U.S. NUCLEAR REGULATORY COMMISSION

REGION III

Docket Nos. 50-254, 50-265 Licenses No. DPR-29; DPR-30

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

Facility Name: Quad Cities Nuclear Power Station

Examination Administered At: Quad Cities Nuclear Power Station

Examination Conducted: March 12-15, 1984

Examiners: T. Lang (Chief Examiner) 4/11/84 Date

W. Cliff 4/11/84 Date

Approved By: J. I. McMillen, Chief
Operator Licensing Section 4/11/84 Date

Examination Summary

Examination administered on March 12-15, 1984
Written and oral examinations were administered to six SRO candidates.
Results: Of the six candidates five successfully passed the written and the oral examination and will be issued licenses.

DETAILS

1. Examiners

*T. Lang (NRC)
W. Cliff (PNL)

*Chief Examiner

2. Examination Review Meeting

At the conclusion of the written examination the examiners met with Messrs. J. Neal and W. Graham of the Training Department to review the written examination and answer key. All comments made concerning the answer key were for clarification only. No comments were made in regard to the questions.

3. Exit Meeting

At the conclusion of the site visit the examiners met with representatives of the plant staff to discuss the known results of the examination. Those individuals who clearly passed the oral examination were identified in this meeting.

The examiners stated that they considered the candidates' knowledge of electrical distribution to be a potential training program weakness. The licensee agreed to review this potential weakness.

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

Mast.

FACILITY: Quad-Cities

REACTOR TYPE: BWR

DATE ADMINISTERED: March 14, 1984

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
25	25	____	____	5. Theory of Nuclear Power Plant Operation, Fluids, and Thermodynamics
25	25	____	____	6. Plant Systems Design, Control, and Instrumentation
25.5	25.5	____	____	7. Procedures - Normal, Abnormal, Emergency, and Radiological Control
24.5	24.5	____	____	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 Plant Operations, Fluids, and Thermodynamics (25)

5.1 a. If your reactor had a doubling time of one minute, what would be the reactor period? (0.5)

b. Using the poet formula show how doubling time can be related to reactor period. (1.0)

5.2 Explain how rod worth will change for an increase in the following core parameters.

a. Fuel temperature (1.0)

b. Void content (1.0)

c. Core age (1.0)

Appropriate to [illegible] that Explain, meant how and why!

5.3 a. Equilibrium Xenon implies that the Rate of Production = Rate of Removal. What is the source of each of these terms? (1.0)

Appropriate to [illegible] that [illegible] Exam[illegible]

b. Explain how and why Xenon changes following a scram from full power. (2.0)

5.4 The reactor is exactly critical Low in the IRM range, when a control rod is withdrawn one notch.

a. Describe what happens to indicated neutron level and why? (Continue your discussion until a steady state condition is reached. Assume no further operator action other than to up range the IRMs.) (1.0)

b. Describe how reactor period would respond and why? (1.0)

5.5 How and why does the magnitude (reactivity added per change in degree F) of the Fuel Temperature Coefficient, Doppler, change given the following changes in core conditions:

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

b. A significant increase in fuel temperature (1.0)

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

5.6 Define the following terms.

a. Latent Heat of Vaporization (1.0)

b. Enthalpy (0.5)

5.7 Assume the plant is at 100% power and flow. Explain why core flow would increase with a reduction in reactor power. (Assume constant recirc. pp. speed.) (1.5)

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

a. Core flow (0.5)

b. Inlet subcooling (0.5)

c. Reactor Pressure (0.5)

5.9 Does the centerline temperature of the fuel pin located closest to a control rod change when the control rod is moved when operating near full power? Explain your answer using general concepts of heat transfer. (2.0)

5.10 Reactor water level is maintained between a High limit and a Low limit. The High limit protects the turbine, and the Low limit protects the recirc. pumps. What are each of these limits protecting against? Be specific in your answer, explain all terms. (2.0)

5.11 a. Why is the feedwater at your plant heated prior to returning it to the vessel? (0.5)

b. In your feedwater heaters, cascading drains are used. Why isn't each heater drain just routed back to the condenser? (0.5)

5.12 What is the purpose or basis for the following limits?

a. LHGR (1.0)

b. APLHGR (1.0)

c. MAPRAT (1.0)

6. Plant System Design, Control, and Instrumentation (25)

6.1 In regards to the HPCI system:

a. Valves 35 and 36 (Torus suction valves) auto open and are interlocked open if either of two (2) conditions occur. What are these conditions? (1.0)

b. If either the 35 or the 36 valve is full open, valves 10, 15 and 49 auto close and are interlocked closed. Explain why. (1.0)

c. If both the 35 and the 36 valves are full open, the 6 valve (Suction from CST) auto closes and is interlocked closed. Explain why. (1.0)

6.2 If the SBLC system were to be injected what are three methods which could be used to determine if it were actually injecting? (1.5)

6.3 a. The difference in speeds of the recirc. pumps is limited based on power level. What are these limits? (1.0)

b. Give two (2) reason for these limits. (1.0)

6.4 a. Assume that the station is on-line at 50% power. Describe the resultant effect of lowering the load limit to 40%. (1.0)

b. What is the intent or purpose of the max combined flow limit? (1.0)

c. What is the setting of the max combined flow limit during a normal unit startup? (0.5)

6.5 In regards to the CRD system:

a. Explain why you should close valve 305-101, control rod drive below piston isolation valve, before closing either valve 305-102 or 305-112 when isolating the CRD mechanism from the hydrolic module. (1.0)

b. Why should you not take an HCU out of service while at operating temperature and pressure. (1.0)

c. After a scram, the CRD pumps will attempt to charge all the accumulators at once. During these conditions, what prevents, the pump from going into "run out"? (1.0)

6.6 The RWM and the RBM are two systems which protect the fuel from damage during rod movement.

a. Although similar, each protects fuel during different events. What event does each system protect against? (1.0)

b. When is each system required to be in operation? Explain why. (2.0)

6.7 One of the flow units associated with the APRM's is inoperative.

a. What automatic action will result from the inop. signal? (1.0)

b. Other than an inop. What are two signals associated with the flow units which will cause the same auto action to occur as in part "a" above? (1.0)

c. What are two (2) conditions which will cause an inop. trip of a flow unit? (1.0)

6.8 Concerning the 1/2 DG ON/OFF switch. (Answer each part as an individual question)

a. What position(s) are the switches normally in, assuming 100% power and no system faults. (1.0)

b. If both units experienced a loss of voltage, to which unit would the 1/2 DG close? Why. (1.0)

c. If an undervoltage condition occurred on Unit 1, and the 1/2 DG closed to Unit 1, what affect if any would there be if the Unit 1 on/off switch were placed in the ON position. Explain your answer. [illegible] (1.0)

6.9 If a feedwater heater were taken out of service, generator output should be reduced. What is the basis for dropping or limiting MW output? (1.0)

6.10 What are four of the five interlocks which must be satisfied in order to have an Auto Start permissive for a RFP? (2.0)

6.11 In order to place a Limitorque Operator in manual it is necessary to trip the feed breaker, then disconnect the motor from the hand wheel by pressing the cluth lever. Once in manual how is it return to automatic. (1.0)

7. Procedures - Normal, Abnormal, Emergency, and Radiological Control (25.5)

7.1 According to QCP 1-1 "Normal Unit Startup" the use of the Notch Override switch is limited.

a. When is Notťch Override Not allowed? (2.0)

b. Why is it necessary to limit the use of Notch Override? Explain. (2.0)

7.2 Reactor Vessel Pressurization requires that the pressure regulator setpoint be maintained higher than reactor pressure.

a. How much higher is the setpoint maintained? (1.0)

b. If this setpoint were not maintained higher than reactor pressure what could occur? Explain. (1.0)

7.3 What are four (4) of five (5) steps which must be performed prior to transferring the mode switch to "Run"? (2.0)

7.4 a. If an ATWS Event were to occur there would be two indications which would be the key to recognition of the event. What are these two indications? (1.0)

b. How does an "ATWS Event" differ form a "Failure of Control Rods to Insert During a Scram"? (2.0)

7.5 What are five immediate operator actions required for a gross fuel failure? (2.5)

7.6 According to QGA T1 "Threat of Loss of Reactor Shutdown or Cooling Capability Flow Diagram." What are four actions or methods to scram the reactor other than Automatically? (2.0)

7.7 For the following torus temperatures what action (8) must be performed? (2.0)

a. 95°

b. 101°

c. 110°

d. 120°

7.8 According to your procedure for "High Airborne Activity" the immediate actions require you to start service air compressor 2-4601 and stop service air compressors 1A-4601 and 1B-4601. Why is this done? (1.0)

7.9 a. What are two actions ~~are~~ required when a loss of feedwater heaters occurs. (Assume multiple heaters). (1)

b. Why is each action performed? (1.0)

7.10 If the following fire protection equipment were found to be inoperative what action(s) would be necessary? Assume individual failures.

a. Unit 2 HPCI Sprinker System. (0.5)

b. Unit 2 Cable Tunnel Spriklet System. (0.5)

c. CO_2 system in DG room. (0.5)

d. Fire stop protecting safety related area not intact. (0.5)

7.11 If a Turbine Runback were to occur due to a loss of Stator Cooling.

a. What signals will intiate a stator cooling runback. (1.5)

b. The immediate action required would be different depending on the conductivity prior to the loss of the Stator Cooling System. Explain how a change in conductivity changes the required actions. (1.5)

8. Administrative Procedures, Conditions and Limitations (24.5)

8.1 In regards to Temporary Changes to Procedures:

a. Who must concur with Temporary changes to operating procedures which do not change the intent of the permanent procedure? (1.0)

b. What are three guidelines used to determine if the intent of a procedure is changed? (1.5)

c. If the authorizing personnel needed to change an operating procedure are available can they authorize or sign concurrence to temporary procedures dealing in other areas, such as maintenance, technical staff, or security? (1.0)

8.2 In accordance to procedure QAP 1150-2 "Access to the Drywell or Suppression Chamber" four conditions must exist simultaneously in order for access to the Drywell to be unlimited. What are these conditions? Do not list RP requirements (2.0)

8.3 Other than the on-shift personnel who by title is allowed unlimited access to the control room? (Five required for full credit.) (2.5)

8.4 The operations department has control of "S", "R", and "V" keys.

a. What is the function or purpose of each key? (1.5)

b. Five "V" keys are distributed to on-shift personnel. How many, and to whom are the keys assigned? (0.5)

[illegible]

8.5 Who by title makes up the on-shift fire brigade? (2.0)

8.6 a. According to QEP 360-4 who has the authority to recommend the use of KI Tablets? (1.0)

b. During normal operation where are these tablets located? (0.5)

8.7 a. How is coupling integrity verified for each withdrawn control rod, after a refueling outage. (2.0)

b. Why are control rod withdrawal sequences established? (1.0)

8.8 What is the basis for the following scrams?

a. Condenser Low Vacuum. (1.0)

b. Turbine Stop Valve Closure. (1.0)

c. Main Steamline Isolation Valve Closure. (1.0)

8.9 Explain what is meant by the following terms.

a. Instrument Calibration (1.0)

b. Instrument Functional Test (1.0)

c. Instrument Check. (1.0)

8.10 When a system is determined inoperable solely because its emergency or normal power source is inoperable, it may be considered operable for the purpose of satisfying the requirements of its Limiting Conditions for Operations, provided what two (2) conditions are met? (2.0)

$f = ma$ $v = s/t$ Cycle efficiency = (Network out)/(Energy in)

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

$E = mc^2$

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

$PE = mgh$

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

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

$\Delta E = 931\, \Delta m$

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

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

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

$Pwr = W_f \Delta n$

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

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

$TVL = 1.3/\mu$

$HVL = -0.693/\mu$

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

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

$SUR = 26.06/T$

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

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

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

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

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

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

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

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

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

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

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

$\ell^* = 10^{-4}$ seconds

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

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

$I_1 d_1 = I_2 d_2$

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

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

$\Sigma = \sigma N$

$R/hr = (0.5\, CE)/d^2$(meters)

Water Parameters

1 gal. = 8.345 lbm.
1 gal. = 3.78 liters
1 ft^3 = 7.48 gal.
Density = 62.4 lbm/ft^3
Density = 1 gm/cm^3
Heat of vaporization = 970 Btu/lbm
Heat of fusion = 144 Btu/lbm
1 Atm = 14.7 psi = 29.9 in. Hg.

Miscellaneous Conversions

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

Table 1. Saturated Steam: Temperature Table

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

*The states shown are metastable

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

Temp Fahr t	Abs Press Lb per Sq In p	Specific Volume Sat Liquid v_f	Specific Volume Evap v_{fg}	Specific Volume Sat Vapor v_g	Enthalpy Sat Liquid h_f	Enthalpy Evap h_{fg}	Enthalpy Sat Vapor h_g	Entropy Sat Liquid s_f	Entropy Evap s_{fg}	Entropy Sat Vapor s_g	Temp Fahr t
180.0	7.5110	0.016510	50.21	50.22	148.00	990.2	1138.2	0.2631	1.5480	1.8111	180.0
182.0	7.850	0.016522	48.172	48.189	150.01	989.0	1139.0	0.2662	1.5413	1.8075	182.0
184.0	8.203	0.016534	46.232	46.249	152.01	987.8	1139.8	0.2694	1.5346	1.8040	184.0
186.0	8.568	0.016547	44.383	44.400	154.02	986.5	1140.5	0.2725	1.5279	1.8004	186.0
188.0	8.947	0.016559	42.621	42.638	156.03	985.3	1141.3	0.2756	1.5213	1.7969	188.0
190.0	9.340	0.016572	40.941	40.957	158.04	984.1	1142.1	0.2787	1.5148	1.7934	190.0
192.0	9.747	0.016585	39.337	39.354	160.05	982.8	1142.9	0.2818	1.5082	1.7900	192.0
194.0	10.168	0.016598	37.808	37.824	162.05	981.6	1143.7	0.2848	1.5017	1.7865	194.0
196.0	10.605	0.016611	36.348	36.364	164.06	980.4	1144.4	0.2879	1.4952	1.7831	196.0
198.0	11.058	0.016624	34.954	34.970	166.08	979.1	1145.2	0.2910	1.4888	1.7798	198.0
200.0	11.526	0.016637	33.622	33.639	168.09	977.9	1146.0	0.2940	1.4824	1.7764	200.0
204.0	12.512	0.016664	31.135	31.151	172.11	975.4	1147.5	0.3001	1.4697	1.7698	204.0
208.0	13.568	0.016691	28.862	28.878	176.14	972.8	1149.0	0.3061	1.4571	1.7632	208.0
212.0	14.696	0.016719	26.782	26.799	180.17	970.3	1150.5	0.3121	1.4447	1.7568	212.0
216.0	15.901	0.016747	24.878	24.894	184.20	967.8	1152.0	0.3181	1.4323	1.7505	216.0
220.0	17.186	0.016775	23.131	23.148	188.23	965.2	1153.4	0.3241	1.4201	1.7442	220.0
224.0	18.556	0.016805	21.529	21.545	192.27	962.6	1154.9	0.3300	1.4081	1.7380	224.0
228.0	20.015	0.016834	20.056	20.073	196.31	960.0	1156.3	0.3359	1.3961	1.7320	228.0
232.0	21.567	0.016864	18.701	18.718	200.35	957.4	1157.8	0.3417	1.3842	1.7260	232.0
236.0	23.216	0.016895	17.454	17.471	204.40	954.8	1159.2	0.3476	1.3725	1.7201	236.0
240.0	24.968	0.016926	16.304	16.321	208.45	952.1	1160.6	0.3533	1.3609	1.7142	240.0
244.0	26.826	0.016958	15.243	15.260	212.50	949.5	1162.0	0.3591	1.3494	1.7085	244.0
248.0	28.796	0.016990	14.264	14.281	216.56	946.8	1163.4	0.3649	1.3379	1.7028	248.0
252.0	30.883	0.017022	13.358	13.375	220.62	944.1	1164.7	0.3706	1.3266	1.6972	252.0
256.0	33.091	0.017055	12.520	12.538	224.69	941.4	1166.1	0.3763	1.3154	1.6917	256.0
260.0	35.427	0.017089	11.745	11.762	228.76	938.6	1167.4	0.3819	1.3043	1.6862	260.0
264.0	37.894	0.017123	11.025	11.042	232.83	935.9	1168.7	0.3876	1.2933	1.6808	264.0
268.0	40.500	0.017157	10.358	10.375	236.91	933.1	1170.0	0.3932	1.2823	1.6755	268.0
272.0	43.249	0.017193	9.738	9.755	240.99	930.3	1171.3	0.3987	1.2715	1.6702	272.0
276.0	46.147	0.017228	9.162	9.180	245.08	927.5	1172.5	0.4043	1.2607	1.6650	276.0
280.0	49.200	0.017264	8.627	8.644	249.17	924.6	1173.8	0.4098	1.2501	1.6599	280.0
284.0	52.414	0.01730	8.1280	8.1453	253.3	921.7	1175.0	0.4154	1.2395	1.6548	284.0
288.0	55.795	0.01734	7.6634	7.6807	257.4	918.8	1176.2	0.4208	1.2290	1.6498	288.0
292.0	59.350	0.01738	7.2301	7.2475	261.5	915.9	1177.4	0.4263	1.2186	1.6449	292.0
296.0	63.084	0.01741	6.8259	6.8433	265.6	913.0	1178.6	0.4317	1.2082	1.6400	296.0
300.0	67.005	0.01745	6.4483	6.4658	269.7	910.0	1179.7	0.4372	1.1979	1.6351	300.0
304.0	71.119	0.01749	6.0955	6.1130	273.8	907.0	1180.9	0.4426	1.1877	1.6303	304.0
308.0	75.433	0.01753	5.7655	5.7830	278.0	904.0	1182.0	0.4479	1.1776	1.6256	308.0
312.0	79.953	0.01757	5.4566	5.4742	282.1	901.0	1183.1	0.4533	1.1676	1.6209	312.0
316.0	84.688	0.01761	5.1673	5.1849	286.3	897.9	1184.1	0.4586	1.1576	1.6162	316.0
320.0	89.643	0.01766	4.8961	4.9138	290.4	894.8	1185.2	0.4640	1.1477	1.6116	320.0
324.0	94.826	0.01770	4.6418	4.6595	294.6	891.6	1186.2	0.4692	1.1378	1.6071	324.0
328.0	100.245	0.01774	4.4030	4.4208	298.7	888.5	1187.2	0.4745	1.1280	1.6025	328.0
332.0	105.907	0.01779	4.1788	4.1966	302.9	885.3	1188.2	0.4798	1.1183	1.5981	332.0
336.0	111.820	0.01783	3.9681	3.9859	307.1	882.1	1189.1	0.4850	1.1086	1.5936	336.0
340.0	117.992	0.01787	3.7699	3.7878	311.3	878.8	1190.1	0.4902	1.0990	1.5892	340.0
344.0	124.430	0.01792	3.5834	3.6013	315.5	875.5	1191.0	0.4954	1.0894	1.5849	344.0
348.0	131.142	0.01797	3.4078	3.4258	319.7	872.2	1191.9	0.5006	1.0799	1.5806	348.0
352.0	138.138	0.01801	3.2423	3.2603	323.9	868.9	1192.7	0.5058	1.0705	1.5763	352.0
356.0	145.424	0.01806	3.0863	3.1044	328.1	865.5	1193.6	0.5110	1.0611	1.5721	356.0
360.0	153.010	0.01811	2.9392	2.9573	332.3	862.1	1194.4	0.5161	1.0517	1.5678	360.0
364.0	160.903	0.01816	2.8002	2.8184	336.5	858.6	1195.2	0.5212	1.0424	1.5637	364.0
368.0	169.113	0.01821	2.6691	2.6873	340.8	855.1	1195.9	0.5263	1.0332	1.5595	368.0
372.0	177.648	0.01826	2.5451	2.5633	345.0	851.6	1196.7	0.5314	1.0240	1.5554	372.0
376.0	186.517	0.01831	2.4279	2.4462	349.3	848.1	1197.4	0.5365	1.0148	1.5513	376.0
380.0	195.729	0.01836	2.3170	2.3353	353.6	844.5	1198.0	0.5416	1.0057	1.5473	380.0
384.0	205.294	0.01842	2.2120	2.2304	357.9	840.8	1198.7	0.5466	0.9966	1.5432	384.0
388.0	215.220	0.01847	2.1126	2.1311	362.2	837.2	1199.3	0.5516	0.9876	1.5392	388.0
392.0	225.516	0.01853	2.0184	2.0369	366.5	833.4	1199.9	0.5567	0.9786	1.5352	392.0
396.0	236.193	0.01858	1.9291	1.9477	370.8	829.7	1200.4	0.5617	0.9696	1.5313	396.0
400.0	247.259	0.01864	1.8444	1.8630	375.1	825.9	1201.0	0.5667	0.9607	1.5274	400.0
404.0	258.725	0.01870	1.7640	1.7827	379.4	822.0	1201.5	0.5717	0.9518	1.5234	404.0
408.0	270.600	0.01875	1.6877	1.7064	383.8	818.2	1201.9	0.5766	0.9429	1.5195	408.0
412.0	282.894	0.01881	1.6152	1.6340	388.1	814.2	1202.4	0.5816	0.9341	1.5157	412.0
416.0	295.617	0.01887	1.5463	1.5651	392.5	810.2	1202.8	0.5866	0.9253	1.5118	416.0
420.0	308.780	0.01894	1.4808	1.4997	396.9	806.2	1203.1	0.5915	0.9165	1.5080	420.0
424.0	322.391	0.01900	1.4184	1.4374	401.3	802.2	1203.5	0.5964	0.9077	1.5042	424.0
428.0	336.463	0.01906	1.3591	1.3782	405.7	798.0	1203.7	0.6014	0.8990	1.5004	428.0
432.0	351.00	0.01913	1.30266	1.32179	410.1	793.9	1204.0	0.6063	0.8903	1.4966	432.0
436.0	366.03	0.01919	1.24887	1.26806	414.6	789.7	1204.2	0.6112	0.8816	1.4928	436.0
440.0	381.54	0.01926	1.19761	1.21687	419.0	785.4	1204.4	0.6161	0.8729	1.4890	440.0
444.0	397.56	0.01933	1.14874	1.16806	423.5	781.1	1204.6	0.6210	0.8643	1.4853	444.0
448.0	414.09	0.01940	1.10212	1.12152	428.0	776.7	1204.7	0.6259	0.8557	1.4815	448.0
452.0	431.14	0.01947	1.05764	1.07711	432.5	772.3	1204.8	0.6308	0.8471	1.4778	452.0
456.0	448.73	0.01954	1.01518	1.03472	437.0	767.8	1204.8	0.6356	0.8385	1.4741	456.0

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

Temp Fahr t	Abs Press Lb per Sq In p	Specific Volume Sat Liquid v_f	Specific Volume Evap v_{fg}	Specific Volume Sat Vapor v_g	Enthalpy Sat Liquid h_f	Enthalpy Evap h_{fg}	Enthalpy Sat Vapor h_g	Entropy Sat Liquid s_f	Entropy Evap s_{fg}	Entropy Sat Vapor s_g	Temp Fahr t
460.0	466.87	0.01961	0.97463	0.99424	441.5	763.2	1204.8	0.6405	0.8299	1.4704	460.0
464.0	485.56	0.01969	0.93588	0.95557	446.1	758.6	1204.7	0.6454	0.8213	1.4667	464.0
468.0	504.83	0.01976	0.89885	0.91862	450.7	754.0	1204.6	0.6502	0.8127	1.4629	468.0
472.0	524.67	0.01984	0.86345	0.88329	455.2	749.3	1204.5	0.6551	0.8042	1.4592	472.0
476.0	545.11	0.01992	0.82958	0.84950	459.9	744.5	1204.3	0.6599	0.7956	1.4555	476.0
480.0	566.15	0.02000	0.79716	0.81717	464.5	739.6	1204.1	0.6648	0.7871	1.4518	480.0
484.0	587.81	0.02009	0.76613	0.78622	469.1	734.7	1203.8	0.6696	0.7785	1.4481	484.0
488.0	610.10	0.02017	0.73641	0.75658	473.8	729.7	1203.5	0.6745	0.7700	1.4444	488.0
492.0	633.03	0.02026	0.70794	0.72820	478.5	724.6	1203.1	0.6793	0.7614	1.4407	492.0
496.0	656.61	0.02034	0.68065	0.70100	483.2	719.5	1202.7	0.6842	0.7528	1.4370	496.0
500.0	680.86	0.02043	0.65448	0.67492	487.9	714.3	1202.2	0.6890	0.7443	1.4333	500.0
504.0	705.78	0.02053	0.62938	0.64991	492.7	709.0	1201.7	0.6939	0.7357	1.4296	504.0
508.0	731.40	0.02062	0.60530	0.62592	497.5	703.7	1201.1	0.6987	0.7271	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	0.7325	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	1.3142	616.0
620.0	1786.9	0.02466	0.19615	0.22081	646.9	506.3	1153.2	0.8403	0.4689	1.3092	620.0
624.0	1839.0	0.02489	0.18737	0.21226	653.1	496.6	1149.8	0.8458	0.4583	1.3041	624.0
628.0	1892.4	0.02514	0.17880	0.20394	659.5	486.7	1146.1	0.8514	0.4474	1.2988	628.0
632.0	1947.0	0.02539	0.17044	0.19583	665.9	476.4	1142.2	0.8571	0.4364	1.2934	632.0
636.0	2002.8	0.02566	0.16226	0.18792	672.4	465.7	1138.1	0.8628	0.4251	1.2879	636.0
640.0	2059.9	0.02595	0.15427	0.18021	679.1	454.6	1133.7	0.8686	0.4134	1.2821	640.0
644.0	2118.3	0.02625	0.14644	0.17269	685.9	443.1	1129.0	0.8746	0.4015	1.2761	644.0
648.0	2178.1	0.02657	0.13876	0.16534	692.9	431.1	1124.0	0.8806	0.3893	1.2699	648.0
652.0	2239.2	0.02691	0.13124	0.15816	700.0	418.7	1118.7	0.8868	0.3767	1.2634	652.0
656.0	2301.7	0.02728	0.12387	0.15115	707.4	405.7	1113.1	0.8931	0.3637	1.2567	656.0
660.0	2365.7	0.02768	0.11663	0.14431	714.9	392.1	1107.0	0.8995	0.3502	1.2498	660.0
664.0	2431.1	0.02811	0.10947	0.13757	722.9	377.7	1100.6	0.9064	0.3361	1.2425	664.0
668.0	2498.1	0.02858	0.10229	0.13087	731.5	362.1	1093.5	0.9137	0.3210	1.2347	668.0
672.0	2566.6	0.02911	0.09514	0.12424	740.2	345.7	1085.9	0.9212	0.3054	1.2266	672.0
676.0	2636.8	0.02970	0.08799	0.11769	749.2	328.5	1077.6	0.9287	0.2892	1.2179	676.0
680.0	2708.6	0.03037	0.08080	0.11117	758.5	310.1	1068.5	0.9365	0.2720	1.2086	680.0
684.0	2782.1	0.03114	0.07349	0.10463	768.2	290.2	1058.4	0.9447	0.2537	1.1984	684.0
688.0	2857.4	0.03204	0.06595	0.09799	778.8	268.2	1047.0	0.9535	0.2337	1.1872	688.0
692.0	2934.5	0.03313	0.05797	0.09110	790.5	243.1	1033.6	0.9634	0.2110	1.1744	692.0
696.0	3013.4	0.03455	0.04916	0.08371	804.4	212.8	1017.2	0.9749	0.1841	1.1591	696.0
700.0	3094.3	0.03662	0.03857	0.07519	822.4	172.7	995.2	0.9901	0.1490	1.1390	700.0
702.0	3135.5	0.03824	0.03173	0.06997	835.0	144.7	979.7	1.0006	0.1246	1.1252	702.0
704.0	3177.2	0.04108	0.02192	0.06300	854.2	102.0	956.2	1.0169	0.0876	1.1046	704.0
705.0	3198.3	0.04427	0.01304	0.05730	873.0	61.4	934.4	1.0329	0.0527	1.0856	705.0
705.47*	3208.2	0.05078	0.00000	0.05078	906.0	0.0	906.0	1.0612	0.0000	1.0612	705.47*

*Critical temperature

Master -

<u>ANSWERS</u>

5.1 a. D.T. x 1.443 = T = 86.6 sec.

b. P = Poe t/T
2P = Poe t/T
ln2 = t/T
T = t/ln2
T = t/.693
T = 1.443 x time

Ref: Rx Physics Review page 20

5.2 a. Fuel temperature primarily affects fast and intermediate neutrons which are resonantly captured, and control rods are thermal neutron absorbers. Therefore control rod worth remains constant as the temperature of the fuel increases.

b. As void content in the core region increases, less moderator is available for moderation. Thermal neutrons travel a greater distance (L increases) in a less dense moderator; however, the voids depress the thermal neutron flux significantly because they are not moderating very many neutrons thus rod worth decreases.

c. Control rod worth changes with respect to exposure are very complex, but essentially it follows a curve similar to the change in Keff over core life. Early in core life, as fission products build up, control rods are withdrawn, increasing core size and decreasing worth.

Ref: Reactor Physics Review page 36, 37, and 38.

5.3 a. Production = Production rate from direct fission yeild + production rate from decay of Iodine.

Removal = Removal rate by burnout + Removal by decay.

b. Following a scram, the burnup term goes to zero while production continues from the decay of iodine. Since the half life of I 135 is smaller than the half life of Xe 135, there is a net increase in Xe 135. The magnitude of the increase is significant and the peak occurs 7-11 hours after the scram. Following the peak removal is by decay with the production by decay decreasing.

Ref: Reactor Physics Review page 44 and 45

5.4 a. Neutron level would start and continue to increase until the point of adding heat is reached. As the coolant heats up negative reactivity is added and power turns. Power would stabilize at the point of adding heat.

b. Period would take a step jump due to the production of prompt neutrons. Immediately after this step, the rate of power change decreases to a rate controlled by delayed neutrons until the reactivity is no longer being increased. Then a sharp drop would occur as the rate of reactivity addition drops to zero. A stable period would continue until negative reactivity is inserted. Stabilizes at infinity.

Ref: Reactor Physics Review page 49 & 50

5.5 a. Increases or becomes more negative due to the buildup of resonance absorption materials, such as Pu -240 and fission products not present at BOL.

b. Decreases or becomes less negative due to a smaller fractional change in the neutrons being resonantly captured.

c. Increase or becomes more negative due to an increase in neutron slowing down length, causes neutrons to spend more time in resonance region.

Ref: Reactor Physics Review pages 30 and 31

5.6 a. The point where further heat addition or removal to a substance will cause it to boil or condense without a change in temperature at a constant pressure.

b. Measure of energy content of a substance.

Ref: Thermodynamics Heat Transfer and Fluid Flow for RO/SRO License Class page 8.

5.7 Insertion of control rods to reduce power will result in an increase in core flow. Reduced power lowers the resistance to flow by lowering the core and separator differential pressures. Since the driving force (Recirc. pps.) remain constant, and the resistance to flow decreases, core flow will increase.

Ref: Thermodynamics Heat Transfer and Fluid Flow for RO/SRO License Class page 40.

5.8 a. As flow increases CP increases since more power required to boil water in the shorter time it's present in the core.

b. As incoming water temperature decreases (Subcooling increases) CP will increase since more power required to boil water.

c. As pressure increases CP decreases since less enthalpy required to boil water. This is a small effect until water temperature approaches saturation.

Ref: Heat Transfer and Fluid Flow for RO/SRO License Class page 82.

5.9 Yes. As the rod is moved, neutron flux will change. Heat flux from fission is directly proportional to neutron flux. The water temperature next to the fuel rod will change only slightly if at all. (The only change would be heating up the subcooled water to saturation conditions in the lower part of the fuel.) Heat transfer is directly proportional to differential temperature. As water temperature stays approximately constant, centerline temperature must change as flux changes. (Will except either an up or down change.)

5.10 If the water level were too high carry over would occur. Carry over is a condition which occurs where moisture droplets are swept into the steam exiting the core due to high water level resulting in a low exit quality. These high velocity water droplets will cause excessive pipe errosions to occur. Damage by impingement to turbine and contamination of pure water by condenser breakdown.

If water level were too low carry under would occur. Carry under is a condition which occurs in the separator area whereas core water level is so low the water seal around the separator is broken and steam blowby to the annulus region occurs. This would result in steam bubbles being swept into the suction of the recirc pump, lowering the pumps NPSH and resulting in a loss of flow.

Ref: Heat Transfer and Fluid Flow for RO/SRO License Class page 79.

5.11 a. The hotter the feedwater is when it is returned to the vessel the higher the cycle efficiency.

b. It would be a waste of energy (heat) to dump each heater drain back to the condenser. The water drained from a heater is hotter than the feedwater in a lower pressure heater and this temperature difference can be used to pre-heat the feedwater.

5.12 a. LHGR is based on prevention of 1% plastic strain on clad due to pellet swelling.

b. Used to limit clad temperature during a DBA to 2200°F.

c. Will ensure APLHGR limits are not exceeded.

Ref: Heat Transfer and Fluid Flow page 81.

ANSWERS

6.1 a. Suppression pool > + 5" or CST < 10,000 gal.

b. Prevent pumping torus to CST

c. Prevent the CST from head drainging into the torus.

Ref: HPCI Lesson Plan

6.2 Any three for full credit.

a. Amber pilot light of squib firing continuity circuit not lit.

b. Flow indicating pilot light lit.

c. Reactor Water cleanup system isolation.

d. Decreasing level of standby liquid storage tank.

e. Standby liquid squib valve circuit fail annciator light lit.

Ref: QOP 1100-2

6.3 a.

Power Level	Speed Mismatch
below 80%	Within 15%
above 80%	Within 10%

b. Primarily to prevent interference with LPCI Loop Selection logic, and larger speed mismatches could produce flow-induced vibration of the lower-speed jet pump risers.

Ref: Recirc Lesson Plan page 19 and 20.

6.4 a. The load limit restricts the maximum opening of the control valves to the value selected by the potentiometer. Therefore, by restricting the control valves to 40% will cause the bypass valves to go open ~ 10% to accomodate the additional flow.

b. The max combined flow limiter places on upper limit on the total turbine and bypass steam flow demand. By restricting the total steam flow demand, an excessive fast blowdown is prevented in the event of a large upscale demand signal failure.

c. According to DGD set pt is 105°. According to Lesson Plan it is set 5% above actual demand. CAF

Ref: EHC Lesson Plan

6.5 a. The 101 valve should be closed prior to closing the 102 or 112 to prevent serious damage if a scram occurred while 101 was open and 102 or 112 was closed.

b. The HCU should not be isolated except during periods when the reactor is in the cold shutdown condition in order to prevent seal damage due to a lack of cooling water.

c. After a scram, the pumps will try to charge all the accumulators at once. Therefore, they would go into "run out" if not restricted. Pump damage or trips are prevented by a series of restricting orifices in the charging line which limits flow to a safe value.

Ref: QOP 300-8

6.6 a. The RBM - prevents local fuel damage that may result from a single rod withdrawal error <u>or</u> the RBM prevents the power in fuel bundles surrounding a control rod being withdrawn from approaching thermal limits.

The RWM is a backup to procedural control to limit control rod worth during startup and low power operation, so that in the event of a control rod drop accident the reactivity addition rate would not lead to damage of the fuel.

b. The RBM is required to be in operation 30% power or greater. It is in operation greater than 30% because the RBM protects against erroneous rod withdrawal in areas of high power density during high power operation. The RWM is required to be operational below 20% power because above 20% power there is no possible rod worth which if dropped at the design rate of the velocity limiter, could result in a peak enthalpy of 280 cal/gm or result in fuel damage.

6.7 a. Alarm and Rod block.

b. Hi -110% flow converter output
mismatch -10% mismatch between two converters.

c. Any two for full credit.

1. Mode switch not in operate

2. Module unplugged.

3. High voltage Power Supply low

Ref: SRO-700-4 page 4

6.8 a. OFF

b. The 1/2 DG will close to the first unit which experienced the undervoltage. As to which would get the DG would depend on which logic had the fastest relays.

c. By placing the switch in the ON position with the DG tied to that unit it would prevent the DG from transferring to Unit 2 if an ECCS and undervoltage condition occurred.

6.9 Removal of a Feedwater heater would cause undue stress and loading to be placed on the turbine. To prevent unbalance loads the feedwater heater removal would cause the MW output is limited.

Ref: QOP 3500-3 page 1

6.10 Any four for full credit.

1. RFP suction pressure greater than 120 psig.

2. Bearing lube oil pressure greater than 10 psig.

3. Condensate booster pump in service.

4. RFP ventilation fan in service.

5. Selected for standby.

Ref: QOP 3200-3 page 2.

6.11 The operator will remain in manual operation indefinitely until the electric motor is energized. When the handwheel is turned, it does not rotate the motor.

Ref: QOP 040-1 page 1

ANSWERS

7.1 a. Use of the Notch Override switch is not allowed between positions 04 and 12 on control rod arrays 3 and 4 and between positions 00 and 24 from half control rod density until the reactor pressure is 920 psig with at least one bypass valve partially open.

b. High rod and notch worths can be encountered during approach to criticality on a hot startup following a scram. The fast recovery after a scram results in peak Xenon conditions at the time you're trying to go critical, and when combined with the zero voids and hot temperatures, can result in very large notch worths in the region of criticality. Caution should be exercised in this area to avoid pulling into a short period with a single notch withdrawal.

7.2 a. 50 psig.

b. If pressure regulator setpoint should become less than reactor pressure with condenser vacuum less than or equal to 7 inches, upon attaining 7 inches of vacuum, a reactor scram could occur from the sudden opening of all turbine bypass valves.

7.3 Any four for full credit.

a. Verify all APRM are indicating between 4% and 12%.

b. Verify that all APRM DOWNSCALE lights are not illuminated.

c. Verify the main condenser backpressure is less than 7 inches Hg (> 23" Hg Vacuum).

d. Verify that Channel A/B Low Vacuum alarm is cleared.

e. Place one IRM/APRM recorder on each RPS channel to APRM.

7.4 a. Reactor pressure and/or neutron flux indication increases abruptly, and may go off-scale on recorders.

b. An ATWS Event is one in which the conditions which should initiate a scram are present but no scram occurs. A "Failure of Control Rods to Insert During a Scram" is when a scram has occurred with a failure of two (2) or more adjacent control rods or thirty (30) or more rods fail to insert below the 06 position.

7.5 a. Verify Reactor Scram.

b. Verify Group 1 Isolation if required.

c. Verify off-gas holdup line isolation if required.

d. Take off-gas and reactor water samples as necessary to determine the amount of activity present and to determine any trends.

e. Notify the Load Dispatcher and the Shift Engineer.

Ref: QGA-16

7.6 a. Manual

b. Tripping CB in Aux Electric Room

c. Tripping RPS MG sets at MCC

d. Stop air to scram solenoid valves.

Ref: QGA T-1

7.7 a. 95° - verify adequate RHRS discharge pressure and flow, to achieve less than 95° supp. pool temperature.

b. 101° - Do not allow pool temperature to exceed 100° if testing HPCI, RCIC or Relief Valves.

c. Scram Reactor.

d. Maintain 100°/hr cooldown if torus temperature reaches 120° if the reactor is isolated from its main heat sink. Continue until less than 150 psig.

7.8 The suction for compressor 2-4601 comes from outside the turbine building. This allows for non-contaminated air to be supplied for breathing purposes when the air around the compressors is contaminated.

Ref: QOA 1800-2

7.9 a. 1. Reduce recirculation flow at least 20% then -
2. Insert control rods.

Ref: QOA 3500-1

b. Control rods are inserted to clear the APRM highs. As feedwater temperature decreases, core inlet subcooling increases. This along with rod insertion tends to peak power low in the core. Recirc. flow is reduced to limit power rise in the lower region to help maintain PCIOMR limits to prevent cladding damage.

7.10 a. Unit 2 HPCI Sprinkler System - Backup fire suppression equipment must be established and inspections twice per shift.

b. Unit 2 Cable Tunnel Sprinker System. Backup fire suppression equipment must be established within one hour and a continuous fire watch provided.

c. Unit 2 DG room CO_2 - backup fire suppression equipment must be provided within 1 hour. Inspections twice per shift.

d. Penetration fire stop - continuous fire watch established within one hour for one side of penetration.

7.11 a. Turbine runback if any of the following exist.

1. Cooling water pressure at stator inlet drops to 13 psig.

2. Water temperature at the stator outlet increases to 95°C.

3. Stator cooling water low flow (98" H_2O DP)

b. If conductivity was greater than 10 umho/cm, trip the unit. If conductivity was greater than Q5 umho/cm, reduce generator load to zero and trip the unit within 3 minutes. If conductivity was less than 05 umho/cm, continue operation at less than or equal to 7380 generator stator amps for 60 minutes if desired.

Ref: QOA 5300-1

ANSWERS

8.1 a. Temporary Changes to Permanent Procedures, which do not change the intent of Permanent Procedures, may be made with the concurrence of 1 SRO and one of the individuals identified in the third column of QAP 1100-T1 (for operating procedures it would be another SRO).

b. The "intent" of a procedure is changed if one or more of the following conditions are met:

1. The procedure is a new procedure being implemented with Temporary Procedure Request sheet.

2. The Temporary Change to a Permanent Procedure is "less conservative" with respect to Technical Specifications or the FSAR than the permanent procedure.

3. The Temporary Changes alters the content or order of the "principle" steps.

c. No they (2 SROs) can authorize or concur with Temporary Changes in all groups except Tech. Staff procedures.

8.2 Access to the Drywell is not limited if all of the following conditions exist simultaneously:

1. Reactor is subcritical.

2. Mode switch is in "Shutdown" or "Refuel."

3. Reactor is vented.

4. Tip system is out of service.

8.3 1. Station Superintendent

2. Assistant Superintendent

3. Operating Engineers

4. Tech Staff Supervisor

5. Station Quality Assurance Personnel

6. NRC

Ref: QAP 1900-3

8.4 a. "S" (To lock the 345 KV yard or/and to lock valves and equipment in the proper position for safe plant operation according to prepared locked valve checklists.

"R" Locks and keys are used to control access to potentially high radiation areas.

"V" Vital area doors.

b. Shift Engineer (4) SCRE (1) Total of 5.

Ref: QAP 1900-9

8.5 Shift Foreman
Radwaste Foreman
Three Equipment Attendents
Duty RCT

Ref: QEP 340-5

8.6 a. Rad Chem Director

b. (Operational Support Center)

Ref: QEP 360-4

8.7 a. When the rod is withdrawn the first time subsequent to each refueling outage or after maintenance, observe discernible response of the nuclear instrumentation; and observe that the drive does not go to the overtravel position.

Ref: T.S. 3.3/4.3-2

b. Control rod withdrawal sequences shall be established so that the maximum reactivity that could be added by dropout of any increment of any one control blade would be such that the rod drop accident design limits are not exceeded.

Ref: T.S. 3.3/4.3-3

8.8 a. The condenser low vacuum scram is an anticipatory scram to the stop valve closure scram and causes a scram before the stop valves are closed and thus the resulting transient is less severe.

b. The turbine stop valve closure scram trip anticipates the pressure, neutron flux, and heat flux increases that could result from rapid closure of the turbine stop valves.

c. The low pressure isolation of the main steamlines at 825 psig was provided to give protection against rapid depressurization and the resulting rapid cooldown of the vessel. Advantage was taken of the scram feature in the Run mode which occurs when the main steamline isolation valves are closed to provide for reactor shutdown so that high power operation at low reactor pressures does not occur, thus providing protection for the fuel cladding integrity safety limit.

Ref: T.S. Basis 1.2/2-1-3

8.9 a. Instrument Calibration - means the adjustment of an instrument signal output so that it corresponds, within acceptable range and accuracy, to a known value of the parameter which the instrument monitors. Calibration shall encompass the entire instrument including actuation, alarm or trip.

b. Instrument Functional Test - means the injection of a simulated signal into the instrument primary sensor to verify the proper instrument response alarm and/or initiating action.

c. Instrument Check is a qualitative determination of acceptable operability by observation of instrument behavior during operation. This determination shall include, where possible, comparison of the instrument with other independent instruments measuring the same variable.

8.10 a. Its corresponding normal or emergency power source is operable.

b. All of its redundant system(s) in the other division are operable, or likewise satisfy the requirements of the specification.