8	0.3921	1.2844	1.6765	40.0
50.0	281.02	0.017274	8.4967	8.5140	250.2	923.9	1174.1	0.4112	1.2474	1.6585	50.0
60.0	292.71	0.017383	7.1562	7.1736	262.2	915.4	1177.6	0.4273	1.2167	1.6440	60.0
70.0	302.93	0.017482	6.1875	6.2050	272.7	907.8	1180.6	0.4411	1.1895	1.6314	70.0
80.0	312.04	0.017573	5.4536	5.4711	282.1	900.9	1183.1	0.4538	1.1675	1.6208	80.0
90.0	320.28	0.017659	4.8779	4.8953	290.7	894.4	1185.1	0.4643	1.1470	1.6113	90.0
100.0	327.82	0.017740	4.4133	4.4310	298.5	888.4	1186.9	0.4743	1.1292	1.6027	100.0
110.0	334.79	0.017817	4.0356	4.0535	305.8	882.7	1188.5	0.4834	1.1125	1.5959	110.0
120.0	341.27	0.017889	3.7267	3.7456	312.6	877.3	1189.9	0.4919	1.0970	1.5889	120.0
130.0	347.33	0.017956	3.4684	3.4544	319.0	872.2	1191.2	0.5000	1.0825	1.5825	130.0
140.0	353.04	0.018019	3.2510	3.2710	325.0	867.3	1192.3	0.5077	1.0687	1.5765	140.0
150.0	358.43	0.018079	3.0668	3.0839	330.6	862.6	1193.3	0.5151	1.0556	1.5706	150.0
160.0	363.55	0.018135	2.9105	2.9336	336.1	858.0	1194.1	0.5222	1.0435	1.5657	160.0
170.0	368.42	0.018191	2.7696	2.7878	341.2	853.8	1194.9	0.5290	1.0319	1.5609	170.0
180.0	373.08	0.018242	2.6429	2.6612	346.2	849.7	1195.9	0.5356	1.0210	1.5566	180.0
190.0	377.53	0.018292	2.5287	2.5472	350.9	845.7	1196.6	0.5420	1.0106	1.5526	190.0
200.0	381.80	0.018340	2.4269	2.4453	355.5	841.9	1197.3	0.5481	1.0007	1.5488	200.0
210.0	385.9	0.018388	2.3347	2.3527	359.9	838.1	1198.0	0.5540	0.9913	1.5453	210.0
220.0	389.84	0.018434	2.2514	2.2698	364.2	834.6	1198.6	0.5597	0.9824	1.5421	220.0
230.0	393.70	0.018479	2.1756	2.1941	368.3	831.1	1199.1	0.5652	0.9738	1.5390	230.0
240.0	397.39	0.018523	2.1059	2.1244	372.3	827.8	1199.6	0.5706	0.9656	1.5362	240.0
250.0	400.97	0.018565	2.0417	2.0603	376.1	824.5	1200.1	0.5758	0.9577	1.5335	250.0
260.0	404.44	0.018607	1.9824	2.0011	379.9	821.3	1200.5	0.5809	0.9501	1.5309	260.0
270.0	407.80	0.018647	1.9277	1.9463	383.4	818.3	1200.9	0.5858	0.9428	1.5287	270.0
280.0	411.07	0.018686	1.8769	1.8956	387.1	815.1	1201.3	0.5905	0.9357	1.5262	280.0
290.0	414.25	0.018725	1.8297	1.8484	390.6	812.0	1201.6	0.5951	0.9289	1.5240	290.0
300.0	417.35	0.018763	1.7858	1.8046	394.0	808.9	1202.9	0.5997	0.9223	1.5220	300.0
350.0	431.73	0.018942	1.6041	1.6230	409.8	794.2	1204.0	0.6205	0.8926	1.5131	350.0
400.0	444.60	0.019104	1.4617	1.4808	424.2	780.4	1204.6	0.6217	0.8630	1.4847	400.0
450.0	456.28	0.019254	1.3453	1.3644	437.3	767.4	1204.8	0.6406	0.8366	1.4772	450.0
500.0	467.01	0.019395	1.2487	1.2681	449.5	754.1	1203.7	0.6555	0.8128	1.4683	500.0
550.0	476.94	0.019528	1.1669	1.1864	460.9	741.3	1202.3	0.6695	0.7914	1.4609	550.0
600.0	486.20	0.019655	1.0964	1.1161	471.7	728.9	1200.6	0.6827	0.7718	1.4545	600.0
650.0	494.89	0.019777	1.0346	1.0544	481.9	716.8	1198.8	0.6953	0.7537	1.4490	650.0
700.0	503.08	0.019895	0.98205	0.99195	491.6	705.0	1196.6	0.7073	0.7370	1.4443	700.0
750.0	510.84	0.020009	0.93496	0.95497	500.9	693.4	1194.3	0.7189	0.7214	1.4403	750.0
800.0	518.21	0.020120	0.89276	0.91288	509.8	682.1	1191.9	0.7300	0.7067	1.4367	800.0
850.0	525.24	0.020228	0.85473	0.87495	518.4	670.9	1189.3	0.7407	0.6928	1.4335	850.0
900.0	531.98	0.020333	0.82029	0.84062	526.7	659.9	1186.6	0.7511	0.6795	1.4306	900.0
950.0	538.45	0.020436	0.78896	0.80940	534.7	649.1	1183.8	0.7612	0.6668	1.4280	950.0
1000.0	544.68	0.020537	0.76035	0.78088	542.4	638.4	1180.8	0.7709	0.6547	1.4256	1000.0
1050.0	550.69	0.020636	0.73413	0.75477	549.9	627.8	1177.8	0.7804	0.6430	1.4234	1050.0
1100.0	556.49	0.020733	0.70999	0.73072	557.2	617.3	1174.6	0.7896	0.6317	1.4213	1100.0
1150.0	562.09	0.020828	0.68769	0.70852	564.3	606.9	1171.2	0.7986	0.6208	1.4194	1150.0
1200.0	567.50	0.020922	0.66705	0.68797	571.2	596.6	1167.8	0.8073	0.6102	1.4175	1200.0
1250.0	572.73	0.021015	0.64788	0.66889	578.0	586.4	1164.4	0.8158	0.5999	1.4157	1250.0
1300.0	577.80	0.021106	0.63004	0.65114	584.6	576.3	1160.9	0.8241	0.5899	1.4140	1300.0
1350.0	582.72	0.021196	0.61340	0.63459	591.1	566.3	1157.4	0.8322	0.5801	1.4123	1350.0
1400.0	587.49	0.021285	0.59784	0.61913	597.4	556.3	1153.7	0.8401	0.5705	1.4106	1400.0
1450.0	592.13	0.021373	0.58327	0.60464	603.7	546.4	1150.1	0.8478	0.5611	1.4089	1450.0
1500.0	596.64	0.021460	0.56960	0.59106	609.8	536.6	1146.4	0.8553	0.5518	1.4071	1500.0
1550.0	601.03	0.021546	0.55675	0.57829	615.8	526.8	1142.6	0.8627	0.5427	1.4054	1550.0
1600.0	605.31	0.021631	0.54466	0.56629	621.7	517.1	1138.8	0.8699	0.5337	1.4036	1600.0
1650.0	609.48	0.021715	0.53327	0.55498	627.5	507.4	1134.9	0.8770	0.5248	1.4018	1650.0
1700.0	613.55	0.021799	0.52252	0.54432	633.3	497.8	1131.0	0.8839	0.5160	1.3999	1700.0
1750.0	617.53	0.021882	0.51236	0.53424	638.9	488.2	1127.1	0.8907	0.5073	1.3980	1750.0
1800.0	621.42	0.021964	0.50274	0.52470	644.5	478.6	1123.1	0.8974	0.4987	1.3961	1800.0
1850.0	625.23	0.022045	0.49362	0.51567	650.0	469.1	1119.1	0.9039	0.4901	1.3940	1850.0
1900.0	628.96	0.022126	0.48497	0.50710	655.5	459.6	1115.1	0.9103	0.4816	1.3919	1900.0
1950.0	632.62	0.022206	0.47675	0.49895	660.9	450.1	1111.0	0.9166	0.4732	1.3898	1950.0
2000.0	636.20	0.022285	0.46893	0.49118	666.2	440.7	1106.9	0.9228	0.4648	1.3876	2000.0
2100.0	643.24	0.022442	0.45417	0.47659	676.8	421.9	1098.7	0.9348	0.4482	1.3830	2100.0
2200.0	650.09	0.022597	0.44041	0.46301	687.2	403.2	1090.4	0.9465	0.4318	1.3783	2200.0
2300.0	656.78	0.022751	0.42753	0.45028	697.4	384.5	1081.9	0.9579	0.4156	1.3735	2300.0
2400.0	663.31	0.022904	0.41544	0.43834	707.4	365.8	1073.2	0.9691	0.3995	1.3686	2400.0
2500.0	669.70	0.023057	0.40406	0.42712	717.3	347.1	1064.4	0.9801	0.3835	1.3636	2500.0
2600.0	675.95	0.023209	0.39331	0.41654	727.1	328.4	1055.5	0.9909	0.3677	1.3586	2600.0
2700.0	682.07	0.023361	0.38314	0.40650	736.7	309.7	1046.4	1.0015	0.3519	1.3534	2700.0
2800.0	688.06	0.023513	0.37349	0.39699	746.3	291.0	1037.3	1.0120	0.3362	1.3482	2800.0
2900.0	693.93	0.023665	0.36432	0.38797	755.8	272.3	1028.0	1.0223	0.3206	1.3429	2900.0
3000.0	699.68	0.023817	0.35559	0.37941	765.2	253.5	1018.7	1.0325	0.3050	1.3375	3000.0
3100.0	705.32	0.023969	0.34727	0.37127	774.5	234.7	1009.2	1.0425	0.2895	1.3320	3100.0
3200.0	710.85	0.024122	0.33933	0.36355	783.8	215.8	999.6	1.0524	0.2740	1.3264	3200.0
3208.2*	705.47	0.05078	0.05078	0.05078	774.7	0.0	774.7	1.0517	0.0000	1.0517	3208.2*

*Critical pressure


CONSTANT PRESSURE
CONSTANT SUPERHEAT DEG. F.
SATURATION LINE
STANDARD ATMOSPHERE
CONSTANT MOISTURE PER CENT
CONSTANT PRESSURE LINES PER SQ. IN.

Farm Copy

ANSWERS -- PERRY 1 -85/03/26-LANG,T.

ANSWER 1.01 (3.00)

a. A neutron whose kinitic energy is comparable to the molecular kinitic energy of the surrounding medium. (1.0)

b. Intrinsic neutron sources are sources of neutrons in a reactor which do not originate in the fission process. Some of these sources provide neutrons that allow the reactor to be started up for the first time. (1.0)

c. Reactivity simply relates the state of the reactor with respect to criticality and can be thought of as a measure of the deviation from criticality. (1.0)

REFERENCE
General Theory

ANSWER 1.02 Trul (2.00)

An important plant parameter which influences rod worth is the moderator temperature. As moderator temperature increases, control rod worth also increases because leakage out of the fuel bundle has increased. This increase results in more interactions with control rods, and more neutrons are lost. This explains why more control rods must be withdrawn to go critical when the reactor is hot then when it is cold-- the control rods are inserting more negitive reactivity.

REFERENCE
General Theory

ANSWER 1.03 (1.00)

a. The subcooling of condensate i.e., the condensed liquid existing in the hotwell usually is about 8 degrees F. below the saturation temperature. (0.5)

b. Without "Condensate Depression" the condensate pumps would cavitate due to the water at the eye of the pump being at saturation temperature. (0.5)

THERMODYNAMICS, HEAT TRANSFER AND FLUID FLOW

ANSWERS -- PERRY 1 -85/03/26-LANG,T.

ANSWER 1.04 (2.00)

Flow is proportional to RPM ← not req'd
Head is proportional to RPM squared.
Power is proportonal to RPM cubed. ←

$$\frac{160 \text{ FT. HEAD}}{(3600 \text{ RPM})^{3 \leftarrow 2}} = \frac{100 \text{ FT. HEAD}}{(X)^{2}}$$

$$100(3600)^{2} = 160\ X^{2}$$

$$\frac{100(3600)^{2}}{160} = X^{2}$$

$$\sqrt{\frac{100(3600)^{2}}{160}} = X \quad = 2846 \text{ RPM}$$

REFERENCE
General Theory

ANSWER 1.05 (3.50)

a. 1. moderator temperature coefficient alpha T=-1 x10 -4 per degree change in temperature.
   2. moderator void coefficient alpha V=1 x 10 -3 per % change in voids.
   3. fuel temperature coefficient alpha D =1 x 10 -5 per degree change in fuel temperature.

b. Alpha T increases core delta K/K.
   Alpha V decreases core delta K/K.
   Dominant effect--- relief valve opening results in decreasing reactor pressure which increased voids and decreases moderator density resulting in more neutrons leaking out of the core and reducing power.

REFERENCE
General Theory

ANSWERS -- PERRY 1 -85/03/26-LANG,T.

ANSWER 1.06 (1.00)

a. Convection is the process of transmitting heat from a heated surface or area to a fluid by circulation or mixing of the fluid (Convection takes place only in fluids.) ← not req'd (0.5)

b. Critical power ratio is the ratio of critical bundle power/ actual bundle power where critical bundle power is the bundle power where the onset of transition boiling occurs. (0.5)

REFERENCE
General Theory

ANSWER 1.07 (1.50)

More NPSH at 100%.Recirc pump NPSH at power >20% is primarily dependent on F.W. Flow Subcooling. There is substantially more F.W. Flow at 100% than at 10%. In addition there is proportionately more cool F.W. Flow than Hot Return Flow from separators and dryers at the higher power. Subcooling at 100% is approximately 20 degrees F.

REFERENCE
Fluid Theeory

ANSWER 1.08 (3.00)

a. produced=direct from fission and decay of iodine 135.
removed=decay and from neutron absorption. (1.0)

b. Xenon is located in the gas plenum and in the fuel. may answer high pwr negative (1.0)

c. Yes. SDM is based on a clean/cold core,meaning Xenon free and cold.
If the core is not clean then SDM will change. (1.0)

REFERENCE
Introduction to Nuclear Reactor Operations, page 8-5

ANSWERS -- PERRY 1 -B5/03/26-LANG,T.

ANSWER 1.09 (3.00)

a. False. It is possible for a thermal flux peak to exist anywhere radially within the core which would increase the worth of the rod within that flux peak even if the rod SpVm<near the edge of the core.

b. True. As moderator temperature increases moderator density decreases. Neutrons travel a greater distance in thermally diffusing and are more likely to come in contact with and be absorbed by a control rod.

c. False. With an increase in void content, the neutron slowing down length increases to the point where a neutron may not be thermalized when it reaches a control rod. Since control rods are thermal absorbers fewer neutrons are captured by the control rod and hence rod worth decreases.

REFERENCE
Introduction to Nuclear Operations Page 7-11

ANSWER 1.10 (2.00)

a. Beta effective is greater than beta because delayed neutrons are born at lower energy than prompt neutrons so a larger percentage of the delayed neutrons will become thermal neutrons and cause fission. To account for this larger percentage at the thermal neutron level than at the fast neutron level we use the effective delayed neutron fraction rather than delayed neutron fraction in our calculations.

b. The difference produces a longer period for a given addition of reactivity which can be seen in the reactor period equation T=(B-p)/Lp With beta effective used instead of beta, the term (Beff-p) is larger giving a longer period.

REFERENCE
Introduction to Reactor Operations

ANSWERS -- PERRY 1 -85/03/26-LANG,T.

ANSWER 1.11 (3.00)

a. $P = P_o e^{\frac{t}{T}}$

$t = T \ln(P/P_o)$

$= 50 \ln(E3/1)$ ~ $50 \ln (P/P_o) = 50 \ln \left(\frac{1000}{2}\right) = 50 \ln (500)$ (1.0)

$= 345 sec.$ $50 \ln (.500) = 50(6.2)$ 310.7 sec.

b. $T = (B-p)/Lp$

$= B/(1+LT)$

$= .0075/(1+(.1)(50))$

$= .0013$ (1.0)

c. $Keff = 1/(1-p)$

$= 1/(1-.0013)$

$= 1.0013$ (1.0)

REFERENCE
General Reactor Theory

ANSWERS -- PERRY 1 -85/03/26-LANG,T.

ANSWER 2.01 (2.00)

1.Engine speed greater than 425 RPM.
2.Up to rated voltage.
3.Prefered and alternate breakers open.
4.Low bus voltage.
5.Breaker racked in.
6.No bus lockout.

(0.5 each)

REFERENCE
Perry Lesson Plan, Standby Diesel Generator and Auxilary, page 8.

ANSWER 2.02 (2.00)

a. Will not inject. (0.25) Steam isolation valve (F045) is interlocked closed if the exhaust valve (F068) is closed ().75).

b. Will inject. (0.25) Possible damage to pump from overheating or at low flows. (0.75).

REFERENCE
Perry Lesson Plan (E51) RCIC

ANSWER 2.03 (2.00)

a.The flow control will see a high flow and the FCV will close. (1.0)
b.1.Rod will not scram. ← ONI-C11-1 Scram may not fully scram (0.5)
2.Rod will scram.(0.25)but scram time will be longer.(0.25) (0.5)

REFERENCE
Perry Lesson Plan,C11 Control Rods.

ANSWER 2.04 25% (2.00) 25%

a.A Stator Cooling Run-Back automaticly reduces generator output to less than 30,297 amps. within 2 min. or/and 9871 amps. within 3.5 min. (1.0)

b.Either 13 psig. Stator Cooling inlet pressure or 203 degrees F. Stator outlet temperature. (1.0)

not req'd

REFERENCE
n43 Stator Cooling Water

ANSWER 2.05 (3.00)

a.Water Seperator-before.
b.Off-Gas Condenser-before.
c.After Filter-after.
d.Cooler Condenser-before.
e.Gas Cooler-after.
f.Moisture Serperator-before. (0.5 each)

REFERENCE
N64 Off Gas

ANSWER 2.06 (2.00)

1.Prevent overspeeding the main turbine following a turbine trip (by preventing steam trapped in the feedwater heaters from returning to the turbine through the extraction steam lines.) not upd (1.0)

2.Prevent water from entering the main turbine through the extraction steam lines in the event the feedwater heaters become flooded. (1.0)

REFERENCE
N36 Extraction Steam

ANSWER 2.07 (2.50)

1.Squib continuity lamp of explosive valve F004A (F004B) extinguishes indicating that the squibs have received a firing permissive.
2.RWCU system outboard (inboard) isolation valve indicate closed.
3.Pump Starter Energized indicator of the selected pump is illuminated.
4.Tank Shutoff valve F001A (F001B) has opened.
5.Pump discharge pressure increases to approximately 25 psig. above reactor pressure.
6.Storage tank level dropping.
7.Reactor power dropping.

REFERENCE
SLC, C41

ANSWER 2.08 (3.00)

a. Wide Range-Inst. Zero
Narrow Range-Inst. Zero
Upset Range-Inst. Zero
Shutdown Range-Inst. Zero
Fuel Zone Range- TAF (0.5 each)

TAF now used in actual Control Room, and could be correct

b. Most of the Reference leg piping is run out of the Drywell into the containment to minimize density changes because of changing drywell temperatures. (0.5)

REFERENCE
Reactor Vessel,B21

ANSWER 2.09 (2.50)

a. To provide seal purge for the recirc pumps. (.75)

b. To cool the CRD pump lube oil coolers. (seals + brgs SDM P43) (.75)

c. To prevent immediate pump damage in the event the containment outboard isolation valve (F083) is closed. (1.0)
(Valve number not required for full credit.)

REFERENCE
SDM, C11, pg. 28-30 EDH-192

ANSWER 2.10 (1.50)

a. LOCA [0.5]. Nuclear Closed Cooling is isolated from the Fuel Pool Cooling and Cleanup system [0.5]. (1.0)

b. Loop A (0.5)

REFERENCE
SDM, P42, pg. 10 and 17 EDH-195

ANSWERS -- PERRY 1 -85/03/26-LANG,T.

ANSWER 2.11 (2.00)

a. A pressure maintenance tank [0.5] and a jockey pump [0.5] (1.0)

b. 1. OPEN (0.5)
2. CLOSED (0.5)

REFERENCE
SDM, P54(WTR) pg.2, P54(CO2) pg. 29

ANSWERS -- PERRY 1 -85/03/26-LANG,T.

ANSWER 3.01 (3.00)

a. The two methods of charging are Float and Equalize. In Float the batteries receive a trikle charge continuously during normal operation.

b. No. Battery chargers can be operated in parallel operation for only a short time. Parallel operation develops excessive circulating currents between chargers which could damage the rectifiers. (1.0)

REFERENCE
R42 D.C. Systems, page 19 and 20.

ANSWER 3.02 (2.00)

a. 1. Manually by positioning control switches in the control room. (0.5)
2. Automaticly, on recept of two independent high reactor pressure vessel signals. (0.5)
3. Automaticly, on recept of an ADS signal. (0.5)

b. Self Actuating Mode. (0.5)

REFERENCE
B21/N11/C85, Main Steam, page 7 and 8.

ANSWER 3.03 (4.00)

a. 1. De-energized, 2. energized, 3. de-energized. (1.5)
b. Each group has power available lights on panel. (0.5)
c. Rod block=24 gal. (0.5)
Scram=48 gal. (0.5)
d. Flow restrictors in each reciculation loop. (0.5)

REFERENCE
RPS and Control Rod Drive, C/71 and C/51.

ANSWERS -- PERRY 1 -85/03/26-LANG,T.

ANSWER 3.04 (2.00)

IRM Downscale-5/125 of scale=rod block. (0.5)
IRM High Flux-108/125 of scale=rod block. (0.5)
IRM Inop.-low high voltage
-module unplugged
-mode switch not in operate (0.5)
IRM High-High Flux-120/125 of scale-scram (0.5)

REFERENCE
Nuclear Instrumentation.

ANSWER 3.05 (4.00)

a.1.Low Feedwater Flow (3.43 E6 lbm/hr) combined with FCV position less than 26.4 % open, (48.4% Recic Flow),and (1.0)
2.Steam Dome/pump suction line temperature differential low (8 degrees delta T). (1.0)

b.1.The low flow interlock monitors the operation of the Feedwater system and will initiate at a predetermined low flow setpoint (22% of rated feedwater flow) if the flow control valve is less than 26.4% open. Will initiate a fast to slow downshift of the reciculation pumps. (1.0)
2.If the temperature between the Rx steam dome and each respective pumps suction temperature becomes excessively low (8 degrees) the recic. pump will downshift to low speed. (1.0)

REFERENCE
B33 Rx Reciculation System.

ANSWER 3.06 (1.50)

a.At high steam flows a lower actual level in the vessel is required to maintain a constant carryover. (0.75)

b.No. Biasing does not occur until >45% steam flow. (0.75)

REFERENCE
Feedwater Control,N27.

ANSWERS -- PERRY 1 -85/03/26-LANG,T.

ANSWER 3.07 (2.50)

a. For turbine overspeed conditions from 100 to 105% the control valves will throttle closed. However, due to the large quantity of steam in the Moisture Seperator and crossaround piping speed could increase even though the C.V. are full closed. The intercept valves will throttle closed from 105 to 107% overspeed to prevent further steam inlet to the L.P. turbine. (1.0)

b. Limits the sum of turbine and bypass steam to a preset limit such that on a Pressure Regulator failure blowdown would be limited. (1.0)

c. 1500 ~~and 1800~~ (0.5)

REFERENCE
T.S. and N32/C85 Steam B/P and Pressure Control.

ANSWER 3.08 (2.00)

Correctly--Manually tripped the circ water reciculation pumps.
Incorrectly---1. Thought that there was a low seal water trip.
2. Though that you couldn't start up a circulation pump with low flow alarm up. (only one complete loop)
3. Started circulation water pump with low seal condition present.
Any two for full credit.

REFERENCE
Recirculation Lession Plan

ANSWERS -- PERRY 1 -85/03/26-LANG,T.

ANSWER 3.09 (2.00)

a.Immediate actions as listed are:
1.Determine whether the alarm is due to high hydrogen or analyzer malfuction.

2.If hydrogen concentration is above 40% of the lower flamability limit, perform the following actions: (0.5)
a.Trip the Generator. (0.5)
b.Conduct a Fast Reactor Shutdown if necessary. (0.5)

NOTE:ONLY PART TWO OF THE ANSWER IS GRADED BECAUSE THE QUESTION SPECIFIES THAT THE ALARM IS NOT DUE TO AND INSTRUMENT FAILURE.

B.The cause of the alarm to annunciate would be the following:
1.25% of the lower flamability limit for hydrogen is reached. (0.5)
2.Combustible Gas Vapor Analyzer inoperable.

NOTE: ONLY PART ONE OF THE ANSWER WAS GRADED BECAUSE THE QUESTION SPECIFIES THAT THE ALARM IS NOT DUE TO AND INSTRUMENT FAILURE.

RE ERENCE
OM6,ARI-R13-1

ANSWER 3.10 (1.50)

a.Temperature difference between reactor vessel bottom drain and reactor steam dome temperature is greater than 100 degrees F. (0.5)

b.Temperature difference between Recirculation Pump A suction temperature and Reactor steam dome temperature is greater than 70 degrees F. (0.5)

c.Temperature difference between the two loop suction lines is greater than 50 degrees F. (0.5)

REFERENCE
ARI-B33-35

50 in T.S

ANSWERS -- PERRY 1 -85/03/26-LANG,T.

ANSWER 4.01 (1.50)

a. Wet pipe sprinkler systems are actuated by melting fuseable links in the sprinkler head(pipe is filled with water up to the sprinkler head). Deluge systems are actuated by rate of rise temperature detectors which open an injection valve- water is not up to the sprinkler head, only up to the injection valve. (0.75)

b. A preaction system operates in conjuction with a standard deluge system. However, the sprinkler heads are of the type used in the wet pipe system. Actuation of the detectors will open the deluge valve but injection will not occur until the fusable link in the sprinkler head melts. (0.75)

REFERENCE
Emergency Plan

ANSWER 4.02 (2.00)

a. If a sustained period of less than 30 seconds is indicated, take prompt action to correct this condition by inserting cotrol rods until a reactor period of greater than 30 seconds is indicated. Contact the Unit Supervisor prior to re-withdrawing the control rods. (1.0)

b. 1. If a reactor period less than 5 seconds occurs, take corrective actions per the ARI for window B-1 on P680-6A (which states to insert control rods until a period of greater than 30 seconds is acheived) (0.5)
2. Notify the NRC within one hour. (0.5)

REFERENCE
IOI-1,ARI for window B-1,T.S.

ANSWER 4.03 (2.50) ← ONI-N36 susp possible Rx Scram

a. There would be a scram ---- the cold water addition which would cause flux levels to increase until you get a High High Flux trip on the APRMs. The action which the operator could take to prevent the scram would be to insert control rods. (2.0)

b. To preven undue loading and overstressing of any turbine part. (0.5)

REFERENCE
ONI-N36,page 3 and 4

ANSWERS -- PERRY 1 -85/03/26-LANG,T.

ANSWER 4.04 (2.00)

a. If permitted by the Rod Patten Contrller, attempt to re-couple the control rod by inserting it two notches. Monitor drive water pressure during insertion. (0.5)

b. 1. Select and fully withdraw the control rod and drive mechanism to be checked, using the continuous out mode.
2. Verify that the rod position display for the selected CRD provides a changing readout in increasing increments until "48" is observed. If flux level permit observe changes in LPRM readings to verify that the rod follows the drive.
3. Depress the rod movement control "withdraw" push button, and also the "Cont. Withdraw" push button and observe that the rod pattern display remains unchanged. Thus verifying that the control rod did not go to the overtravel position. (1.5)

REFERENCE
ONI-C11-2 page 2

ANSWER 4.05 (2.00)

CONDITION	MODE SWITCH POSITION	RX.COOLANT TEMP.
Hot Standby	Startup/Hot Standby	Any temperature.
Hot Shutdown	Shutdown	Above 200 deg.F.

REFERENCE
IOI-5 page 1

ANSWERS -- PERRY 1 -85/03/26-LANG,T.

ANSWER 4.06 (2.00)

1.Main steam pressure is greater than 850 psig., and the MSL Isol. Logic Main Steam Line Pressure Low annunciator has cleared.

2.Condenser Vacuum is greater than 26 inches Hg. vac., and the MSL Isol. Logic Main Condenser Vacuum Low annunciator has cleared.

3.The APRM Downscale annunciators have cleared.

4.The reactor coolant has been verified to be within the chemistry limits for Operational Condition 1 per tech. specs.

5.&6.IRM/APRM OEVRLAP per tech. specs. and:
all APRMs are indicating between 5% and 12%
all IRMs are indicating on scale.

Any four for full credit. at 0.5 each.

REFERENCE
IOI 1,page 18

ANSWER 4.07 (1.50)

a. Overlap between the SRM/IRM means that the flux level on the IRMs should increase prior to increasing flux higher than the SRM can read. Flux level should be indicated on both the SRMs and the IRMs at the same time. (0.5)

b.In order to be proper at least three IRMs in each trip system should be indicating an increase in flux level when the SRMs are reading 4-6E4 with the SRMs fully inserted. (1.0)

REFERENCE
Startup Procedure

ANSWER 4.08 (2.00)

It is recommended that from the point of reactor criticality until the first bypass valve is partially opened, the 'Continuous Withdrawal' mode not be used between positions 12 and 24. (2.0)

REFERENCE
Cold Startup Procedure OM4A IOI-1,PAGE 10

ANSWERS -- PERRY 1 -85/03/26-LANG,T.

ANSWER 4.09 (3.00)

1.Arm and depress div. 1,2,3, and 4 Manual Scram push buttons and verify all control rods inserted.
2.Place the Reactor System Mode Switch in the 'Shutdown' position.
3.Trip the turbine generator.
4.Verify neutron monitors indicate a decreasing power lever.
5.Verify station loads have automaticly transfered to the Startup Transformer on tripping the turbine generator.
6.Place the div.3 diesel generator 'Diesel Control Transfer' switch to local. (0.5) each, six required for full credit.

REFERENCE
ONI-C61,Evacuation of the control room.

ANSWER 4.10 (2.00)

The initiation of an emergency system shall not be assumed to be inadvertant. Prior to securing an emergency system, the operator shall verify, by multiple indications, that a valid initiation signal does not exist or that the system operation is no longer required to maintain core cooling. PEI's or test procedures are allowed - PAP-0205

REFERENCE
Safety System Operation.

ANSWER 4.11 (2.00)

The reactor mode switch may be placed in the Run or Startup/Hot Standby position to test the switch interlock functions provided that the control rods are verified to remain fully inserted by a second licensed operator or other technically qualified member of the unit technical staff.

REFERENCE
Tech.Specs. Table 1.2 'Operational Conditions'

ANSWER 4.12 (2.50)

a.Trip the Main Turbine
b.1.Generator brks open.
2.Normal Supply brks trip.
3.Startup Supply brks close.
4.Generator Field brks trip.

(0.5) each

ANSWERS -- PERRY 1 -85/03/26-LANG,T.

REFERENCE
ONI-N32

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

FACILITY: Perry Unit 1

REACTOR TYPE: BWR

DATE ADMINISTERED: 3/26/85

EXAMINER: T. Lang

APPLICANT: _____

INSTRUCTIONS TO APPLICANT:

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

Category Value	% Of Total	Applicant's Score	% Of Category Value	Category
26	26			5. Theory of Nuclear Power Plant Operation, Fluids, and Thermodynamics
25	25			6. Plant Systems Design, Control, and Instrumentation
25	25			7. Procedures - Normal, Abnormal, Emergency, and Radiological Control
24	24			8. Administrative Procedures, Conditions, and Limitations
100	100			TOTALS

Final Grade _____ %

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

_____
Applicant's Signature

5. Theory of Nuclear Power Operations, Fluids, and Thermodynamics (26.0)

5.1 You increase core power by pulling control rods around the center fuel bundle. Assuming that recirculation ~~speed~~ flow is kept constant would the flow through the center bundle increase, decrease, or stay the same? Explain your answer. (2.0)

5.2 Your latest computer printout of MFLPD and MAPRAT shows the following values for Regions 1 to 3.

Region	1	2	3
MFLPD	1.10	0.95	1.05
MAPRAT	1.02	0.92	1.00

a. Which, if any, of these values are beyond their thermal limits? (1.0)

b. Why are each of the above limits imposed? (What do they protect against?) (1.5)

c. Compared to EOL, would values for MAPRAT at BOL be larger or smaller? Why? THIS MATERIAL IS NOT NORMALLY COVERED FOR CONTROL ROOM OPERATOR RO/SRO CANDIDATES (1.5)

5.3 a. List the three (3) reactivity coefficients in a BWR at power and give approximate values for each. (1.5)

b. What effect (increase, decrease, or no effect) do each of the three coefficients have on total core reactivity following a safety/relief valve failing open? Briefly explain why the dominant coefficient effects reactivity in the manner you indicate. (2.0)

5.4 What effect does an increase in feedwater flow have on recirculation pump NPSH? Explain why. (1.0)

5.5 The following statement relates to rod worth. For each of the following state whether it is TRUE or FALSE and explain the reason for your answer.

a. Control Rod Worth is greater at the center of the core than at anywhere else. (1.0)

b. As moderator temperature increases rod worth increases. (1.0)

c. As voids increase rod worth increases. (1.0)

5.6 The Perry-1 reactor is taken to criticality from a cold condition and then placed on an 80 second positive period.

a. From control room nuclear instrumentation, how can the operator tell when the heating reange has been reached? (Rod position and recirculation are held constant.) (1.0)

b. In which of the following intervals was the heating range entered? Explain the reason for your answer. (Show all work) (1.5)

Interval 1 - reactor power increased by a factor of 6 in 143.3 seconds.

Interval 2 - reactor power increased by a factor of 3 in 99.0 seconds.

Interval 3 - reactor power increased by a factor of 5 in 128.8 seconds.

(Note: The intervals may not be in sequence.)

5.7 With regard to Reactivity Coefficients:

Which reactivity coefficient is the <u>most</u> dominant under the following conditions: (2.0)

1) During rod drop accident at 15% power
2) MSIV closure at 100% power
3) Pulling rods at 1% power
4) Feedwater controller fails high at 100% power (i.e., water level initially drops)?

5.8 a. Beta for U235 is 0.0065. Why is Beta effective approximately 0.007? (1.0)

b. How does the above affect reactor period? (1.0)

5.9 Perry-1 reactor is operating at 85% power when one recirculation pump trips. Indicate how the following parameters would initially change (increase or decrease) and briefly explain why the change occurs:

a. Reactor power (1.0)

b. Reactor water level (1.0)

c. Feedwater flow (1.0)

5.10 In your reactor you produce and remove Xenon during normal operation.

a. How is Xenon produced and removed in your core? (1.0)

b. Where physically in your core is Xenon found? (1.0)

c. Does shutdown margin change when Xenon concentration changes? Explain your answer. (1.0)

- End of Category 5 -

6. Plant Systems Design, Control, and Instrumentation (25.0)

6.1 There are five (5) instrument ranges used at your plant for level:

a. What are these five (5) ranges and to what are they referenced? (2.5)

b. Why is the piping for most reference legs run outside the drywell into the containment? (0.5)

6.2 For the following components in the Off-Gass System signify if they are before or after the Desicant Dryer in the Off-Gas flow path. (3.0)

a. Water Separator

b. Off-Gas Condenser

c. After Filter

d. Cooler Condenser

e. Gas Cooler

f. Moisture Separator

6.3 With regard to the Standby Diesel Generators:

a. List the five (5) prerequisites that must exist before an auto-start will be initiated. (Do not include the auto-start signals.) (1.5)

b. What is the purpose of the 150 psig interlock in the starting air system? (0.5)

c. With regard to the Fuel Oil System:

1) What causes the Fuel Oil Booster Pump to automatically start? (0.5)

2) On a fuel pump overspeed failure, a pressure switch initiates an alarm and affects another Fuel Oil System component. What component is affected and in what way? (1.0)

6.4 With respect to the Automatic Depressurization System (ADS):

a. What Levels (1, 2, 3, etc.) provide input to ADS? (1.0)

b. Under what normal condition(s) will pushing the four ADS manual initiation pushbuttons not result in ADS initiation? What is the reason for this? (1.0)

c. What are the two (2) Seal-In functions contained in each ADS logic channel? (1.0)

6.5 In regards to the CRD System:

a. How does the on-line control valve respond following a scram? (1.0)

b. Briefly explain the operational consequences of the scram inlet valve sticking shut on a scram. Consider the following two situations and the effect(s) on a single CRD HCU mechanism. (1.0)

1. At 200 psig reactor pressure.

2. At 800 psig reactor pressure.

6.6 With regard to the Remote Reactor Shutdown Panel:

a. List the five (5) systems or system modes (portions of systems) that are controlled from the Remote Reactor Shutdown Panel. (1.5)

b. In what position should the "NORM-EMERG" switches be left when panel is not in operation? (0.5)

6.7 With regard to the Rod Control and Information System (RCIS):

a. The operator accidentally selected a rod out of sequence and received a rod block. He depressed the ROD SELECT CLEAR pushbutton on the Operator Control Module and then attempted to select the correct rod but could not. Why? (1.0)

b. What indication(s) would the operator see when a ganged rod is:

1. more than one (1) notch out of alignment while driving? (0.5)

2. more than two (2) notches out of alignment while stationary or moving? (0.5)

c. A control rod drive (CRD) is bypassed by the "Drive Bypass" function on the Rod Gang Drive System. Under what normal (not scram) condition(s) can the CRD move while in this bypassed condition? (0.5)

d. When withdrawing Group 5, at what notch is it banked and what is its notch withdrawal limit? (1.0)

6.8 a. Following WHAT MAJOR ACCIDENT would the Emergency Closed Cooling (ECC) System be used to supply the Fuel Pool Cooling and Cleanup System heat exchangers? WHY? (1.0)

b. Which ECC loop can be operated from the Remote Shutdown Panel? (0.5)

6.9 a. The reactor recirculation pumps require protection from two (2) conditions which can produce cavitation. Explain each condition. Include in your answer any automatic action or interlock associated with each condition. (2.0)

b. In regards to the recirc pumps, what action will occur when an ATWS signal is received? Be specific. (1.5)

- End of Category 6 -

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

7.1 According to procedures for Emergency RPV Depressurization:

a. What is the primary system used to cause depressurization? (0.5)

b. If the system in (a) is partially or totally unavailable, what action is to be taken? (1.0)

7.2 a. Give four (4) of the nine (9) automatic actions that you would expect to occur on a loss of service water. (2.0)

b. What are two (2) of the three (3) immediate operator actions that should be performed? (2.0)

7.3 The procedures for the Operational ALARA Program describe three (3) simple concepts that station personnel should utilize to minimize their own exposure and that of their fellow workers. What are these concepts? (1.5)

7.4 According to procedures for Gross Fuel Cladding Failure (ONI-J11-1):

a. If the "OG POST-TREAT PRCS RAD MON A/B RAD" Hi Hi Hi alarm clears, the operator is to reset the OFF-GAS POST-TREATMENT trip module. What is the reason for this action? (1.0)

b. Once the OFF-GAS POST-TREATMENT trip is reset the positions of the seven valves listed below are to be verified. What should be the new positions of each of these valves? (2.5)

1. Absorber train bypass valve (N64-F045)
2. Bypass line blockvalve (N64-F062)
3. Bypass line air seal valve (N64-F063)
4. Inlet-absorber train A (N64-F051A)
5. Inlet-absorber train B (N64-F051B
6. Absorber train-A D012 A bypass valve
7. Absorber train-B Do12 B bypass valve

7.5 According to the procedures for Reactor Shutdown (IOI-3, Section 4.2, Power Decrease, and IOI-4 Shutdown), at what percent power (approximate) should the following actions be performed? (2.0)

a. Transfer normal station electrical loads from the Auxiliary Transformer to the Startup Transformer.

b. Secure one of the running feedwater pumps and one feedwater booster pump.

c. Verify operability of RPCS.

d. Transfer recirculation pump to slow speed.

e. Unload and shut down main turbine.

7.6 While operating at 65% power, the only operating pressure regulator fails open, such that the control valves open (the alternate regulator had earlier failed and was being worked on by I&C personnel). What immediate action should the operator take to control reactor pressure? (Assume a slow failure) (2.0)

7.7 According to the Personnel Radiation Protection Requirements:

a. What is the administrative whole body dose limit(s) for an individual 20 years or older, who has a completed lifetime occupational exposure history record? (0.5)

b. Based on 10CFR20, what is the maximum allowable accumulated whole body exposure for a 38 year old person? (0.5)

c. When taping protective coveralls, when wearing two pairs of coveralls or when a wet suity is worn over one pair of coveralls, only the outer pair normally need taping. (TRUE or FALSE) (0.5)

d. What are the whole body dose limits for life-saving actions? (0.5)

e. What are the whole body dose limits when immediate action is required to prevent serious injury? (0.5)

7.8 While operating at 100% power, the plant suffers a complete loss of instrument air. How will valve operations be affected (open, close, or fail as is) for the following valves: (3.5)

a. Feedwater pump recirculation flow control valves
b. NCC surge tank make-up valves
c. MSIVs
d. Temperature control valves for TBCC heat exchangers
e. Scram valves
f. Flow control valve A(B) of CRD system
g. SJAEs A(B) suction valve on Main Condenser

7.9 ONI-N36 "Loss of Feedwater Heating" states that the immediate action would be to reduce recirculation flow. The first subsequent action is to insert CRDs.

a. Of the two actions above which is more likely to prevent a scram? Explain why. (1.0)

b. Why is each action performed? (1.0)

c. If a scram were to occur, what would be the cause? (0.5)

7.10 According to IOI-1 four (4) conditions must be verified prior to placing the mode switches in "Run." What are these four (4) conditions? (2.0)

- End of Category 7 -

8. Administrative Procedures, Conditions, and Limitations (24.0)

8.1 During a unit startup, you discover that a control rod is immovable. What action must be taken if it failed to move because of excessive friction? Be specific. (2.0)

8.2 During plant cold shutdown, the maintenance supervisor informs you that on routine checking he found the Division 1 125 volt battery discharged, the reason unknown: Do Tech Specs. require action (Yes or No)? Explain. (2.0)

8.3 Which of the following occurrences require 1 hour reports to the NRC: (2.0)

a. Inadvertent HPCS initiation
b. Reactor heatup rate of 150°F in a one-hour period
c. Site boundary dose > 50 MR/hr whole body
d. Stuck open main steam relief valve

8.4 With regard to the Fire Brigade:

a. What is the minimum number of personnel required? (0.5)

b. Who are specifically excluded from the Fire Brigade? (1.0)

8.5 According to Tech. Specs., Secondary Containment Integrity:

a. What parameter(s) is monitored to demonstrate secondary containment integrity and what should its value(s) be? (1.0)

b. What five (5) conditions must be met for Secondary Containment to exist? (2.5)

8.6 With regard to Equipment Tagging, Bypasses, Lifted, Leads and Jumpers:

a. The presence of a Danger tag on a component allows repositioning of the component but only with permission of the designated Job Supervisor. (True or False) (0.5)

b. Under what condition(s) may the independent verification requirements for return of safety equipment to standby readiness be waived? (1.0)

c. What does a pink half-dot on an annunciator window signify? (1.0)

d. Who performs the technical evaluation required for all proposed temporary bypasses, lifted leads, and jumpers? (0.5)

8.7 With regard to certain shift personnel and their functions:

a. There need only be one (1) licensed operator "at the controls" during Operational Condition 4. (True or False)? (0.5)

b. During new fuel handling operations, in the Fuel Handling Building, a licensed Senior Reactor Operator must be supervising. (True or False)? (0.5)

c. During what Operational Conditions shall the Shift Technical Advisor be on shift? (0.5)

d. Who approves surveillance test results to determine if they meet Tech. Spec. requirements? (0.5)

8.8 With regard to Accident Monitoring Instrumentation, according to Tech. Specs., under what operational conditions (use number only) are the following instruments to be operable? (2.0)

1. Primary Containment and Drywell Hydrogen Concentration Analyzer and Monitor

2. Drywell Air Temperature

3. Offgas Ventilation Exhaust Monitor

4. Safety/Relief Valve Position Indicators

8.9 Prior to securing a safety system once initiated the operator must ensure himself that certain conditions are met. What are these conditions? (2.0)

8.10 With regard to the Emergency Planning Instruction:

a. In which of the four (4) emergency classes would you place the following: (2.5)

1. Transport of a contaminated individual to an offsite hospital

2. Tornado striking facility

3. Control room evacuation with shutdown controlled at Remote Shutdown Panel

4. A 7 gpm increase in unidentified leakage within the last 4 hrs

5. An ATWS

b. Concerning the Operations Support Center (OSC)

1. Who is in charge of the OSC? (0.5)

2. Where is it located? (0.5)

3. Under what condition(s) is it activated? (0.5)

- End of Exam -

EQUATIONS/DATA SHEET

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

$1Ci = 3.7 \times 10^{10} Bq$

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

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

$\alpha_H = -4.5 \times 10^{-4} \frac{\Delta K/°F}{K}$

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

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

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

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

$Q = MCp\ \Delta t$

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

$f = 64/Re$

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

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

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

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

$M = 1/(1-k)$

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

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

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

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

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

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

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

$v = v_f + xv_{fg}$

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

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

1 in = 2.54 cm

1 gal. = 3.785 liters = 8.33 lb.

1 kg = 2.205 lb

$N = \rho A_o/A$

17.58 watts = 1 BTU/min
1psi = 6.895 Pa
1psi = 2.036 " H_g (@ 0C)
1psi = 27.68 " H^2O (@ 4C)

$\bar{\beta} = .0071$

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

Table 1. Saturated Steam: Temperature Table

Temp Fahr t	Abs Press Lb per Sq In p	Specific Volume Sat Liquid v_f	Evap v_{fg}	Sat Vapor v_g	Enthalpy Sat Liquid h_f	Evap h_{fg}	Sat Vapor h_g	Entropy Sat Liquid s_f	Evap s_{fg}	Sat Vapor s_g	Temp Fahr t
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	2.0763	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	1.9709	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	Evap v_{fg}	Sat Vapor v_g	Enthalpy Sat Liquid h_f	Evap h_{fg}	Sat Vapor h_g	Entropy Sat Liquid s_f	Evap s_{fg}	Sat Vapor s_g	Temp t
180.0	7.5110	0.016510	50.71	50.22	148.00	990.3	1138.2	0.2631	1.5890	1.8521	180.0
182.0	7.850	0.016522	48.172	18.189	150.01	991.0	1141.0	0.2662	1.5814	1.8476	182.0
184.0	8.201	0.016534	46.732	46.749	152.01	991.8	1143.8	0.2694	1.5738	1.8432	184.0
186.0	8.568	0.016547	44.383	44.400	154.02	992.5	1146.5	0.2725	1.5662	1.8387	186.0
188.0	8.947	0.016559	42.621	42.638	156.03	993.3	1149.3	0.2756	1.5587	1.8343	188.0
190.0	9.340	0.016572	40.941	40.957	158.04	994.1	1152.1	0.2787	1.5513	1.8299	190.0
192.0	9.747	0.016585	39.337	39.354	160.05	994.8	1154.9	0.2818	1.5438	1.8256	192.0
194.0	10.168	0.016598	37.808	37.824	162.05	995.6	1157.7	0.2849	1.5364	1.8213	194.0
196.0	10.605	0.016611	36.348	36.364	164.06	996.4	1160.4	0.2879	1.5291	1.8170	196.0
198.0	11.058	0.016624	34.954	34.970	166.08	997.1	1163.2	0.2910	1.5218	1.8128	198.0
200.0	11.526	0.016637	33.627	33.639	168.09	997.9	1166.0	0.2940	1.5145	1.8086	200.0
202.0	12.012	0.016650	32.355	32.371	170.11	998.6	1168.7	0.2971	1.5073	1.8044	202.0
204.0	12.514	0.016663	31.135	31.151	172.14	999.4	1171.5	0.3001	1.5001	1.8002	204.0
206.0	13.034	0.016677	29.965	29.982	174.16	1000.1	1174.3	0.3031	1.4929	1.7961	206.0
208.0	13.568	0.016691	28.842	28.858	176.18	1000.8	1177.0	0.3061	1.4858	1.7919	208.0
210.0	14.120	0.016705	27.762	27.779	178.21	1001.5	1179.8	0.3091	1.4787	1.7878	210.0
212.0	14.696	0.016719	26.722	26.739	180.17	1002.3	1182.5	0.3121	1.4717	1.7838	212.0
214.0	15.301	0.016733	25.720	25.737	182.24	1003.0	1185.2	0.3151	1.4647	1.7797	214.0
216.0	15.901	0.016747	24.878	24.894	184.20	1003.8	1187.9	0.3181	1.4577	1.7758	216.0
218.0	17.186	0.016775	23.131	23.148	188.23	1005.2	1193.4	0.3241	1.4701	1.7442	218.0
220.0	18.556	0.016805	21.529	21.545	192.27	1006.6	1198.9	0.33300	1.4091	1.7380	220.0
228.0	20.015	0.016834	20.056	20.073	196.31	1008.0	1204.3	0.3359	1.3961	1.7320	228.0
232.0	21.567	0.016864	18.701	18.718	200.35	1009.4	1209.8	0.3417	1.3842	1.7260	232.0
236.0	23.216	0.016895	17.454	17.471	204.40	1010.8	1215.2	0.3476	1.3725	1.7201	236.0
240.0	24.968	0.016926	16.304	16.321	208.45	1012.1	1220.6	0.3533	1.3609	1.7142	240.0
244.0	26.826	0.016958	15.243	15.260	212.50	1013.5	1226.0	0.3591	1.3494	1.7085	244.0
248.0	28.796	0.016990	14.264	14.281	216.56	1014.8	1231.4	0.3649	1.3379	1.7028	248.0
252.0	30.883	0.017022	13.358	13.375	220.62	1016.1	1236.7	0.3706	1.3265	1.6972	252.0
256.0	33.091	0.017055	12.520	12.538	224.69	1017.4	1242.1	0.3763	1.3154	1.6917	256.0
260.0	35.427	0.017089	11.745	11.762	228.76	1018.6	1247.4	0.3819	1.3043	1.6862	260.0
264.0	37.894	0.017123	11.025	11.042	232.83	1019.9	1252.7	0.3876	1.2933	1.6808	264.0
268.0	40.500	0.017157	10.358	10.375	236.91	1021.1	1258.0	0.3932	1.2823	1.6755	268.0	
272.0	43.249	0.017193	9.738	9.755	240.99	1022.3	1263.3	0.3987	1.2715	1.6702	272.0
276.0	46.147	0.017228	9.167	9.180	245.08	1023.5	1268.5	0.4043	1.2607	1.6650	276.0
280.0	49.200	0.017264	8.637	8.654	249.17	1024.6	1273.8	0.4098	1.2501	1.6599	280.0
284.0	52.414	0.01730	8.1280	8.1453	253.3	1025.7	1279.0	0.4154	1.2395	1.6548	284.0
288.0	55.795	0.01734	7.6634	7.6807	257.4	1026.8	1284.2	0.4208	1.2290	1.6498	288.0
292.0	59.350	0.01738	7.2301	7.2475	261.5	1027.9	1289.4	0.4263	1.2186	1.6449	292.0
296.0	63.084	0.01741	6.8259	6.8433	265.6	1029.0	1294.6	0.4317	1.2082	1.6400	296.0
300.0	67.005	0.01745	6.4483	6.4658	269.7	1030.0	1299.7	0.4372	1.1979	1.6351	300.0
304.0	71.119	0.01749	6.0955	6.1130	273.8	1031.0	1304.9	0.4426	1.1877	1.6303	304.0
308.0	75.433	0.01753	5.7655	5.7810	278.0	1032.0	1310.0	0.4479	1.1776	1.6256	308.0
312.0	79.953	0.01757	5.4566	5.4742	282.1	1033.0	1315.1	0.4533	1.1676	1.6209	312.0
316.0	84.688	0.01761	5.1673	5.1849	286.3	1033.9	1320.1	0.4586	1.1576	1.6162	316.0
320.0	89.643	0.01766	4.8961	4.9138	290.4	1034.8	1325.2	0.4640	1.1477	1.6116	320.0
324.0	94.826	0.01770	4.6418	4.6595	294.6	1035.6	1330.2	0.4692	1.1378	1.6071	324.0
328.0	100.245	0.01774	4.4030	4.4208	298.7	1036.5	1335.2	0.4745	1.1280	1.6025	328.0
332.0	105.907	0.01779	4.1788	4.1966	302.9	1037.3	1340.2	0.4798	1.1183	1.5981	332.0
336.0	111.820	0.01783	3.9681	3.9859	307.1	1038.1	1345.1	0.4850	1.1086	1.5936	336.0
340.0	117.992	0.01787	3.7699	3.7878	311.3	1038.8	1350.1	0.4902	1.0990	1.5892	340.0
344.0	124.430	0.01792	3.5834	3.6013	315.5	1039.6	1355.0	0.4954	1.0894	1.5849	344.0
348.0	131.142	0.01797	3.4078	3.4258	319.7	1040.3	1359.9	0.5006	1.0799	1.5805	348.0
352.0	138.138	0.01801	3.2423	3.2603	323.9	1041.0	1364.9	0.5058	1.0705	1.5763	352.0
356.0	145.424	0.01806	3.0863	3.1044	328.1	1041.7	1369.8	0.5110	1.0611	1.5721	356.0
360.0	153.010	0.01811	2.9392	2.9573	332.3	1042.4	1374.7	0.5161	1.0517	1.5678	360.0
364.0	160.903	0.01816	2.8002	2.8184	336.5	1043.0	1379.5	0.5212	1.0424	1.5637	364.0
368.0	169.113	0.01821	2.6691	2.6873	340.8	1043.7	1384.4	0.5263	1.0332	1.5595	368.0
372.0	177.648	0.01826	2.5451	2.5633	345.0	1044.3	1389.3	0.5314	1.0240	1.5554	372.0
376.0	186.517	0.01831	2.4279	2.4462	349.3	1044.9	1394.2	0.5365	1.0148	1.5513	376.0
380.0	195.729	0.01836	2.3170	2.3353	353.5	1045.5	1398.0	0.5416	1.0057	1.5473	380.0
384.0	205.294	0.01842	2.2120	2.2304	357.8	1046.1	1403.7	0.5466	0.9966	1.5432	384.0
388.0	215.220	0.01847	2.1126	2.1311	362.2	1046.7	1408.6	0.5516	0.9876	1.5392	388.0
392.0	225.516	0.01853	2.0184	2.0369	366.5	1047.4	1413.4	0.5567	0.9786	1.5352	392.0
396.0	236.193	0.01858	1.9291	1.9477	370.8	1047.9	1418.4	0.5617	0.9696	1.5313	396.0
400.0	247.259	0.01864	1.8444	1.8630	375.1	1048.9	1423.0	0.5667	0.9607	1.5274	400.0
404.0	258.725	0.01870	1.7640	1.7827	379.4	1049.0	1428.5	0.5717	0.9518	1.5234	404.0
408.0	270.600	0.01875	1.6877	1.7064	383.8	1049.6	1433.4	0.5766	0.9429	1.5195	408.0
412.0	282.894	0.01881	1.6152	1.6340	388.1	1050.2	1438.4	0.5816	0.9341	1.5157	412.0
416.0	295.617	0.01887	1.5463	1.5651	392.5	1050.7	1443.2	0.5866	0.9253	1.5118	416.0
420.0	308.780	0.01894	1.4808	1.4997	396.9	1051.2	1448.1	0.5915	0.9165	1.5080	420.0
424.0	322.391	0.01900	1.4184	1.4374	401.3	1051.7	1453.0	0.5965	0.9077	1.5042	424.0
428.0	336.463	0.01906	1.3591	1.3787	405.7	1052.0	1457.7	0.6014	0.8990	1.5004	428.0
432.0	351.00	0.01913	1.30766	1.32179	410.1	1052.5	1462.6	0.6063	0.8903	1.4966	432.0
436.0	366.03	0.01919	1.24887	1.26806	414.6	1052.9	1467.5	0.6112	0.8816	1.4928	436.0
440.0	381.54	0.01925	1.19261	1.21687	419.0	1053.4	1472.4	0.6161	0.8729	1.4890	440.0
444.0	397.56	0.01931	1.13874	1.15806	423.5	1053.8	1477.3	0.6210	0.8643	1.4853	444.0
448.0	414.09	0.01940	1.10212	1.12152	428.0	1054.2	1482.2	0.6259	0.8557	1.4815	448.0
452.0	431.14	0.01947	1.05764	1.07711	432.5	1054.5	1487.0	0.6308	0.8471	1.4778	452.0
456.0	448.73	0.01954	1.01518	1.03472	437.0	1054.8	1491.8	0.6356	0.8385	1.4741	456.0

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

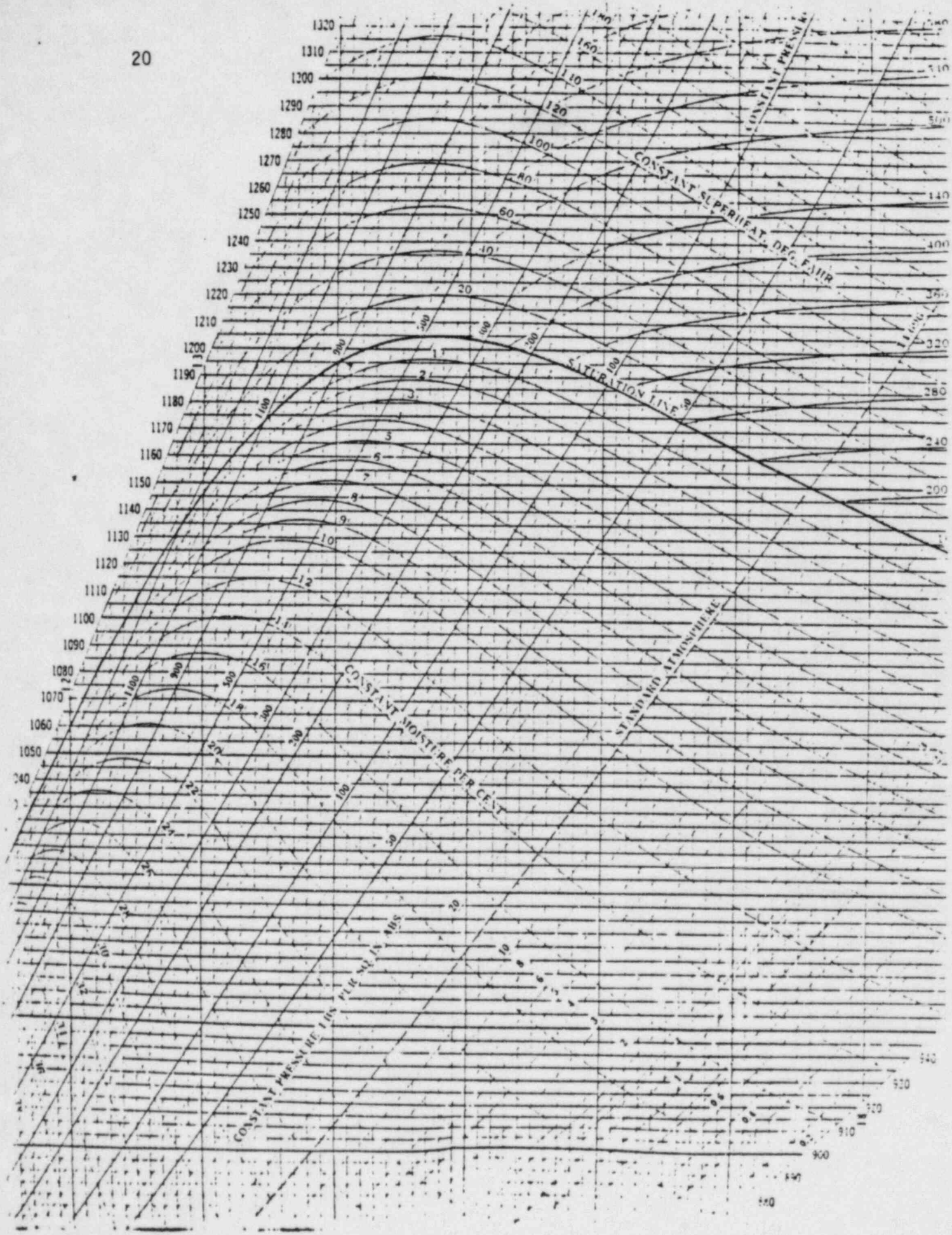
Temp Fahr t	Abs Press Lb per Sq In p	Specific Volume Sat Liquid v_f	Evap v_{fg}	Sat Vapor v_g	Enthalpy Sat Liquid h_f	Evap h_{fg}	Sat Vapor h_g	Entropy Sat Liquid s_f	Evap s_{fg}	Sat Vapor s_g	Temp Fahr t
458.0	466.87	0.01961	0.97463	0.99424	441.5	763.2	1204.8	0.6405	0.8299	1.4704	458.0
464.0	485.56	0.01969	0.93588	0.95557	448.1	758.6	1206.7	0.6454	0.8213	1.4667	464.0
468.0	504.83	0.01976	0.89885	0.91862	450.7	754.0	1.04.6	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	1.4445	488.0
492.0	633.03	0.02026	0.70794	0.72820	478.5	724.6	1203.1	0.6793	0.7614	1.4407	492.0
496.0	656.61	0.02034	0.68065	0.70100	483.2	719.5	1202.7	0.6842	0.7528	1.4370	496.0
500.0	680.86	0.02043	0.65448	0.67492	487.9	714.3	1202.2	0.6890	0.7443	1.4333	500.0
504.0	705.78	0.02053	0.62938	0.64991	492.7	709.0	1201.7	0.6939	0.7357	1.4296	504.0
508.0	731.40	0.02062	0.60530	0.62592	497.5	703.7	1201.1	0.6987	0.7271	1.4258	508.0
512.0	757.72	0.02072	0.58218	0.60289	502.3	698.2	1200.5	0.7036	0.7185	1.4221	512.0
516.0	784.76	0.02081	0.55997	0.58079	507.1	692.7	1199.8	0.7085	0.7099	1.4183	516.0
520.0	812.51	0.02091	0.53864	0.55956	512.0	687.0	1199.0	0.7133	0.7013	1.4146	520.0
524.0	841.00	0.02102	0.51814	0.53916	516.9	681.3	1198.2	0.7182	0.6926	1.4108	524.0
528.0	870.21	0.02112	0.49843	0.51955	521.8	675.5	1197.3	0.7231	0.6839	1.4070	528.0
532.0	900.14	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	1190.5	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	0.5195	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	0.3891	1.2698	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	0.2725	1.2086	680.0
684.0	2781.1	0.03114	0.07349	0.10463	768.2	290.2	1058.4	0.9447	0.2551	1.1998	684.0
688.0	2854.4	0.03204	0.06595	0.09799	778.8	268.2	1047.0	0.9535	0.2367	1.1872	688.0
692.0	2928.5	0.03313	0.05797	0.09110	790.5	243.1	1033.6	0.9634	0.2170	1.1744	692.0
696.0	3013.4	0.03455	0.04916	0.08371	804.4	212.8	1017.2	0.9749	0.1841	1.1591	696.0
700.0	3094.3	0.03662	0.03857	0.07519	822.4	172.7	995.2	0.9901	0.1490	1.1390	700.0
702.0	3135.5	0.03874	0.03173	0.06937	835.0	144.7	979.7	1.0006	0.1246	1.1252	702.0
704.0	3177.2	0.04108	0.02137	0.06100	850.2	107.0	956.2	1.0149	0.0876	1.1046	704.0
705.0	3198.3	0.04427	0.01304	0.05730	871.0	61.4	934.4	1.0329	0.0527	1.0856	705.0
705.47*	3208.2	0.05078	0.00000	0.05078	906.0	0.0	906.0	1.0612	0.0000	1.0612	705.47*

*Critical temperature

Table 2: Saturated Steam: Pressure Table

Abs Press Lb/Sq In p	Temp Fahr t	Specific Volume Sat Liquid v_f	Specific Volume Evap v_{fg}	Specific Volume Sat Vapor v_g	Enthalpy Sat Liquid h_f	Enthalpy Evap h_{fg}	Enthalpy Sat Vapor h_g	Entropy Sat Liquid s_f	Entropy Evap s_{fg}	Entropy Sat Vapor s_g	Abs Press Lb/Sq In p
0.08865	32.018	0.016022	3302.4	3302.4	0.0003	1075.5	1075.5	0.0000	2.1872	2.1872	0.08865
0.25	59.323	0.016012	1235.5	1235.5	27.382	1060.1	1087.4	0.0542	2.0445	2.0987	0.25
0.50	79.586	0.016071	641.5	641.5	47.623	1018.6	1066.3	0.0925	1.9446	2.0370	0.50
1.0	101.74	0.016136	333.59	333.60	69.73	1036.1	1105.8	0.1326	1.8355	1.9681	1.0
5.0	162.24	0.016407	73.515	73.532	130.20	1000.9	1131.1	0.2349	1.6094	1.8443	5.0
10.0	193.21	0.016592	38.404	38.420	161.25	982.1	1143.3	0.2836	1.5043	1.7879	10.0
14.696	212.00	0.016719	26.782	26.799	180.17	970.3	1150.5	0.3137	1.4447	1.7584	14.696
15.0	213.03	0.016726	26.274	26.290	181.21	969.7	1150.9	0.3153	1.4415	1.7568	15.0
20.0	227.96	0.016834	20.070	20.087	196.27	960.1	1156.3	0.3358	1.3962	1.7320	20.0
30.0	250.34	0.017009	13.7266	13.7436	218.9	945.2	1164.1	0.3682	1.3313	1.6995	30.0
40.0	267.25	0.017151	10.4794	10.4965	235.1	933.6	1168.8	0.3921	1.2844	1.6765	40.0
50.0	281.02	0.017274	8.4967	8.5140	250.2	923.9	1174.1	0.4112	1.2474	1.6585	50.0
60.0	292.71	0.017383	7.1562	7.1736	262.2	915.4	1177.6	0.4273	1.2167	1.6440	60.0
70.0	302.93	0.017382	6.1875	6.2050	272.7	907.8	1180.6	0.4411	1.1905	1.6316	70.0
80.0	312.04	0.017573	5.4536	5.4711	282.1	900.9	1183.1	0.4534	1.1675	1.6209	80.0
90.0	320.28	0.017659	4.8779	4.8953	290.7	894.6	1185.3	0.4643	1.1470	1.6113	90.0
100.0	327.82	0.017740	4.4133	4.4310	298.5	888.6	1187.2	0.4743	1.1284	1.6027	100.0
110.0	334.79	0.01782	4.0306	4.0484	305.8	883.1	1188.9	0.4834	1.1115	1.5950	110.0
120.0	341.27	0.01789	3.7097	3.7275	312.6	877.8	1190.4	0.4919	1.0959	1.5879	120.0
130.0	347.33	0.01796	3.4363	3.4544	319.0	872.8	1191.7	0.4998	1.0815	1.5813	130.0
140.0	353.04	0.01803	3.2010	3.2190	325.0	868.0	1193.0	0.5071	1.0681	1.5752	140.0
150.0	358.43	0.01809	2.9948	3.0129	330.6	863.4	1194.1	0.5141	1.0554	1.5695	150.0
160.0	363.55	0.01815	2.8155	2.8336	336.1	859.0	1195.1	0.5206	1.0435	1.5641	160.0
170.0	368.42	0.01821	2.6556	2.6738	341.2	854.8	1196.0	0.5269	1.0322	1.5591	170.0
180.0	373.08	0.01827	2.5129	2.5312	346.2	850.7	1196.9	0.5328	1.0215	1.5543	180.0
190.0	377.53	0.01833	2.3847	2.4030	350.9	846.7	1197.6	0.5384	1.0113	1.5498	190.0
200.0	381.80	0.01839	2.2689	2.2873	355.5	842.8	1198.3	0.5438	1.0016	1.5454	200.0
210.0	385.91	0.01844	2.16373	2.18217	359.9	839.1	1199.0	0.5490	0.9923	1.5413	210.0
220.0	389.88	0.01850	2.06779	2.08629	364.2	835.4	1199.6	0.5540	0.9834	1.5374	220.0
230.0	393.70	0.01855	1.97991	1.99846	368.3	831.8	1200.1	0.5588	0.9748	1.5336	230.0
240.0	397.39	0.01860	1.89909	1.91769	372.3	828.4	1200.6	0.5634	0.9665	1.5299	240.0
250.0	400.97	0.01865	1.82457	1.84317	376.1	825.0	1201.1	0.5679	0.9585	1.5264	250.0
260.0	404.44	0.01870	1.75548	1.77418	379.9	821.6	1201.5	0.5722	0.9508	1.5230	260.0
270.0	407.80	0.01875	1.69127	1.71003	383.4	818.3	1201.9	0.5764	0.9433	1.5197	270.0
280.0	411.07	0.01880	1.63159	1.65049	387.1	815.1	1202.3	0.5805	0.9361	1.5166	280.0
290.0	414.25	0.01885	1.57597	1.59482	390.6	812.0	1202.6	0.5844	0.9291	1.5135	290.0
300.0	417.35	0.01889	1.52384	1.54274	394.0	808.8	1202.9	0.5882	0.9223	1.5105	300.0
350.0	431.73	0.01912	1.30642	1.32554	409.8	794.2	1204.0	0.6059	0.8909	1.4968	350.0
400.0	444.60	0.01934	1.14162	1.16095	424.2	780.4	1204.6	0.6217	0.8630	1.4847	400.0
450.0	456.28	0.01954	1.01223	1.03178	437.3	767.5	1204.8	0.6360	0.8378	1.4738	450.0
500.0	467.01	0.01975	0.90787	0.92762	449.5	755.1	1204.7	0.6490	0.8148	1.4638	500.0
550.0	476.94	0.01994	0.82183	0.84177	460.9	743.3	1204.3	0.6611	0.7936	1.4547	550.0
600.0	486.20	0.02013	0.75062	0.76975	471.7	732.0	1203.7	0.6723	0.7738	1.4461	600.0
650.0	494.89	0.02032	0.68811	0.70843	481.9	720.9	1202.8	0.6828	0.7552	1.4381	650.0
700.0	503.08	0.02050	0.63505	0.65556	491.6	710.2	1201.8	0.6928	0.7377	1.4304	700.0
750.0	510.84	0.02069	0.58980	0.60949	500.9	699.8	1200.7	0.7022	0.7210	1.4232	750.0
800.0	518.21	0.02087	0.54836	0.56936	509.8	689.6	1199.4	0.7111	0.7051	1.4163	800.0
850.0	525.24	0.02105	0.51197	0.53207	518.4	679.5	1198.0	0.7197	0.6899	1.4096	850.0
900.0	531.95	0.02123	0.47868	0.50091	526.7	669.7	1196.4	0.7279	0.6753	1.4032	900.0
950.0	538.39	0.02141	0.45043	0.47205	534.7	660.0	1194.7	0.7358	0.6612	1.3969	950.0
1000.0	544.58	0.02159	0.42516	0.44596	542.6	650.3	1192.9	0.7434	0.6476	1.3910	1000.0
1050.0	550.53	0.02177	0.40047	0.42224	550.1	640.9	1191.0	0.7507	0.6344	1.3851	1050.0
1100.0	556.28	0.02195	0.37863	0.40058	557.5	631.5	1189.1	0.7578	0.6216	1.3794	1100.0
1150.0	561.82	0.02214	0.35859	0.38073	564.8	622.2	1187.0	0.7647	0.6091	1.3738	1150.0
1200.0	567.19	0.02232	0.34013	0.36245	571.9	613.0	1184.8	0.7714	0.5969	1.3683	1200.0
1250.0	572.39	0.02250	0.32306	0.34556	578.8	603.8	1182.6	0.7780	0.5850	1.3630	1250.0
1300.0	577.42	0.02269	0.30722	0.32991	585.6	594.6	1180.2	0.7843	0.5733	1.3577	1300.0
1350.0	582.32	0.02288	0.29250	0.31537	592.3	585.4	1177.8	0.7906	0.5620	1.3526	1350.0
1400.0	587.07	0.02307	0.27871	0.30178	598.8	576.5	1175.3	0.7966	0.5509	1.3474	1400.0
1450.0	591.70	0.02327	0.26584	0.28911	605.3	567.4	1172.8	0.8026	0.5399	1.3425	1450.0
1500.0	596.20	0.02346	0.25372	0.27719	611.7	558.4	1170.1	0.8085	0.5292	1.3377	1500.0
1550.0	600.59	0.02366	0.24235	0.26601	618.0	549.4	1167.4	0.8142	0.5187	1.3329	1550.0
1600.0	604.87	0.02387	0.23159	0.25545	624.2	540.3	1164.5	0.8199	0.5084	1.3283	1600.0
1650.0	609.05	0.02407	0.22141	0.24551	630.4	531.3	1161.6	0.8254	0.4982	1.3236	1650.0
1700.0	613.13	0.02428	0.21178	0.23607	636.5	522.2	1158.6	0.8309	0.4882	1.3191	1700.0
1750.0	617.12	0.02450	0.20263	0.22713	642.5	513.1	1155.6	0.8363	0.4785	1.3148	1750.0
1800.0	621.02	0.02472	0.19390	0.21861	648.5	503.8	1152.3	0.8417	0.4687	1.3104	1800.0
1850.0	624.83	0.02495	0.18558	0.21052	654.5	494.6	1149.0	0.8470	0.4591	1.3061	1850.0
1900.0	628.56	0.02517	0.17764	0.20278	660.4	485.2	1145.6	0.8522	0.4496	1.3018	1900.0
1950.0	632.22	0.02541	0.17009	0.19540	666.3	475.8	1142.0	0.8574	0.4402	1.2976	1950.0
2000.0	635.80	0.02565	0.16286	0.18831	672.1	466.2	1138.3	0.8625	0.4309	1.2934	2000.0
2100.0	642.76	0.02615	0.14895	0.17501	683.8	446.7	1130.5	0.8727	0.4125	1.2853	2100.0
2200.0	649.45	0.02669	0.13601	0.16272	695.5	426.7	1122.2	0.8828	0.3940	1.2768	2200.0
2300.0	655.89	0.02727	0.12396	0.15124	707.5	406.0	1113.5	0.8929	0.3753	1.2682	2300.0
2400.0	662.11	0.02790	0.11267	0.14056	719.8	384.4	1104.2	0.9030	0.3563	1.2593	2400.0
2500.0	668.11	0.02859	0.10203	0.13062	732.7	361.6	1094.4	0.9132	0.3366	1.2498	2500.0
2600.0	673.91	0.02938	0.09197	0.12130	746.5	337.6	1084.0	0.9237	0.3157	1.2395	2600.0
2700.0	679.53	0.03029	0.08235	0.11264	761.3	312.3	1073.7	0.9346	0.2931	1.2277	2700.0
2800.0	684.96	0.03134	0.07311	0.10445	777.7	285.1	1062.8	0.9460	0.2681	1.2141	2800.0
2900.0	690.22	0.03262	0.06418	0.09680	795.1	256.8	1051.9	0.9582	0.2398	1.1980	2900.0
3000.0	695.33	0.03428	0.05537	0.08965	813.8	227.1	1040.9	0.9718	0.2071	1.1789	3000.0
3100.0	700.28	0.03691	0.04631	0.08322	834.0	195.3	1029.3	0.9874	0.1681	1.1555	3100.0
3200.0	705.08	0.04312	0.03614	0.07926	856.4	161.3	1017.7	1.0059	0.1206	1.1265	3200.0
3208.2*	705.47	0.05078	0.00000	0.05078	906.0	0.0	906.0	1.0612	0.0000	1.0612	3208.2*

*Critical pressure


CONSTANT PRESSURE
CONSTANT SUPERHEAT DEG. FAHR
SATURATION LINE
STANDARD ATMOSPHERE
CONSTANT MOISTURE PER CENT
CONSTANT PRESSURE LBS PER SQ IN ABS

Answers to Perry-1 SRO Exam

5. Theory of Nuclear Power Plant Operations, Fluids and Thermodynamics (26.0)

5.1 As fuel temperature is increased (due to control rod pull) more voiding is created. Therefore more back pressure, which would mean less flow. However, because of core orificing back pressure is less significant and flow through bundle is almost the same. (2.0)

Ref: Thermodynamics

5.2 a. MFLPD Region 3, REGION 1 (0.5)
MAPRAT Region 1 (0.5)

b. MFLPD - Maintains < 1% cladding strain, fuel failure. (0.75)

MAPRAT - Maintains < 2200°F following LOCA, decay heat removal. (0.75)

c. MAPRAT at BOL Smaller (0.5); MAPLHGR limit is larger at BOL (0.5) since, with exposure, local peaking factor gets smaller as heat transfer is reduced (0.5). (1.5)

Ref: Perry-NPP Thermal Sciences, pg. 10.3.

5.3 a. 1. Moderator temperature coefficient alpha T = -1×10^{-4} per degree change in temperature.

2. Moderator void coefficient alpha V = -1×10^{-3} per % change in voids.

3. Fuel temperature coefficient alpha D = -1×10^{-5} per degree change in fuel temperature. (1.5)

b. Alpha T increases core delta K/K
Alpha V decreases core delta K/K
Dominant effect - relief valve opening results in decreasing reactor pressure which increased voids and decreases moderator density resulting in more neutrons leaking out the core and reducing power. (2.0)

Ref: General Theory

5.4 Increase (0.5); increased subcooling (0.5) (1.0)

Ref: Morris, T. C.; Thermo/HT/Fluid flow (3/83), pg. 7-96

5.5 a. False. It is possible for a thermal flux peak to exist anywhere radially within the core which would increase the worth of the rod within that flux peak even if the rod 5pVm near the edge of the core. (1.0)

b. True. As moderator temperature increases moderator density decreases. Neutrons travel a greater distance in thermally diffusing and are more likely to come in contact with and be absorbed by a control rod. (1.0)

c. False. With an increase in void content, the neutron slowing down length increases to the point where a neutron may not be thermalized when it reaches a control rod. Since control rods are thermal absorbers fewer neutrons are captured by the control rod and hence rod worth decreases. (1.0)

Ref: Introduction to Nuclear Operations, pg 7-11

5.6 a. Operator can notice that period has become longer and that power change on IRMs, SRMs is leveling off and turning around. (1.0)

b. (From $P = Poe^{t/T} \rightarrow T = \frac{t}{\ln P/Po}$) Interval 2 (0.5): the period has lengthened from 80 seconds. The other intervals have 80 second periods (1.0). (1.5)

Ref: General control room indications; Perry, Intro to NR Operations, pg 4.18-4.19.

5.7 (0.5 for each) (2.0)

1) Doppler coefficient

2) Void coefficient

3) Moderator coefficient

4) Void coefficient

Ref: Standard Reactor Theory

5.8 a. Beta effective is greater than beta because delayed neutrons are born at lower energy than prompt neutrons so a larger percentage of the delayed neutrons will become thermal neutrons and cause fission. To account for this larger percentage at the thermal neutron level than at the fast neutron level we use the effective delayed neutron fraction rather than delayed neutron fraction in our calculations. (1.0)

b. The difference produces a longer period for a given addition of reactivity which can be seen in the reactor period equation T=(B-p)/Lp. With beta effective used instead of beta, the term (Beff-p) is larger giving a longer period. (1.0)

Ref: Introduction to Reactor Operations

5.9 a. Decrease (0.34) due to increased void content in the core (0.33) as flow decreases (0.33). (1.0)

b. Increase (0.34) due to increased voiding in the core (0.33) and recirc pump no longer taking suction on the annulus (0.33). (1.0)

c. Decrease (0.34) due to steam flow decrease (0.33) and level increase (0.33). (1.0)

Ref: Standard BWR Transient Analysis

5.10 a. Produced = direct from fission and decay of iodine 135. (1.0)
Removed = decay and from neutron absorption.

b. Xenon is located in the gas plenum and in the fuel. (1.0)

c. Yes. SDM will change as Xenon changes. (1.0)

Ref: Introduction to Nuclear Reactor Operations

Answers to Perry-1 SRO Exam

6. Plant Systems Design, Control, and Instrumentation (25.0)

6.1 a. Wide Range - Inst Zero
Narrow Range - Inst Zero
UPSET ~~Bysat~~ Range - Inst Zero
Shutdown Range - Inst Zero
FUEL ~~Level~~ Zone Range - TAF
OR { REF TO TAF (LATEST CHANGE) (2.5)

b. Most of the reference leg piping is run out of the drywell into the containment to minimize density changes because of changing drywell temperatures. (0.5)

Ref: Reactor Vessel B21

6.2 a. Before

b. Before

c. After

d. Before

e. After

f. Before (3.0)

Ref: N64 Off-Gas

6.3 a. (0.3 pt. each) (1.5)

1. Normal/Inop. switch in normal
2. Local/Control Room switch in CONTROL ROOM position
3. Air bank pressure about 250 psig SHOULD BE 150 PSIG
4. Control room OFF/AUTO/START switch in AUTO or START
5. Barring device retaining pin installed

6. NO OVERSPEED TRIP 7. NO GENERATOR LOCKOUT.

b. To allow manual restart after a failure to start (0.5)

c. 1) Automatic diesel start signals (0.5)

2) DC fuel oil booster pump (0.5); prevents automatic start (0.5); CAUSES DIESEL TRIP (1.0)

Ref: Perry, System Description Manual, R43, pg. 8; R44, pg 5a; R45, pg. 5, respectively.

6.4 a. Level 1 (0.5) and Level 3 (0.5) (1.0)

b. If one RHR or the LPCS pump is not operating (0.5); ensures ECCS capability to deliver water to cool the core before depressurization (0.5) (1.0)

c. HI drywell pressure (0.5) ADS Logic (0.5) (1.0)

NOW HIGH DRYWELL INPUT SIGNALS NOW REJECTED

Ref: Perry System Description Manual, B21C, pg. 13, 11, and 10 respectively.

6.5 a. The flow control will see a high flow and the FCV will close. (1.0)

b. 1. Rod will not scram. (0.5)

2. Rod will scram (0.25) but scram time will be longer (.25) (0.5)

Ref: Perry Lesson Plan C11 Control Rods

6.6 a. (0.30 each) (1.5)

1. Reactor pressure relief
2. RCIC flow
3. RHR flow → MODES OF RHR: LPCI; SHUTDOWN COOLING; SUPPRESSION POOL COOLING
4. ESW loop A
5. ECC loop A

b. NORM (0.5)

Ref: Perry, System Description Manual, C61, pg. 2 and 24, respectively.

6.7 a. Depressing ROD select clear inhibits further rod ~~motion~~ Selection unless re-depressed. (1.0)

b. 1. "NEXT" on Rod Display module Gang Position display, OR (0.5)
POSSIBLY "MISALIGNED"

2. "Misaligned" on Rod Display Module Gang Position display (0.5)

c. If "gang" mode is selected (0.5)

d. Banked at notch 12 (0.5); 1 notch limit below notch 12 (0.5) WHEN < 20% POWER (1.0)

NO ~~BANK NOTCH~~ LIMITS ABOVE 20% POWER; 6 NOTCH LIMIT ABOVE 20% POWER; 2 NOTCH LIMIT ABOVE ~~20%~~ 70% POWER

Ref: Perry, Systems Description Manual - C11(RCIS), pg. 30, 26, 43, and 9 respectively.

6.8 a. LOCA (0.5). Nuclear Closed Cooling is isolated from the Fuel Pool Cooling and Cleanup system (0.5). POWER SUPPLIES (BUSSES) FOR NCC PUMPS DE-ENERGIZED DURING LOCA (1.0)

b. Loop A (0.5)

Ref: Perry, Systems Description Manual, P 44, pg. 5, 8, and 6, respectively.

6.9 a. 1. Low Total Feedwater Flow - If during fast speed pump operation feedwater flow is excessively low, water temperature in the downcomer region will increase. This condition could result in cavitation in the flow control valve. This interlock monitors the operation of the F.W. system and will initiate a fast to slow speed transfer if the flow control valve is less than 26.4% open.

2. Steam Dome/Pump Suction Line Temperature Differential. If the differential temp. between the MSL B and/or C and each respective pump suction becomes excessively low ~ 8°F, cavitation can occur. The recirc pumps are therefore down shifted to slow speed. EQUIVALENT STEAM DOME TEMPERATURE FROM STEAM DOME PRESSURE (2.0)

b. High Reactor Vessel pressure and low reactor water level are both ATWS signals. The recirc pumps receive the recirc pump trip signals from the Redundant Reactivity Control System. Low reactor vessel water level will cause the system to trip the LFMGs input and output breakers, and will trip the recirc pump fast speed breakers. High reactor pressure will trip the fast speed breakers and will initiate an auto shift to slow speed. The slow speed pumps will trip 25 seconds later unless the APRMs are downscale. (1.5)

Answers to Perry-1 SRO Exam

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

7.1 a. ADS (0.5)

b. Open other SRV's (until 8 are open) (1.0)

Ref: Perry PEI-1, pg. 31, 32 respectively

7.2 a. (any 4: 0.5 each) (2.0)

- Turbine runback will occur (as temp. increases to 81 C); turbine trip could occur if runback is too slow.
- Service and instrument air compressor will trip.
- RWCU pumps will trip.
- RWCU outboard ~~isol~~ suction. valves shut (when non-regen. H_X outlet T reaches 140 F).
- Isolated ph ase bus cooling fan will trip; standby will start.
- Offgas glycol coolers refrig. unit compressors will trip.
- Offgas vault refrig. unit compressor will trip.
- Service water traveling screens will automatically start.
- Service water strainers backwash cycle will start.

b. (any 2: 1.0 each) (2.0)

- If the SW HDR PRESS is less than 37 psig, start the standby Service water Pump per SOI-P41.
- If NCC HX OUT TEMP cannot be restored to less than 95 F, place the third NCC heat exchanger on service per SOI-P43.
- If TBCC HX OUTLET TEMP cannot be restored to less than 95 F, place the second TBCC heat exchanger on service per SOI-P44.

Ref: Perry ONI-P41, pg. 1, 2, 2, respectively.

7.3 Time: to minimize time in radiation areas. (1.5)

Distance: maintain as much distance as possible between worker and rad. source.

Shielding: shield the source or the worker.

Ref: PAP-0118, pg. 2.

7.4 a. To prevent further loss of Main Condenser vacuum (1.0)

b. (0.357 each) (2.5)

1. open
2. open
3. close
4. close
5. close
6. close
7. close

Ref: Perry ONI-J11-1, pg. 3, 3.

7.5 (0.4 each) (2.0)

a. 10% 15%

b. 40% 35%

c. 20% 15%

d. 35%

e. 5%

Ref: Perry IOI-4, pg. 14; IOI-3, pg. 8 and 9; IOI-4, pg.4; IOI-3, pg. 9; and IOI-4, pg. 15.

7.6 Reduce the MAX COMBINED Flow Limit setpoint until steam flow is compatible with reactor power. Maintain turbine inlet pressure constant at approximately 920 psig. (2.0)

Ref: Perry ONI-CB5-2

7.7 a. ~~500~~ 1250 mrem/quarter (0.5)
b. 5 (N-18) = 5 (38-18) = 5 x 20 = 100 rem (0.5)
c. False (0.5)
d. 100 rems (0.5)
e. 25 rems (0.5)

Ref: Perry, PAP-0208, pg 7, 9, 16, 13; PR-2, pg. 4; and PAP-0208, pg. 13, respectively

7.8 (0.5 each) (3.5)

a. Open
b. Closed
c. Closed
d. As is
e. Closed
f. Closed
g. Closed

Ref: Perry ONI-P52

7.9 a. Inserting a CRD will be more likely to prevent a scram because it will bring you farther away from the flow biased scram setpoint. (1.0)

b. You decrease recirc flow to decrease power so the effects of a scram would be less, and by decreasing power you decrease steam flow, thereby decreasing feed flow. CRD insertion is performed to increase the margin between the flow biased scram setpoint and actual power, and to prevent exceeding any local thermal power. (1.0)

c. High Flux - APRM High OR [redacted] Flow Biased APRM SCRAM (0.5)

7.10 1. Main Steam line pressure greater than 850 psig. ~ 744
2. Condenser Vacuum is greater than 26 inches Hg.
3. APRM downscale lights are cleared.
4. Reactor coolant has been verified to be within chemistry limits. (2.0)
OR 5. APRM/IRM OVERLAP
Ref: IOI-1

Answers to Perry-1 SRO Exam

8. Administrative Procedures, Conditions, and Limitations (24.0)

8.1 1. Verify that the inoperable control rod, if withdrawn, is separated from all other inoperable control rods by at least two control cells in all directions. (.5)

2. Disarm the associated directional control valves either:

1) Electrically ~~by bypassing on the RDGs analyzer card~~, or
~~2)~~ hydrolically by closing the drive water and exhaust water isolation valves. (1)

3. Comply with SDM Tech. Specs. (.5) (2.0)

Ref: Tech. Specs.

8.2 Yes, (0.5); with less than Div. 1 and/or Div. 2 required battery operable, suspend core alterations, handling of irradiated fuel in sec. containment and operations with potential of draining vessel (1.5) Ref: Perry T/S (2.0)

8.3 All of the 4 occurrences (since each requires a declaration of an emergency event and this is a category of reportable events). (2.0)

Ref: Perry EPI-A1; EPI-B1

8.4 a. 5 (0.5)

b. The Shift Supervisor, the STA nor the 2 other members of the minimum shift crew necessary for safe shutdown of the unit and any personnel required for other essential functions during a fire emergency. (1.0)

Ref: Perry Tech. Spec. pg 6-1

8.5 a. pressure within containment
0.40 inches vacuum H_2O (1.0)

b. 1. All penetrations terminating in the annulus and required to be closed during accident conditions are either:

a) capable of being closed by an operable automatic isolation valve; or
b) closed by at least one manual valve, fluid flange or deactivated automatic valve.

2. The primary containment equipment hatch is closed and sealed and the shield blocks are installed.

3. The door in the access to the annulus is closed.

4. The sealing mechanism associated with each shield penetration is operable.

5. The pressure within secondary containment is less than or equal to T.S. requirements. (2.5) (.5 each)

Ref: Perry T.S. pg 3/4 6-37 and 1-6 respectively

8.6 a. False (0.5)

b. If radiation exposure of 25 millirems per lineup or if the lineup requires entry into a High Radiation Zone. (1.0)

c. One or more logic inputs to an annunciator are defeated but the annunciator is otherwise operable. (1.0)

d. The STA (0.5)

Ref: Perry PAP-1401, pg 5; PAP-0205, pg 6; PAP-1402, pg 3, 8, 10, and 4, respectively

8.7 a. True (0.5)

b. False (0.5)

c. 1, 2, and 3 (0.5)

d. Shift Supervisor (0.5)

Ref: Perry, PAP-0110, pg 5 and 3 (for a and c); PAP-1301, pg 4 for (b); PAP-1105, pg 4 for (d)

8.8 1. 1, 2 (0.5)

2. 1, 2 (0.5)

3. 1, 2, 3 (0.5)

4. 1, 2 (0.5)

Ref: Perry, Tech. Specs,. pg 3/4 3/77

8.9 The initiation of an emergency system shall not be assumed to be inadvertant,. Prior to securing an emergency system, the operator shall verify, by multiple indications, that a valid initiation signal does not exist or that the system operation is no longer required to maintain core cooling. (2.0)

Ref: Safety System Operation

8.10 a. (0.5 each) (2.5)

1. Unusual Event
2. Alert
3. Alert
4. Unusual Event
5. Site Area Emergency

Ref: Perry EPI: EPI-A1, pg 7, 49, 7, 9 (with T.S. 3.43.2, pg 8), and 6 respectively

b. 1. Maintenance Coordinator OR MAINTENANCE SUPERVISOR (0.5)

2. On the 599' and 574' elevation of Control Complex adjacent to the Rod Controlled area control point and the Health Physics/Chem. areas. (0.5)

3. At an Alert or at discretion of Emergency Director. (0.5)

Ref: Perry EPI: EPI-A7, pg 2, 1 and 3 respectively