U.S. NUCLEAR REGULATORY COMMISSION

REGION III

Licensee: Commonwealth Edison Company
Post Office Box 767
Chicago, Illinois 60690

Facility Name: Braidwood Station

Examination Administered At: Production Training Center

Examination Conducted: May 21-25, 1984

Examiners: R. L. Higgins
R. L. Higgins — 7/11/84
Date

T. M. Burdick
T. M. Burdick — 7/11/84
Date

Roger D. Walker for
F. S. Jaggar — 7/11/84
Date

Approved By: Roger D. Walker for
J. I. McMillen, Chief
Operator Licensing Section — 7/11/84
Date

Examination Summary

Examinations Administered during the week of May 21-25, 1984
Written, oral, and simulator examinations were administered to nine instructor certification candidates.
Results: Four candidates passed, five candidates failed.

REPORT DETAILS

1. Personnel Examined

   K. G. Bartes
   J. E. Browning
   D. E. Cooper
   G. L. Gruhn
   T. D. Ireland
   M. G. Olson
   T. E. Petelle
   D. G. Selph
   J. Skoryi, Jr.

2. Examiners

   *R. L. Higgins
   T. M. Burdick
   F. S. Jaggar

   *Chief Examiner

3. Examination Review Meeting

   At the conclusion of the written examination the chief examiner met with Messrs. L. Kline, T. Chasensky, and K. Gerling of the Braidwood Simulator Training Staff to review the written examination and answer key.

   One facility comment was made concerning the questions. A facility representative felt that question 6.5 (a one point question concerning moisture separator reheaters) and question 6.6 (a one and one half point question concerning moisture separator shell drain tanks) together covered the same topic thus placing undue importance on this one topic. The facility's contention was rejected for two reasons. First, the total point value of the two questions combined is only two and one half points, only ten percent of the section. Examiner standards permit as much as 20 percent of a section to be devoted to a single topic. In addition, the questions did not address the same topic. Question 6.5 concerned the steam system, while question 6.6 concerned the heater drain system.

   Facility comments about the answers, as well as the disposition of the facility's comments, are summarized in the following paragraphs.

   a. In the answer for question 5.2, the facility requested that fuel densification and crud buildup also be accepted as correct responses. Both phenomena do in fact impede heat transfer from the fuel rods into the coolant, thus causing average fuel temperature to increase as fuel burnup increases. Therefore the facility's request was granted and the answer key expanded to include fuel densification and crud buildup as correct responses.

b. In the answer for question 5.3, the facility requested that the responses "allows loading of additional excess reactivity" and "minimizes the required number of control rods" be accepted as correct responses. Burnable poison rods offset some of the excess reactivity loaded into the core initially, so the first response was accepted. Burnable poison rods also increase the shutdown margin of the reactor, thereby reducing the number of control rods required to maintain the reactor shutdown, so the second response was also accepted. The answer key was expanded to reflect these additions.

c. In the answer for question 5.4.b, the facility requested that Pu-Be be deleted as a required response, since it is not going to be used at Braidwood, though originally it had been planned to be used. The latest references were checked to verify the facility's request, and Pu-Be will not be used at Braidwood. The facility's request was granted and the answer was changed to no longer require Pu-Be in order to get full credit.

d. In the answer for question 5.7, the facility requested that the equation $Q = UA\Delta T$ be used to solve for Tave. The relationship was in fact used to generate the answer, so the facility's requested was granted.

e. In the answer for question 5.9.c, the facility requested that samarium not be needed in order for full credit to be awarded. BOS 1.1.1.1.e-1, Byron Operating Surveillance, was given as a reference. Since the samarium contribution is small and is ignored by other facilities when calculating the shutdown margin, the facility's request was granted. Samarium was not necessary for full credit.

f. In the answer for question 5.10.a, the facility requested that the phrase "at height Z" be required for fully credit. Because the references the examiner used did not specify "at height Z", the facility's request was denied. The answer was not changed.

g. In the answer for question 5.12.b, the facility requested that the response of "radial xenon oscillation" be counted as a correct response. Since a radial xenon oscillation would cause power to shift from one side of the core to the other, adversely affecting the Quadrant Power Tilt Ratio, the answer was modified to include "radial xenon oscillation" as a correct response.

h. In the answer for question 6.4, the facility wanted the response "high auctioneered Tave" to be considered optional, since the input for this parameter is multiplied by zero. Since multiplying Tave by zero effectively eliminates it as an input in the Rod Insertion Limit calculation, the facility's request was granted. The answer was modified to no longer require Tave in order to be awarded full credit.

i. In the answer for question 6.10, the facility requested that full credit be given for the response "381A and B modulate opposite of each other - as one throttles shut, the other throttles open." Since these valves modulate in order to control the temperature exiting the letdown reheat heat exchanger, the facility's request was granted. The answer was expanded to grant full credit if an examinee stated that 381A and B are throttled.

j. In the answer for question 6.12.b, the facility requested that the answer be modified to require the examinee to include the relief valve in the return line set to relieve at 2485 psig in order to receive full credit. Since the intent of the question was to determine the strengthened design of the thermal barrier return line, the relief valve was not considered to be a required response. The facility's request was denied.

k. In the answer for question 6.14, the facility requested that the answer be modified to include the Centrifugal Charging starting at 10 seconds and the Control Room Refrigeration Unit starting at 25 seconds. The reference, BCA 2, page 6, was checked to verify the facility's request, and the answer was changed. In addition, the examiner decided that the response "4160V/480V transformer" was trivial and therefore was not required for full credit. The answer as revised is:

Centrifugal Charging Pump 10 sec.	(0.4)
Control Room Refrigeration Unit 25 sec.	(0.4)
Component Cooling Pumps 30 sec.	(0.4)
Essential Service Water Pumps 35 sec.	(0.4)
Auxiliary Feedwater Pump 45 sec.	(0.4)

Ref: Training Manual 9-31; BCA 2, p. 6

l. In the answer for question 7.8, the facility requested that the response "prevent crud from entering the RCP seals" be given full credit. The facility's request met the intent of the question, so the request was granted.

m. In the answer for question 8.7, the facility requested that the answer be modified so that full credit be given to examinees who did not specifically mention "telephone voice communications system" or "State and local authorities." This request was granted, since other organizations share this communications link with State and local authorities. The examiner agreed that the fact that the communications link was a telephone was not a necessary part of the answer.

n. In the answer for question 8.14, the facility requested that the response "changes which would result in operation outside of the assumptions of FSAR accident analysis" be awarded full credit. Since this statement is a paraphrase of the answer, the request was granted.

o. In the answer for question 8.15, the facility requested that the response "maximum allowed by ASME code" be granted full credit. Since the ASME allowance is only 400 cc per hour, which is very nearly 0 gpm, the facility's request was granted.

p. In the answer for question 8.16.a, the facility requested that the response "250°F", as well as the response "380°F", both be counted as correct since the plant reference material contradicts itself. The references - BGP 100-5 Rev. 1, page 13, step 41, and Tech Spec 3/4 4-35 - were checked and verified so the facility's request was granted.

4. Exit Meeting

At the conclusion of the visit to the Production Training Center the chief examiner, Mr. R. L. Higgins, and one of the examiners, Mr. F. S. Jaggar, met with Mr. Louis Kline, the Braidwood Simulator Manager, and with Messrs. Tom Chasensky and Ken Gerling, Braidwood Simulator Instructors. This meeting was held to discuss the known results of the examination as well as other observations noted by the examiners during the examination. The facility was informed that seven examinees definitely passed the simulator/oral portion of the examination, while two examinees were considered marginal. The other observations made by the examiners are listed in following paragraphs.

a. The Production Training Center personnel were complimented for the cooperation shown to the examiners during the course of the examinations.

b. The Simulator operator, Mr. Gerling, was complimented on the expeditious response to requests made during the simulatory examinations. This greatly reduced the amount of time required to conduct the examinations.

c. Some of the initial conditions used by the Braidwood Simulator were not compatible with steps in the Braidwood procedures. This problem manifested itself when the examinees discovered during one of the scenarios that plant components were not in the status required by the procedure. This fact caused much confusion for the examinees and made one of the examinees extremely upset, no doubt contributing to his marginal performance. The facility representatives were told to revise the Braidwood Simulator's initial conditions to accurately match steps in the procedures before any more NRC simulator examinations are administered at the Braidwood simulator.

d. It was discovered during the examination that a conflict existed between the Byron Tech Specs and the Byron Startup Procedures. Tech Specs 3.5.3 requires that a maximum of one centrifugal charging pump shall be operable whenever the temperature of one or more of the Reactor Coolant System (RCS) cold legs is less than or equal to 350°F. Procedure BGP 100-1 Revision 3 step 37 contains a caution statement requiring that two centrifugal charging pumps be operable prior to exceeding an RCS temperature of 250°F.

   The conflict between Tech Specs and procedures resulted in one of the examinees refusing to comply with the simulator operator's order to continue the startup. The examinee, when again ordered to follow the procedure, demanded to be relieved. At this time the examiners intervened to acknowledge the examinee's concern but told him to continue the startup in order to expedite the exam. The simulator operator was told by the examiners not to require the examinees to violate Tech Specs or procedures during an NRC exam. If the examiners want the examinees to do so in order to expedite the examination, the examiners will personally make this known to the examinee.

Though the simulator has no control over the procedures or Tech Specs which are provided by the plant, the conflict between the two documents is a serious one and should be resolved as soon as possible.

e. Several labels and meters were discovered to be inaccurate during the examination, and inappropriate chart paper was used in several recorders. The specific meters, charts, and labels were shown to the facility personnel at the conclusion of the exit meeting. The facility will correct the meters and labels, but since the proper chart paper is in short supply and the Byron and Braidwood plants are given priority over the simulator, the facility personnel made no commitment to use appropriate chart paper for the foreseeable future.

f. It was pointed out by the examiners that an open steam generator PORV would be extremely difficult to notice. One simulator scenario contained a failed open steam generator PORV; it took an extremely long time for the examinees to notice the failure. It was also pointed out that no indication for steam generator safety valves existed in the control room.

g. During the conduct of the exams anyone walking through the hall adjacent to the Braidwood simulator could view the simulator examinations being conducted. The examiners therefore recommended that venetian blinds be installed on the windows between the hall and the simulator so that future NRC exams could be conducted in privacy.

h. The procedures used at the simulator had pages falling out of them, and no ruler was available to aid in reading graphs.

i. The steam generator tube rupture emergency conducted during one of the scenarios seemed unrealistic because level in the ruptured steam generator kept dropping even though there was a 350 gallons per minute leak into the generator from the RCS. The facility promised to reevaluate the steam generator tube rupture scenario to ensure that the simulator provides a realistic simulation.

5. Generic Weaknesses

The only generic weakness noted during the simulator/oral portion of the examination was the unfamiliarity which most of the examinees evidenced when operating the simulator in cold shutdown conditions. This may have been due in part to the incompatibility between the initial conditions used for cold shutdown and the steps in the procedures.

The following generic weaknesses were exhibited on the written examination:

a. Calculation of OTΔT
b. Determination of Shutdown Margin
c. Definition of $F_Q(Z)$
d. Automatic actions associated with Radiation Monitors
e. Fire Protection Deluge System
f. Automatic closure feature of Breaker 1592
g. Effect of a low level in the Moisture Separator Drain Tank
h. Interlocks between the Letdown Orifice Isolation Valves and the Letdown Line Control Valves
i. RHR Hot Leg Suction Valve interlocks
j. CCW Pump trip on low CCW expansion tank level
k. CCW Thermal Barrier Heat Exchanger Piping Design
l. Emergency backup method of tripping the Turbine from the Control Room
m. Basis for placing the turbine driven Main Feed Pumps on the turning gear when filling and venting the Condensate System
n. Verification of the deenerization of an ESF DC bus
o. Purpose of the OSC
p. Recovery Group and the near-site EOF
q. Symbols used on the procedure flow charts
r. Verification of System Lineups
s. Definition of "change in intent" when applied to a Temporary Procedure
t. Allowable leakage through a Pressurizer Safety Valve
u. Methods for providing Low Temperature Overpressure Protection for the RCS

Master

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

FACILITY: Braidwood Simulator
REACTOR TYPE: Westinghouse PWR
DATE ADMINISTERED: May 21, 1984
EXAMINER: R. L. Higgins
APPLICANT: ____________________

INSTRUCTIONS TO APPLICANT:

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

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

Final Grade ________%

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

____
Applicant's Signature

5.1 With the plant at 100% power, normal pressure and flux distribution, how much of an increase in RCS average temperature from the 100% power reference temperature value would cause an OTΔT trip? Assume plant power remains at 100%. Show your work! (2.0)

5.2 What phenomenon causes the average fuel temperature at 100% power to increase as fuel burnup increases? (1.0)

5.3 Give two reasons for the use of burnable poison rods. (1.0)

5.4 a. What element is used as the absorber material in the control rod? (0.5)

b. Explain how each type of primary neutron source produces neutrons. (1.5)

5.5 Explain why the moderator temperature coefficient is more negative when control banks C and D are inserted than it is when control bank D alone is inserted. Refer to Figure 5.5-1. (2.0)

5.6 What limitation is imposed by regulation to ensure that a zirconium-water reaction will not take place? (1.0)

5.7 With reactor power remaining constant at 50% power, what value of Tave would cause the steam generator safety valve with the lowest lift setting to open? Assume that the normal steam generator pressure at 50% power is 1030 psig. Show your work! (2.0)

5.8 The initial RT_{NDT} of the reactor vessel is 40°F. After 32 EFPY the RT_{NDT} will rise to 121°F at 1/4 T and 94°F at 3/4 T.

a. Define RT_{NDT}. (1.0)

b. Why will the RT_{NDT} be higher at 1/4 T than it is at 3/4 T after 32 EFPY? (2.0)

5.9 a. Why must the required shutdown margin be greater in modes 1, 2, 3, and 4 than it is in mode 5? (1.0)

b. How is shutdown margin determined in mode 1? (1.0)

c. How is shutdown margin determined in mode 3? (1.0)

d. What action must be taken if the shutdown margin is determined to be inadequate? (1.0)

5.10 a. What is $F_Q(Z)$? (1.0)

b. Why must $F_Q(Z)$ be modified by $K(Z)$? (1.5)

5.11 Why must the injection of accumulator nitrogen into the RCS be prevented? (1.0)

Sheet of Information

OTΔT

$\Delta T = \Delta T_0 \{K_1 - K_2 (T - T^1) + K_3 (P - P^1) - f_1 (\Delta I)\}$

ΔT_1 = Indicated ΔT at rated power

K_1 = 1.072

K_2 = .0265 per °F

T = average temperature

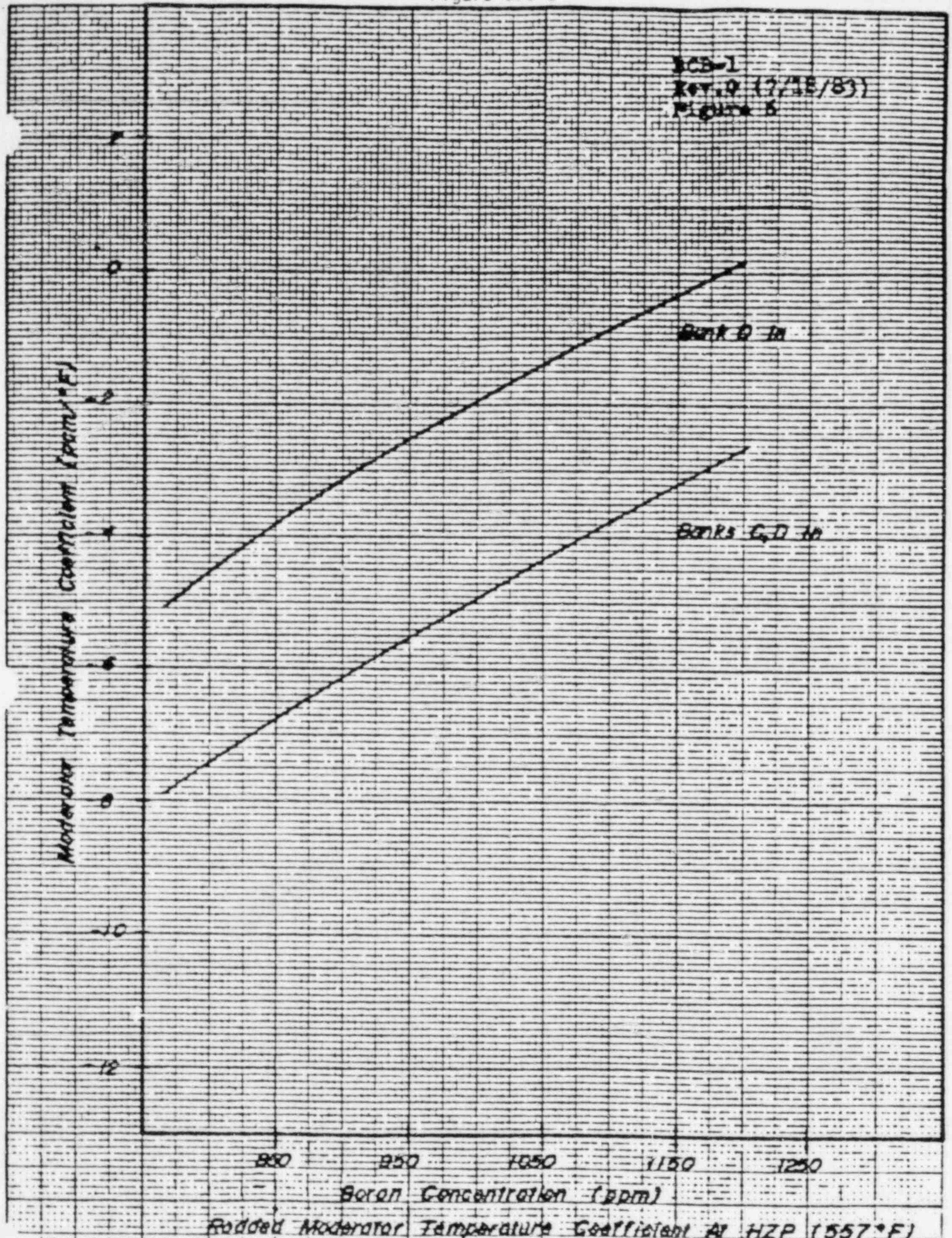
T^1 = 587.7 (Nominal Tave at rated thermal power)

K_3 = .00134 per psi

P = Pressurizer pressure, psig

P^1 = 2235 psig (Nominal RCS operating pressure)

Figure 5.5-1



Rodded Moderator Temperature Coefficient At HZP (557°F) vs Boron Concentration BOL no Xenon

APPROVED

JUL 1 8 1983

Table 1. Saturated Steam: Temperature Table

Temp Fahr t	Abs Press Lb per Sq In. p	Specific Volume Sat. Liquid v_f	Specific Volume Evap v_{fg}	Specific Volume Sat. Vapor v_g	Enthalpy Sat. Liquid h_f	Enthalpy Evap h_{fg}	Enthalpy Sat. Vapor h_g	Entropy Sat. Liquid s_f	Entropy Evap s_{fg}	Entropy Sat. Vapor s_g	Temp Fahr t
32.0*	0.08859	0.016022	3304.7	3304.7	-0.0179	1075.5	1075.5	0.0000	2.1873	2.1873	32.0*
34.0	0.09600	0.016021	3061.9	3061.9	1.996	1074.4	1076.4	0.0041	2.1762	2.1802	34.0
36.0	0.10395	0.016020	2839.0	2839.0	4.008	1073.2	1077.2	0.0081	2.1651	2.1732	36.0
38.0	0.11249	0.016019	2634.1	2634.2	6.018	1072.1	1078.1	0.0122	2.1541	2.1663	38.0
40.0	0.12163	0.016019	2445.8	2445.8	8.027	1071.0	1079.0	0.0162	2.1432	2.1594	40.0
42.0	0.13143	0.016019	2272.4	2272.4	10.035	1069.8	1079.9	0.0202	2.1325	2.1527	42.0
44.0	0.14192	0.016019	2112.8	2112.8	12.041	1068.7	1080.7	0.0242	2.1217	2.1459	44.0
46.0	0.15314	0.016020	1965.7	1965.7	14.047	1067.6	1081.6	0.0282	2.1111	2.1393	46.0
48.0	0.16514	0.016021	1830.0	1830.0	16.051	1066.4	1082.5	0.0321	2.1006	2.1327	48.0
50.0	0.17796	0.016023	1704.8	1704.8	18.054	1065.3	1083.4	0.0361	2.0901	2.1262	50.0
52.0	0.19165	0.016024	1589.2	1589.2	20.057	1064.2	1084.2	0.0400	2.0798	2.1197	52.0
54.0	0.20625	0.016026	1482.4	1482.4	22.058	1063.1	1085.1	0.0439	2.0695	2.1134	54.0
56.0	0.22183	0.016028	1383.6	1383.6	24.059	1061.9	1086.0	0.0478	2.0593	2.1070	56.0
58.0	0.23843	0.016031	1292.2	1292.2	26.060	1060.8	1086.9	0.0516	2.0491	2.1008	58.0
60.0	0.25611	0.016033	1207.6	1207.6	28.060	1059.7	1087.7	0.0555	2.0391	2.0946	60.0
62.0	0.27494	0.016036	1129.2	1129.2	30.059	1058.5	1088.6	0.0593	2.0291	2.0885	62.0
64.0	0.29497	0.016039	1056.5	1056.5	32.058	1057.4	1089.5	0.0632	2.0192	2.0824	64.0
66.0	0.31676	0.016043	989.0	989.1	34.056	1056.3	1090.4	0.0670	2.0094	2.0764	66.0
68.0	0.33889	0.016046	926.5	926.5	36.054	1055.2	1091.2	0.0708	1.9996	2.0704	68.0
70.0	0.36292	0.016050	868.3	868.4	38.052	1054.0	1092.1	0.0745	1.9900	2.0645	70.0
72.0	0.38844	0.016054	814.3	814.3	40.049	1052.9	1093.0	0.0783	1.9804	2.0587	72.0
74.0	0.41550	0.016058	764.1	764.1	42.046	1051.8	1093.8	0.0821	1.9708	2.0529	74.0
76.0	0.44420	0.016063	717.4	717.4	44.043	1050.7	1094.7	0.0858	1.9614	2.0472	76.0
78.0	0.47461	0.016067	673.8	673.9	46.040	1049.5	1095.6	0.0895	1.9520	2.0415	78.0
80.0	0.50683	0.016072	633.3	633.3	48.037	1048.4	1096.4	0.0932	1.9426	2.0359	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	1.86[illegible]	1.9876	98.0
100.0	0.94924	0.016130	350.4	350.4	67.999	1037.1	1105.1	0.1295	1.8530	1.9[illegible]	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	75.99	1032.5	1108.5	0.1437	1.8188	1.9626	108.0
110.0	1.2750	0.016165	265.37	265.39	77.98	1031.4	1109.3	0.1472	1.8105	1.9577	110.0
112.0	1.3505	0.016173	251.37	251.38	79.98	1030.2	1110.2	0.1507	1.8021	1.9528	112.0
114.0	1.4299	0.016180	238.21	238.22	81.97	1029.1	1111.0	0.1542	1.7938	1.9480	114.0
116.0	1.5133	0.016188	225.84	225.85	83.97	1027.9	1111.9	0.1577	1.7856	1.9433	116.0
118.0	1.6009	0.016196	214.20	214.21	85.97	1026.8	1112.7	0.1611	1.7774	1.9386	118.0
120.0	1.6927	0.016204	203.25	203.26	87.97	1025.6	1113.6	0.1646	1.7693	1.9339	120.0
122.0	1.7891	0.016213	192.94	192.95	89.96	1024.5	1114.4	0.1680	1.7613	1.9293	122.0
124.0	1.8901	0.016221	183.23	183.24	91.96	1023.3	1115.3	0.1715	1.7533	1.9247	124.0
126.0	1.9959	0.016229	174.08	174.09	93.96	1022.2	1116.1	0.1749	1.7453	1.9202	126.0
128.0	2.1068	0.016238	165.45	165.47	95.96	1021.0	1117.0	0.1783	1.7374	1.9157	128.0
130.0	2.2230	0.016247	157.32	157.33	97.96	1019.8	1117.8	0.1817	1.7295	1.9112	130.0
132.0	2.3445	0.016256	149.64	149.66	99.95	1018.7	1118.6	0.1851	1.7217	1.9068	132.0
134.0	2.4717	0.016265	142.40	142.41	101.95	1017.5	1119.5	0.1884	1.7140	1.9024	134.0
136.0	2.6047	0.016274	135.55	135.57	103.95	1016.4	1120.3	0.1918	1.7063	1.8980	136.0
138.0	2.7438	0.016284	129.09	129.11	105.95	1015.2	1121.1	0.1951	1.6986	1.8937	138.0
140.0	2.8892	0.016293	122.98	123.00	107.95	1014.0	1122.0	0.1985	1.6910	1.8895	140.0
142.0	3.0411	0.016303	117.21	117.22	109.95	1012.9	1122.8	0.2018	1.6534	1.8852	142.0
144.0	3.1997	0.016312	111.74	111.76	111.95	1011.7	1123.6	0.2051	1.6759	1.8810	144.0
146.0	3.3653	0.016322	106.58	106.59	113.95	1010.5	1124.5	0.2084	1.6684	1.8769	146.0
148.0	3.5381	0.016332	101.68	101.70	115.95	1009.3	1125.3	0.2117	1.6610	1.8727	148.0
150.0	3.7184	0.016343	97.05	97.07	117.95	1008.2	1126.1	0.2150	1.6536	1.8686	150.0
152.0	3.9065	0.016353	92.66	92.68	119.95	1007.0	1126.9	0.2183	1.6463	1.8646	152.0
154.0	4.1025	0.016363	88.50	88.52	121.95	1005.8	1127.7	0.2216	1.6390	1.8606	154.0
156.0	4.3068	0.016374	84.56	84.57	123.95	1004.6	1128.6	0.2248	1.6318	1.8566	156.0
158.0	4.5197	0.016384	80.82	80.83	125.96	1003.4	1129.4	0.2281	1.6245	1.8526	158.0
160.0	4.7414	0.016395	77.27	77.29	127.96	1002.2	1130.2	0.2313	1.6174	1.8487	160.0
162.0	4.9722	0.016406	73.90	73.92	129.96	1001.0	1131.0	0.2345	1.6103	1.8448	162.0
164.0	5.2124	0.016417	70.70	70.72	131.96	999.8	1131.8	0.2377	1.6032	1.8409	164.0
166.0	5.4623	0.016428	67.67	67.68	133.97	998.6	1132.6	0.2409	1.5961	1.8371	166.0
168.0	5.7223	0.016440	64.78	64.80	135.97	997.4	1133.4	0.2441	1.5892	1.8333	168.0
170.0	5.9926	0.016451	62.04	62.06	137.97	996.2	1134.2	0.2473	1.5822	1.8295	170.0
172.0	6.2736	0.016463	59.43	59.45	139.98	995.0	1135.0	0.2505	1.5753	1.8258	172.0
174.0	6.5656	0.016474	56.95	56.97	141.98	993.8	1135.8	0.2537	1.5684	1.8221	174.0
176.0	6.8690	0.016486	54.59	54.61	143.99	992.6	1136.6	0.2568	1.5616	1.8184	176.0
178.0	7.1840	0.016498	52.35	52.36	145.99	991.4	1137.4	0.2600	1.5548	1.8147	178.0

*The states shown are metastable

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

Temp Fahr t	Abs Press Lb per Sq In. p	Specific Volume Sat Liquid v_f	Specific Volume Evap v_{fg}	Specific Volume Sat Vapor v_g	Enthalpy Sat Liquid h_f	Enthalpy Evap h_{fg}	Enthalpy Sat Vapor h_g	Entropy Sat Liquid s_f	Entropy Evap s_{fg}	Entropy Sat Vapor s_g	Temp Fahr t
180.0	7.5110	0.016510	50.21	50.22	148.00	990.2	1138.2	0.2631	1.5480	1.8111	180.0
182.0	7.850	0.016522	48.172	48.189	150.01	989.0	1139.0	0.2662	1.5413	1.8075	182.0
184.0	8.203	0.016534	46.232	46.249	152.01	987.8	1139.8	0.2694	1.5346	1.8040	184.0
186.0	8.568	0.016547	44.383	44.400	154.02	986.5	1140.5	0.2725	1.5279	1.8004	186.0
188.0	8.947	0.016559	42.621	42.638	156.03	985.3	1141.3	0.2756	1.5213	1.7969	188.0
190.0	9.340	0.016572	40.941	40.957	158.04	984.1	1142.1	0.2787	1.5148	1.7934	190.0
192.0	9.747	0.016585	39.337	39.354	160.05	982.8	1142.9	0.2818	1.5082	1.7900	192.0
194.0	10.168	0.016598	37.808	37.824	162.05	981.6	1143.7	0.2848	1.5017	1.7865	194.0
196.0	10.605	0.016611	36.348	36.364	164.06	980.4	1144.4	0.2879	1.4952	1.7831	196.0
198.0	11.058	0.016624	34.954	34.970	166.08	979.1	1145.2	0.2910	1.4888	1.7798	198.0
200.0	11.526	0.016637	33.622	33.639	168.09	977.9	1146.0	0.2940	1.4824	1.7764	200.0
204.0	12.512	0.016664	31.135	31.151	172.11	975.4	1147.5	0.3001	1.4697	1.7698	204.0
208.0	13.568	0.016691	28.862	28.878	176.14	972.8	1149.0	0.3061	1.4571	1.7632	208.0
212.0	14.696	0.016719	26.782	26.799	180.17	970.3	1150.5	0.3121	1.4447	1.7568	212.0
216.0	15.901	0.016747	24.878	24.894	184.20	967.8	1152.0	0.3181	1.4323	1.7505	216.0
220.0	17.186	0.016775	23.131	23.148	188.23	965.2	1153.4	0.3241	1.4201	1.7442	220.0
224.0	18.556	0.016805	21.529	21.545	192.27	962.6	1154.9	0.3300	1.4081	1.7380	224.0
228.0	20.015	0.016834	20.056	20.073	196.31	960.0	1156.3	0.3359	1.3961	1.7320	228.0
232.0	21.567	0.016864	18.701	18.718	200.35	957.4	1157.8	0.3417	1.3842	1.7260	232.0
236.0	23.216	0.016895	17.454	17.471	204.40	954.8	1159.2	0.3476	1.3725	1.7201	236.0
240.0	24.968	0.016926	16.304	16.321	208.45	952.1	1160.6	0.3533	1.3609	1.7142	240.0
244.0	26.826	0.016958	15.243	15.260	212.50	949.5	1162.0	0.3591	1.3494	1.7085	244.0
248.0	28.796	0.016990	14.264	14.281	216.56	946.8	1163.4	0.3649	1.3379	1.7028	248.0
252.0	30.883	0.017022	13.358	13.375	220.62	944.1	1164.7	0.3706	1.3266	1.6972	252.0
256.0	33.091	0.017055	12.520	12.538	224.69	941.4	1166.1	0.3763	1.3154	1.6917	256.0
260.0	35.427	0.017089	11.745	11.762	228.76	938.6	1167.4	0.3819	1.3043	1.6862	260.0
264.0	37.894	0.017123	11.025	11.042	232.83	935.9	1168.7	0.3876	1.2933	1.6808	264.0
268.0	40.500	0.017157	10.358	10.375	236.91	933.1	1170.0	0.3932	1.2823	1.6755	268.0
272.0	43.249	0.017193	9.738	9.755	240.99	930.3	1171.3	0.3987	1.2715	1.6702	272.0
276.0	46.147	0.017228	9.162	9.180	245.08	927.5	1172.5	0.4043	1.2607	1.6650	276.0
280.0	49.200	0.017264	8.627	8.644	249.17	924.6	1173.8	0.4098	1.2501	1.6599	280.0
284.0	52.414	0.01730	8.1280	8.1453	253.3	921.7	1175.0	0.4154	1.2395	1.6548	284.0
288.0	55.795	0.01734	7.6634	7.6807	257.4	918.8	1176.2	0.4208	1.2290	1.6498	288.0
292.0	59.350	0.01738	7.2301	7.2475	261.5	915.9	1177.4	0.4263	1.2186	1.6449	292.0
296.0	63.084	0.01741	6.8259	6.8433	265.6	913.0	1178.6	0.4317	1.2082	1.6400	296.0
300.0	67.005	0.01745	6.4483	6.4658	269.7	910.0	1179.7	0.4372	1.1979	1.6351	300.0
304.0	71.119	0.01749	6.0955	6.1130	273.8	907.0	1180.9	0.4426	1.1877	1.6303	304.0
308.0	75.433	0.01753	5.7655	5.7830	278.0	904.0	1182.0	0.4479	1.1776	1.6256	308.0
312.0	79.953	0.01757	5.4566	5.4742	282.1	901.0	1183.1	0.4533	1.1676	1.6209	312.0
316.0	84.688	0.01761	5.1673	5.1849	286.3	897.9	1184.1	0.4586	1.1576	1.6162	316.0
320.0	89.643	0.01766	4.8961	4.9138	290.4	894.8	1185.2	0.4640	1.1477	1.6116	320.0
324.0	94.826	0.01770	4.6418	4.6595	294.6	891.6	1186.2	0.4692	1.1378	1.6071	324.0
328.0	100.245	0.01774	4.4030	4.4208	298.7	888.5	1187.2	0.4745	1.1280	1.6025	328.0
332.0	105.907	0.01779	4.1788	4.1966	302.9	885.3	1188.2	0.4798	1.1183	1.5981	332.0
336.0	111.820	0.01783	3.9681	3.9859	307.1	882.1	1189.1	0.4850	1.1086	1.5936	336.0
340.0	117.992	0.01787	3.7699	3.7878	311.3	878.8	1190.1	0.4902	1.0990	1.5892	340.0
344.0	124.430	0.01792	3.5834	3.6013	315.5	875.5	1191.0	0.4954	1.0894	1.5849	344.0
348.0	131.142	0.01797	3.4078	3.4258	319.7	872.2	1191.1	0.5006	1.0799	1.5806	348.0
352.0	138.138	0.01801	3.2423	3.2603	323.9	868.9	1192.7	0.5058	1.0705	1.5763	352.0
356.0	145.424	0.01806	3.0863	3.1044	328.1	865.5	1193.6	0.5110	1.0611	1.5721	356.0
360.0	153.010	0.01811	2.9392	2.9573	332.3	862.1	1194.4	0.5161	1.0517	1.5678	360.0
364.0	160.903	0.01816	2.8002	2.8184	336.5	858.6	1195.2	0.5212	1.0424	1.5637	364.0
368.0	169.113	0.01821	2.6691	2.6873	340.8	855.1	1195.9	0.5263	1.0332	1.5595	368.0
372.0	177.648	0.01826	2.5451	2.5633	345.0	851.6	1196.7	0.5314	1.0240	1.5554	372.0
376.0	186.517	0.01831	2.4279	2.4462	349.3	848.1	1197.4	0.5365	1.0148	1.5513	376.0
380.0	195.729	0.01836	2.3170	2.3353	353.6	844.5	1198.0	0.5416	1.0057	1.5473	380.0
384.0	205.294	0.01842	2.2120	2.2304	357.9	840.8	1198.7	0.5466	0.9966	1.5432	384.0
388.0	215.220	0.01847	2.1126	2.1311	362.2	837.2	1199.3	0.5516	0.9876	1.5392	388.0
392.0	225.516	0.01853	2.0184	2.0369	366.5	833.4	1199.9	0.5567	0.9786	1.5352	392.0
396.0	236.193	0.01858	1.9291	1.9477	370.8	829.7	1200.4	0.5617	0.9696	1.5313	396.0
400.0	247.259	0.01864	1.8444	1.8630	375.1	825.9	1201.0	0.5667	0.9607	1.5274	400.0
404.0	258.725	0.01870	1.7640	1.7827	379.4	822.0	1201.5	0.5717	0.9518	1.5234	404.0
408.0	270.600	0.01875	1.6877	1.7064	383.8	818.2	1201.9	0.5766	0.9429	1.5195	408.0
412.0	282.894	0.01881	1.6152	1.6340	388.1	814.2	1202.4	0.5816	0.9341	1.5157	412.0
416.0	295.617	0.01887	1.5463	1.5651	392.5	810.2	1202.8	0.5866	0.9253	1.5118	416.0
420.0	308.780	0.01894	1.4808	1.4997	396.9	806.2	1203.1	0.5915	0.9165	1.5080	420.0
424.0	322.391	0.01900	1.4184	1.4374	401.3	802.2	1203.5	0.5964	0.9077	1.5042	424.0
428.0	336.463	0.01906	1.3591	1.3782	405.7	798.0	1203.7	0.6014	0.8990	1.5004	428.0
432.0	351.00	0.01913	1.30266	1.37179	410.1	793.9	1204.0	0.6063	0.8903	1.4966	432.0
436.0	366.03	0.01919	1.24887	1.26806	414.6	789.7	1204.2	0.6112	0.8816	1.4928	436.0
440.0	381.54	0.01926	1.19761	1.21687	419.0	785.4	1204.4	0.6161	0.8729	1.4890	440.0
444.0	397.56	0.01933	1.14874	1.16806	423.5	781.1	1204.6	0.6210	0.8643	1.4853	444.0
448.0	414.09	0.01940	1.10212	1.12152	428.0	776.7	1204.7	0.6259	0.8557	1.4815	448.0
452.0	431.14	0.01947	1.05764	1.07711	432.5	772.3	1204.8	0.6308	0.8471	1.4778	452.0
456.0	448.73	0.01954	1.01518	1.03472	437.0	767.8	1204.8	0.6356	0.8385	1.4741	456.0

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

Temp Fahr t	Abs Press Lb per Sq In p	Specific Volume Sat Liquid v_f	Specific Volume Evap v_{fg}	Specific Volume Sat Vapor v_g	Enthalpy Sat Liquid h_f	Enthalpy Evap h_{fg}	Enthalpy Sat Vapor h_g	Entropy Sat Liquid s_f	Entropy Evap s_{fg}	Entropy Sat Vapor s_g	Temp Fahr t
460.0	466.87	0.01961	0.97463	0.99424	441.5	763.2	1204.8	0.6405	0.8299	1.4704	460.0
464.0	485.56	0.01969	0.93588	0.95557	446.1	758.6	1204.7	0.6454	0.8213	1.4667	464.0
468.0	504.83	0.01976	0.89885	0.91862	450.7	754.0	1204.6	0.6502	0.8127	1.4629	468.0
472.0	524.67	0.01984	0.86345	0.88329	455.2	749.3	1204.5	0.6551	0.8042	1.4592	472.0
476.0	545.11	0.01992	0.82958	0.84950	459.9	744.5	1204.3	0.6599	0.7956	1.4555	476.0
480.0	566.15	0.02000	0.79716	0.81717	464.5	739.6	1204.1	0.6648	0.7871	1.4518	480.0
484.0	587.81	0.02009	0.76613	0.78622	469.1	734.7	1203.8	0.6696	0.7785	1.4481	484.0
488.0	610.10	0.02017	0.73641	0.75658	473.8	729.7	1203.5	0.6745	0.7700	1.4444	488.0
492.0	633.03	0.02026	0.70794	0.72820	478.5	724.6	1203.1	0.6793	0.7614	1.4407	492.0
496.0	656.61	0.02034	0.68065	0.70100	483.2	719.5	1202.7	0.6842	0.7528	1.4370	496.0
500.0	680.86	0.02043	0.65448	0.67492	487.9	714.3	1202.2	0.6890	0.7443	1.4333	500.0
504.0	705.78	0.02053	0.62938	0.64991	492.7	709.0	1201.7	0.6939	0.7357	1.4296	504.0
508.0	731.40	0.02062	0.60530	0.62592	497.5	703.7	1201.1	0.6987	0.7271	1.4258	508.0
512.0	757.72	0.02072	0.58218	0.60289	502.3	698.2	1200.5	0.7036	0.7185	1.4221	512.0
516.0	784.76	0.02081	0.55997	0.58079	507.1	692.7	1199.8	0.7085	0.7099	1.4183	516.0
520.0	812.53	0.02091	0.53864	0.55956	512.0	687.0	1199.0	0.7133	0.7013	1.4146	520.0
524.0	841.04	0.02102	0.51814	0.53916	516.9	681.3	1198.2	0.7182	0.6926	1.4108	524.0
528.0	870.31	0.02112	0.49843	0.51955	521.8	675.5	1197.3	0.7231	0.6839	1.4070	528.0
532.0	900.34	0.02123	0.47947	0.50070	526.8	669.6	1196.4	0.7280	0.6752	1.4032	532.0
536.0	931.17	0.02134	0.46123	0.48257	531.7	663.6	1195.4	0.7329	0.6665	1.3993	536.0
540.0	962.79	0.02146	0.44367	0.46513	536.8	657.5	1194.3	0.7378	0.6577	1.3954	540.0
544.0	995.22	0.02157	0.42677	0.44834	541.8	651.3	1193.1	0.7427	0.6489	1.3915	544.0
548.0	1028.49	0.02169	0.41048	0.43217	546.9	645.0	1191.9	0.7476	0.6400	1.3876	548.0
552.0	1062.59	0.02182	0.39479	0.41660	552.0	638.5	1190.6	0.7525	0.6311	1.3837	552.0
556.0	1097.55	0.02194	0.37966	0.40160	557.2	632.0	1189.2	0.7575	0.6222	1.3797	556.0
560.0	1133.38	0.02207	0.36507	0.38714	562.4	625.3	1187.7	0.7625	0.6132	1.3757	560.0
564.0	1170.10	0.02221	0.35099	0.37320	567.6	618.5	1186.1	0.7674	0.6041	1.3716	564.0
568.0	1207.72	0.02235	0.33741	0.35975	572.9	611.5	1184.5	0.7725	0.5950	1.3675	568.0
572.0	1246.26	0.02249	0.32429	0.34678	578.3	604.5	1182.7	0.7775	0.5859	1.3634	572.0
576.0	1285.74	0.02264	0.31162	0.33426	583.7	597.2	1180.9	0.7825	0.5766	1.3592	576.0
580.0	1326.17	0.02279	0.29937	0.32216	589.1	589.9	1179.0	0.7876	0.5673	1.3550	580.0
584.0	1367.7	0.02295	0.28753	0.31048	594.6	582.4	1176.9	0.7927	0.5580	1.3507	584.0
588.0	1410.0	0.02311	0.27608	0.29919	600.1	574.7	1174.8	0.7978	0.5485	1.3464	588.0
592.0	1453.3	0.02328	0.26499	0.28827	605.7	566.8	1172.6	0.8030	0.5390	1.3420	592.0
596.0	1497.8	0.02345	0.25425	0.27770	611.4	558.8	1170.2	0.8082	0.5293	1.3375	596.0
600.0	1543.2	0.02364	0.24384	0.26747	617.1	550.6	1167.7	0.8134	0.5196	1.3330	600.0
604.0	1589.7	0.02382	0.23374	0.25757	622.9	542.2	1165.1	0.8187	0.5097	1.3284	604.0
608.0	1637.3	0.02402	0.22394	0.24796	628.8	533.6	1162.4	0.8240	0.4997	1.3238	608.0
612.0	1686.1	0.02422	0.21442	0.23865	634.8	524.7	1159.5	0.8294	0.4896	1.3190	612.0
616.0	1735.9	0.02444	0.20516	0.22960	640.8	515.6	1156.4	0.8348	0.4794	1.3141	616.0
620.0	1786.9	0.02466	0.19615	0.22081	646.9	506.3	1153.2	0.8403	0.4689	1.3092	620.0
624.0	1839.0	0.02489	0.18737	0.21226	653.1	496.6	1149.8	0.8458	0.4583	1.3041	624.0
628.0	1892.4	0.02514	0.17880	0.20394	659.5	486.7	1146.1	0.8514	0.4474	1.2988	628.0
632.0	1947.0	0.02539	0.17044	0.19583	665.9	476.4	1142.2	0.8571	0.4364	1.2934	632.0
636.0	2002.8	0.02566	0.16226	0.18792	672.4	465.7	1138.1	0.8628	0.4251	1.2879	636.0
640.0	2059.9	0.02595	0.15427	0.16[illegible]21	679.1	454.6	1133.7	0.8686	0.4134	1.2821	640.0
644.0	2118.3	0.02625	0.14644	0.17269	685.9	443.1	1129.0	0.8746	0.4015	1.2761	644.0
648.0	2178.1	0.02657	0.13876	0.16534	692.9	431.1	1124.0	0.8806	0.3893	1.2699	648.0
652.0	2239.2	0.02691	0.13124	0.15816	700.0	418.7	1118.7	0.8868	0.3767	1.2634	652.0
656.0	2301.7	0.02728	0.12387	0.15115	707.4	405.7	1113.1	0.8931	0.3637	1.2567	656.0
660.0	2365.7	0.02768	0.11663	0.14431	714.9	392.1	1107.0	0.8995	0.3502	1.2498	660.0
664.0	2431.1	0.02811	0.10947	0.13757	722.9	377.7	1100.6	0.9064	0.3361	1.2425	664.0
668.0	2498.1	0.02858	0.10229	0.13087	731.5	362.1	1093.5	0.9137	0.3210	1.2347	668.0
672.0	2566.6	0.02911	0.09514	0.12424	740.2	345.7	1085.9	0.9212	0.3054	1.2266	672.0
676.0	2636.8	0.02970	0.08799	0.11769	749.2	328.5	1077.6	0.9287	0.2892	1.2179	676.0
680.0	2708.6	0.03037	0.08080	0.11117	758.5	310.1	1068.5	0.9365	0.2720	1.2086	680.0
684.0	2782.1	0.03114	0.07349	0.10463	768.2	290.2	1058.4	0.9447	0.2537	1.1984	684.0
688.0	2857.4	0.03204	0.06595	0.09799	778.8	268.2	1047.0	0.9535	0.2337	1.1872	688.0
692.0	2934.5	0.03313	0.05797	0.09110	790.5	243.1	1033.6	0.9634	0.2110	1.1744	692.0
696.0	3013.4	0.03455	0.04916	0.08371	804.4	212.8	1017.2	0.9749	0.1841	1.1591	696.0
700.0	3094.3	0.03662	0.03857	0.07519	822.4	172.7	995.2	0.9901	0.1490	1.1390	700.0
702.0	3135.5	0.03824	0.03173	0.06997	835.0	144.7	979.7	1.0006	0.1246	1.1252	702.0
704.0	3177.2	0.04108	0.02192	0.06300	854.2	102.0	956.2	1.0169	0.0876	1.1046	704.0
705.0	3198.3	0.04427	0.01304	0.05730	873.0	61.4	934.4	1.0329	0.0527	1.0856	705.0
705.47*	3208.2	0.05078	0.00000	0.05078	906.0	0.0	906.0	1.0612	0.0000	1.0612	705.47*

*Critical temperature

Table 2: Saturated Steam: Pressure Table

Abs Press Lb/Sq In. p	Temp Fahr t	Specific Volume: Sat Liquid v_f	Specific Volume: Evap v_{fg}	Specific Volume: Sat Vapor v_g	Enthalpy: Sat Liquid h_f	Enthalpy: Evap h_{fg}	Enthalpy: Sat Vapor h_g	Entropy: Sat Liquid s_f	Entropy: Evap s_{fg}	Entropy: Sat Vapor s_g	Abs Press Lb/Sq In p
0.08865	32.018	0.016022	3302.4	3302.4	0.0003	1075.5	1075.5	0.0000	2.1872	2.1872	0.08865
0.25	59.323	0.016032	1235.5	1235.5	27.382	1060.1	1087.4	0.0542	2.0425	2.0967	0.25
0.50	79.586	0.016071	641.5	641.5	47.623	1048.6	1096.3	0.0925	1.9446	2.0370	0.50
1.0	101.74	0.016136	333.59	333.60	69.73	1036.1	1105.8	0.1326	1.8455	1.9781	1.0
5.0	162.24	0.016407	73.515	73.532	130.20	1000.9	1131.1	0.2349	1.6094	1.8443	5.0
10.0	193.21	0.016592	38.404	38.420	161.26	982.1	1143.3	0.2836	1.5043	1.7879	10.0
14.696	212.00	0.016719	26.782	26.799	180.17	970.3	1150.5	0.3121	1.4447	1.7568	14.696
15.0	213.03	0.016726	26.274	26.290	181.21	969.7	1150.9	0.3137	1.4415	1.7552	15.0
20.0	227.96	0.016834	20.070	20.087	196.27	960.1	1156.3	0.3358	1.3962	1.7320	20.0
30.0	250.34	0.017009	13.7266	13.7436	218.9	945.2	1164.1	0.3682	1.3313	1.6995	30.0
40.0	267.25	0.017151	10.4794	10.4965	236.1	933.6	1169.8	0.3921	1.2844	1.6765	40.0
50.0	281.02	0.017274	8.4967	8.5140	250.2	923.9	1174.1	0.4112	1.2474	1.6586	50.0
60.0	292.71	0.017383	7.1562	7.1736	262.2	915.4	1177.6	0.4273	1.2167	1.6440	60.0
70.0	302.93	0.017482	6.1875	6.2050	272.7	907.8	1180.6	0.4411	1.1905	1.6316	70.0
80.0	312.04	0.017573	5.4536	5.4711	282.1	900.9	1183.1	0.4534	1.1675	1.6208	80.0
90.0	320.28	0.017659	4.8779	4.8953	290.7	894.6	1185.3	0.4643	1.1470	1.6113	90.0
100.0	327.82	0.017740	4.4133	4.4310	298.5	888.6	1187.2	0.4743	1.1284	1.6027	100.0
110.0	334.79	0.01782	4.0306	4.0484	305.8	883.1	1188.9	0.4834	1.1115	1.5950	110.0
120.0	341.27	0.01789	3.7097	3.7275	312.6	877.8	1190.4	0.4919	1.0960	1.5879	120.0
130.0	347.33	0.01796	3.4364	3.4544	319.0	872.8	1191.7	0.4998	1.0815	1.5813	130.0
140.0	353.04	0.01803	3.2010	3.2190	325.0	868.0	1193.0	0.5071	1.0681	1.5752	140.0
150.0	358.43	0.01809	2.9958	3.0139	330.6	863.4	1194.1	0.5141	1.0554	1.5695	150.0
160.0	363.55	0.01815	2.8155	2.8336	336.1	859.0	1195.1	0.5206	1.0435	1.5641	160.0
170.0	368.42	0.01821	2.6556	2.6738	341.2	854.8	1196.0	0.5269	1.0322	1.5591	170.0
180.0	373.08	0.01827	2.5129	2.5312	346.2	850.7	1196.9	0.5328	1.0215	1.5543	180.0
190.0	377.53	0.01833	2.3847	2.4030	350.9	846.7	1197.6	0.5384	1.0113	1.5498	190.0
200.0	381.80	0.01839	2.2689	2.2873	355.5	842.8	1198.3	0.5436	1.0016	1.5454	200.0
210.0	385.91	0.01844	2.16373	2.18217	359.9	839.1	1199.0	0.5490	0.9923	1.5413	210.0
220.0	389.88	0.01850	2.06779	2.08629	364.2	835.4	1199.6	0.5540	0.9834	1.5374	220.0
230.0	393.70	0.01855	1.97991	1.99846	368.3	831.8	1200.1	0.5588	0.9748	1.5336	230.0
240.0	397.39	0.01860	1.89909	1.91769	372.3	828.4	1200.6	0.5634	0.9665	1.5299	240.0
250.0	400.97	0.01865	1.82452	1.84317	376.1	825.0	1201.1	0.5679	0.9585	1.5264	250.0
260.0	404.44	0.01870	1.75548	1.77418	379.9	821.6	1201.5	0.5722	0.9508	1.5230	260.0
270.0	407.80	0.01875	1.69137	1.71013	383.6	818.3	1201.9	0.5764	0.9433	1.5197	270.0
280.0	411.07	0.01880	1.63169	1.65049	387.1	815.1	1202.3	0.5805	0.9361	1.5166	280.0
290.0	414.25	0.01885	1.57597	1.59482	390.6	812.0	1202.6	0.5844	0.9291	1.5135	290.0
300.0	417.35	0.01889	1.52384	1.54274	394.0	808.9	1202.9	0.5882	0.9223	1.5105	300.0
350.0	431.73	0.01912	1.30642	1.32554	409.8	794.2	1204.0	0.6059	0.8909	1.4968	350.0
400.0	444.60	0.01934	1.14162	1.16095	424.2	780.4	1204.6	0.6217	0.8630	1.4847	400.0
450.0	456.28	0.01954	1.01224	1.03179	437.3	767.5	1204.8	0.6360	0.8378	1.4738	450.0
500.0	467.01	0.01975	0.90787	0.92762	449.5	755.1	1204.7	0.6490	0.8148	1.4639	500.0
550.0	476.94	0.01994	0.82183	0.84177	460.9	743.3	1204.3	0.6611	0.7936	1.4547	550.0
600.0	486.20	0.02013	0.74962	0.76975	471.7	732.0	1203.7	0.6723	0.7738	1.4461	600.0
650.0	494.89	0.02032	0.68811	0.70843	481.9	720.9	1202.8	0.6828	0.7552	1.4381	650.0
700.0	503.08	0.02050	0.63505	0.65556	491.6	710.2	1201.8	0.6925	0.7377	1.4304	700.0
750.0	510.84	0.02069	0.58880	0.60949	500.9	699.8	1200.7	0.7022	0.7210	1.4232	750.0
800.0	518.21	0.02087	0.54809	0.56896	509.8	689.6	1199.4	0.7111	0.7051	1.4163	800.0
850.0	525.24	0.02105	0.51197	0.53302	518.4	679.5	1198.0	0.7197	0.6899	1.4096	850.0
900.0	531.95	0.02123	0.47968	0.50091	526.7	669.7	1196.4	0.7279	0.6753	1.4032	900.0
950.0	538.39	0.02141	0.45064	0.47205	534.7	660.0	1194.7	0.7358	0.6612	1.3970	950.0
1000.0	544.58	0.02159	0.42436	0.44596	542.6	650.4	1192.9	0.7434	0.6476	1.3910	1000.0
1050.0	550.53	0.02177	0.40047	0.42224	550.1	640.9	1191.0	0.7507	0.6344	1.3851	1050.0
1100.0	556.28	0.02195	0.37863	0.40058	557.5	631.5	1189.1	0.7578	0.6218	1.3794	1100.0
1150.0	561.82	0.02214	0.35859	0.38073	564.8	622.2	1187.0	0.7647	0.6091	1.3738	1150.0
1200.0	567.19	0.02232	0.34013	0.36245	571.9	613.0	1184.8	0.7714	0.5969	1.3683	1200.0
1250.0	572.38	0.02250	0.32306	0.34556	578.8	603.8	1182.6	0.7780	0.5850	1.3630	1250.0
1300.0	577.42	0.02269	0.30722	0.32991	585.6	594.6	1180.2	0.7843	0.5733	1.3577	1300.0
1350.0	582.32	0.02288	0.29250	0.31537	592.3	585.4	1177.8	0.7906	0.5620	1.3525	1350.0
1400.0	587.07	0.02307	0.27871	0.30178	598.8	576.5	1175.3	0.7966	0.5507	1.3474	1400.0
1450.0	591.70	0.02327	0.26584	0.28911	605.3	567.4	1172.8	0.8026	0.5397	1.3423	1450.0
1500.0	596.20	0.02346	0.25372	0.27719	611.7	558.4	1170.1	0.8085	0.5288	1.3373	1500.0
1550.0	600.59	0.02366	0.24235	0.26601	618.0	549.4	1167.4	0.8142	0.5182	1.3324	1550.0
1600.0	604.87	0.02387	0.23159	0.25545	624.2	540.3	1164.5	0.8199	0.5076	1.3274	1600.0
1650.0	609.05	0.02407	0.22143	0.24551	630.4	531.3	1161.6	0.8254	0.4971	1.3225	1650.0
1700.0	613.13	0.02428	0.21178	0.23607	636.5	522.2	1158.6	0.8309	0.4867	1.3176	1700.0
1750.0	617.12	0.02450	0.20263	0.22713	642.5	513.1	1155.6	0.8363	0.4765	1.3128	1750.0
1800.0	621.02	0.02472	0.19390	0.21861	648.5	503.8	1152.3	0.8417	0.4662	1.3079	1800.0
1850.0	624.83	0.02495	0.18558	0.21052	654.5	494.6	1149.0	0.8470	0.4561	1.3030	1850.0
1900.0	628.56	0.02517	0.17761	0.20278	660.4	485.2	1145.6	0.8522	0.4459	1.2981	1900.0
1950.0	632.22	0.02541	0.16999	0.19540	666.3	475.8	1142.0	0.8574	0.4358	1.2931	1950.0
2000.0	635.80	0.02565	0.16266	0.18831	672.1	466.2	1138.3	0.8625	0.4256	1.2881	2000.0
2100.0	642.76	0.02615	0.14885	0.17501	683.8	446.7	1130.5	0.8727	0.4053	1.2780	2100.0
2200.0	649.45	0.02669	0.13603	0.16272	695.5	426.7	1122.2	0.8828	0.3848	1.2676	2200.0
2300.0	655.89	0.02727	0.12406	0.15133	707.2	406.0	1113.2	0.8929	0.3640	1.2569	2300.0
2400.0	662.11	0.02790	0.11287	0.14076	719.0	384.8	1103.7	0.9031	0.3430	1.2460	2400.0
2500.0	668.11	0.02859	0.10209	0.13068	731.7	361.6	1093.3	0.9139	0.3206	1.2345	2500.0
2600.0	673.91	0.02938	0.09172	0.12110	744.5	337.6	1082.0	0.9247	0.2977	1.2225	2600.0
2700.0	679.53	0.03029	0.08165	0.11194	757.3	312.3	1069.7	0.9356	0.2741	1.2097	2700.0
2800.0	684.96	0.03134	0.07171	0.10305	770.7	285.1	1055.8	0.9468	0.2491	1.1958	2800.0
2900.0	690.22	0.03262	0.06158	0.09420	785.1	254.7	1039.8	0.9588	0.2215	1.1803	2900.0
3000.0	695.33	0.03428	0.05073	0.08500	801.8	218.4	1020.3	0.9728	0.1891	1.1619	3000.0
3100.0	700.28	0.03681	0.03771	0.07452	824.0	169.3	993.3	0.9914	0.1460	1.1373	3100.0
3200.0	705.08	0.04472	0.01191	0.05663	875.5	56.1	931.6	1.0351	0.0482	1.0832	3200.0
3208.2*	705.47	0.05078	0.00000	0.05078	906.0	0.0	906.0	1.0612	0.0000	1.0612	3208.2*

*Critical pressure

5.12 a. What is the maximum Quadrant Power Tilt Ratio value which will permit indefinite operation at 100% power? (0.5)

b. Name two events, not including a failed power range channel, which could cause the Quadrant Power Tilt Ratio to exceed the value in part "a". (1.5)

5.13 Name three reasons (bases) for the establishment of a minimum RCS temperature for criticality. (1.5)

6.1 State the automatic actions (if any) associated with the following process/area radiation monitors:

a. Main Control Room Turbine Building Air Intakes (0.5)

b. Component Cooling Water Radiation Monitor ORE-PR009 (0.5)

c. Fuel Building Area Radiation Monitors ORE-AR055 and ORE-AR058 (0.5)

d. Gross Failed Fuel Detector (0.5)

6.2 List the signals that will automatically activate the main power transformer's fire protection deluge system. (1.0)

6.3 List 4 of the 6 conditions which must be satisfied in order for breaker 1592 to AUTO close. (2.0)

6.4 Which signa 's) is (are) used to generated the following:

a. Rod Insertion Limit (0.5)

b. Pressurizer Level Program (0.5)

c. Mainfeed/Main Steam Differential Pressure Program (0.5)

6.5 Explain why, when a moisture separator reheater tube bundle is removed from service, the bundle on the opposite side must also be removed from service. (1.0)

6.6 What problem may result if the moisture separator shell drain tank level drops too low? (1.5)

6.7 Why is reverse rotation of an RCP undesirable? (1.0)

6.8 Explain how one of the pressurizer PORVs (PCV-455A) is designed to open at a pressure below 2335 psig for a very fast high pressure transient. (1.5)

6.9 Explain how the letdown orifice isolation valves are interlocked with the letdown line control valves (CV460 and CV459). (1.5)

6.10 On Figure 6.10-1, circle the valves which will be open and place an X through the valves which will be shut when the BTRS is in the Boration mode. (3.0)

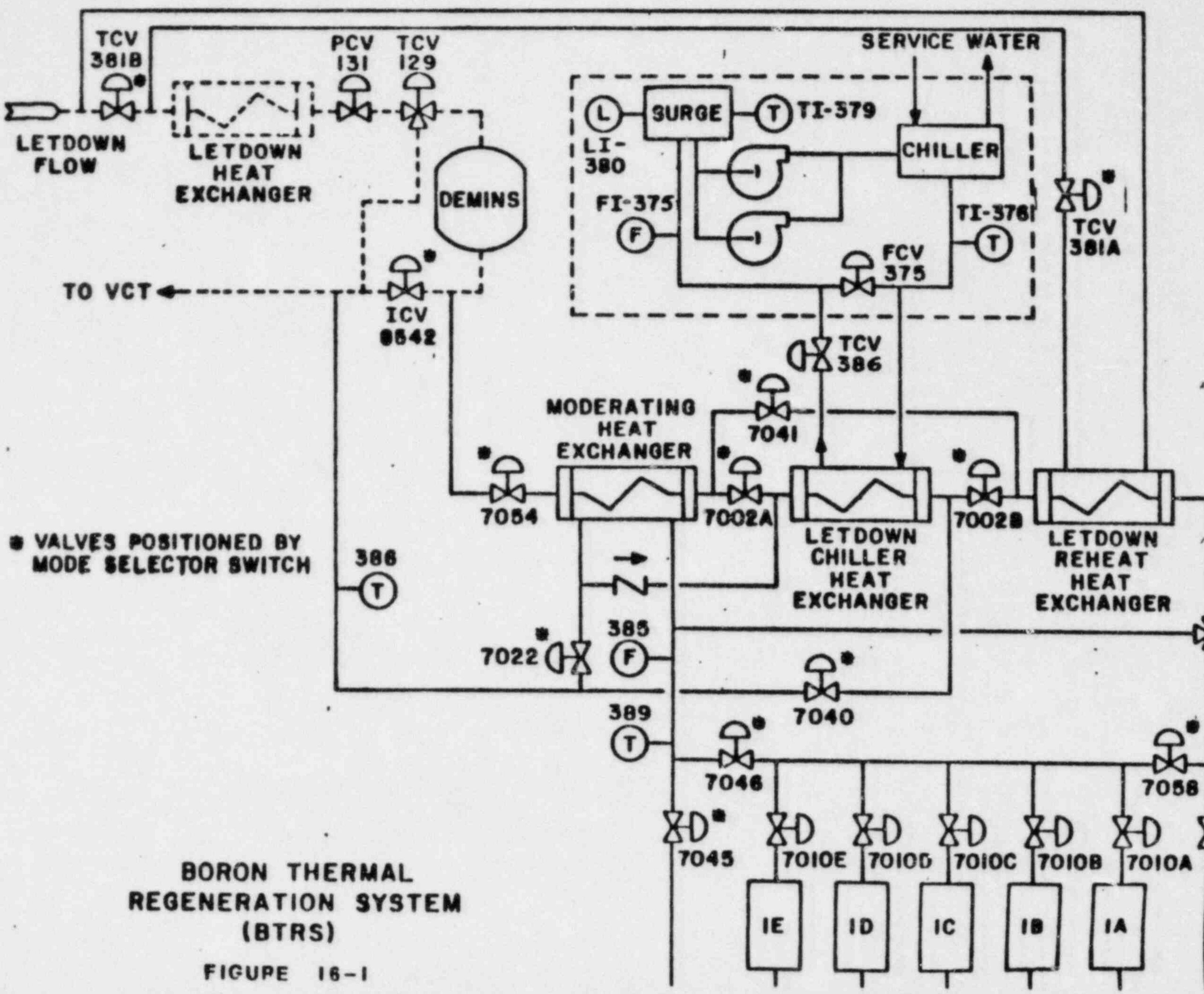
6.11 What four interlocks must be satisfied in order to open the RCS Hot Leg Suction valves to the RHR pumps, 8701A(B) and 8702A(B)? (2.0)

6.12 a. What interlock prevents damage to the component cooling water pumps due to loss of suction head? (1.0)

b. How is the CCW piping from the thermal barrier heat exchanger protected from overpressurization due to an RCS to CCW leak? (2.0)

6.13 When is hot leg recirculation initiated and why? (2.0)

6.14 State the timing sequence of the Safe Shutdown (Blackout) Sequential Timer. (2.0)



BORON THERMAL REGENERATION SYSTEM (BTRS)

FIGURE 16-1

Figure 6.10-1

7.1 "Adverse Containment" as used in the Byron Emergency Procedures exists when either or both of two criteria are met. What are those criteria? (1.0)

7.2 Why does 1BEP-0 require the RCPs to be stopped if containment pressure exceeds 20 psig? (2.0)

7.3 What parameters (setpoints are not required) must be satisfied prior to terminating an SI? (2.0)

7.4 What actions can be taken in the control room to trip the turbine if the Turbine Manual Trip push button will not work? (2.0)

7.5 a. What action must be taken if criticality is achieved below the low low insertion limit? (1.5)

b. What is the zero-power rod insertion limit? (0.5)

7.6 How quickly must RCP shaft rotation occur after the RCP's breaker is shut? (0.5)

7.7 Why must the B and C Main Feedwater pumps be placed on their Turning Gear prior to filling and venting the Condensate System? (1.0)

7.8 Why should the RCP Seal Return Valves be shut prior to depressurizing the RCS? (1.0)

7.9 a. How is the de-energization of an ESF DC bus verified? (1.0)

b. What immediate action must be taken if the de-energization of an ESF DC bus is verified? (1.0)

7.10 What effect will the failure of two power range detectors have if the failures occur while the plant is in cold shutdown? (1.0)

7.11 a. In the event of Control Room Inaccessibility, where does the Shift Engineer go? (0.5)

b. Where does the NSO go? (0.5)

7.12 a. An explosive flammable mixture is a concentration of hydrogen between ___ and ___. (1.0)

b. If stator coil inlet conductivity is equal to or greater than _____, then manually trip the Main Generator without delay and go to 1BEP-0, Reactor Trip or Safety Injection. (0.5)

7.13 Briefly explain how water could be added to a steam generator if none of the feedwater pumps or AFW pumps are operable. (2.0)

7.14 How is a reactor trip verified? (1.5)

7.15 Why is Manual SI actuation not advisable during an ATWOS? (1.5)

7.16 List the steps, in detail, for two different methods of emergency boration. (3.0)

8.1 Name four reasons, other than the completion of his work assignment, which would require an individual to leave the controlled area as quickly as possible. (2.0)

8.2 a. When can an extended RWP be used? (1.0)

b. What is the maximum amount of time for which an extended RWP is valid? (0.5)

8.3 a. What is the NRC quarterly external dose limit for radiation exposure to the skin? (0.5)

b. How can the skin get exposed but not the whole body? (1.0)

8.4 Why are thyroid blocking agents administered to individuals in case of a fission product release? (1.5)

8.5 What is the purpose of the OSC? (1.0)

8.6 a. Who normally functions as the initial GSEP Station Group Director? (0.5)

b. During the more serious emergencies, the GSEP Corporate Command Center Director is responsible for activating a ________________ at the affected station's ______________ ______________. (1.0)

8.7 What is the function of NARS? (1.0)

8.8 What is the Daily Order Book used for? (1.0)

8.9 List the Critical Safety Functions in their order of priority. (1.5)

8.10 a. What are Caution Cards used for? (1.0)

b. Special Order Cards are used on what equipment? (0.5)

8.11 What do the large circle and small box around step 31, RCP starts, on the BGP 100-1 Flowchart signify? Refer to Figure 8.11-1. (2.0)

8.12 Verification of the correct alignment of components during System Lineups can be accomplished by any of three methods. Name two. (2.0)

8.13 a. Who normally functions as the Fire Chief? (0.5)

b. A fire brigade of at least _____ members shall be maintained at all times. (0.5)

8.14 One criterion which must be met before a Temporary Procedure is written is that there be no change in intent for any established procedure. What is meant by the term "change in intent"? (2.0)

8.15 a. How many reactor coolant loops must be operable in mode 3? (0.3)

b. What is the maximum allowable leakage through a pressurizer safety valve? (0.3)

c. What is the RCS limit for fluoride contamination in the RCS? (0.3)

d. What are the two specific activity limits of the RCS? (0.6)

8.16 a. When must low temperature overpressure protection be operable? (0.5)

b. What are the two methods of satisfying the low temperature overpressure protection requirement? (2.0)

APPROVED
JUN 19 1983
B.O.S.R.

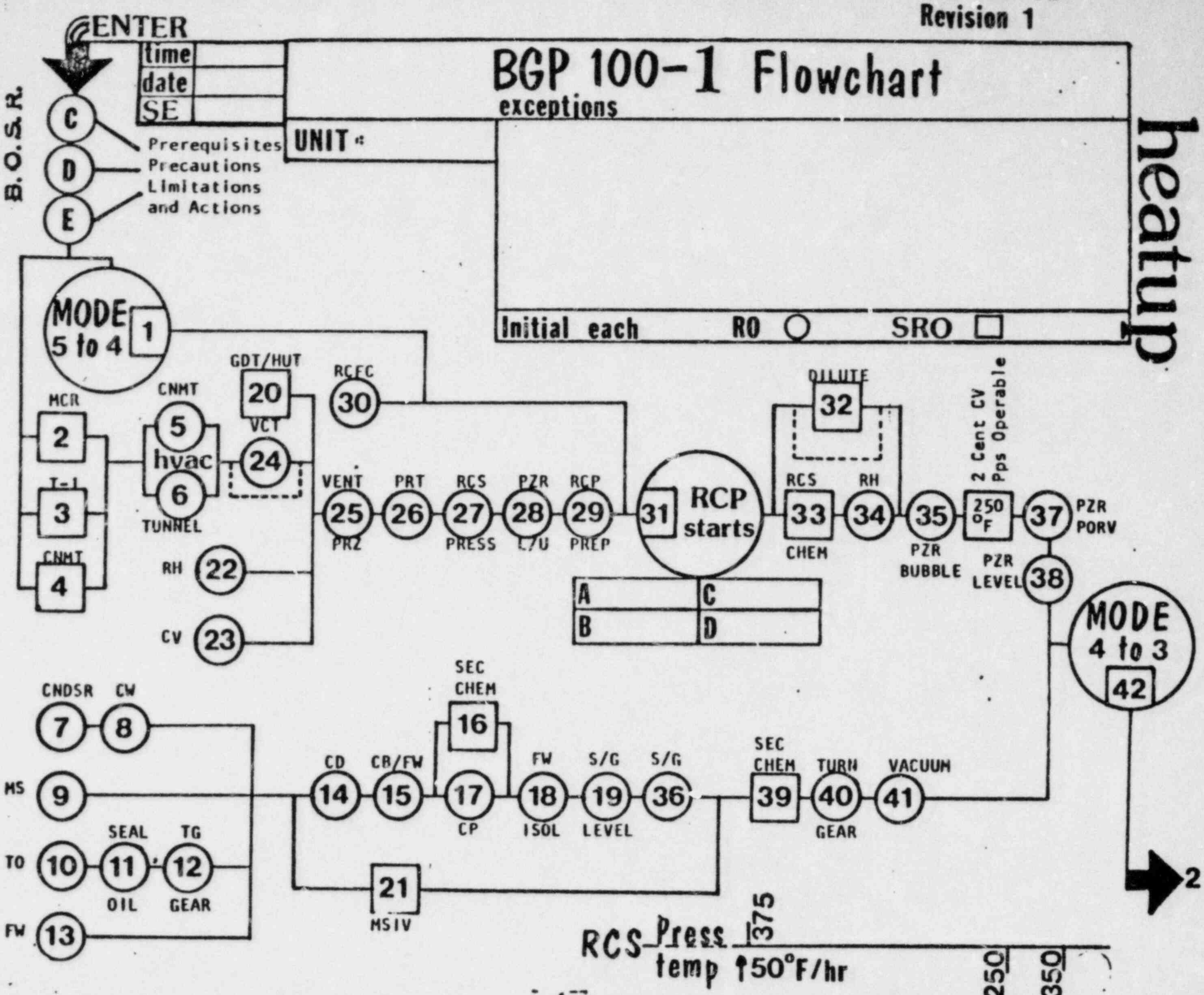


Figure 8.11-1

Master

ANSWERS

5.1 ΔT setpoint = ΔT full power $[K_1 - K_2 (T-T^1) + K_3 (P-P^1) - f(\Delta I)]$ (0.2)

at normal pressure and flux distribution, $K_3 (P-P^1)$ and $f(\Delta I)$ both equal zero. (0.2)

ΔT setpoint = ΔT full power $[K_1 - K_2 (T-T^1)]$ (0.2)

With plant power at 100% at the time of the trip, ΔT setpoint = ΔT full power. (0.5)

therefore $\frac{\Delta T \text{ setpoint}}{\Delta T \text{ full power}} = 1$ (0.2)

$1 = K_1 - K_2 (T-T^1)$ (0.1)
$1 - K_1 = -K_2 (T-T^1)$ (0.1)
$K_1 - 1 = K_2 (T-T^1)$
$1.072 - 1 = .0265 (T-587.7)$ (0.1)
$.072 = .0265T - 15.574$ (0.1)
$.0265T = 15.646$ (0.1)
$T = 590.4$ (0.1)
$590.4 - 587.7 = 2.7$ (0.1)

At 100% power, if Tave rises 2.7 degrees from its normal value an OTΔT trip will occur.

Ref: Tech Specs Table 2.2-1, p 2-8.

5.2 The thermal conductivity of the gas in the gap between the clad and fuel decreases with burnup (0.5) due to the buildup of the fission product gases krypton and xenon which possess very poor thermal conductivities. (0.5) (see notes)
fuel densification (0.5) crud buildup (0.5)
Ref: Training Manual p. 11-8

5.3 1. Flatten the radial flux distribution. (0.5)

2. Lower the beginning-of-life, hot zero power boron concentration to guarantee a negative moderator temperature coefficient. (see notes) (0.5)
allows loading of excess (0.5)
allows minimizing

Ref: Training Manual p. 11-5

5.4 a. Hafnium (0.5)

Ref: Training Manual p. 11-18

b. 1. Californium 252 undergoes spontaneous fission. (0.5)
2. Plutonium undergoes alpha decay. (not required) (0.5)
Pu/Be is not required

The alpha combines with berylium, emitting a neutron in the process. (0.5)

Ref: Lesson Notes, Nuclear Fuel Structure, p. 31

5.5 As moderator temperature rises, the migration length of the neutrons will increase, so each control rod will interact with more neutrons, absorbing additional neutrons and removing them from the fission chain. (1.0) With more control rods inserted, more neutrons will be removed from the fission process for a given rise in moderator temperature. (1.0)

Ref: PWR Core Physics Text, Phase I, Module B-3 p. 24.

5.6 Peak clad temperature shall not exceed 2200°F even during postulated accident conditions. (1.0)

Ref: Training Manual 11-11; 10 CFR 50.46(b)(1)

5.7 Normal steam generator temperature at 50% power is obtained from the steam tables.
1030 psig = 1045 psia which corresponds to 550°F. (0.4)

The steam generator safety valve with the lowest lift setting will open at 1175 psig = 1190 psia, which corresponds to 566°F. (0.4)

The steam generator temperature must therefore be raised 566-550 = 16°F. (0.4)

Normal Tave at 50% power is (557 + 587)/2, which is 572°F. (0.4)

If Tave rises to 572 + 16 = 588 at 50% power the steam generator safety valve with the lowest relief setting will open. (0.4)

Ref: Tech Specs 3/4 p. 7-3; Training Manual Figure 14-1

5.8 a. RT_{NDT} is the reference transition nil ductility temperature, the temperature below which a material will fail in a brittle rather than a ductile manner. (max) (1.0)

b. The RT_{NDT} increases with EFPY due to neutron embrittlement, the deformation of the metal lattice caused by high-energy neutrons striking metal atoms. (1.0) At 3/4T, 3/4 of the distance from the inner wall of the reactor vessel to the outer wall of the reactor vessel, the high energy neutron flux is less than it is at 1/4 T because of the shielding provided by the metal in the reactor vessel. (0.5) With a smaller neutron flux at 3/4T than at 1/4T the neutron embrittlement will be less, so the increase in RT_{NDT} will not be as great. (0.5)

Ref: Tech Spec 3/4 4-31; B 3/4 4-8

5.9 a. In modes 1, 2, 3, and 4, the shutdown margin is based on a postulated steam line break and resulting uncontrolled cooldown. (0.5) In mode 5, Tave is below 200°F, so the reactivity transients resulting from a postulated steam line break cooldown are minimal. (0.5)

Ref: Tech Spec B 3/4 1-1

b. The contol rods are withdrawn beyond the rod insertion limits. (1.0)

(RIL met)

Ref: Tech Specs 4.1.1.1.1.b; B 3/4 1-3

c. Consideration of the following factors

1.	RCS boron concentration	(0.2)
2.	Control rod position	(0.2)
3.	RCS Tave	(0.2)
4.	Fuel burnup based on gross thermal energy generation	(0.2)
5.	Xenon concentration	(0.1)
6.	Samarium concentration ← not req'd	(0.1)

Ref: Tech Specs 4.1.1.1.1.e

d. Immediately initiate boration at greater than or equal to 30 gpm (0.5) of a solution containing greater than or equal to 7000 ppm boron or equivalent until the required shutdown margin is restored. (0.5)

Ref: Tech Specs 3.1.1.1

5.10 a. Heat Flux Hot Channel Factor (0.2), is defined as the maximum local heat flux on the surface of a fuel rod at core elevation Z divided by the average fuel rod heat flux. (0.8) $\frac{peak}{ave}$ at height Z Mitigating Core Damage page 1-27

Ref: Tech Spec B 3/4 2-1

b. Coolant temperature increases as it flows upward through the core, (.75) so DNBR is lowest towards the top of the core. (.75)

or

During a LOCA, the top of the core is the first part uncovered. (0.5) When the ECCS refills the core, the top portion of the core is the last recovered. (0.5) Since the top of the core is uncovered for the longest period of time, it will reach the highest temperature. (0.5)

Ref: Thermal-Hydraulic Principles and Applications to the Pressurized Water Reactor II, Chap 13, p. 33

5.11 Nitrogen is an insoluble, incompressible gas which has poor heat transfer characteristics. (0.4) If it accumulated in the reactor vessel head, coolant flow through the core might be blocked. (0.3) If it surrounded the fuel rods, the heat removal rate would be reduced greatly, causing fuel temperature to rise drastically. (0.3)

Ref: 1BCA-2 p. 20

5.12 a. 1.02 (0.5)

Ref: Tech Specs 3.2.4

b. Any two of the following:

Misaligned control rod	(.75)
Flow blockage through the core	(.75)
Improper fuel loading	(.75)
radial xenon oscillation	

5.13 Any three of the following:

1. MTC is within its analyzed range (0.5)
2. Trip instrumentation is within its normal operating range (0.5)
3. The pressurizer is capable of being in an operable status with a steam bubble (0.5)
4. The reactor vessel is above its minimum RT_{NDT} temperature (0.5)
5. The plant is above the cooldown steam dump premissive, P-12 (0.5)
6. Plant operation will be in the bounds of accident analysis

Ref: Tech Specs B 3/4 1-2

ANSWERS

6.1 a. None (0.5)

Ref: Training Manual 49-16

b. Shuts the vent valves on both component cooling surge tanks. (0.5)

Ref: Training Manual 49-8

c. Booster fans OVA04CA and B start and bypass dampers shut to route the exhaust through the filter prior to release. (0.5)

Ref: Training Manual 50-16

d. None (0.5)

Ref: Training Manual 49-10

6.2 Differential current (0.5)
Sudden pressure (0.5)

Ref: Training Manual 4-17

6.3 Any 4 of the following:

a. No overcurrents (phases or to ground) breaker 1592 (0.5)
b. No overcurrents (phases or to ground) breaker 1591 (0.5)
c. No malfunctions on SAT 142-1 (0.5)
d. Breaker 1591 open (0.5)
e. Control switch for breaker 1591 in "after close" (0.5)
f. Control switch for breaker 1592 in "after trip" (0.5)

Ref: Training Manual 4-100

6.4 a. Auctioneered high ΔT (~~.25~~ .5) and auctioneered high Tave (~~.25~~ 0) is multiplied by zero

Ref: Training Manual 12-44

b. Auctioneered high Tave (0.5)

Ref: Training Manual 12-44

c. Total Steam Flow (0.5)

Ref: Training Manual 27-20

6.5 To limit the temperature differential across the LP turbine. (1.0)

Ref: Training Manual 35-38

6.6 Steam from the moisture separator may be passed directly to the heater drain tank (0.5) allowing water contained in the heater drain tank to flash to steam (0.5), possibly overpressurizing the heater drain tank. (0.5)

Ref: Training Manual 36-29

6.7 If an attempt were made to start an RCP rotating in the reverse direction, excessive starting currents would be drawn (0.5), resulting in overheating of the motor. (0.5)

Ref: Training Manual 13-16

6.8 The pressure signal used to actuate the PORV is a PID compensated signal. (0.5) (PID stands for proportional, integral, and derivative.) The derivative function will reduce the setpoint in direct proportion to the rate at which pressure is increasing. (1.0)

Ref: Training Manual 14-28

6.9 1. To open any of the letdown orifice isolation valves, CV459 and CV460 must be opened. (.75)

2. Closing either CV459 or CV460 will automatically close all the letdown orifice isolation valves. (.75)

Ref: Training Manual 15a-9

6.11 1. 8812A(B) RHR pump suction valves from the RWST must be shut. (0.5)
2. 8804A(B) RHR to charging (SI) pump suction valves must be shut. (0.5)
3. 8811A(B) RHR pump suction valves from the containment sump must be shut. (0.5)
4. The RCS pressure must be less than 382 psig. (0.5)

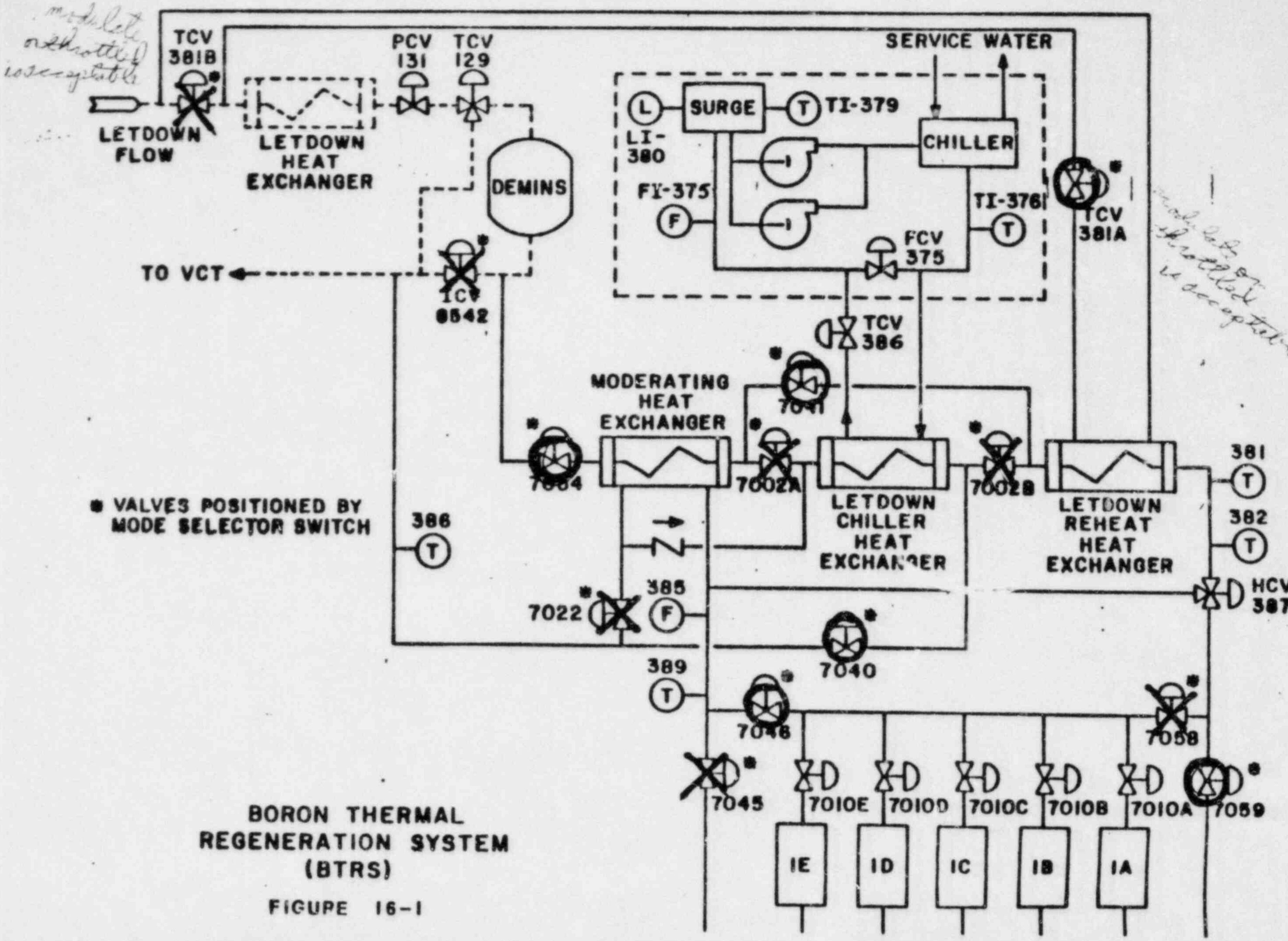
Ref: Training Manual 18-12

6.12 a. A low-low level in the CCW surge tank will trip the CCW pumps. (1.0)

Ref: Training Manual 19-13

b. A leak into the CCW system at the thermal barrier would greatly increase the flow rate in the return line from the RCP. (0.5) (A check valve prevents leakage out the supply line. (0.5)) The increased flow through the return line would be sensed by a flow orifice, which would cause MOV 685, the CCW thermal barrier return line isolation valve, to shut. (~~0.5~~ 1.0) The CCW piping between the check valve in the thermal barrier supply line to the isolation valve is designed to withstand full RCS pressure. (0.5)

Ref: Training Manual 19-15, 28, 39



BORON THERMAL REGENERATION SYSTEM (BTRS)

FIGURE 16-1

Figure 6.10-1

6.13 Approximately 18 hours after the initiation of cold leg recirculation. (0.5)
Hot leg recirculation provides a means of terminating boiling in the core should a LOCA be due to a break in one of the RCS cold legs (0.5), reduces boron precipitation in the top of the core (0.5), and maintains the core in a subcooled condition as long as core cooling is required. (0.5)

Ref: Training Manual 58-52

6.14 4160V/480V transformer 10 sec. (0.5)
Component Cooling Pumps 30 sec. (0.5)
Essential Service Water Pumps 35 sec. (0.5)
Auxiliary Feedwater Pump 45 sec. (0.5)

Ref: Training Manual 9-31 Cent Ch pump 10 sec (.4)
MCR Refrigeration unit 25 sec (.4)

ANSWERS

7.1 1. Containment Pressure greater than 5 psig. (0.5)
2. Containment Radiation greater than 10^4 R/hr (0.5)

Ref: 1BEP-0 p. 2

7.2 1. Containment pressure exceeding 20 psig will cause a phase B containment isolation. (1.0)

2. A phase B containment isolation will cause component cooling water flow to the RCPs to be isolated. (0.5)

3. The RCPs must be stopped if CCW is lost for greater than one minute. (0.5)

Ref: Training Manual 13-31, Figure 19-2, 61-39; Tech Specs 3/4 6-22; 1BEP-0 p. 9; BGP 100-1, p. 1

7.3 1. RCS pressure (0.5)
2. RCS subcooling (0.5)
3. Pressurizer level (0.5)
4. Secondary heat sink (0.5)

Ref: 1BEP-0, p. 12; 1BEP-1, p. 3; 1BEP-2, p. 8; 1BEP-3, p. 15

7.4 1. Pull-to-lock the EH pumps (1.0)
2. Close the MSIVs and their bypasses (1.0)

Ref: 1BEP-0 p. 3

7.5 a. Emergency borate 100 ppm (.75) and reinsert all control rods (.75)

Ref: BGP 100-2 p. 5

b. 47 steps on bank C or 162 steps on bank B (0.5)

Ref: Tech Spec 3/4 1-22

7.6 10 seconds (0.5)

Ref: BGP 100-1 p. 3

7.7 Prevent the Main Feedwater Pumps from rotating without the oil systems running. (1.0)

Ref: BGP 100-1 p. 5

7.8 Prevent backflushing the Seal Return Filter into the RCP Seals. (1.0)
prevent crud from entering RCP seals

Ref: BGP 100-5 p. 17

7.9 a. Feedwater regulating valves will fail closed. (1.0)

b. Manually trip the reactor. (1.0)

Ref: BOA Elec - 1 p. 3, 4

7.10 A false P-10 will be generated, deenergizing the high voltage to the Source Range detectors. (1.0)

Ref: 1BOA INST-1, p. 5

7.11 a. TSC (0.5)

b. Shutdown panel (0.5)

Ref: 1BOA Pri - 5

7.12 a. 4% (0.5) and 75% (0.5)

Ref: 0BOA PRI-8, p. 3

b. 9.5 micromhos (0.5)

Ref: 1BOA SEC-7, p. 4

7.13 Use a running CD/CB pump (0.5) to supply water through an idle FW pump (0.5) to a S/G which has been depressurized below 670 psig (1.0).

Ref: 1BFR-H.1, p. 8

7.14 1. Rod bottom lights are lit. (0.5)
2. Reactor trip and bypass breakers are open. (0.5)
3. Neutron flux is decreasing. (0.5)

Ref: 1BEP-0, p. 3

7.15 A possible loss of heat sink (0.5) due to tripping of the main feedwater pumps (0.5) and a feedwater isolation actuation. (0.5)

Ref: 1BCA-1, p. 2; Training Manual 25-47

7.16 Two of the following:

1. a. Manually open emergency boration valve 1CV8104 (0.5)
   b. Manually start a boric acid transfer pump (0.5)
   c. Verify emergency boration flow (0.3)
   d. Manually increase charging flow (0.2)

2. a. Increase pot setting for boration flow to maximum valve (0.3)
   b. Place make-up control selector switch to borate (0.3)
   c. Place make-up control switch to start (0.3)
   d. Verify 1CV110A and 1CV110B open (0.3)
   e. Verify required boration flow (0.3)

3. a. Manually Open 1CV112D/112E (0.5)
   b. Manually Close 1CV112B/112C (0.5)
   c. Verify one centrifugal charging pump running (0.3)
   d. Verify charging flow of at least 105 gpm (0.2)

4. a. Manually open 1CV110A (0.4)
   b. Obtain key for pad lock on 1CV8439 from Shift Engineer and locally open 1CV8439 (0.6)
   c. Manually start a boric acid transfer pump (0.4)
   d. Verify required boration flow (0.1)

Ref: 1BOA PRI-2, p. 3

ANSWERS

8.1 Four of the following:

a. When instructed or signaled to do so by the Radiation Chemistry Department (0.5)

b. Failure or suspected failure of personnel protective equipment (0.5)

c. Unexpected deterioration of radiological conditions (0.5)

d. In the event that the worker's current accumulated dose equivalent status becomes uncertain for any reason or dose equivalent is equal to the exposure authorized for the job. (0.5)

e. "Assembly" sirens sound - practice or actual (0.5)

f. Injury (0.5)

g. Unexpected area radiation monitor alarm and the area dose rate is unknown. (0.5)

Ref: Radiation Protection Standards, p. 7

8.2 a. Routine job (0.3) where workers may receive greater than 50 mrem but less than 100 mrem in one day for two or more days (0.4), but less than 300 mrem in a week on a given task. (0.3)

b. 7 days (0.5)

Ref: Radiation Protection Standards, p. 13

8.3 a. 7.5 rems (0.5)

b. Beta radiation (0.5), which exposes the skin but does not penetrate past the skin into the body (0.5).

Ref: Radiation Protection Standards, p. 24

8.4 A (relatively) large proportion of fission products are radioactive iodines (0.5). Iodines will collect in the thyroid until the thyroid is saturated. (0.5) A thyroid blocking agent administered to an individual will result in sufficient accumulation of stable iodine in the thyroid to prevent significant uptake of radioiodine. (0.5)

Ref: GSEP p. 2-3

8.5 Location to which support personnel will report during an emergency (0.5) and from which they will be dispatched for assignment or duties in support of emergency operations. (0.5)

Ref: GSEP p. 3-3

8.6 a. Shift Engineer (0.5)

b. GSEP Recovery Group (0.5)
Nearsite EOF (0.5)

Ref: GSEP p. 3-2

8.7 The Nuclear Accident Reporting System is a dedicated telephone voice communications system (0.5) that has been installed for the purpose of notifying State and local authorities of declared nuclear emergencies. (0.5)

Ref: GSEP p. 7-5

8.8 Issuing management instructions (0.5) which have short term applicability and require dissemination. (0.5)

Ref: BAP 300-3, p. 1

8.9 a. Subcriticality (.25)
b. Core Cooling (.25)
c. RCS Integrity (.25)
d. Heat Sink (.25)
e. Containment (.25)
f. Inventory (.25)

Ref: BAP 300-11, p. 6

8.10 a. Call attention to a temporary change of normal operating routine of equipment or a special condition of an operating system. (1.0)

Ref: BAP 300-18, p. 6

b. Equipment under the jurisdiction of the load dispatcher. (0.5)

Ref: BAP 300-18 p. 3

8.11 a. The large circle signifies a major step in procedure. (1.0)

b. The box signifies a step that is to be approved prior to starting and initialled after completion by an SRO. (1.0)

Ref: BAP 300-34, p. 2

8.12 a. Functional testing (1.0)

b. Second qualified individual (1.0)

c. Automatic System Status Monitoring System (1.0)

Ref: BAP 399-3, p. 3

8.13 a. Cognizant Shift Foreman (0.5)

Ref: BAP 1100-1, p. 3

b. 5 (0.5)

Ref: BAP 1100-1, p. 1

8.14 Changes which result in operation outside the FSAR described design envelope (1.0) and result in operation outside the Plant Safety Analysis as described in the FSAR. (1.0)

Ref: BAP 1310-4, p. 1

8.15 a. 2 (0.3)

Ref: Tech Spec 3/4 4-?

b. 0 (0.3)

Ref: Tech Spec 3/4 4-19

c. .15 ppm (0.3)

Ref: Tech Spec 3/4 4-23

d. Less than or equal to 1 microcurie per gram dose equivalent I-131. (0.3)
Less than or equal to 100/E microcuries per gram of gross radioactivity. (0.3)

Ref: Tech Spec 3/4 4-25

8.16 a. When the temperature of any RCS cold leg is less than 380°F and the reactor vessel head is on. 250°F is also correct (0.5)
BAP 100-5 Rev 1 p. 13

b. 1. Two PORVs with nominal setpoints which vary with RCS temperature. (1.0)

2. The RCS depressurized with an RCS vent of greater than or equal to 2 square inches. (1.0)

Ref: Tech Spec 3/4 4-35