U. S. NUCLEAR REGULATORY COMMISSION

REGION III

Report No. 50-456/OL-88-01(DRS)

Docket Nos. 50-456; 50-457 Licenses No. NPF-72; NPF-77

Licensee: Commonwealth Edison Company
Braidwood Station
R.R. 1, Box 84
Braceville, IL 60407

Facility Name: Braidwood Station

Examination Administered At: Braidwood Station and Production Training Center

Examination Conducted: July 18-22, 1988

Examiners: D. J. Damon — Date 8/18/88

P. R. Sunderland — 8-18-88 Date

J. A. Hopkins — 18 Aug 1988 Date

Approved By: Thomas M. Burdick, Chief, Operating Licensing Section 2 — 8/18/88 Date

Examination Summary

Examination administered on July 18-22, 1988 (Report No 50-456/OL-88-01(DRS)) to six Reactor Operator and seven Senior Operator candidates.
Results: Three Senior Reactor Operators candidates failed the examinations and one Reactor Operator candidate failed the examinations.

REPORT DETAILS

1. Examiners

T. M. Burdick
*D. J. Damon
J. A. Hopkins
P. R. Sunderland
T. Guilfoil, SONALYSTS
F. Victor, SONALYSTS

*Chief Examiner

2. Exit Meeting

On July 25, 1988, the examiners met with the members of the plant staff to discuss findings made during the course of the examinations. The following personnel attended the exit meeting.

Commonwealth Edison Company (CECo)

R. Querio, Station Manager
R. Ungeran, Operations Engineer, Unit 1
K. Kofron, Production Superintendent
D. O'Brien, Services Superintendent
T. Chasensky, Training Supervisor
D. Huston, Operator Licensing Training Group Leader

U.S. Nuclear Regulatory Commission (USNRC)

D. J. Damon, Region III Examiner
J. A. Hopkins, Region III Examiner

The following strengths and weaknesses were detailed to the facility staff:

a. Strengths

(1) The candidates exhibited strong team work and practiced good communication skills by using "repeat backs" or some other positive acknowledgement of most orders and most communications.

(2) The candidates demonstrated positive control in each phase of the bistable tripping procedure.

(3) The candidates exhibited good knowledge of individual systems and good familiarity with Technical Specifications.

(4) In general, the candidates used the operating procedures well, especially the Emergency Procedures.

b. Weaknesses

(1) In simulation scenarios with a loss of Centrifugal Charging Pump, most candidates did not shut Valve FCV-121 prior to starting the standby pump, as required by procedure BwAR 1-9-A3.

(2) In simulator scenarios with a loss of an electrical bus, the candidates would focus on an individual piece of equipment and ignore other equipment that had been lost. For example, the BOP would focus on the loss of an ESW pump, and ignore a stopped CC pump and the de-energized bus. In some cases, candidates did not even recognize that a bus had been lost.

(3) In general, the candidates had difficulty:

(a) identifying Temporary Alterations on a Critical Drawing; and

(b) explaining the meaning of the circled numbers on the Radiation Survey Maps.

(4) Some of the candidates were not aware that the RWP requires a review of the Radiation Survey Map prior to signing the RWP.

(5) On the SRO written exam, the majority of the candidates did not correctly answer a question concerning the verification of a reactor trip in the Emergency Operating Procedures.

(6) On the RO written exam, all candidates failed to correctly answer a question concerning verification of a stuck control rod. BwOA-ROD-3 specifies exercising rod banks in five step increments. Most candidates stated that rod banks must be exercised in 10 step increments.

c. General Comments

Although these topics were not covered by every examiner and are not considered generic in nature, they deserve mention in this report.

(1) QA by the licensee's Training Department on examination materials sent to the NRC was inconsistent. For example, one side of a two sided page would not be copied, drawings and even entire chapters would be missing. Additionally, the system descriptions were not all current, which affected the written examination.

(2) During the conduct of the operating examination, some deficiencies were noted in the implementation of certain Administrative Procedures. For example:

(a) A caution card on the Main Control Board could not be found in the Master Caution Logbook.

(b) The status of an Out of Service (OOS) Tag logged in the Master OOS Logbook could not be determined.

(c) The status of a Nuclear Work Request identified on the Shift Engineer's Turnover Log could not be determined.

3. Examination Review

The following are facility comments on the written examination and their respective NRC resolutions:

Question 1.20

Facility Comment

Part a — Acceptable answer for description should also be ". . . suction pressure less than minimum required NPSH . . . ."

NRC Resolution

Comment accepted. Answer Key modified to give credit for "When pump suction pressure (0.25) is less than minimum required NPSH (0.25) bubbles form." This first phase of the second sentence will be accepted for credit, as well as the current key.

Part b — Additional acceptable answers should be:

- Temperature alarms on components served
- Low flow alarms on components served

NRC Resolution

Comment not accepted. These alarms are considered annunciators in the Control Room and were specifically excluded in the question. However, "Temperature increasing on components served" will be added to the answer key. Answer key modified.

Question 3.02

Facility Comment

Part b — The question is very confusing, difficult to tell what is wanted. The questions asks what generates a Logic Cabinet Urgent Failure. The key gives answers for "Power Cabinet Urgent Failure." Recommend that Logic Cabinet Urgent Failure Alarms also be acceptable.

1. Loose or missing card
2. Slave Cycler failure
3. Oscillator failure
4. Shutdown banks C, D, E circuit failure

NRC Resolution

Part b deleted.

Question 3.03

Facility Comment

Part b — The question asks for four rod stops that block both manual and auto withdrawal other than OTDT and OPDT. The key lists only two. The key is correct in that there are only two such rod stops.

Recommend full credit for the two listed in the key.

NRC Resolution

Part b deleted.

Question 3.12(a) (Third Sentence)

Facility Comment

Part a — Answer should state: Chilled water to the RCFC chilled water coils vice "Essential Service Water to the chilled water coils."

NRC Resolution

Comment not accepted. Chilled water to the RCFC chilled water coils is not isolated on a Safety Injection signal. The SI signal bypasses SX to the Primary Containment Refrigeration Unit. This causes the chill water pump to trip. Chilled water is not isolated. Answer key modified.

Question 4.05(b)

Facility Comment

Part b — Typical valve numbers should be acceptable for full credit.

NRC Resolution

Comment accepted. Answer key modified.

Question 5.01

Facility Comment

The question asks for a description of the effects of a boration on shutdown margin. The answer key then requires an explanation of the effect on a trip. Recommend that the last sentence not be required for full credit.

NRC Resolution

Comment accepted. Answer key modified.

Question 5.03

Facility Comment

Significantly different values for Delta-rho can be obtained by using different calculational methods. Request that a band of ±30 pcm be acceptable on the answer, and the following calculational methods for delta-rho be acceptable.

a. $\text{Delta-rho} = \ln \frac{(K^2)}{K_1}$

b. $\text{Delta-rho} = \frac{K_2 - K_1}{K_2 K_1}$

NRC Resolution

Comment partially accepted. Alternate calculational methods will be accepted for full credit. Because of this, a range for the total delta-rho will be set at 960 to 1000 pcm. The range for xenon delta-rho will be set at -500 to -540 pcm.

Question 5.08 (a)

Facility Comment

Part a   Since the question did not specify that only moderator temperature changed; recommend that the following answer be considered:

If moderator temperature increases, fuel temperature must increase (at or above POAH) thus doppler power coefficient will add negative reactivity.

NRC Resolution

Comment partially accepted. While it is true that a fuel temperature increase will result in a moderator temperature increase, this is not the only method that can be used to raise moderator temperature. Therefore, if a candidate states the assumption that the moderator temperature increase was due to a fuel temperature increase, credit will be given for the facility requested answer as one part of the overall answer. Answer Key is modified accordingly.

Question 5.09(b)

Facility Comment

Part b — The reason for a smaller power decrease given in the answer key is incorrect. Doppler Power Coefficient gets less negative as the core ages. Even though Fuel Temperature Coefficient gets more negative due to buildup of Pu^{240}, clad creep causes the change in Fuel Temperature per % power to decrease--this overrides the Pu^{240} effect. The power decreases is smaller at the end of life because MTC is so much more negative, temperature does not have to decrease as much to compensate for rods.

NRC Resolution

Comment accepted. Answer Key modified.

Question 6.03

Facility Comment

Question premise is false, all Diesel Generator and Diesel engine trips are simultaneous. Thus, examinees were unable to determine what the question was asking. Recommend this question be deleted.

NRC Resolution

Comment not accepted. The answers given in the original key energize a generator trip relay which in turn energizes a engine shutdown relay. Though the two trip signals are fractions of a second apart, the generator trip does in fact occur first. Also, based on additional references, the answer key is expanded to include the following: manual, bus lockout, and SI. Answer Key modified as indicated.

Question 6.08(d)

Facility Comment

High water temperature should by 205° vice 225°.

NRC Resolution

Comment accepted. Typographical error was corrected.

Question 6.10

Facility Comment

Contact 3 should be (RTA) (BYA)

This was recently changes as a result of the modification to P-8. This change is still in routing and has not been incorporated into all of the Braidwood Training Material.

NRC Resolution

Comment accepted. Answer Key modified. It is expected that the facility develop a system to inform the NRC examiners prior to examinations when a change has been made that has not been incorporated into training materials.

Question 7.06

Facility Comment

1. Should be an Unusual Event, Lake level is below Tech Spec minimum; as this Tech Spec has no correction period, we must immediately begin shutting down.

2. Could be an Unusual Event. Question does not state why the operator initiated S.I. but indicates it might have been required as pressure has stabilized below shutoff head of Hi Head SI and below Normal Operating Pressure. This is symptomatic of a small break LOCA. Recommend either answer, None or Unusual Event be accepted.

3. Answer could be None as EAL, specifies that an inadvertent dilution must be cause for rods going below Low-Low insertion limit and question does not give enough information to determine whether or not that is cause of runback. Recommend that either answer, None or Unusual Event be accepted.

NRC Resolution

1. Comment accepted. Answer Key modified.

2. Comment partially accepted. Answer Key modified to require Unusual Event as the answer.

3. Comment accepted. Answer Key modified.

Question 7.07

Facility Comment

Training guidance as agreed to by PTC, Braidwood and Byron in this matter, is that if one trip breaker is open and all other Rx trip parameters are verified, i.e. rod bottom lights are lit and a negative startup rate exists, it is not necessary to go to BwFR-S.1.

Recommend that an answer along the line of "Send a person to locally open the closed trip breaker" be acceptable for full credit.

NRC Response

Comment not accepted. BwAP 340-1, Paragraph C.2.b.1 states in part "When the sequence is not important, the low-level step shall be preceded by a bullet. A "closed bullet" requires all steps to be completed in any order "(•)." This statement removes all decision making from the operator regarding the completion of low-level steps preceded by a closed bullet. BwAP 340-1 further states that "If an action cannot be performed or an expected response is not obtained, the user should go to the contingency response or action." Thus, to conform with BwAP 340-1, if a low-level step that is preceded by a closed bullet cannot be performed, the major step is not considered to be completed satisfactory and the response not obtained column must be entered.

Training policy as generated by PTC regarding the implementation of EP-0 step 1 violates the guidance contained in BwAP 340-1. Technical Specification 6.8.1 gives specific guidance concerning the use of procedures. Technical Specification 6.8.2 sets forth the review requirements that must be met prior to implementing changes to the procedures as listed in 6.8.1. Since the training policy has not been reviewed by the Onsite Review and Investigative Function as stated in Technical Specification 6.5.2, the facility may not be operated in accordance with training policy and must be operated in accordance with approved administrative and emergency operating procedures.

The Answer Key remains unchanged.

Question 7.08

Facility Comment

Point source formula not provided on formula sheet. Recommend that full credit be awarded for any reasonable and conservative attempt to solve, or the question be deleted.

NRC Resolution

Comment accepted. The fact that the formula was not provided will be taken into account and credit will be assigned accordingly.

Question 8.10

Facility Comment

An alternate acceptable answer should be: ". . . provides assurance that a mass addition pressure transient can be relieved by the operation of a single PORV or an RHR relief valve."

NRC Resolution

Comment accepted. Answer Key modified.

Question 8.11

Facility Comment

Key is only practically correct. Additional instances are:

1. To prevent injury to public or company personnel.
2. To prevent releases off-site in excess of Tech Spec limits.
3. To prevent damage to equipment if such damage is tied to a possible adverse effect on public health and safety.

Also:

In an emergency when this action is immediately needed to protected the public health and safety and no action consistent with license conditions and Tech Specs is immediately apparent. Recommend that these two answers also be acceptable for full credit.

NRC Resolution

Comment accepted. Answer Key modified.

MASTER COPY

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

FACILITY: BRAIDWOOD 1&2

REACTOR TYPE: PWR-WEC4

DATE ADMINISTERED: 88/07/18

EXAMINER: DAMON, D.

CANDIDATE: ______________________

INSTRUCTIONS TO CANDIDATE:

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

CATEGORY VALUE	% OF TOTAL	CANDIDATE'S SCORE	% OF CATEGORY VALUE	CATEGORY
25.00	25.00	________	________	5. THEORY OF NUCLEAR POWER PLANT OPERATION, FLUIDS, AND THERMODYNAMICS
25.00	25.00	________	________	6. PLANT SYSTEMS DESIGN, CONTROL, AND INSTRUMENTATION
25.00	25.00	________	________	7. PROCEDURES - NORMAL, ABNORMAL, EMERGENCY AND RADIOLOGICAL CONTROL
25.00	25.00	________	________	8. ADMINISTRATIVE PROCEDURES, CONDITIONS, AND LIMITATIONS
100.00		________ Final Grade	________%	Totals

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

____
Candidate's Signature

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NRC RULES AND GUIDELINES FOR LICENSE EXAMINATIONS

During the administration of this examination the following rules apply:

1. Cheating on the examination means an automatic denial of your application and could result in more severe penalties.

2. Restroom trips are to be limited and only one candidate at a time may leave. You must avoid all contacts with anyone outside the examination room to avoid even the appearance or possibility of cheating.

3. Use black ink or dark pencil only to facilitate legible reproductions.

4. Print your name in the blank provided on the cover sheet of the examination.

5. Fill in the date on the cover sheet of the examination (if necessary).

6. Use only the paper provided for answers.

7. Print your name in the upper right-hand corner of the first page of each section of the answer sheet.

8. Consecutively number each answer sheet, write "End of Category __" as appropriate, start each category on a new page, write only on one side of the paper, and write "Last Page" on the last answer sheet.

9. Number each answer as to category and number, for example, 1.4, 6.3.

10. Skip at least three lines between each answer.

11. Separate answer sheets from pad and place finished answer sheets face down on your desk or table.

12. Use abbreviations only if they are commonly used in facility literature.

13. The point value for each question is indicated in parentheses after the question and can be used as a guide for the depth of answer required.

14. Show all calculations, methods, or assumptions used to obtain an answer to mathematical problems whether indicated in the question or not.

15. Partial credit may be given. Therefore, ANSWER ALL PARTS OF THE QUESTION AND DO NOT LEAVE ANY ANSWER BLANK.

16. If parts of the examination are not clear as to intent, ask questions of the examiner only.

17. You must sign the statement on the cover sheet that indicates that the work is your own and you have not received or been given assistance in completing the examination. This must be done after the examination has been completed.

18. When you complete your examination, you shall:

a. Assemble your examination as follows:

(1) Exam questions on top.

(2) Exam aids - figures, tables, etc.

(3) Answer pages including figures which are part of the answer.

b. Turn in your copy of the examination and all pages used to answer the examination questions.

c. Turn in all scrap paper and the balance of the paper that you did not use for answering the questions.

d. Leave the examination area, as defined by the examiner. If after leaving, you are found in this area while the examination is still in progress, your license may be denied or revoked.

DATA SHEET

REACTOR THEORY FORMULAS:

$$P = P_0 e^{t/\tau}$$

$$P = P_0 10^{SUR(t)}$$

$$P = \frac{\Sigma\ \phi_{th}\ V}{3.12 \times 10^{10} \text{ fissions/sec}}$$

$$SUR = 26.06/\tau$$

$$P_{th} = \frac{1}{1 + (B^2 L_{th}^2)} = e^{-(B^2 L_{th}^2)}$$

$$\rho = \frac{l^*}{\tau} + \frac{\overline{\beta}_{eff}}{1 + \lambda\tau}$$

$$P_f = e^{-(B^2 L_f^2)}$$

$$\rho = \frac{K - 1}{K}$$

$$p = e^{-[N][I_{eff}]/\xi\Sigma_s}$$

$$\Delta\rho = \ln \frac{K_{final}}{K_{initial}}$$

$$C_1 (1-K_{eff1}) = C_2 (1-K_{eff2})$$

$$\tau = \frac{\overline{\beta}_{eff} - \rho}{\lambda\rho}$$

$$= \frac{l^*}{\rho}$$

$$m = \frac{1}{1-K} = \frac{C_{final}}{C_{initial}}$$

$$\alpha_T = \frac{1}{f}\frac{\Delta f}{\Delta t} + \frac{1}{p}\frac{\Delta p}{\Delta t} - B^2 \left(\frac{\Delta L_f^2}{\Delta t} + \frac{\Delta L_{th}^2}{\Delta t}\right)$$

$$K_{eff} = \epsilon\ P_f\ p\ P_{th}\ f\ \eta$$

$$P_1 = P_0 \frac{\overline{\beta}_{eff} - \rho_0}{\overline{\beta}_{eff} - \rho_1}$$

DATA SHEET

THERMODYNAMICS AND FLUID MECHANICS FORMULAS:

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

$$\dot{Q} = \frac{2 \pi L \Delta T}{\frac{1}{K} + \frac{\ln R_2/R_1}{K_2} + \frac{\ln R_3/R_2}{K_3}}$$

$$\dot{Q} = U A (\Delta T_m)$$

$$\dot{Q} = \dot{m} c_p (\Delta T)$$

$$\dot{Q} = \alpha \delta A R^4$$

$$\eta = \frac{\dot{Q}_{in} - \dot{Q}_{out}}{\dot{Q}_{in}}$$

$$\eta = \frac{(h_{in} - h_{out})real}{(h_{in} - h_{out})ideal}$$

$$\eta_p = \frac{W_{actual}}{W_{supplied}}$$

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$$\dot{m} = \rho A V$$

$$\rho_1 A_1 V_1 = \rho_2 A_2 V_2$$

$$\dot{m} = KA \sqrt{\Delta P_x \rho}$$

$$\dot{m}_{nc} = KA_Q \sqrt[3]{Q} = KA \Delta T \sqrt{\Delta T} = KA \Delta p \sqrt{\Delta P}$$

$$\Delta T_m = \frac{\Delta T (in) - \Delta T (out)}{\ln \left(\frac{\Delta T (in)}{\Delta T (out)} \right)}$$

$$G = \frac{\Sigma_f \delta_{th}}{8.8 \times 10^9}$$

$$T_{cl} - T_{ps} = \frac{Gr^2}{4k}$$

$$\dot{Q} = \frac{kA\Delta T}{\Delta x}$$

$$\dot{Q} = \frac{A \Delta T_{total}}{\frac{\Delta x_a}{K_a} + \frac{\Delta x_b}{K_b} + \ldots + \frac{\Delta x_n}{K_n}}$$

DATA SHEET

CENTRIFUGAL PUMP LAWS:

$$\frac{N_1}{N_2} = \frac{\dot{m}_1}{\dot{m}_2} \qquad \frac{(N_1)^2}{(N_2)^2} = \frac{H_1}{H_2} \qquad \frac{(N_1)^3}{(N_2)^3} = \frac{P_1}{P_2}$$

RADIATION AND CHEMISTRY FORMULAS:

$R/hr = 6CE/d^2$ $\qquad I_x = I_0 e^{-mx}$ $\qquad C_1V_1 = C_2V_2$

$G = \frac{\text{Dilution Rate}}{\text{Volume}}$ $\qquad I = I_0 \frac{(1)^n}{10}$ $\qquad C = C_0 e^{-Gt}$

$A = A_0 e^{-\lambda t}$ $\qquad A = \lambda N$

CONVERSIONS:

1 gm/cm^3 = 62.4 lbm/ft^3	Density of water (20 C) = 62.4 lbm/ft^3
1 gal = 8.345 lbm	
1 ft^3 = 7.48 gal	Avogadro's Number = 6.023 x 10^{23}
1 gal = 3.78 liters	Heat of Vapor (H_2O) = 970 Btu/lbm
1 lbm = 454 grams	Heat of Fusion (ICE) = 144 Btu/lbm
e = 2.72	1 AMU = 1.66 x 10^{-24} grams
π = 3.14159	Mass of Neutron = 1.008665 AMU
1 KW = 738 ft-lbf/sec	Mass of Proton = 1.007277 AMU
1 KW = 3413 Btu/hr	Mass of Electron = 0.000549 AMU
1 HP = 550 ft-lbf/sec	One atmosphere = 14.7 psia = 29.92 in. Hg
1 HP = .746 KW	°F = 9/5 °C + 32
1 HP = 2545 Btu/hr	°C = 5/9 (°F - 32)
1 Btu = 778 ft-lbf	°R = °F + 460
1 MEV = 1.54 x 10^{-16} Btu	°K = °C + 273
h = 4.13 x 10^{-21} M-sec	
1 W = 3.12 x 10^{10} fissions/sec	
g_c = 32.2 lbm-ft/lbf-sec^2	c^2 = 931 MEV/AMU
1 inch = 2.54 cm	C = 3 x 10^8 m/sec
σ = 0.1714 x 10^{-8} Btu/hr ft^2 R^4	

DATA SHEET

AVERAGE THERMAL CONDUCTIVITY (K)

Material	K
Cork	0.025
Fiber Insulating Board	0.028
Maple or Oak Wood	0.096
Building Brick	0.4
Window Glass	0.45
Concrete	0.79
1% Carbon Steel	25.00
1% Chrome Steel	35.00
Aluminum	118.00
Copper	223.00
Silver	235.00
Water (20 psia, 200 degrees F)	0.392
Steam (1000 psia, 550 degrees F)	0.046
Uranium Dioxide	1.15
Helium	0.135
Zircaloy	10.0

MISCELLANEOUS INFORMATION:

$E = mc^2$

$KE = 1/2\ mv^2$

$PE = mgh$

$V_f = V_0 + at$

Geometric Object	Area	Volume
Triangle	$A = 1/2\ bh$	//////////////////
Square	$A = S^2$	//////////////////
Rectangle	$A = L \times W$	//////////////////
Circle	$A = \pi r^2$	//////////////////
Rectangular Solid	$A = 2(L \times W + L \times H + W \times H)$	$V = L \times W \times H$
Right Circular Cylinder	$A = (2\ \pi r^2)h + 2(\pi r^2)$	$V = \pi r^2 h$
Sphere	$A = 4\ \pi r^2$	$V = 4/3\ (\pi r^2)$
Cube	///////////////////////////////	$V = S^3$

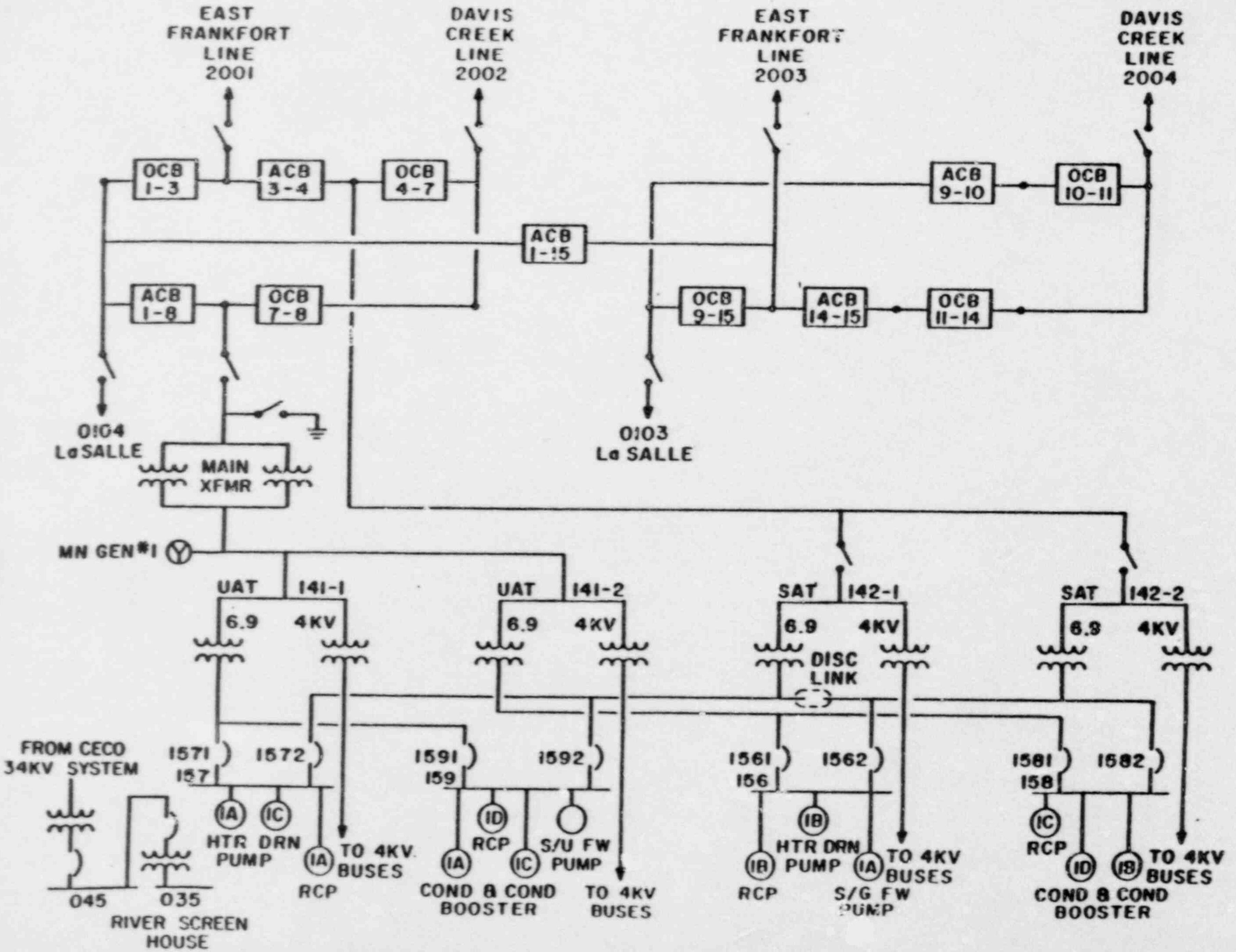
DATA SHEET

MISCELLANEOUS INFORMATION (continued):

Material	Half-Life	Gamma Energy MEV per Disintegration		10 CFR 20 Appendix B Table I Col I Air uc/ml	Table I Col II Water uc/ml	Table II Col I Air uc/ml	Table II Col II Water uc/ml
Ar-41	1.84 h	1.3	Sub	2×10^{-6}	-----	4×10^{-8}	------
Co-60	5.27 y	2.5	S	3×10^{-7}	1×10^{-3}	1×10^{-8}	5×10^{-5}
I-131	8.04 d	0.36	S	9×10^{-9}	6×10^{-5}	1×10^{-10}	3×10^{-7}
Kr-85	10.72 y	0.04	Sub	1×10^{-5}	-----	3×10^{-7}	------
Ni-65	2.52 h	0.59	S	9×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
Pu-239	2.41×10^{4} y	0.008	S	2×10^{-12}	1×10^{-4}	6×10^{-14}	5×10^{-6}
Sr-90	29 y	-----	S	1×10^{-9}	1×10^{-5}	3×10^{-11}	3×10^{-7}
Xe-135	9.09 h	0.25	Sub	4×10^{-6}	-----	1×10^{-7}	------
Any single radionuclide with $T_{1/2} > 2$ hr which does not decay by alpha or spontaneous fission				3×10^{-9}	9×10^{-5}	1×10^{-10}	3×10^{-6}

Neutron Energy (MEV)	Neutrons per cm^2 equivalent to 1 rem	Average flux to deliver 100 mrem in 40 hours (neutrons / $cm^2 \times$ sec)
thermal	970×10^{6}	670
0.02	400×10^{6}	280
0.5	43×10^{6}	30
10	24×10^{6}	17

Linear Absorption Coefficients μ (cm^{-1})				
Energy (MEV)	Water	Concrete	Iron	Lead
0.5	0.090	0.21	0.63	1.7
1.0	0.067	0.15	0.44	0.77
1.5	0.057	0.13	0.40	0.57
2.0	0.048	0.11	0.33	0.51
2.5	0.042	0.097	0.31	0.49
3.0	0.038	0.088	0.30	0.47



INFORMATION ONLY

FIGURE 4.1 A.C. DISTRIBUTION SINGLE

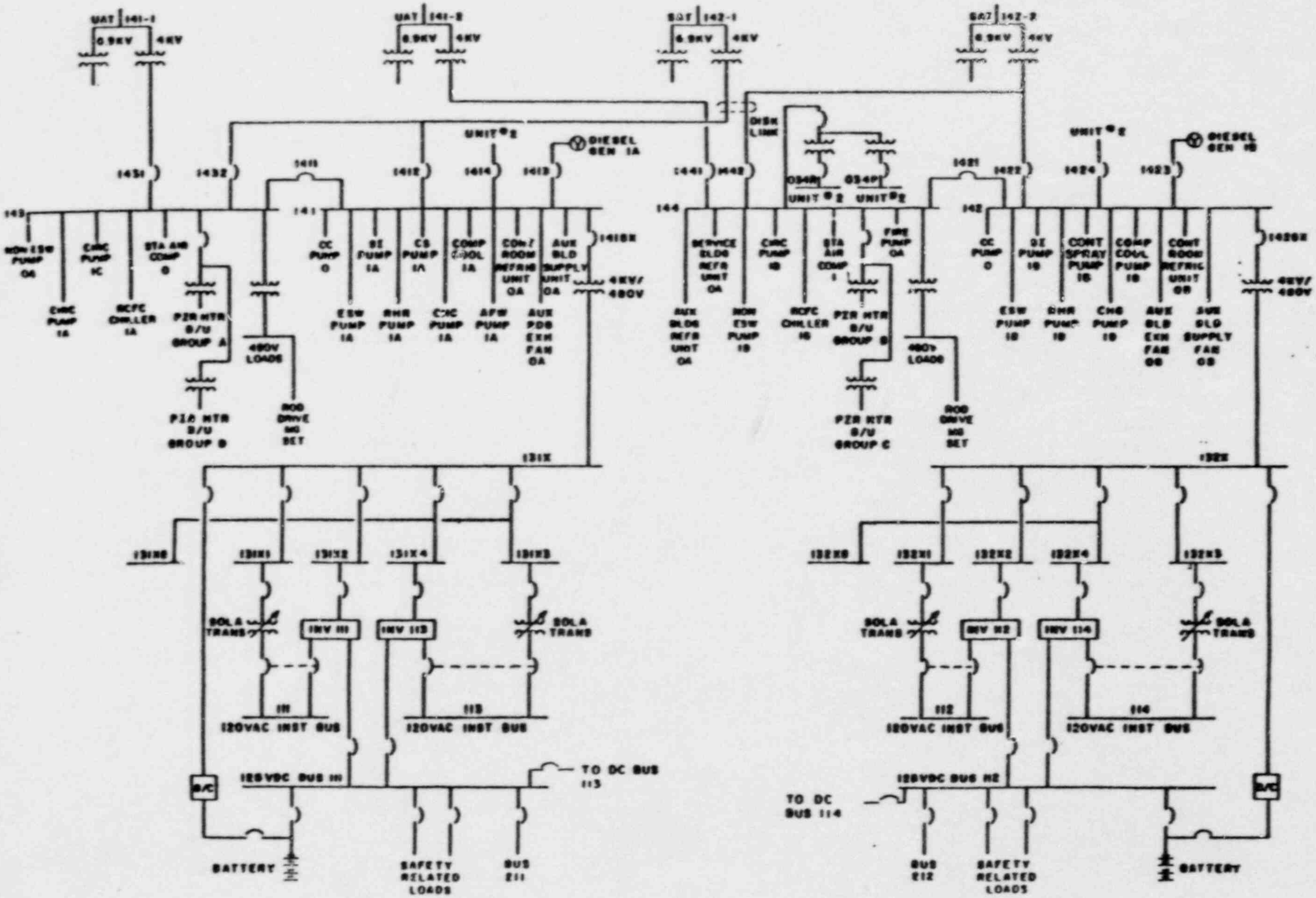


FIGURE 4-2 A.C. DISTRIBUTION SINGLE LINE DIAGRAM PART 2 (REV. 0)

INFORMATION ONLY

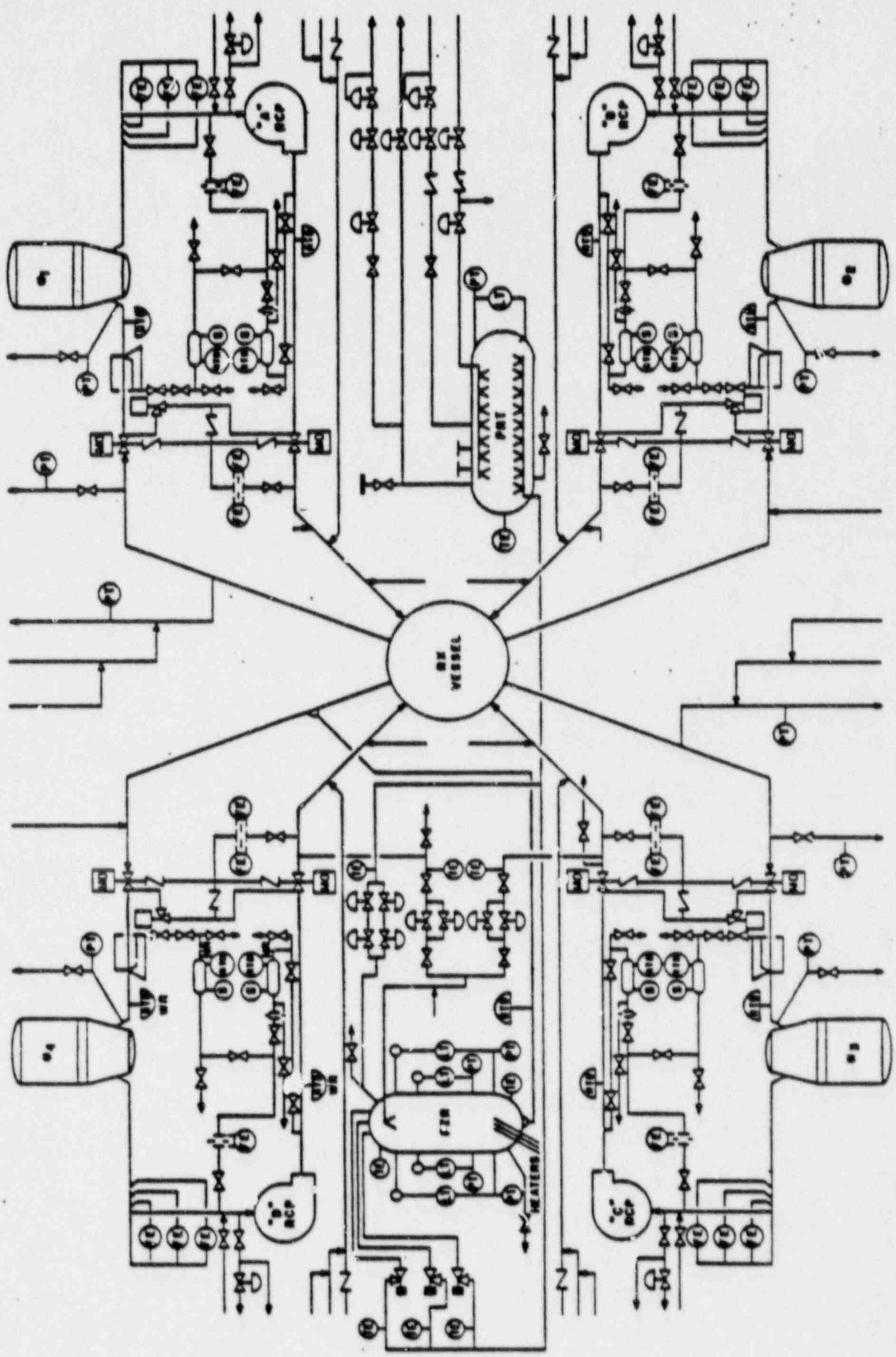


FIGURE 12-1A REACTOR COOLANT SYSTEM

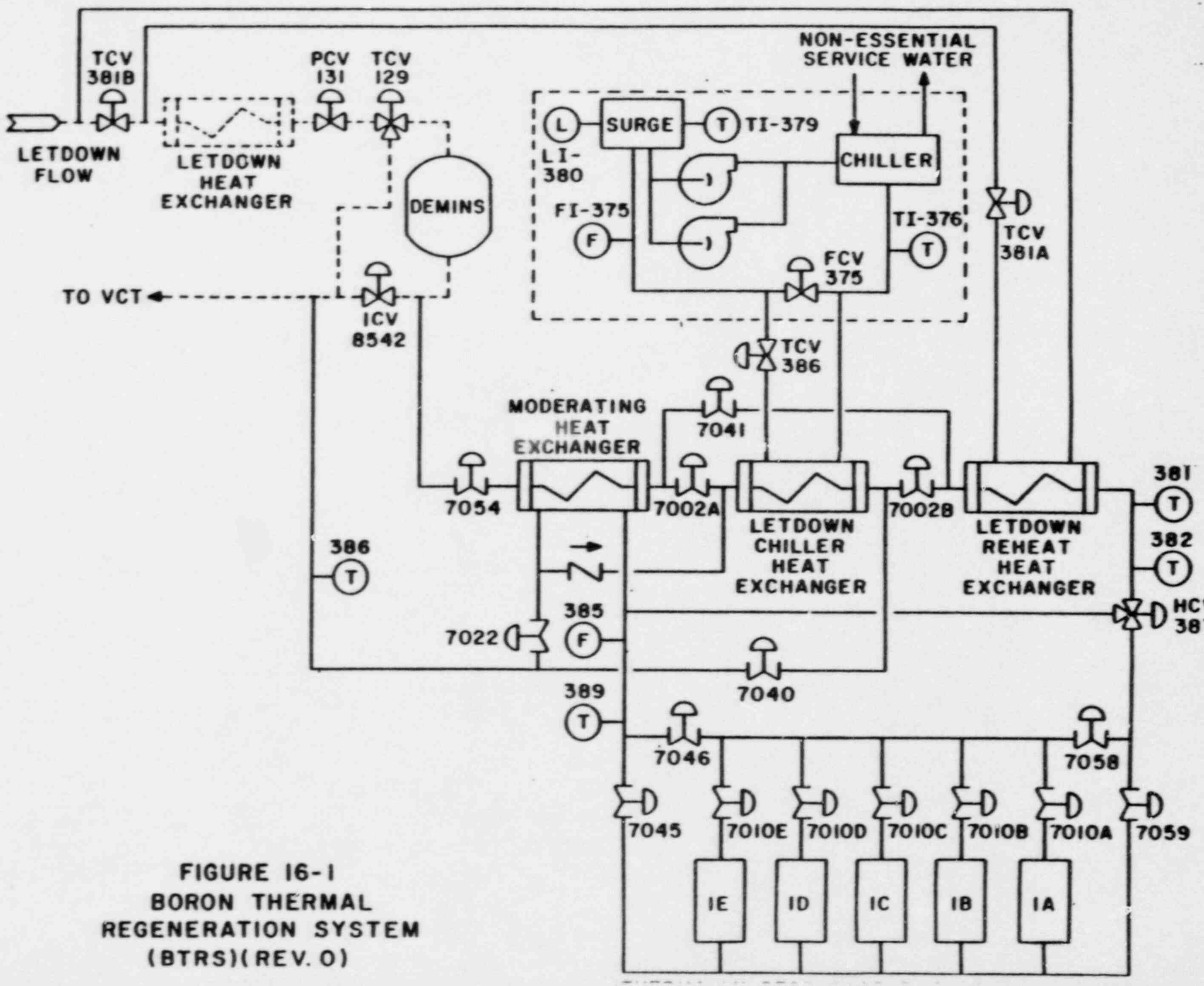


FIGURE 16-1
BORON THERMAL
REGENERATION SYSTEM
(BTRS)(REV. 0)

INFORMATION ONLY

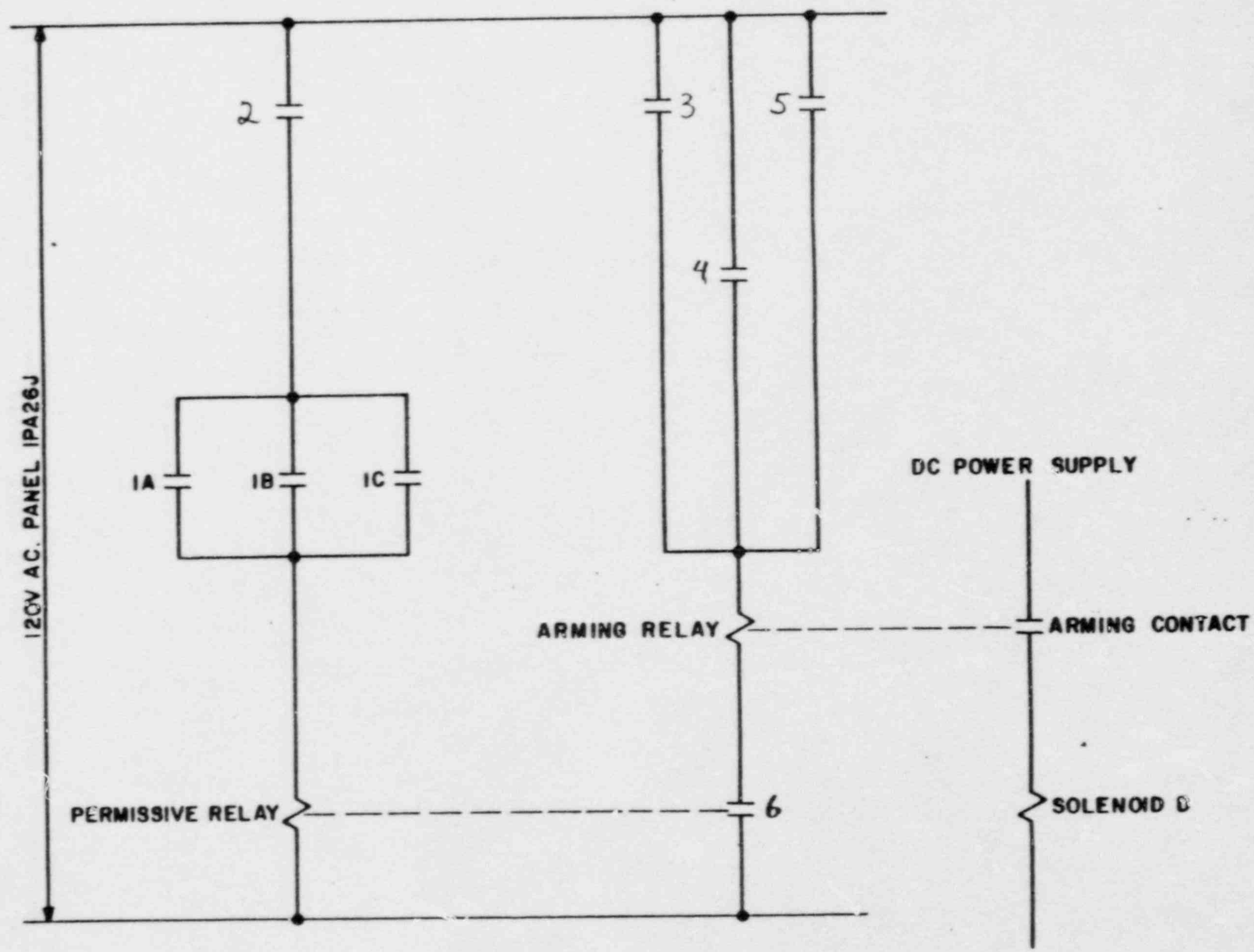


FIGURE 24-11 CONDENSER PERMISSIVE CIRCUIT (REV. 0)

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED

CAUTION

Steps 1 thru 5 should be performed without delay. BwFRs should NOT be implemented prior to completion of these steps.

CAUTION

The following Spurious Valve Actuation Guideline (SVAG) valves must be energized locally at MCCs, before transfer to Cold Leg Recirculation.

- SI pump suction from RWST Isol Valve:
  - 1SI8806 (MCC 131X 1AP3)
- SI pump Mini Flow Isol Valve:
  - 1SI8813 (MCC 132X 4AL3)

CAUTION

SI recirculation flow to the RCS must be maintained at all times.

CAUTION

If offsite power is lost after SI reset, then manual action may be required to restart safeguard equipment.

NOTE

With this procedure in effect, notify the Station Director who will evaluate for GSEP conditions, per BwZP 200-1, BRWD EMERGENCY ACTION LEVELS.

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Step continued on next page

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED
1	RESET SI:	Reset SI per 1BwOA PRI-5, CONTROL ROOM INACCESSIBLITY.
	a. Depress both SI reset pushbuttons	
	b. Verify SI ACTUATED permissive light - NOT LIT	
	c. Verify AUTO SI BLOCKED permissive light - LIT	
2	VERIFY CC WATER FLOW TO THE RH HEAT EXCHANGERS:	
	a. CC to RH HX isol valves - OPEN: • 1CC9412A • 1CC9412B	a. Manually open CC to RH HX isol valves: • 1CC9412A • 1CC9412B
	b. CC flow indicated on 1FI688 and 1FI689 - GREATER THAN 4670 GPM	b. Verify locally RH HX outlet butterfly valve throttled: • 1CC9507A (364' +12' S16 AB) • 1CC9507B (364' +12' S17 AB)
3	VERIFY ADEQUATE CNMT RECIRCULATION SUMP LEVEL:	
	a. Bottom 4 Cnmt recirc sump level indicator lights - LIT	a. Check floor water level channels A (1LI-PC006) and B (1LI-PC007), greater than 1 inch. IF level greater than 1 inch, THEN GO TO Step 4. IF level is less than 1 inch, THEN GO TO 1BwCA-1.1, LOSS OF EMERGENCY COOLANT RECIRCULATION, Step 1.

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STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED

CAUTION

Any pumps taking suction from RWST should be stopped upon RWST EMPTY alarm (5.9%).

CAUTION

SI pumps should be stopped if RCS pressure is GREATER THAN 1590 PSIG, their shutoff head pressure.

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED

4	VERIFY CNMT RECIRCULATION SUMP ISOLATION VALVES POSITION:
	
	• Cnmt recirc sump isol valves - OPEN:
	  • 1SI8811A
	  • 1SI8811B
		Establish RH pump suction from the Cnmt recirc sump on one RH train at a time as follows:
		
		a. Check adequate Cnmt recirc sump level:
		  o Bottom 4 sump level indicator lights - LIT.
		  -OR-
		  o Level indication on floor water level channels A (1LI-PC006) and B (1LI-PC007) greater than 1 inch.
		
		b. Stop RH pump in affected train:
		  o RH pump 1A
		  o RH pump 1B
		
		Step continued on next page

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STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED

Step 4 (continued)

c. Close RWST to RH pump suction valve for affected RH pump:

- o 1SI8812A
- o 1SI8812B

d. Stop CS pump in affected train by placing control switch in PULL OUT:

- o CS pump 1A
- o CS pump 1B

e. Close RWST to CS pump suction valve for affected CS pump:

- o 1CS001A
- o 1CS001B

f. Open Cnmt recirc sump suction valve to affected RH pump:

- o 1SI8811A
- o 1SI8811B

g. Restart affected RH pump:

- o RH pump 1A
- o RH pump 1B

h. Open RWST to CS pump suction valve for affected CS pump:

- o 1CS001A
- o 1CS001B

Step continued on next page

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STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED
		Step 4 (continued) i. Restart affected CS pump: o CS pump 1A o CS pump 1B <u>IF</u> both RH trains were affected, <u>THEN</u> repeat Steps a through i for remaining train. <u>IF</u> at least one flow path from Cnmt recirc sump to the RCS can <u>NOT</u> be established or maintained, <u>THEN</u> GO TO 1BwCA-1.1, LOSS OF EMERGENCY COOLANT RECIRCULATION, Step 1.

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STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED

CAUTION
Prior to initiation of Cold Leg Recirculation, verify Control Room and Aux Bldg Charcoal Booster Fans are discharging thru the Charcoal absorbers.

5 ALIGN ECCS FOR COLD LEG RECIRCULATION:

a. Verify CENT CHG pumps miniflow valves - CLOSED:

- 1CV8110
- 1CV8111
- 1CV8114
- 1CV8116

RESPONSE NOT OBTAINED:

a. Manually close CENT CHG pump miniflow valves

IF 1CV8111 and 1CV8114 will NOT close and 1B CENT CHG pump is running, THEN:

1) Trip the 1A CENT CHG pump.
2) Locally CLOSE 1A CENT CHG pump miniflow isol valve:
   - 1CV8479A (364' S14 outside 1A CENT CHG pump Rm).
3) START 1A CENT CHG pump.

IF 1CV8110 and 1CV8116 will NOT close and 1A CENT CHG pump is running, THEN:

1) Trip 1B CENT CHG pump
2) Locally CLOSE 1B CENT CHG pump miniflow isol valve:
   - 1CV8479B (364' X14, outside 1B CENT CHG pup Rm).
3) START 1B CENT CHG pump.

Step continued on next page

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STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED

Step 5 (continued)

b. Verify RH pump suction from RWST isol valves - CLOSED:

- 1SI8812A
- 1SI8812B

b. Manually close valves.

c. Close SI pump miniflow isol valves:

- 1SI8813
- 1SI8814
- 1SI8920

d. Close RH HX discharge crosstie valves:

- 1SI8716A
- 1SI8716B

e. Open SI and CENT CHG pumps suction crosstie valves:

- 1SI8807A
- 1SI8807B
- 1SI8924

f. Open RH pumps discharge to suction of CENT CHG and SI pumps valves:

- 1CV8804A
- 1SI8804B

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STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED

6 <u>ISOLATE RWST FROM SI AND CENT CHG PUMPS</u>:

a. Close SI pump suction from RWST isol valve:

- 1SI8806

b. Close RWST to CENT CHG pump suction valves:

- 1CV112D
- 1CV112E

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED
7	START ECCS PUMPS AS NECESSARY	
8	ALIGN CONTAINMENT SPRAY SYSTEM FOR RECIRCULATION IF NECESSARY:	
	a. Check RWST level LESS THAN 5.9%: • RWST EMPTY status lights - LIT	a. GO TO Step 9.
	b. Open Cnmt recirc sump supply valves: • 1CS009A • 1CS009B	
	c. Close RWST supply isol valves: • 1CS001A • 1CS001B	
9	ALIGN CC FOR POST LOCA RECOVERY PER BwOP CC- 14 COMPONENT COOLING POST LOCA ALIGNMENT	
10	RETURN TO PROCEDURE AND STEP IN EFFECT	

-END-

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APPENDIX A
BRAIDWOOD
EMERGENCY ACTION LEVELS

1) Aircraft crash or missiles from whatever source.
2) Control Room evacuation.
3) Earthquake.
4) Unplanned Explosion
5) Fire.
6) Flood or Low Water Level.
7) Security Threat.
8) Tornado/Severe winds.
9) Toxic Gas.
10) Loss of AC power.
11) Loss of DC power.
12) Plant Shutdown Functions.
13) Loss of Annunciator Alarm Capability.
14) Other systems required by Technical Specifications.
15) Inadequate Core Coolant.
16) Loss of primary coolant.
17) Main Steam Line Break/Feed Line Break.
18) Loss of Heat Sink.
19) Steam Generator Tube Rupture.
20) Inadvertent Positive Reactivity
21) Feedwater Malfunction.
22) ECCS Actuation.
23) Turbine - Generator Accedent.
24) Loss of Fission Product Barriers.
25) Fuel Handling Accident.
26) Elevated Area Rad Monitor Readings.
27) Gaseous Radiation Releases.
28) Liquid Radiation Releases.
29) Personal Injury.
30) Hazardous Materials.
31) Other Conditions.
32) Transportation Accidents.

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BRAIDWOOD
EMERGENCY ACTION LEVELS

CONDITIONS	UNUSUAL EVENT	ALERT	SITE EMERGENCY	GENERAL EMERGENCY
Class Description	Events in progress or have occurred which indicate a potential degradation of the level of safety of the plant.	Events in progress or have occurred which involve an actual or potential substantial degradation of the level of safety of the plant.	Events in progress or have occurred which involve actual or likely major failures of plant functions needed for protection of the public.	Events in progress or have occurred which involve actual or imminent substantial core degradation or melting with potential for loss of containment integrity.
1) Aircraft crash or missiles from whatever source.	Impacted on-site.	Impacted on-site and has degraded equipment described in the Technical Specifications such that a limiting condition for operation requires a shutdown.	A) Impacted on-site and has degraded equipment described in the Technical Specifications beyond the limiting condition for operation that requires a shutdown; or B) has exceed a Technical Specification safety limit.	
2) Control Room Evacuation.		Due to exceeding 10CFR20 exposure limits, evacuation is required and control is established from local control stations or from Remote Shutdown Panel within 15 minutes.	Due to exceeding 10CFR20 exposure limits, evacuation is required and control is not established from Local Control Stations or from Remote Shutdown Panel within 15 minutes.	

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BRAIDWOOD
EMERGENCY ACTION LEVELS

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CONDITIONS	UNUSUAL EVENT	ALERT	SITE EMERGENCY	GENERAL EMERGENCY
3) Earthquake (activation of seismic monitoring alarm with level verification, not spurious, or testing.)	Seismic equipment is activated. (at level of 0.02g).	At a level greater than Operating Basis Earthquake (> 0.095g).	At a level greater than Safe Shutdown (> 0.21g).	
4) Unplanned Explosion.	Onsite but not affecting plant operations.	Explosion onsite has degraded equipment described in the Technical Specifications such that a limiting condition for operation requires a shutdown.	A) Explosion has degraded equipment described in the Technical Specifications beyond the condition for operation that requires a shutdown; or B) has exceeded a Technical Specification safety limit.	
5) Fire (ongoing as described by observation or alarm, and verified by the (fire brigade).	A) Fire requires NRC notification if not identified within 10 mins.; or B) Fire requiring offsite assistance but not affecting plant operation.	Fire requires offsite assistance and has degraded equipment described in the Technical Specifications such that a limiting condition for operation requires a shutdown.	A) Fire requires offsite assistance and has degraded equipment described in Technical Specifications beyond the limiting condition for operation that requires a shutdown; or B) has exceeded a Technical Specification safety limit.	

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CONDITIONS	UNUSUAL EVENT	ALERT	SITE EMERGENCY	GENERAL EMERGENCY
6) Flood OR Low Water Level	Cooling pond dike failure affecting offsite property.	Water at level of Probable Maximum Flood (Cooling Pond water level ≥ 598.17 feet MSL). EG: Precipitation greater than or equal to the Probable Maximum Precipitation of 31.9 inches in 48 hrs) OR Cooling Pond water level ≤ 590 feet MSL with coincident cooling pond dike failure.	Water level at plant grade elevation (≥ 601 feet MSL). EG: Rainfall in excess of Probable Maximum Precipitation OR Cooling Pond water level ≤ 584 feet MSL with coincident cooling pond dike failure.	

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EMERGENCY ACTION LEVELS

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CONDITIONS	UNUSUAL EVENT	ALERT	SITE EMERGENCY	GENERAL EMERGENCY
7) Security Threat Definition: Acts which threaten the safety of station personnel or security of the nuclear units or special nuclear material. This includes crowd disturbances or acts of sabotage.	The following events as described in the Security Plan: (1) Obvious attempt to sabotage. (2) Internal disturbance (disturbance which is not short lived or is not a harmless outburst involving one or more individuals within the protected area). (3) Bomb device discovered. (4) Hostage. (5) Civil disturbance (spontaneous collective group gathering which disrupts normal operations). (6) Armed or forced protected area intrusion. (7) Armed or forced vital area intrusion.	An ongoing security threat (event) of increasing severity that persists for more than 60 min.	An ongoing security threat (event) involving an imminent loss of physical control of the facility.	An ongoing security threat (event) involving a loss of physical control of the facility.

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EMERGENCY ACTION LEVELS

CONDITIONS	UNUSUAL EVENT	ALERT	SITE EMERGENCY	GENERAL EMERGENCY
8) Tornado or severe winds being experienced (Wind speed as indicated in Control Room is used to classify condition.)	A) Tornado near Facility (1) Control Room informed by Load Dispatcher OR (2) Station personnel have made visual sighting; or B) Sustained winds > 60 mph.	A) Tornado strikes Facility or B) Sustained winds > 75 mph.	Sustained winds > 85 mph and either unit not in cold shutdown.	
9) Toxic Gas.	Uncontrolled release of Toxic gas at life threatening levels near or onsite.	Entry of Toxic Gas into the protected area.	Entry of Toxic Gas gas into vital areas affecting the safe shutdown of the plant.	
10) Loss of AC Power.	Loss of all offsite AC power or loss of all onsite AC power required per unit.	Loss of all off-site AC power and loss of all onsite AC power required per unit.	Both ESF 4KV busses per unit deenergized for > 15 minutes.	Ongoing loss of power and total loss of feedwater makeup capability.

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EMERGENCY ACTION LEVELS

CONDITIONS	UNUSUAL EVENT	ALERT	SITE EMERGENCY	GENERAL EMERGENCY
11) Loss of DC Power.	Loss of DC Power sources has degraded equipment described in the Technical Specifications such that a limiting condition for operation requires a shutdown.	Loss of all ESF DC power, per unit.	Busses 111 (211) and 112 (212) are both deenergized for > 15 minutes.	
12) Plant Shutdown functions.		A) Complete loss of any function needed to maintain cold shutdown (Both RH trains, OR both CC trains, OR both SX trains.) OR B) Failure of the Reactor Protection System instrumentation to initiate and complete a reactor trip, which brings the reactor subcritical once a limiting safety system setpoint has been exceeded.	A) Complete loss of any function needed to maintain hot shutdown. (If you do not have at least one operable S/G with Wide Range water level $\geq$ 65% AND ability to control steam release either by S/G PORV, or steam dump capability to the condenser.) OR B) Transient requiring operation of shutdown systems with failure to trip. (Power Generation continues, but no core damage evident.)	Transient requiring Operation of shutdown systems with failure to trip and core damage is evident.

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CONDITIONS	UNUSUAL EVENT	ALERT	SITE EMERGENCY	GENERAL EMERGENCY
13) Loss of most or all alarm capability of annunciators.		In the Main Control Room.	In the Main Control Room and a plant transient in progress.	
14) Conditions or systems required by Technical Specifications (i.e. ECCS, fire protection, etc.)	Equipment described in the Technical Specifications is degraded such that a limiting condition for operation requires a shutdown.	A) Equipment described in the Technical Specifications is degraded beyond the limiting condition for operation that requires a shutdown; OR B) has exceeded a Technical Specification safety limit.		
15) Inadequate Core Coolant.	$>$ 650°F in average of 10 highest incore thermocouple readings OR Subcooling $<$ 25°F for 15 minutes.	Braidwood Status Tree's (BwST's) require entry into BwFR-C.2 Response to Degraded Core Cooling, based on subcooling, number of RCP's running, vessel level, and core exit thermocouples.	Braidwood Status Tree's (BwST's) require entry into BwFR-C.1 Response to Inadequate Core Cooling based on subcooling, number of RCP's running, vessel level, and core exit thermocouples.	

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EMERGENCY ACTION LEVELS

CONDITIONS	UNUSUAL EVENT	ALERT	SITE EMERGENCY	GENERAL EMERGENCY
16) Loss of Primary Coolant.	A) Failure of a primary system safety or relief valve to close, OR a primary PORV failure to close, and its block valve will not isolate. B) Total Reactor Coolant leakage, excluding Pressure Boundary leakage, exceeds the limits specified in the Technical Specification limiting condition for operation for greater than or equal to 4 hours. C) Detection of any Reactor Coolant Pressure Boundary leakage.	A > 50 gpm leakage increase in a 4 hour period as indicated by either leak rate calculations, charging pump flow or VCT level changes.	Primary system leakage is beyond makeup capabilities of charging pumps.	Primary system leakage is beyond makeup capabilities of charging pumps AND Failure to activate ECCS.
17) Main Steam Line Break/Feed line Break.	With zero or small primary to secondary leakage and/or small percentage of failed fuel.	With 1 gpm primary to secondary leakage and with 1% failed fuel.	Ten (10) gpm primary to secondary leakage And significant fuel damage.	

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EMERGENCY ACTION LEVELS

CONDITIONS	UNUSUAL EVENT	ALERT	SITE EMERGENCY	GENERAL EMERGENCY
18) Loss of Heat Sink.		Braidwood Status Tree's (BwST's) require entry to BwFR-H.1 Resp nse to Loss of Secondary Heat Sink, based on total feedwater flow to the steam generators.	Alert condition is on going for 15 minutes. (Loss of all feedwater and all auxiliary feed water, and the residual heat removal system is not in operation.)	**Alert condition is on going for 45 minutes. (Loss of all feedwater and all auxiliary feed water and the residual heat removal system is not in operation.)**
19) Steam Generator Tube Rupture.	Exceeding primary to secondary leakage rates as specified in Technical Specifications.	Entry into BwEP-3 Steam Generator Tube Rupture with the following: Reactor Trip/ Safety Injection <u>AND</u> 1. High radiation in the condenser air removal system. <u>OR</u> 2. High radiation in steam generator blow-down. <u>OR</u> 3. Unexplained increase in any steam generator level.	Same condition as Alert <u>and</u> loss of offsite power <u>OR</u> Tube(s) rupture is beyond the capability of the charging pumps.	

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EMERGENCY ACTION LEVELS

CONDITIONS	UNUSUAL EVENT	ALERT	SITE EMERGENCY	GENERAL EMERGENCY
20) Inadvertent positive reactivity insertions due to rods or dilution.	A. Inadvertent dilution such that: 1) Technical Specification shutdown margin requirements are violated. OR 2) The control bank low low insertion limit is reached. B. Uncontrolled rod withdrawal from subcriticality or power operation.			
21) Feedwater Malfunction.	Any feedwater malfunction resulting in a sustained decrease in Feedwater temperature to the steam generators by > 60°F.			
22) ECCS Actuation.	ECCS initiation. (Non Spurious) with flow into reactor coolant system.			

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EMERGENCY ACTION LEVELS

CONDITIONS	UNUSUAL EVENT	ALERT	SITE EMERGENCY	GENERAL EMERGENCY
23) Turbine-Generator accident in which missiles are generated.	A turbine generator failure in which missiles are generated and no penetration of the casing occurs and normal reactor shutdown follows.	A turbine generator failure in which missiles are generated and penetration of the casing does occur; all possible impact areas containing essential equipment are protected and normal reactor shutdown follows.		

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CONDITIONS	UNUSUAL EVENT	ALERT	SITE EMERGENCY	GENERAL EMERGENCY
24) Loss of Fission Product Barriers.		A. > 2 x 10^2R/hr Primary Containment Radiation, OR	A. > 4 x 10^2R/hr Primary Containment Radiation, OR	A. > 2 x 10^3R/hr Primary Containment Radiation, and probable loss of primary containment, OR
Primary Containment Radiation is observed on the RM-11 display console for: 1(2)RE-AR020 or 1(2)RE-AR021		B. Loss of 1 of the following 3 fission product barriers:	B. Loss of 2 of the following 3 fission product barriers:	B. Loss of 2 of the following 3 fission product barriers: with an imminent loss of the third barrier:
		1) Cladding: grab sample results > 300 uCi/cc equivalent of I-131	1) Cladding: grab sample results > 300 uCi/cc equivalent of I-131	1) Cladding: grab sample results > 300 uCi/cc equivalent of I-131
		2) Reactor Coolant System: a) Containment press. > 5 psig and b) Containment temp. > 150°F and c) Containment humidity > 50%	2) Reactor Coolant System: a) Containment press. > 5 psig and b) Containment temp. > 150°F and c) Containment humidity > 50%	2) Reactor Coolant System: a) Containment press. > 5 psig and b) Containment temp. > 150°F and c) Containment humidity > 50%
		3) Primary Containment a) Containment press. > 50 psig or b) Containment temp. > 280°F, or c) Loss of containment integrity when containment integrity is required.	3) Primary Containment a) Containment press. > 50 psig or b) Containment temp. > 280°F or c) Loss of containment integrity when containment integrity is required.	3) Primary Containment a) Containment press. > 50 psig or b) Containment temp. > 280°F or c) Loss of containment integrity when containment integrity is required.

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EMERGENCY ACTION LEVELS

CONDITIONS	UNUSUAL EVENT	ALERT	SITE EMERGENCY	GENERAL EMERGENCY
25) Fuel Handling Accident (Direct information from fuel handling personnel indicating that an irradiated fuel assembly has been damaged.)		Fuel Handling Building exhaust has been diverted through the charcoal filters.	A) Radiation levels in the Fuel Handling Building are > 100 mR/hr as observed on the RM-11 display console for ORE-AR055 or ORE-AR056. OR B) Fuel Handling Building exhaust charcoal filters are depleted OR inoperable and radioactivity is being released to the atmosphere.	
26) Elevated Area Rad Monitor readings	Unplanned increase by factor of 20 in any ARM.	Unplanned increase (Resulting from degradation in the control of radioactive material and confirmed by survey or redundant instrumentation) by a factor of 100 of any ARM.		

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CONDITIONS	UNUSUAL EVENT	ALERT	SITE EMERGENCY	GENERAL EMERGENCY
27) Gaseous Radiation Releases**				
A. Core Damage Suspected	No core damage event is postulated at the Unusual Event level.	Instantaneous release rate exceeds 1.8×10^6 uCi/sec	Release rate averaged for 2 minutes exceeds > 500 mrem/hr whole body at the site boundary (8.9×10^6 uCi/sec) OR Release rate averaged for 30 minutes exceeds > 50 mrem/hr whole body at the site boundary (8.9×10^5 uCi/sec)	Instantaneous release rate exceeds level corresponding to > 1 rem/hr whole body at the site boundary under actual meteorology. This condition exists when $Q > 7 \times 10^6 \times U$ where Q = release rate in uCi/sec U = mean wind speed in meters/sec
B. NO Core Damage Suspected	Instantaneous release rate exceeds 1.8×10^6 uCi/sec Noble gas OR 30 uCi/sec Iodine OR 10 CFR 20.105 instantaneous release limits are exceeded.	Instantaneous release rate exceeds 1.8×10^7 uCi/sec Noble gas OR 300 uCi/sec Iodine OR 10 times 10 CFR 20.105 instantaneous release limits are exceeded.	Release rate averaged for 2 minutes exceeds > 500 mrem whole body at the site boundary (1.6×10^8 uCi/sec) OR Release rate averaged for 30 min. exceeds > 50 mrem hr whole body at the site boundary (1.6×10^7 uCi/sec)	Instantaneous release rate exceeds level corresponding to > 1 rem/hr whole body at the site boundary under actual meteorology. This condition exists when: $Q > 1.3 \times 10^8 \times U$ where Q = release rate in uCi/sec U = mean wind speed in meters/sec

**Monitored releases can be measured by effluent monitoring or counting instrumentation. For noble gases, effluent monitor 1(2)RE-PR0030, channel 4, displays the release rate in uCi/sec on the RM-11 display console. For iodines, effluent monitor 1(2)RE-PR028 displays a concentration in uCi/cc that must be corrected for stack flow rate to obtain a release rate in uCi/sec.
**Unmonitored releases can be estimated by field measurements taken by Environmental Survey Teams.

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CONDITIONS	UNUSUAL EVENT	ALERT	SITE EMERGENCY	GENERAL EMERGENCY
28) Liquid Radiation Release from the Plant as measured by counting instrumentation or effluent monitoring instrumentation. (Radiation releases are observed on the RM-11 display console for ORE-PR010.)	1) Gross Beta > 1×10^{-7} uCi/ml OR 2) Tritium > 3×10^{-3} uCi/ml	1) Gross Beta ≥ 1×10^{-6} uCi/ml or > 40 Ci total in 24 hours OR 2) Tritium ≥ 3×10^{-2} uCi/ml or ≥ 500 Ci total in 24 hours.	1) Gross Beta ≥ 2,000 Ci total in 24 hours OR 2) Tritium ≥ 2×10^{4} Ci total in 24 hrs.	1) Gross Beta ≥ 2×10^{4} Ci total in 24 hours OR 2) Tritium ≥ 2×10^{5} Ci total in 24 hrs.
29) Personnel Injury	Transportation of a radioactively contaminated injured person to hospital			
30) Hazardous Materials	As a direct result of hazardous materials a person is killed or hospitalized or estimated property damage exceeds $50,000.			

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EMERGENCY ACTION LEVELS

CONDITIONS	UNUSUAL EVENT	ALERT	SITE EMERGENCY	GENERAL EMERGENCY
31) Any other Conditions of equivalent magnitude to the criteria used to define the accident category as determined by the Station Director.*	Warrants increased awareness on the part of the state and/or local off-site officials.	Warrants activation of Technical Support Center.	Warrants activation of the Emergency Operations Facility and monitoring teams; warrants notification of the public by State and local agencies.	Imminent Core Melt

*Conditions that may or may not warrant classification under GSEP include:

a. Incident reporting per 10CFR50.72
b. Incident reporting per 10CFR20.403 or Illinois Rules and Regulations, Part D.403.
c. Discharges of oil or hazardous substances into waterways per 33CFR153.
d. Security contingency events per the Station Security Plan.

The Station Director may, at his discretion, categorize the above situations as GSEP emergencies, depending upon the seriousness of the situation. (Refer to Section 9.3 of the generic plan for additional information.)

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EMERGENCY ACTION LEVELS

32) A. A vehicle transporting radioactive materials or non-radioactive Hazardous materials from a Commonwealth Edison generating station is involved in a situation in which:

1. Fire, breakage or suspected radioactive contamination occurs involving a shipment of radioactive material or;

2. As a direct result of Hazardous materials,

   (a) A person is killed; or
   (b) A person receives injuries requiring hospitalization; or
   (c) Estimated carrier or other property damage exceeds $50,000.

B. Any other condition involving Hazardous material transportation and equivalent to the criteria in Item A.

(Final)

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED
2	<u>VERIFY TURBINE TRIP</u>: • All Turbine throttle stop valves - <u>CLOSED</u> • All Turbine governor valves - <u>CLOSED</u>	Manually trip the Turbine. <u>IF</u> Turbine will <u>NOT</u> trip, <u>THEN</u> manually run back the Turbine at maximum rate by the following method: 1) Press TURB MAN. 2) Press FAST ACTION and GOV LWR simultaneously. <u>IF</u> Turbine can <u>NOT</u> be run back, <u>THEN</u> place EH pumps in PULL OUT position. <u>IF</u> Turbine still will <u>NOT</u> trip, <u>THEN</u> manually initiate Main Steamline Isolation and manually close MSIV bypass valves.
3	<u>VERIFY POWER TO 4KV ESF BUSSES</u>:	
	a. ESF busses - <u>AT LEAST ONE ENERGIZED</u>: o Bus 141 alive light - <u>LIT</u> -OR- o Bus 142 alive light - <u>LIT</u>	a. Try to restore power to a least one ESF bus. <u>IF</u> power can <u>NOT</u> be restored to at least one ESF bus, <u>THEN</u> GO TO 1BwCA-0.0, LOSS OF ALL AC POWER, Step 1.
	b. ESF busses - <u>ALL ENERGIZED</u>: • Bus 141 alive light - <u>LIT</u> -AND- • Bus 142 alive light - <u>LIT</u>	b. Try to restore power to deenergized ESF bus while continuing with this procedure.

APPROVED

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BRAIDWOOD ON-SITE REVIEW

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED

CAUTION

During a loss of offsite power, operator action will be necessary to actuate PZR PORVs.

NOTE

With this procedure in effect, notify the Station Director who will evaluate for GSEP conditions per BwZP 200-1, BRWD EMERGENCY ACTION LEVELS.

NOTE

Steps 1 through 15 are IMMEDIATE ACTION steps.

NOTE

"Adverse Containment" as used in Braidwood Emergency Procedures is defined as:

- o Containment pressure GREATER THAN 5 PSIG

  -OR-

- o Contaiment radiation level GREATER THAN 10^5 R/HR.

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DEC 1 1 198

BRAIDWOOD ON-SITE REVIEW

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED
1	VERIFY REACTOR TRIP: • Rod bottom lights - LIT • Reactor trip and bypass breakers - OPEN • Neutron flux - DECREASING	Manually trip the Reactor. IF the Reactor will NOT trip THEN GO TO 1BwFR-S.1, RESPONSE TO NUCLEAR POWER GENERATION/ATWS, Step 1.

QUESTION 5.01 (1.00)

The plant is operating at 85% power with rod control in manual and all other control systems in automatic. The operator inadvertently aligns charging pump suction to the RWST. Describe the changes to the shutdown margin.

QUESTION 5.02 (2.00)

A centrifugal charging pump is running with the discharge flow control valve FCV-121 in mid position. Indicate how each parameter will change (Increase, Decrease, or Remain the Same) if the discharge valve is fully opened.

a. Discharge flow
b. Pump discharge pressure upstream of the discharge valve
c. Motor amps
d. Available NPSH to the pump
e. Seal injection flow

QUESTION 5.03 (3.00)

Consider the following plant conditions:

MODE 3, BOL
Boron concentration is 900 ppm
All shutdown banks withdrawn
Actual reactivity present in the core is minus 4% delta-K/K
Source range indication of 100 CPS
Differential boron worth is minus 10 pcm/ppm

A boron dilution to 750 ppm increases the source range indication to 132 CPS. During the dilution, Xenon concentration has changed. How many PCM of reactivity did xenon contribute during the dilution? State all equations used and assumptions made and show all work.

QUESTION 5.04 (1.50)

Explain how the venturi-type flow restrictor will act to limit main steam line flow if a line break occurs downstream of the venturi.

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

QUESTION 5.05 (3.00)

The reactor is at 100% power at BOL with equilibrium xenon and all rods out when the boron concentration is reduced, causing a deep insertion of control rod bank D to maintain Tave constant. Describe how the axial core power distribution will change as a result of this action. ASSUME NO FURTHER ROD MOTION. Continue the explanation until steady state conditions are restored.

QUESTION 5.06 (3.00)

a. Why does a single RCP pump running during hot shutdown draw more motor amperage than when one of four running at power? (0.75)

b. Why does a RCP running at cold conditions draw more motor amperage than at hot conditions? (0.75)

c. Why is RCP motor amperage higher when starting the pump than when running? (0.75)

d. Why should operating a pump with too much flow and no discharge pressure be avoided? (0.75)

QUESTION 5.07 (1.00)

WHY will Axial Flux Difference change if reactor power is reduced from 100% to 50%? Assume the reactor is operating at 100% power with all rods out, early in cycle life at equilibrium Xenon conditions when power is reduced to 50% by borating (no rod motion). Neglect changes due to Xenon.

QUESTION 5.08 (2.50)

a. Explain two effects on core reactivity that occur as Reactor Coolant temperature is increased? (0.75)

b. Briefly explain why there is a larger change in the magnitude of MTC with changes in boron concentration at 560 degrees than there is at 100 degrees. (1.0)

c. WHY does power defect coefficient become more negative as the core ages? (0.75)

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

QUESTION 5.09 (2.00)

a. Describe how inserting a control rod group 50 steps (from ARO) would affect each of the parameters below. Continue description until equilibrium is reached. Assume the plant is operating at 100% power early in cycle life and all other parameters are normal for this condition.

   1. Reactor power. (0.75)

   2. RCS Tave. (0.75)

b. How would the plant response differ at end of life? (0.5)

QUESTION 5.10 (2.00)

a. Why can the neutron population remain relatively constant in a subcritical reactor with Keff of 0.5? (0.75)

b. Explain why initially locating the detector further from the neutron source than required during core loading will still result in an accurate 1/M plot. (0.75)

c. Why is locating the detector between the source and the fuel being loaded during a core load considered unconservative? (0.5)

QUESTION 5.11 (2.00)

Explain WHY each of the condenser conditions below act to decrease overall efficiency of the plant. Consider each case separately. Use of appropriate thermodynamics formulas is acceptable.

a. Hotwell level increases (above the bottom rows of tubes).

b. Noncondensible gas inventory increases.

c. Circulating water flow decreases.

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

QUESTION 5.12 (2.00)

Briefly describe 2 power distribution limits that are used to ensure that the power distribution shape in the core is acceptable, how they are determined, and what direction (radially or axially) each ensures acceptable power distribution. (NOTE: include 1 limit for radial distribution AND 1 limit for axial distribution.)

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

QUESTION 6.01 (1.50)

Per BwOA-RCP-2, "Loss of Seal Injection", explain why an RCP does not necessarily have to be tripped when seal injection flow to the RCP is lost.

QUESTION 6.02 (3.50)

Refer to figure 4-1 and 4-2 attached.

a. What position (OPEN or SHUT) would each of the following breakers be in for a SHUTDOWN electrical plant lineup? (2.5)

1. 1571	6. 1562	11. 1411	16. 1442
2. 1572	7. 1581	12. 1412	17. 1421
3. 1591	8. 1582	13. 1414	18. 1422
4. 1592	9. 1431	14. 1413	19. 1424
5. 1561	10. 1432	15. 1441	20. 1423

b. Which breakers from the above list would be in a different position from the shutdown lineup if the plant is placed into an AT-POWER lineup? (1.0)

QUESTION 6.03 (2.50)

List or describe 5 trips associated with the Emergency Diesel Generators that will cause the generator output breaker to trip open before causing the EDG to trip. (I.E. DO NOT include trips that DO NOT cause a generator trip prior to engine trip.) Assume the EDG is running for surveillance testing.

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

QUESTION 6.04 (3.00)

Refer to figure 12-1A attached.

On the drawing, label each of the following penetrations as indicated: (.1 ea)

a.	SI	(8 connections)
b.	RHR	(8 connections)
c.	Accumulators	(4 connections)
d.	Hi head charging	(4 connections)
e.	CVCS letdown	(1 connection)
f.	Normal charging	(1 connection)
g.	Alternate charging	(1 connection)
h.	Auxiliary spray	(1 connection)
i.	RCDT	(2 connections)

QUESTION 6.05 (2.00)

Assume that power is steady at 35%. I&C technicians are performing cal**-ations on a stator cooling water differential pressure transmitter. One of the other channel transmitters fails low and a reactor trip occurs. Explain why the reactor tripped.

QUESTION 6.06 (2.50)

Refer to the attached diagram concerning the Boron Thermal Regeneration System (BTRS):

a. Describe the flow path during the release (boration) mode. (1.5)

b. Describe the flow path during the storage (dilution) mode. (1.0)

QUESTION 6.07 (3.00)

Briefly describe the Reactor Vessel Level Indicating System, including the types of detectors used and the principles of operation of the system.

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

QUESTION 6.08 (3.50)

a. List or describe 8 conditions that will cause an auto trip of a running Motor Driven Feedwater Pump. Include setpoints where applicable.

b. List or describe 6 conditions that will cause an auto trip of a running Turbine Driven Feedwater Pump. Include setpoints where applicable.

c. List or describe 3 conditions that will cause a trip of a running motor driven AUXILIARY FEEDWATER PUMP. Include setpoints where applicable.

d. List or describe 3 conditions that will cause a trip of a running diesel driven AUXILIARY FEEDWATER PUMP. Include setpoints where applicable.

(.175 ea)

NOTE: different conditions that send the same trip signal to the pump will count as 1 response.

QUESTION 6.09 (2.00)

Assume that you are the SRO reviewing RO logs and note the following data:

Turbine load = 80%
Steam Generator pressure = 998 psig
Steam flow (per generator) = 3.4 x 10E6 lbm/hr
All systems operating in automatic

Are the above indications consistent with each other? Justify your answer, SHOWING ALL CALCULATIONS. State all assumptions.

QUESTION 6.10 (1.50)

Refer to figure 24-11 attached concerning the steam dump system.

Label the contacts on the figure numbered 1A, 1B, 1C, 2, 3, 4, 5 and 6.

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

QUESTION 7.01 (2.50)

What are the entry conditions for BwEP ES-0.0, "Rediagnosis"? Be specific.

QUESTION 7.02 (2.50)

BwEP ES-1.3, "Transfer to Cold Leg Recirculation" (attached), contains a caution stating that BwFRs should NOT be implemented prior to completion of steps 1 thru 5. What are the reasons (bases) for this caution?

QUESTION 7.03 (1.50)

Per BwEP-0, "Reactor Trip or Safety Injection", list or describe 3 symptoms that require a reactor trip AND safety injection, if both have not occurred. Include setpoints.

QUESTION 7.04 (1.50)

State the line of succession (who has the responsibilities) of the Acting Station Director if the Station Director is not available or not on site during an emergency.

QUESTION 7.05 (.50)

True or False?

General categorization and declaration of an emergency condition may be delegated by the Station Director to the Corporate Command Center Director.

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

QUESTION 7.06 (3.00)

Classify each of the following as to their appropriate Emergency Action Level. Limit your answers to NONE, UNUSUAL EVENT, ALERT, SITE EMERGENCY, or GENERAL EMERGENCY. BwZP 100-1A1 is attached. (.75 ea)

1. cooling pond level is at 588 ft due to dry weather

2. an operator initiates safety injection with the plant at power. Pressure remains stable at 2135 psig.

3. while removing the main generator from the grid, the operator inadvertently opens the SAT disconnects instead of the UAT disconnects

4. a runback results in driving bank D control rods below the low-low rod insertion limit

QUESTION 7.07 (2.00)

Refer to the attached pages from 1BwEP-0.

While performing step 1 of this procedure, you note that one of the reactor trip breakers did not open. All rod bottom lights are lit. What action(s) do you take and WHY?

QUESTION 7.08 (2.00)

Assume that the long fuel handling tool must be physically inspected by removing it from the spent fuel pool. The tool will be out of the pool for 2 weeks. Readings at the end of the tool are 240 mrem per hour at a distance of 2 feet.

Where (at what distance) must a RADIATION AREA sign be posted? Show all work and state all assumptions.

QUESTION 7.09 (1.50)

Per BwGP 100-2, "Plant Startup", certain actions must be taken by the operator if the source range count rate increases unexpectedly by a factor of two or more during any operation. What immediate actions must be taken and when can the operation be resumed?

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

QUESTION 7.10 (3.00)

BwGP 100-2, "Plant Startup", states in part "the shutdown banks must be at the fully withdrawn position whenever positive reactivity is being added..." Describe 3 exceptions to this rule.

QUESTION 7.11 (2.50)

Per BwGP 100-6, "Refueling Outage", describe 5 occurrences that require that core alteration operations be suspended.

QUESTION 7.12 (2.50)

Per BwRP 1120-1, "Controlled Area Access", personnel entry into a controlled area is not permitted unless certain requirements are met. List or describe 5 of these requirements.

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

QUESTION 8.01 (2.00)

Per Technical Specification 3.1.1.4, the lowest operating loop temperature shall be greater than or equal to 550 degrees F when in mode 1 or 2. Give 4 reasons for this limit.

QUESTION 8.02 (2.50)

Assume that one of the governor valves for the Unit 2 high pressure turbine is stuck and declared inoperable. Per Technical Specification 3.3.4, "Turbine Overspeed Protection", what are your 3 options?

QUESTION 8.03 (2.50)

Assume that you are the on-shift SCRE, unit 1 is in an outage, and unit 2 is at 40% power.

An auxiliary operator who is enrolled in the train g program for reactor operator at Byron is at Braidwood to assist the operations department during the outage. He asks you if he may move the control rods in manual on unit 2 in order to complete practical factors for his training as an RO.

What administrative requirements must be met before you let him perform the manipulation? Be specific.

QUESTION 8.04 (2.50)

Per BwAP 350-1, "Operating Logs and Records", give 10 types of entries that should be made in the SHIFT ENGINEER'S LOG. Do not give actual examples.

QUESTION 8.05 (2.00)

Per BwAP 350-1, "Operating Logs and Records", give 8 types of entries that should be made in the CONTROL ROOM LOGS. Do not give actual examples.

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

QUESTION 8.06 (3.00)

Assume that you are the SRO on shift with unit 1 in mode 3 when you receive the following chemistry sample results for unit 1:

dissolved oxygen:	1.1 ppm
chloride:	0.25 ppm
fluoride:	0.11 ppm
specific activity:	1.2 microcuries/gram dose equivalent I-131
gross activity:	24 microcuries/gram
E-bar:	0.4

Explain what basis would be used (if any) for entering the actions statements for:

a. Technical Specification 3.4.7, "Chemistry"

b. Technical Specification 3.4.8, "Specific Activity"

QUESTION 8.07 (1.50)

Assume that you are the Shift Engineer and are notified that an acid spill occurred while regenerating ion exchanger resin beds. Per BwAP 550-13, "Caustic and Acid Spill Cleanup Procedure", list 3 actions that you should take.

QUESTION 8.08 (2.00)

Per BwAP 900-9, "Telephone Bomb/Sabotage Threat", list 4 persons or organizations that you should notify of a bomb threat if you are the Shift Engineer.

QUESTION 8.09 (.50)

Per the license for Unit 1, what is the maximum power level (thermal) that Unit 1 is authorized to operate at?

QUESTION 8.10 (1.50)

Technical Specification 3.5.3 specifies that a maximum of one centrifugal charging pump shall be operable whenever the temperature of one or more of the RCS cold legs is less than or equal to 330 degrees F. Technical Specification 4.5.3.2 further states that no safety injection pumps shall be operable n this condition.

What is the basis for these technical specification limits?

QUESTION 8.11 (1.00)

Explain under what conditions an operator may be allowed to violate technical specifications when performing an Emergency Procedure (BwEP series).

QUESTION 8.12 (2.50)

Technical Specification 3.6.2.2 places limits on the volume and concentration of NaOH in the spray additive tanks. What are the bases for these limits? Be specific.

QUESTION 8.13 (1.50)

State whether or not each of the following cases would require entry into a Technical Specification LCO. Limit your answer to YES or NO. (.75 ea)

1. A containment pressure channel monthly channel check was performed on the following dates this year: Jan 4, Feb 6, Mar 6, Apr 13, May 12 and June 6.

2. Control room temperature has been 100 degrees for the last 2 shifts. The plant is in mode 3.

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

(************* END OF EXAMINATION ***************)

ANSWER 5.01 (1.00)

SDM increases [0.3]
The decrease in the reactivity by the boron will be equal to the increase in reactivity by the temperature and/or power decrease. [0.7]

REFERENCE
Reactor Theory, ch 7, obj 8 and pp 7-8 to 7-14
004000K519 ...(KA'S)

ANSWER 5.02 (2.00)

a. Increase
b. Decrease
c. Increase
d. Decrease (will accept remain the same)
e. Increase [0.4 pts each]

REFERENCE
Fluid Flow, ch 2, obj 5 and pp 2-38 to 2-46
004000K604 191004K105 191004K106 191004K107 193006K115
...(KA'S)

ANSWER 5.03 (3.00)

Keff1 = 1/((1-(-0.04)) = 0.9615 [0.3]
100(1 - .9615) = 132(1 - Keff2) , Keff2 = 0.9708 [0.7]
rho2 = (0.9708 -1)/0.9708 = -0.03 [0.3]
delta rho = rho2 - rho1 = -0.03 -(-0.04) = 0.01 = 1000 pcm [0.6]
(accept delta rho=ln(k2/k1)=963 pcm and
delta rho=(k2-k1)/k2k1=996 pcm)
(acceptable range on delta rho is 960 to 1000 pcm)

Boron delta rho = -150 ppm x -10 pcm/ppm = 1500 pcm [0.5]
Xenon delta rho = 1000pcm - 1500 pcm = -500 pcm [0.6]
(acceptable range on Xenon delta rho is -500 to -540 pcm)

REFERENCE
Reactor Theory, ch 4, obj 4
Reactor Theory, ch 5, pp 5-28 to 5-31
Reactor Physics, ch 6, obj 13 and pp 6-21 to 6-24
001000K528 ...(KA'S)

ANSWER 5.04 (1.50)

As the area of the venturi decreases, fluid velocity increases.(.5) The velocity is limited to sonic velocity in the throat of the nozzle.(.5) Since mass flow rate is proportional to velocity, mass flow rate is limited by sonic velocity in the throat.(.5)

(full credit for concept)

REFERENCE
Fluid Flow, ch 3, obj 1b and pp 3-17 to 3-23
039000A201 191002K101 191002K105 193004K103 193006K115 ...(KA'S)

ANSWER 5.05 (3.00)

Rod insertion causes flux shift towards bottom of core (0.5). Xenon buildup in top of core due to less burnout and xenon reduction in bottom of core due to increased burnout causes flux to shift towards the bottom of the core even more (1.0). Later, xenon buildup in bottom of the core due to increased production and xenon reduction in top of the core due to xenon decay causes a flux swing towards the top of the core (1.0). These feedback effects between xenon and power result in an axial power oscillation (0.5) (which will die out with time).

REFERENCE
Reactor Theory, ch 4, obj 10 and pp 4-29 to 4-34
192005K114 192005K116 ...(KA'S)

ANSWER 5.06 (3.00)

a. A single pump running has a higher flow than when all 4 are operating (due to reduced discharge pressure) so more work is done and more amperage drawn. (0.75)

b. At cold conditions, fluid density is higher, so more mass is moved so more work is done and more amperage drawn. (0.75)

c. It must accelerate more mass, which requires more work, and amps. (0.75)

d. Operating at runout may cause pump damage/trip on overcurrent. (0.75)

will accept concept for all parts

REFERENCE
Fluid Flow, ch 2, obj's 1, 5, 9, 14 and pp 2-24 to 2-25, 2-63 to 2-69
Fig's FF-2-32, FF-2-33
191004K105 191004K107 191004K108 191004K112 ...(KA'S)

ANSWER 5.07 (1.00)

Due to the greater decrease in the temperature of the coolant exiting the core relative to the decrease of the inlet coolant (0.5), more positive reactivity will be added in the upper core regions (0.5), (resulting in a more positive (less negative) AFD.)

REFERENCE
Reactor Theory, ch 8, obj 4 and pp 8-14 to 8-16
193009K102 193009K107 ...(KA'S)

ANSWER 5.08 (2.50)

a. The increasing temperature causes a density change of the coolant which results in negative reactivity,(.25) due to the decrease in moderating ability of the water. (.25) The subsequent decrease in density results in removing boron, causing positive reactivity due to fewer losses to the boron poison. (.25) [Accept the following for ONE reactivity effect: If the candidate assumed that the moderator temperature rise was due to fuel temperature rise, doppler power coefficient will add negative reactivity.]

b. The change in density of the coolant with changing temperature at higher temperature is much greater than at lower temperature, (0.5) so more boron atoms enter or leave the core at higher temperatures which causes a larger reactivity change for a given temperature change (0.5)

c. Lowering boron concentration over life makes MTC more negative due to the decreased poisoning changes with density/temperature changes. (.5) MTC's contribution to power defect overrides other changes over core life, (.25) (causing power defect coefficient to become more negative.)

REFERENCE
Reactor Theory, ch 2, obj's 6, 8, 9 and pp 2-63 to 2-69
192004K108 ...(KA'S)

ANSWER 5.09 (2.00)

a. 1. Reactor power will initially decrease to add positive reactivity from doppler due to the negative reactivity added by the control rods. (.5) Power will return to 100% since power follows steam demand. (.25)

2. Tave will decrease because of steam flow/reactor power mismatch (.5) until enough positive reactivity is added to return reactor power to 100%. (.25)

b. The difference is that Tave will decrease less (since MTC is more negative at EOL). Also accept smaller power decrease. (0.5)

REFERENCE
Heat Transfer, ch 7, obj's 7, 8 and pp 7-32 to 7-56
192004K106 192004K107 192008K124 ...(KA'S)

ANSWER 5.10 (2.00)

a. The loss of fission neutrons is made up by source neutrons. (0.75)

b. The initial count rate is low as well as the subsequent count rates so that the ratio of 1/M is constant and not affected. (0.75)

c. The detector will detect only source neutrons in this geometry until there is a relatively large flux from the fuel being loaded. (0.5)

REFERENCE
Reactor Physics, ch 8, obj's 4, 16 and pp 8-13 to 8-30
192003K101 192008K104 ...(KA'S)

ANSWER 5.11 (2.00)

a. Effective area available to condense steam is reduced, which increases Tsat and Psat in the condenser. The increase in Psat causes the extraction of less work from the turbine since work is proportional to delta P across the turbine, so efficiency decreases.

b. Increasing noncondensibles block some tube area, with same consequences as above. Also, this reduces the amount of steam undergoing phase change, which decreases the specific volume change, leading to higher pressure, and the effects above.

c. Reduced mass flow reduces heat rejected from the steam in the condenser, causing less dT, with a corresponding increase in Tsat and Psat, with the effects above.

(3 answers @ 0.666 ea.; General concept required, not specific answer) (will also accept explanations utilizing appropriate heat transfer equations)

REFERENCE
Thermodynamics, ch 4, obj 11 and pp 4-64 to 4-106
191006K110 191006K112 191006K114 193005K103 ...(KA'S)

ANSWER 5.12 (2.00)

Axial Flux Difference (0.25) determines axial distribution (0.25) and is determined by subtracting calibrated I from the bottom detectors from the calibrated I from the top detectors and dividing by the 100% power calibrated I (0.5).

Quadrant Power Tilt Ratio (0.25) determines the radial flux shape (0.25) and is determined by ratioing the maximum upper half excore detector I to the average upper excore detector I (also applies to lower detectors)(0.5).

F(Q)Z [0.25] determines local heat flux at a specific elevation [0.25] by use of the in-core NI's to ensure both axial and radial flux within limits. [0.5]

Fxy [0.25] ensures that radial peaking factors within limits [0.25] and is determined with in-core NI's. [0.5]

[Any 2 of 4 that addresses both radial and axial flux] (2.0)

REFERENCE
Reactor Theory, ch 8, obj 7 and pp 8-16 to 8-24
193009K101 193009K102 ...(KA'S)

ANSWER 6.01 (1.50)

As long as CCW is supplied to the thermal barrier (.75), reactor coolant is cooled to acceptable temperatures prior to reaching the seals and bearings. (.75)

REFERENCE
System Description ch 13, objective 4d and pp 13-42 to 13-43
003000A201 ...(KA'S)

ANSWER 6.02 (3.50)

a.

1.	open	6.	shut	11.	open	16.	shut
2.	shut	7.	open	12.	shut	17.	open
3.	open	8.	shut	13.	open	18.	shut
4.	shut	9.	open	14.	open	19.	open
5.	open	10.	shut	15.	open	20.	open

b. 1571, 1572, 1561, 1562, 1431, 1432, 1441, 1442

(.125 for each answer, 3.5 total)

REFERENCE
System Description ch. 4, objective 9 and pp 4-105 to 4-106
062000K104 ...(KA'S)

ANSWER 6.03 (2.50)

Any 5 @ .5 ea:
Generator over-current
Generator neutral to ground over-current
Loss of field
Reverse Power
Under-frequency
Manual
Bus lockout
Safety Injection

REFERENCE
System Description ch. 9, objective 5 and pp 9-48 to 9-51
Figure 9-2
064000K402 ...(KA'S)

INFORMATION ONLY

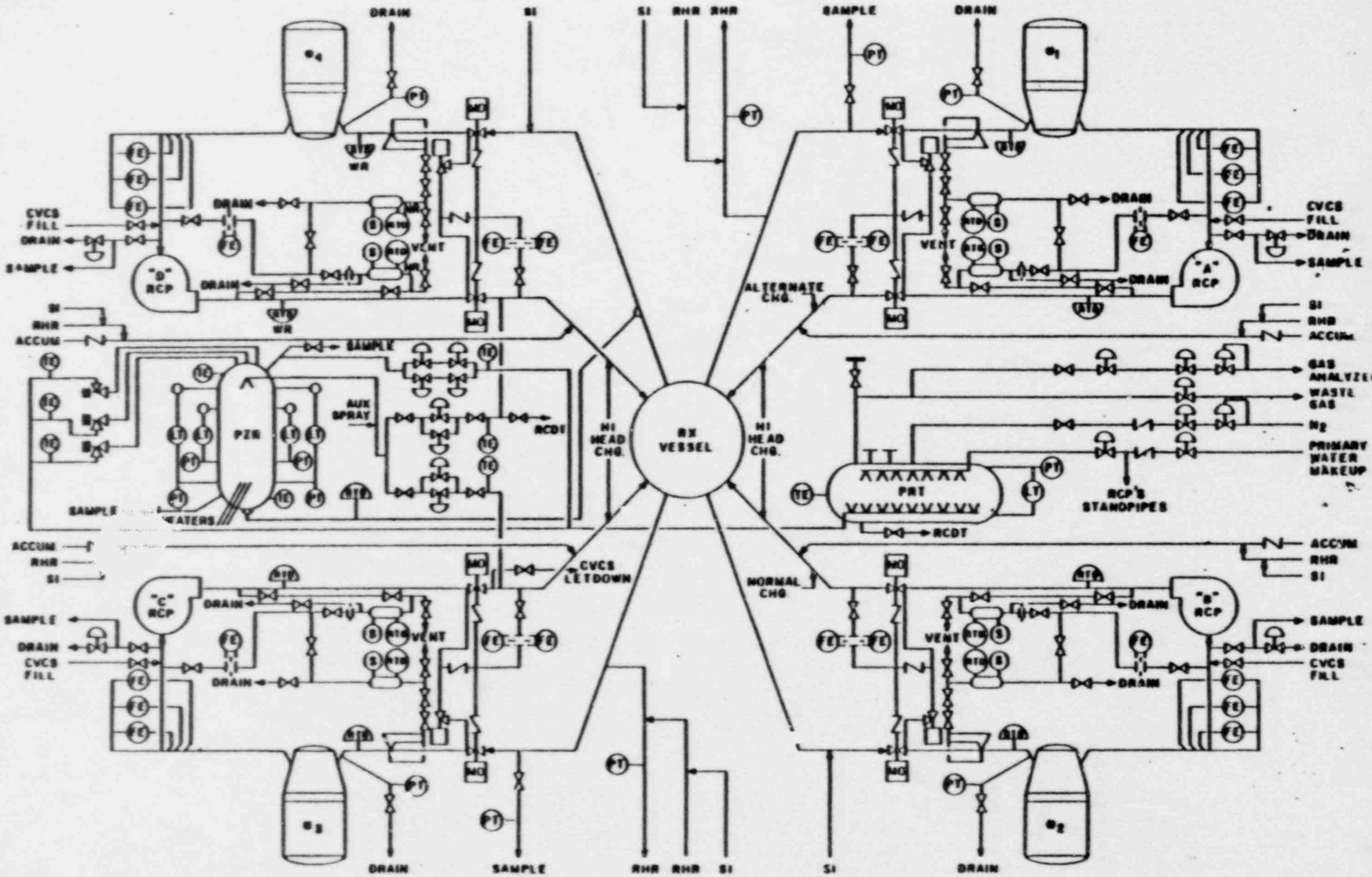

FIGURE 12-1A REACTOR COOLANT SYSTEM

ANSWER 6.04 (3.00)

See attached drawing

REFERENCE
System Description ch 12, objective 2h and figure 12-1A
002000K106 002000K108 002000K110 ...(KA'S)

ANSWER 6.05 (2.00)

A combination of 2 stator water DP transmitters low give a generator trip (45 seconds later). (.75) Generator trip gives turbine trip. (.5) With reactor power above 30% (p-8), turbine trip will give reactor trip. (.75)

REFERENCE
System Description ch 7c, objective 1e and pp 7c-23 to 7c-25
012000K106 045050K101 ...(KA'S)

ANSWER 6.06 (2.50)

a. moderating heat exchanger, bypasses letdown chiller heat exchanger, through letdown reheat heat exchanger, through resin beds, to moderating heat exchanger, and letdown chiller heat exchanger

b. moderating heat exchanger, through letdown chiller heat exchanger, to resin beds, to moderating heat exchanger

(.25 for each component)

REFERENCE
System Description ch 16, obj 6 and pg 16-5
004000K405 ...(KA'S)

ANSWER 6.07 (3.00)

System consists of a series of heated junction thermocouple sensors. (.25) Each sensor consists of a thermocouple near a heater and another away from the heater. (.75)
If liquid water is covering the sensor, the delta T between thermocouples is small due to the good heat transfer properties of liquid water. (1.0) If steam voiding occurs, the heat transfer goes down and a larger delta T is present, indicating the level change. (1.0)

REFERENCE
System Description, ch 34b, obj 4 and pp 34b-10 to 34b-11
016000K101 016000K102 ...(KA'S)

ANSWER 6.08 (3.50)

a. any 8 of the following:
   1. phase OA overcurrent
   2. phase OC overcurrent
   3. neutral ground overcurrent
   4. hi differential current
   5. hi lube oil temp - 175 degrees
   6. lo lube oil press - 10 psig
   7. loss of only CD/CB pump
   8. low suction pressure - 400 psig ↓ JH 2 Aug 88
   9. hi-2 S/G level any S/G
   10. any SI
   11. undervoltage

b. any 6 of the following:
   1. overspeed - 5720 RPM
   2. lo autostop oil press - 35 psig
   3. lo bearing press - 10 psig
   4. lo vacuum - zone C @ 14" Hg
   5. hi-2 S/G level any S/G
   6. any SI
   7. thrust bearing wear - 10 mils

c. any 3 of the following:
   1. control switch (manual)
   2. overcurrent
   3. lo-2 suction press-4.48"Hg
   4. undervoltage bus 141

d. any 3 of the following:
   1. overcrank - 55 secs
   2. high water temp - 205 degrees
   3. lo oil pressure - 10 psig
   4. overspeed - 1900 RPM
   5. lo-2 suction press-4.48"Hg

.175 ea; for answers with setpoints, .0875 for trip and .0875 for setpoint

REFERENCE
System Description, ch 25, obj 7 and pp 25-82 to 25-83
ch 26, obj 7 and pp 26-14, 26-17
059000K416 061000K407 ...(KA'S)

ANSWER 6.09 (2.00)

Not consistent. (.5)

Steam pressure ramps from 1092 to 975 from 0 to 100% power (.5)
80% turbine load = 998 psig (.25)

Steam flow 0 to 100% power = 0 to 3.75 x 10E6 lbm/hr
(15 x 10E6 lbm/hr all S/G's)
80% turbine load = 3 x 10E6 lbm/hr. (.25) (This is the inconsistency)

REFERENCE
System Description, ch 23, obj 11 and pg 23-10
039000A106 ...(KA'S)

ANSWER 6.10 (1.50)

1A, 1B, 1C - circ water pump breakers (.25)
2 - condenser vacuum (.25)
3 - RTA (.125) and BYA (.125)
4 - loss of load (C-7) (.25)
5 - steam pressure mode (.25)
6 - permissive (C-9) (.25)

NOTE: 3, 4, 5 may be interchanged in any order

REFERENCE
System Description, ch 24, obj 7 and figure 24-11
041020K401 ...(KA'S)

ANSWER 7.01 (2.50)

Entered based on operator judgement when: (.75)
1. SI is actuated or required AND (.75)
2. BwEP-0 has been implemented (.5) AND a transition has been made to another BwEP (.5)

(.5 pts off if the AND logic is missing)

REFERENCE
BwEP ES-0.0 symptoms or entry conditions
000011G011 ...(KA'S)

ANSWER 7.02 (2.50)

The amount of water in the RWST between the switchover setpoint and the empty point is limited, (.75) so the realignment of the SI system must be done quickly to maintain SI pump suction. (.75) These steps must be completed even if challenges to the CSFs occur at this time, (.5) since they relate to the maintenance of core cooling. (.5)

(credit given for concept, not exact wording)

REFERENCE
BwEP ES-1.3, first caution
BwEP Simulator Lesson Plans, EP-1, obj 1c and pg 157
ERG background, ES-1.3, Step 1 Note 1, (HP-Rev. 1A)
000011G007 ...(KA'S)

ANSWER 7.03 (1.50)

1. PZR pressure less than or equal to 1829 psig
2. steamline pressure less than or equal to 640 psig
3. containment pressure greater than or equal to 3.4 psig

(.4 for each symptom, .1 for each setpoint)

REFERENCE
BwEP-0 symptoms or entry conditions
000007G011 ...(KA'S)

ANSWER 7.04 (1.50)

Shift Engineer
Shift Foreman
SCRE (.5 ea, order important)

REFERENCE
BwZP 090-1, E.1
194001A116 ...(KA'S)

ANSWER 7.05 (.50)

False

REFERENCE
BwZP 090-1, D.1.a
194001A116 ...(KA'S)

ANSWER 7.06 (3.00)

1. unusual event
2. unusual event
3. unusual event
4. unusual event or none

REFERENCE
BwZP 200-1A1
194001A116 ...(KA'S)

ANSWER 7.07 (2.00)

Since not all reactor trip and bypass breakers are open, the second substep cannot be completed. (.5) Since this is a "closed bullet" item, all substeps must be completed to complete the major step. (.5) Since the major step cannot be satisfied, the RNO column must be entered, (.5) so go to BwFR-S.1, step 1. (.5)

REFERENCE
BwEP-0, step 1
BwAP 340-1, C.2.b.1
194001A102 ...(KA'S)

ANSWERS -- BRAIDWOOD 1&2 -88/07/18-DAMON, D.

ANSWER 7.08 (2.00)

Assume a point source, so R1 (D1)**2 = R2 (D2)**2 (.5)

R1=240 mrem/hr D1=2 ft
Radiation Area = 5 mrem/hr or
100 mrem/5 days. Assuming 8 hr work day = 100 mrem/40 hrs
or 2.5 mrem/hr for worker in that area for the week (1.0)

therefore R2=2.5 mrem/hr (.25)
and D2=19.6 feet (credit given for 19.5 to 20 ft) (.25)

(credit given for any other valid assumptions, such as covering with shielding to reduce rad levels, etc)

REFERENCE
BwRP 100-A1, pg 3 of 69 -
Radiological Protection Module, ch 5, Appendix A
194001K103 ...(KA'S)

ANSWER 7.09 (1.50)

The operation shall be stopped immediately (.75) and suspended until a satisfactory evaluation has been made. (.75)

REFERENCE
BwGP 100-2, E.1.a
015000G001 ...(KA'S)

ANSWER 7.10 (3.00)

(1.0 ea)

1. If the shutdown banks cannot be withdrawn, the reactor coolant must be borated to ensure adequate shutdown margin, and the boron concentration confirmed by sampling.

2. If the reactor coolant has been borated to at least the hot, xenon-free boron concentration, and is being maintained at hot standby, the shutdown banks need not be withdrawn.

3. If the reactor coolant has been borated to the cold shutdown concentration, the shutdown banks need not be withdrawn.

(exact wording not required)

REFERENCE
BwGP 100-2, E.2.c
001000G001 ...(KA'S)

ANSWER 7.11 (2.50)

any 5 of the following @ .5 ea:

1. less than one boron injection flow path available
2. no centrifugal charging pump operable
3. less than one borated water source available
4. less than two source range monitors in service
5. direct communications between control room and refueling station lost
6. less than one RH loop in operation
7. less than 23 feet of water above Rx vessel flange
8. less than one fuel building exhaust vent system operable
9. activation of containment evacuation alarm
10. RCS or refueling canal Keff greater than 0.95
11. RCS or refueling canal boron concentration less than 2000 ppm

REFERENCE
BwGP 100-6, E.3
000036G010 000036G011 ...(KA'S)

ANSWER 7.12 (2.50)

Any 5 of the following @ .5 ea:

1. Supervision has authorized the entry.
2. each person has a valid NGET card
3. each person has read and understands the appropriate RWP
4. each person has received a bioassay
5. the job supervisor or the person performing the work has checked with Rad/chem for requirements
6. each person is aware of the maximum dose equivalent authorized
7. each person has read and understood all radiological signs and labels at the access control point

REFERENCE
BwRP 1120-1, F.2
194001K103 ...(A'S)

ANSWER 8.01 (2.00)

Any 4 of the following @ .5 ea:

1. MTC is within analyzed temperature range
2. trip instrumentation is in normal operating range
3. PZR capable of being in an OPERABLE status with a steam bubble
4. reactor vessel is above minimum RT NDT
5. plant is above cooldown steam dump permissive (P-12)

REFERENCE
Tech. Spec. bases 3/4.1.1.4
001000K516 002000G006 ...(KA'S)

ANSWER 8.02 (2.50)

restore valve to operable status (.5) (within 72 hrs)
or
close at least one valve in the affected steam line (1.0)
or
isolate the turbine from the steam supply (1.0) (within 6 hrs)

REFERENCE
Tech. Spec 3.3.1
045000G005 ...(KA'S)

ANSWER 8.03 (2.50)

must be under the direct supervision of a licensed operator (.75)
his name must be on the memo from the Braidwood training department verifying that he is in a training status and eligible to perform reactivity manipulations (1.75)

REFERENCE
BwAP 300-1, para C.8
10 CFR 55.59
inspection report 50-456/87042(DRP)
194001A103 ...(KA'S)

ANSWER 8.04 (2.50)

any 10 of the following @ .25 ea:

1. major equipment status changes
2. major system and equipment testing
3. personnel accidents or injuries
4. entering a tech spec action statement
5. leaving a tech spec action statement
6. potential reportable occurrences
7. occurrence of significant events, such as reactor trips or unexpected power changes
8. criticality data, such as rod position and boron concentration
9. implementation of GSEP
10. security incidents
11. out-of-spec chemistry results
12. off-site calls to/from NRC, upper management, or Duty Officer concerning significant events
13. pertinent miscellaneous information

Note: will accept other answers on a case-by-case basis

REFERENCE
BwAP 350-1, para C.1.c.2
194001A103 ...(KA'S)

ANSWER 8.05 (2.00)

Any 8 of the following @ .25 ea:

1. mode changes
2. load changes
3. reactivity changes (other than during startup and shutdown)
4. equipment status changes
5. time of criticality during startup and pertinent plant data at criticality
6. performance of surveillance testing
7. reportable occurrences
8. safety-related and other important equipment maintenance in progress
9. entering a tech spec action statement
10. leaving a tech spec action statement
11. implementation of GSEP
12. all releases of radioactive effluents, including start and stop times
13. pertinent miscellaneous information

Note: will accept other answers on a case-by-case basis.

REFERENCE
BwAP 350-1, para C.1.d.3
194001A103 ...(KA'S)

ANSWER 8.06 (3.00)

1. exceeding oxygen transient limit (1.0) and exceeding chloride steady state limit (1.0)

2. exceeding dose equivalent I-131 limit (1.0)

REFERENCE
Tech Spec 3.4.7, TS table 3.4-2, 3.4.8
004000G005 ...(KA'S)

ANSWER 8.07 (1.50)

1. Contact medical personnel if needed and/or chemistry supervision
2. Ensure that the area of the spill is roped off with caution signs
3. ensure the spill is cleaned up with non-combustible absorbing material (.5 ea)

REFERENCE
BwAP 550-13, F.1
194001K110 ...(KA'S)

ANSWER 8.08 (2.00)

any 4 of the following @ .5 ea:
1. security control center operator
2. station manager
3. construction superintendents
4. project manager
5. station security administrator
6. load dispatcher, southern division
7. NRC

REFERENCE
BwAP 900-9, C.2.c
194001K116 ...(KA'S)

ANSWER 8.09 (.50)

3411 megawatts thermal

REFERENCE
Unit 1 license section 2.C.1
015000G010 ...(KA'S)

ANSWER 8.10 (1.50)

Provides assurance that a mass addition pressure transient (.5) can be relieved by the operation of a single PORV (.5) or an RHR suction relief valve. (.5)

REFERENCE
TS basis 3/4.5.3, 3/4.1.2
006000G006 ...(KA'S)

ANSWER 8.11 (1.00)

Any one of the following:

1. When the actions are directed by the EP in order to maint~in plant safety.

2. a. To prevent injury to the public or company personnel
   b. To prevent releases off-site in excess of the TS limits
   c. To prevent damage to equipment if such damage is tied to a possible adverse effect on public health and safety

3. In an emergency when this action is immediately needed to protect the public health and safety and no action consistent with license conditions and Tech Specs is immediately apparent.

(credit given for concept, not exact wording)

REFERENCE
ERG Executive Volume, Generic Issues, Technical Specification Violation
BwAP 300-1, pp 17-18
10CFR50.54x
006000G001 ...(KA'S)

ANSWER 8.12 (2.50)

Ensures a pH value of between 8.5 and 11.0 for the solution recirculated within containment after a LOCA. (1.0) This band minimized the evolution of iodine (.75) and minimizes the effect of chloride and caustic stress corrosion on mechanical systems and components. (.75)

REFERENCE
TS basis 3/4.6.2.2
026000G006 ...(KA'S)

ANSWER 8.13 (1.50)

1. no
2. yes

REFERENCE
TS 4.01, 3.7.12,
000068G003 103000G006 ...(KA'S)

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U. S. NUCLEAR REGULATORY COMMISSION
REACTOR OPERATOR LICENSE EXAMINATION

FACILITY: BRAIDWOOD 1&2

REACTOR TYPE: PWR-WEC4

DATE ADMINISTERED: 88/07/18

EXAMINER: VICTOR, F.

CANDIDATE: ______________________

INSTRUCTIONS TO CANDIDATE:

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

CATEGORY VALUE	% OF TOTAL	CANDIDATE'S SCORE	% OF CATEGORY VALUE		CATEGORY
25.00	~~25.51~~ 26.04	________	________	1.	PRINCIPLES OF NUCLEAR POWER PLANT OPERATION, THERMODYNAMICS, HEAT TRANSFER AND FLUID FLOW
23.00	~~23.47~~ 23.97	________	________	2.	PLANT DESIGN INCLUDING SAFETY AND EMERGENCY SYSTEMS
~~25.00~~ 23.00	~~25.51~~ 23.97	________	________	3.	INSTRUMENTS AND CONTROLS
25.00	~~25.51~~ 26.04	________	________	4.	PROCEDURES - NORMAL, ABNORMAL, EMERGENCY AND RADIOLOGICAL CONTROL
~~98.00~~ 96.00		Final Grade	________%		Totals

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

____
Candidate's Signature

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NRC RULES AND GUIDELINES FOR LICENSE EXAMINATIONS

During the administration of this examination the following rules apply:

1. Cheating on the examination means an automatic denial of your application and could result in more severe penalties.

2. Restroom trips are to be limited and only one candidate at a time may leave. You must avoid all contacts with anyone outside the examination room to avoid even the appearance or possibility of cheating.

3. Use black ink or dark pencil only to facilitate legible reproductions.

4. Print your name in the blank provided on the cover sheet of the examination.

5. Fill in the date on the cover sheet of the examination (if necessary).

6. Use only the paper provided for answers.

7. Print your name in the upper right-hand corner of the first page of each section of the answer sheet.

8. Consecutively number each answer sheet, write "End of Category __" as appropriate, start each category on a new page, write only on one side of the paper, and write "Last Page" on the last answer sheet.

9. Number each answer as to category and number, for example, 1.4, 6.3.

10. Skip at least three lines between each answer.

11. Separate answer sheets from pad and place finished answer sheets face down on your desk or table.

12. Use abbreviations only if they are commonly used in facility literature.

13. The point value for each question is indicated in parentheses after the question and can be used as a guide for the depth of answer required.

14. Show all calculations, methods, or assumptions used to obtain an answer to mathematical problems whether indicated in the question or not.

15. Partial credit may be given. Therefore, ANSWER ALL PARTS OF THE QUESTION AND DO NOT LEAVE ANY ANSWER BLANK.

16. If parts of the examination are not clear as to intent, ask questions of the examiner only.

17. You must sign the statement on the cover sheet that indicates that the work is your own and you have not received or been given assistance in completing the examination. This must be done after the examination has been completed.

18. When you complete your examination, you shall:

a. Assemble your examination as follows:

(1) Exam questions on top.

(2) Exam aids - figures, tables, etc.

(3) Answer pages including figures which are part of the answer.

b. Turn in your copy of the examination and all pages used to answer the examination questions.

c. Turn in all scrap paper and the balance of the paper that you did not use for answering the questions.

d. Leave the examination area, as defined by the examiner. If after leaving, you are found in this area while the examination is still in progress, your license may be denied or revoked.

QUESTION 1.01 (1.00)

MULTIPLE CHOICE

Which one of the following conditions will result in a negative startup rate when the reactor is at power. Assume the reactor does not trip/scram.

a. Inadvertant dilution.

b. Steam line break.

c. Feedwater regulator valve fails full open.

d. Dropped control rod.

QUESTION 1.02 (1.00)

MULTIPLE CHOICE

The effective multiplication factor (Keff) is the ratio between the number of:

a. Neutrons in one generation and the number of neutrons in the previous generation.

b. Fast neutrons produced by all neutron-induced fissions and the number of fast neutrons produced by thermal neutron-induced fissions.

c. Thermal neutrons absorbed in the core and the number of thermal neutrons produced in the core.

d. Fast neutrons produced from thermal neutron-induced fission and the number of thermal neutrons absorbed in the fuel.

(***** CATEGORY 01 CONTINUED ON NEXT PAGE *****)

QUESTION 1.03 (1.00)

MULTIPLE CHOICE

Differential boron worth (DBW) becomes MORE NEGATIVE (the absolute value becomes larger) with an increase in which one of the following?

a. Coolant boron concentration

b. Coolant average temperature

c. Controlling rod group height

d. Fission product poison buildup

QUESTION 1.04 (2.00)

Answer the following TRUE or FALSE.

a. To reduce the possibility of moisture carryover in Unit 1 Steam Generators, FOUR additional swirl vane separators (total of 16) have been added to each steam generator. (0.5)

b. Unit 2 Steam Generators have higher flow rates through the riser section than Unit 1 Steam Generators which helps to reduce potential corrosion problems. (0.5)

c. For equivalent transients, the Unit 1 Steam Generator level indication response will be slower and less pronounced when compared with Unit 2. (0.5)

d. During a normal plant transient on Unit 2, the operator should expect the narrow range and wide range Steam Generator level indication to move in opposite directions. (0.5)

(***** CATEGORY 01 CONTINUED ON NEXT PAGE *****)

QUESTION 1.05 (1.00)

MULTIPLE CHOICE

How will affected pressurizer level indication compare to actual pressurizer level if a pressurizer level reference line ruptures?

a. Indicated pressurizer level will be lower than actual pressurizer level.

b. Indicated pressurizer level will be higher than actual pressurizer level.

c. Indicated pressurizer level will be equal to actual pressurizer level.

d. Indicated pressurizer level will fail as is.

QUESTION 1.06 (1.00)

MULTIPLE CHOICE

The plant is operating at 30 percent load during a load ramp to full power. If steam flow denisity compensation pressure channel fails at its 30 % load value, then at full power, affected steam flow indication will:

a. Be less than actual steam flow.

b. Be equal to actual steam flow.

c. Be greater than actual steam flow.

d. Fail at the 30 percent load value.

(***** CATEGORY 01 CONTINUED ON NEXT PAGE *****)

QUESTION 1.07 (1.00)

MULTIPLE CHOICE

Which of the following statements best describes the change in count rate resulting from a short rod withdrawal with Keff at 0.99 as compared to an identical rod withdrawal with Keff at 0.95.

a. Less time will be required to reach steady-state following the rod withdrawal and the count rate will be greater with Keff at 0.99.

b. More time will be required to reach steady-state following the rod withdrawal and the change in count rate will be less with Keff at 0.99.

c. Less time will be required to reach steady-state following the rod withdrawal and the count rate will be less with Keff at 0.99.

d. More time will be required to reach steady-state following the rod withdrawal and the change in count rate will be greater with Keff at 0.99.

QUESTION 1.08 (1.00)

MULTIPLE CHOICE

During a reactor startup, control rods are withdrawn such that 1,000 pcm (1% delta-K/K) of reactivity is added. Before the withdrawal Keff was 0.97 and count rate was 500 cps. What will the final steady state count rate be following rod withdrawal?

a. 750 cps.

b. 1000 cps.

c. 2000 cps.

d. 2250 cps.

QUESTION 1.09 (1.50)

When fuel temperature is increased, the resonance absorption peaks are shortened and broadened such that more neutron energies are susceptible to absorption, but the average probability of resonance absorption (average microscopic cross-section) remains constant.

Explain why the doppler effect adds negative reactivity with increasing fuel temperture despite the constant average microscopic cross- ctions of the resonance absorbers.

QUESTION 1.10 (1.00)

MULTIPLE CHOICE

During a loss-of-coolant accident that results in fuel damage, several thermocouples exceed their melting temperature. The temperature indication from these thermocouples will be:

a. Lower than the actual temperature being measured.

b. Higher than the actual temperature being measured.

c. About the same as the actual temperature being measured.

d. Impossible to describe due to the lack of a similar previous operating event.

QUESTION 1.11 (1.00)

MULTIPLE CHOICE

How does critical heat flux vary from the bottom to the top of the reactor core during normal full power operation?

a. Increases, then decreases.

b. Decreases, then increases.

c. Continuously decreases.

d. Continuously increases.

(***** CATEGORY 01 CONTINUED ON NEXT PAGE *****)

QUESTION 1.12 (1.50)

Answer the following TRUE or FALSE.

a. When subcooled nucleate boiling is occurring in the core, fuel rod surface temperature is greater than coolant saturation temperature. (0.5)

b. Convection is the primary mechanism by which heat is transferred between the fuel rod surface and the reactor coolant during normal operations. (0.5)

c. During a LOCA with steam blanketing the fuel rod, radiation becomes the principle method of heat transfer. (0.5)

QUESTION 1.13 (1.00)

MULTIPLE CHOICE

The moderator temperature coefficient (MTC) becomes LEAST NEGATIVE (the absolute value becomes smallest) under which one of the following conditions?

a. Average temperature is decreased while boron concentration is decreased.

b. Average temperature is decreased while boron concentration is increased.

c. Average temperature is increased while boron concentration is increased.

d. Average temperature is increased while boron concentration is decreased.

(***** CATEGORY 01 CONTINUED ON NEXT PAGE *****)

QUESTION 1.14 (1.00)

MULTIPLE CHOICE

Which one of the following is NOT a purpose for rod insertion limits?

a. Minimize the time required for the control rods to add negative reactavity following a reactor trip.

b. Produce axial flux distributions that will prevent local power peaking.

c. Provide a shutdown reactivity margin that will offset the power defect at any power level.

d. Minimize the reactivity added in the event of a rod ejection accident.

QUESTION 1.15 (1.00)

MULTIPLE CHOICE

Which of the following conditions will result in criticality occurring at a lower than estimated control rod position?

a. A malfunction resulting in control rod speed being slower than normal speed.

b. Delaying the time of start up from 3 hours to 5 hours following a trip from 100% power equilibrium conditions.

c. Misadjusting the steam dump controller such that steam pressure is maintained 50 psig higher than the required no load setting.

d. Inadvertent dilution of RCS boron concentration.

(***** CATEGORY 01 CONTINUED ON NEXT PAGE *****)

QUESTION 1.16 (1.00)

MULTIPLE CHOICE

The plant is stable at 90 percent power with rod control in manual (Tave. equal Tref.). The controlling rod group is inserted about 10 steps. No other operator action is taken. Which one of the following properly describes the sequence of the plant response resulting from the rod insertion?

a. Reactor power remains constant, Tave increases. Tave stabilizes above Tref.

b. Reactor power decreases. Tave decreases, reactor power stabilizes below 90 percent, Tave stabilizes at approximately Tref.

c. Reactor power remains constant. Tave decreases, Tave increases, Tave stabilizes at approximately Tref.

d. Reactor power decreases, Tave decreases, reactor power increases to approximately 90 percent, Tave stabilizes below Tref.

QUESTION 1.17 (1.00)

MULTIPLE CHOICE

At the time of reactor shutdown from 100 percent power, shutdown margin was determined to be -5883 pcm with all control rods fully inserted. Three days later Xenon reactivity had changed by 2675 pcm, temperature reactivity had changed by 500 pcm due to cooling down to 140 degrees F and boron concentration had changed by 1040 pcm due to borating the RCS. What is the new shutdown margin?

a. -2168 pcm.

b. -3748 pcm.

c. -4843 pcm.

d. -5883 pcm.

QUESTION 1.18 (1.00)

How does reactor power respond during a plant startup at end of life (EOL) when the point of adding heat is reached with a 1.0 dpm startup rate? Assume no operator action and no reactor trip.

(***** CATEGORY 01 CONTINUED ON NEXT PAGE *****)

QUESTION 1.19 (1.00)

MULTIPLE CHOICE

Fast neutron irradiation adversely affects the reactor pressure vessel primarily by causing.

a. Embrittlement stress.

b. Brittle fracture.

c. Thermal gradients.

d. Pressurized thermal shock.

QUESTION 1.20 (2.00)

a. Define pump cavitation and describe how it occurs. (1.25)

b. List THREE conditions monitored by the control room operator that would indicate that a Component Cooling Water pump was cavitating. (Do not include noise and annunciators.) (0.75)

QUESTION 1.21 (1.00)

MULTIPLE CHOICE

Which of the following is NOT compensated for by K excess (Excess Multiplication Factor).

a. Fuel burn up.

b. Fission product poison buildup.

c. Chemical shim.

d. Reactivity effects of fuel and moderator temperature.

(***** CATEGORY 01 CONTINUED ON NEXT PAGE *****)

QUESTION 1.22 (1.00)

MULTIPLE CHOICE

To increase nuclear power from 15% power to 100% power normally requires which one of the following combinations of actions?

a. Increasing turbine first-stage pressure, decreasing RCS boron concentration, and increasing rod height.

b. Decreasing turbine first-stage pressure, decreasing RCS boron concentration, and increasing rod height.

c. Increasing turbine first-stage pressure, increasing RCS boron concentration, and decreasing rod height.

d. Decreasing turbine first-stage pressure, increasing RCS boron concentration, and decreasing rod height.

(***** END OF CATEGORY 01 *****)

QUESTION 2.01 (2.00)

How do the following systems connect to the reactor coolant system?

a. Pressurizer spray? [STATE LOOP NUMBER(S) AND WHETHER HOTLEG OR COLDLEG]

b. Pressurizer surge? [STATE LOOP NUMBER(S) AND WHETHER HOTLEG OR COLDLEG]

c. Emergency Core Cooling System? [LIST FOUR SYSTEMS CONNECTING TO COLDLEGS]

d. CVCS charging? [STATE LOOP NUMBER(S)]

e. CVCS letdown? [STATE LOOP NUMBER(S)]

f. CVCS fill? [STATE LOOP NUMBER(S) AND WHETHER HOTLEG OR COLDLEG]

QUESTION 2.02 (2.00)

a. How are the reactor coolant pump breakers interlocked with the loop isolation valves? [LIST TWO INTERLOCKS] [1.25]

b. Why must the RCPs be tripped on a Phase B isolation signal? [INCLUDE TWO RCP COMPONENTS AFFECTED] [0.75]

QUESTION 2.03 (2.00)

a. Why is a constant bypass spray flow maintained through the pressurizer spray system? [LIST THREE REASONS] [0.75]

b. What are the sources of water discharged to the Pressurizer Relief Tank [PRT]? [LIST FIVE SOURCES OTHER THAN VALVE LEAK OFFS SUCH AS RHR SUCTION VALVES ETC] [1.25]

QUESTION 2.04 (2.50)

List FIVE functions of the Volume Control Tank.

(***** CATEGORY 02 CONTINUED ON NEXT PAGE *****)

QUESTION 2.05 (2.00)

a. When in the BORATE MODE of operation, why is the blender output directed to the VCT outlet instead of the VCT inlet? [0.5]

b. Why is the amount of time using the ALTERNATE DILUTE mode of operation limited? [INCLUDE IN THE ANSWER WHERE THE BLENDER OUTPUT IS DIRECTED AND LIST TWO UNDESIRABLE EFFECTS OF ALTERNATE DILUTION] [1.5]

QUESTION 2.06 (2.50)

a. Why does each SI and CV line entering the RCS contain valves [for example 1SI 8810A,B,C,D] which are locked in a throttled positions? [LIST TWO REASONS] [1.0]

b. List SIX systems associated with the ECCS which have pumps that are automatically started following a LOCA. [1.5]

QUESTION 2.07 (3.00)

a. Describe the two [2] interlock conditions that must be satisfied in order to open the Containment Spray Pump Recirc Sump suction Valves CS009A(B) and include the reasons for each interlock. [2.0]

b. Describe the interlock condition that must be satisfied in order to open the Containment Spray Pump RWST Suction Isolation Valves CS001A(B) and include the reason for the interlock. [1.0]

QUESTION 2.08 (1.50)

List THREE conditions that will cause automatic closure of the MSIVs? [INCLUDING SETPOINTS, INTERLOCKS AND COINCIDENCES AS APPROPRIATE]

(***** CATEGORY 02 CONTINUED ON NEXT PAGE *****)

QUESTION 2.09 (1.00)

How will the steam dump system be affected by a failure/loss of the 125VDC non ESF bus 113? [SELECT THE CORRECT ANSWER]

a. The steam dumps will be inoperable because the D solenoid is powered from the 125VDC non ESF bus 113.

b. The steam dump system will be inoperable because ALL of the solenoids are powered from the 125VDC non ESF bus 113.

c. The steam dumps will trip to the full open position because the C solenoid repositions to the instrument air port upon the failure/loss of the 125VDC non ESF bus 113.

d. The steam dump system will be fully operable because the steam dump solenoids are not powered by the 125VDC non ESF bus 113.

QUESTION 2.10 (1.50)

What condition is required for the auxiliary feedwater ESW suction valves to automatically open? [assume the valve control switch is in the auto position? [INCLUDE SETPOINT AND THREE COINCIDENCE SIGNALS]

QUESTION 2.11 (1.00)

During normal at-power operations with on-site power from the SATs and UATs, how are the inplant loads split? [SELECT THE CORRECT ANSWER]

a. UAT 141-1 supplies buses 157 and 141 and ~~UAT~~ SAT 142-1 supplies buses 159 and 143

b. UAT 141-2 supplies buses 142 and 156 and ~~UAT~~ SAT 142-2 supplies buses 144 and 158

c. UAT 141-1 supplies buses 144 and 156 and ~~UAT~~ SAT 142-2 supplies buses 142 and 158

d. UAT 141-2 supplies buses 156 and 144 and ~~UAT~~ SAT 142-1 supplies buses 159 and 141

QUESTION 2.12 (2.00)

What are the purposes of the component cooling water surge tank? [LIST FOUR]

(***** END OF CATEGORY 02 *****)

QUESTION 3.01 (2.00)

Units 1 and 2 are operating at 100% load. Both Units have been experiencing frequent makeup to the VCT. I&C technicians are investigating.

1. If Unit 1 is in the auto M/U mode, how would Unit 1 VCT level be affected if LT-112 fails at 56%? [ASSUME NO OPERATOR ACTION; SELECT THE CORRECT ANSWER] [1.0]

   a. VCT level will increase until LT-185 opens CV-112A to full divert at 95%

   b. VCT level will decrease to 5%; at 5% VCT level CV-112D and E opens and CV-112B and C close

   c. VCT level will go to zero

   d. VCT level will decrease to 37% and then increase until LT-185 opens CV-112A to full divert at 95%

2. If Unit 2 is in the auto M/U mode, how would Unit 2 VCT level be affected if LT-185 fails at 0%? [ASSUME NO OPERATOR ACTION; SELECT THE CORRECT ANSWER] [1.0]

   a. VCT level will increase until LT-112 opens CV-112A to full divert at 95%

   b. VCT level will decrease to 5%; at 5% VCT level CV-112D and E opens and CV-112B and C close

   c. VCT level will go to zero

   d. VCT level will be maintained in the normal operating range

QUESTION 3.02 ~~(1.50)~~ (0.50)

During operation at power [93%], you are manually withdrawing the controlling bank of rods and the "Rod Control URGENT Failure" annunciator is actuated in the control room.

a. How is rod motion affected? [ANSWER FOR BOTH MANUAL AND AUTO] [0.5]

~~b. What are the power cabinet conditions/failures that cause a "Logic Cabinet Urgent Failure"? [LIST FOUR CONDITIONS/FAILURES] [1.0]~~ Deleted

(***** CATEGORY 03 CONTINUED ON NEXT PAGE *****)

QUESTION 3.03 ~~(2.00)~~ 1.00

a. What are the rod stops that block only automatic rod withdrawal? [LIST TWO; INCLUDE SETPOINTS AND COINCIDENCE AS APPROPRIATE] [1.0]

~~b. Other than the overtemperature and over power delta T rod stops, what are the rod stops that block both automatic and manual rod withdrawal? [LIST FOUR; INCLUDE SETPOINTS AND COINCIDENCE AS APPROPRIATE] [1.0]~~ Deleted

QUESTION 3.04 (1.00)

The Rod Position Indication System consists of two different position indication systems. Briefly describe how each system senses/determines rod position?

QUESTION 3.05 (2.00)

The auctioneered high Tavg signal is used as an input to several circuits including the computer and recorder. List FIVE different circuits, other than the computer and recorder, that are supplied with auctioneered high Tavg inputs.

QUESTION 3.06 (1.50)

With the Steam Dump System aligned for normal 100 % power operations, explain how the Steam Dump System would be affected if PT-505 [HP Turbine First Stage Impulse Pressure] fails LOW.

QUESTION 3.07 (2.50)

While operating at 75% power, the Pressurizer Pressure Control System reference pressure, Pref, [Proportional-Integral-Derivative (PID) Controller setting] fails to zero. [ASSUME PLANT SYSTEMS RESPOND AS DESIGNED AND AS NORMALLY ALIGNED; NO OPERATOR ACTION TAKEN]

How will the pressurizer pressure control system respond to the failure? [DESCRIBE HOW PRESSURIZER PRESSURE RESPONDS AND INCLUDE JUSTIFICATION FOR YOUR DESCRIPTION] [2.5]

(***** CATEGORY 03 CONTINUED ON NEXT PAGE *****)

QUESTION 3.08 (3.00)

a. What condition(s) are required for the P-4 permissive actions to occur? [LIST TWO COMPONENTS AND THEIR REQUIRED POSITION] [0.75]

b. What are the actions that the P-4 permissive initiates? [LIST FOUR ACTIONS and ASSOCIATED CONDITIONS SETPOINTS & COINCIDENCES AS APPROPRIATE] [2.25]

QUESTION 3.09 (2.00)

Lable ITEMS A. through E. on the attached source range block diagram, Figure 3-1.

QUESTION 3.10 (2.25)

a. List THREE inadequate core cooling instrumentation sensors. [0.75]

b. What is the significance of the following indications on the inadequate core cooling detection system:

1. Interval 1? [DESCRIBE THE CONDITION OF THE REACTOR COOLANT] [0.5]

2. Interval 2? [DESCRIBE THE STATUS OF THE REACTOR COOLANT INVENTORY] [0.5]

3. Interval 3? [DESCRIBE HOW CORE EXIT TEMPERATURES ARE TRENDING AND STATE WHY.]

QUESTION 3.11 (2.25)

a. Describe the operation of the interlocks associated with AREA RADIATION MONITORS ORE-AR055 and ORE-AR056 (Fuel Building Fuel Handling Incident). [1.5]

b. Describe the operation of the interlocks associated with PROCESS RADIATION MONITORS ORE-PR033 and ORE-PR034 (Control Room Outside Air Intake B Monitors). [0.75]

(***** CATEGORY 03 CONTINUED ON NEXT PAGE *****)

QUESTION 3.12 (3.00)

a. Describe the operating sequence for the Reactor Containment Fan cooler System following a Safety Injection Actuation. [Include the operation of interlocks were appropriate.] [2.0]

b. What conditions will actuate the P-14 Interlock and what actions are initiated by this permissive? [LIST THREE ACTIONS AND INCLUDE SETPOINTS & COINCIDENCE AS APPROPRIATE] [1.0]

(***** END OF CATEGORY 03 *****)

QUESTION 4.01 (1.50)

Procedure 1BWOA ELEC-1, "Loss of DC Bus Unit 1" requires a reactor trip on loss of either 125 VDC Bus-111 or Bus-112. What is the basis for requiring this action?

QUESTION 4.02 (1.50)

In BWAP 340-1, "Use of Procedures for Operating Department", it is stated that ," Due to the large number of procedures, which vary widely in complexity and impact, it is recognized that their content must be retrieved on differing bases." In accordance with BWAP 340-1 how are Braidwood General Procedures (BwGP's) to be used?

QUESTION 4.03 (2.00)

Procedure 1 BWEP, ES-1.3, "Transfer To Cold Leg Recirculation Unit 1", contains a caution stating that:

"SI pumps should be stopped if RCS pressure is GREATER THAN 1590 PSIG".

Provide a detailed explaination why the cold leg recirculation procedure contains this caution.

QUESTION 4.04 (1.50)

In accordance with Technical Specifications 3/4.4.6, "Reactor Coolant System Leakage", list the THREE Reactor Coolant System Leakage Detection Systems that should be operable in Modes 1 through 4.

QUESTION 4.05 (1.50)

List the SUBSTEPS required to verify the following immediate action steps as stated in 1BWEP-0, "Reactor Trip or Safety Injection Unit 1".

a. VERIFY REACTOR TRIP: (0.375)
b. VERIFY FW ISOLATION: (1.125)

(***** CATEGORY 04 CONTINUED ON NEXT PAGE *****)

QUESTION 4.06 (2.00)

a. Having observed the symptoms in procedure 1BWOA ROD-3 "Stuck or Misaligned Rod", what action is taken by the reactor operator to determine/verify that the rod is actually stuck. (1.0)

b. According to procedure; 1BWOA ROD-3; the method used to realign a rod that is misaligned LOW with respect to its group is significantly different from the procedure for realigning a rod that is misaligned HIGH. State the basic difference between the two realignment procedures (1.0)

QUESTION 4.07 (1.50)

BWRP 1000-A1, "Commonwealth Edison Radiation Protection Standards", provides guidance on the wearing and use of personnel dosimeters, and dose limits for individuals.

a. State where on the body and how in relation to each other personnel dosimeters are required to worn. (Normal position only, DO NOT state exceptions.) (0.5)

b. State the required action for an individual who after entering a Radiologically Controlled Work area discovers that their self-reading dosimeter reads off-scale. (0.5)

c. List the whole body and extremity dose limits for life-saving activities. (0.5)

QUESTION 4.08 (1.00)

In accordance with BWAP 330-1 "Station Equipment Out-of-Service Procedures", WHAT is the recommended sequence for the placement of Out of Service Cards when removing a power operated valve from service?

QUESTION 4.09 (2.00)

List FOUR symptoms for a failed number one RCP seal per procedure 1BWOA RCP-1, "Reactor Coolant Pump Seal Failure Unit 1."

(***** CATEGORY 04 CONTINUED ON NEXT PAGE *****)

QUESTION 4.10 (1.00)

Using the guidance provided in BWAP 1100-1, "Fire Protection Program", what action should you take when discovering a fire in the Turbine Building?

QUESTION 4.11 (2.00)

Abnormal procedure 1 BWOA PRI-2, "Emergency Boration-Unit 1", lists in order of preference, FOUR methods used to emergency borate the RCS.

a. List the first THREE methods in order of preference. (1.0)

b. State why emergency boration using the MANUAL emergency borate valve (1CV8439) is the fourth or least prefered method. (1.0)

QUESTION 4.12 (1.00)

List the TWO parameters, including set points, that indicate adverse containment conditions have been reached.

QUESTION 4.13 (1.50)

Fill in the blank for the following concerning Plant Technical Specifications:

a. Reactor Coolant System pressure shall not exceed______ psig and RCS temperature (Tavg) in Mode 1 must be greater than ____________ degrees F.

MULTIPLE CHOICE

b. Reactor Coolant System (RCS) leakage through a steam generator to the secondary coolant is known as:
   (1) Controlled Leakage
   (2) Identified Leakage
   (3) Pressure Boundary Leakage
   (4) Unidentified Leakage

(***** CATEGORY 04 CONTINUED ON NEXT PAGE *****)

QUESTION 4.14 (1.50)

State the RCP Trip Criteria as listed in "Operator Action Summary Sheet for 1BWEP-0 Series Procedure" (fold-out page).

QUESTION 4.15 (1.00)

Fill in the blanks for the following "Precautions and Limitations" for the Component Cooling System as stated in WEC's "Precautions, Limitations and Setpoints for Nuclear Steam Supply Systems".

a. The temperature of the cooling water supplied to the various components should be greater than or equal to ____________ degrees F and should NOT exceed ______________ degrees F during normal operations. (0.5)

b. The normal source of makeup water to the CC surge tanks is ____________________. If the normal source is not available, then ______________________ is used as an emergency source. (0.5)

QUESTION 4.16 (1.50)

The control room operators are performing 1BWFR-C.2 "Response to Degraded Core Cooling", in response to an ORANGE path condition shown on the Core Cooling Critical Safety Function (CSF) status tree. Answer the following TRUE or FALSE. Consider each one separately.

a. The operators must leave this procedure before completion and go to 1BWFR-S.2 "Response to Loss of Core Shutdown", if the subcriticality status tree indicates an ORANGE path condition.

b. The operators may leave this procedure at any step as soon as the core cooling CSF adverse condition has cleared. (GREEN path established)

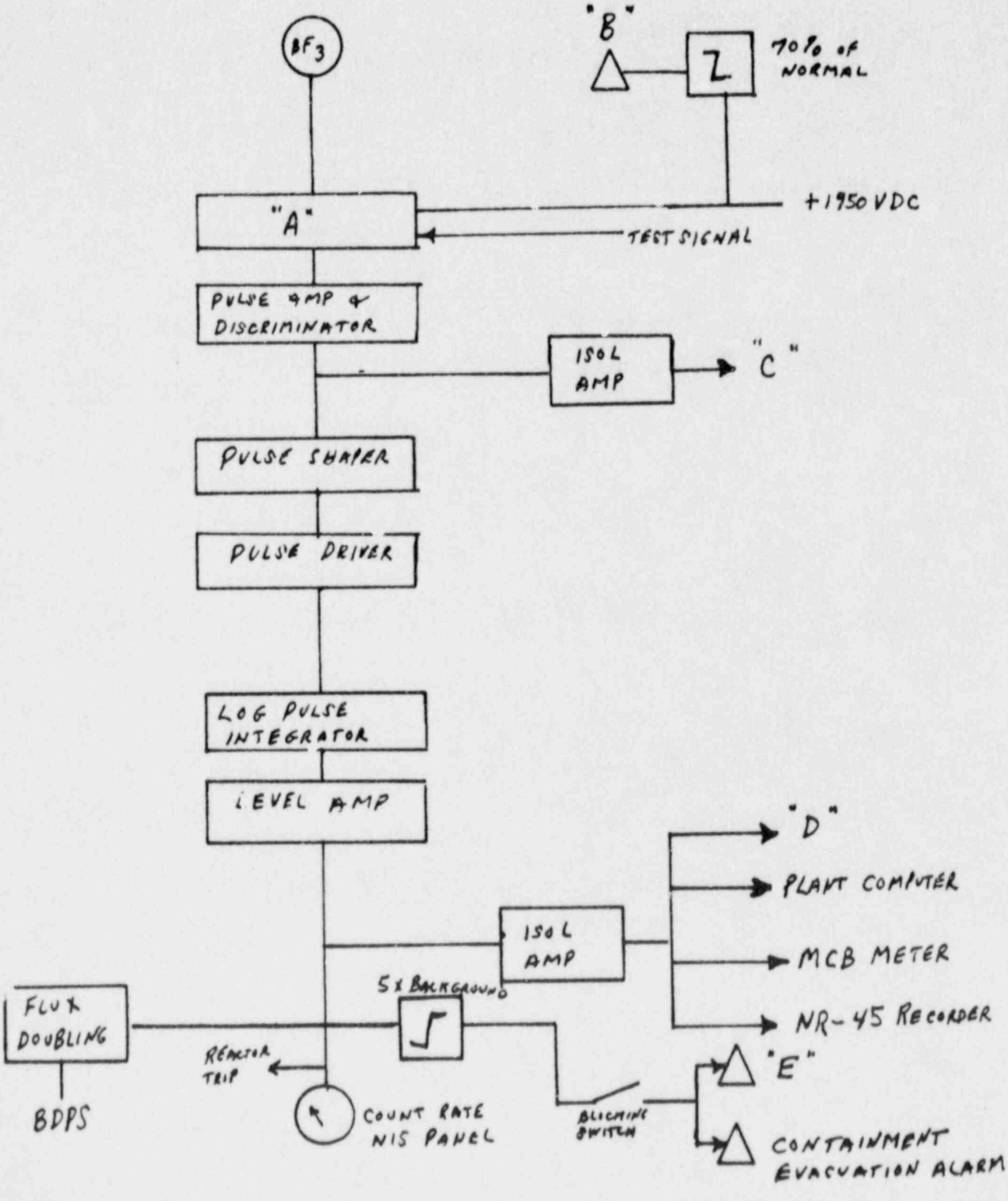
c. The operators must leave this procedure before completion and go to 1BWFR-H.1,"Response to Loss of Secondary Heat Sink", if the heat sink CSF status tree indicates a RED path condition.

(***** CATEGORY 04 CONTINUED ON NEXT PAGE *****)

QUESTION 4.17 (1.00)

Special Operating Order Number SO-ST-0014 is entitled "Mandatory In-Hand Procedure". Define a mandatory in-hand procedure and list by number or title description the ONE Braidwood OP applicable to this special order.

(***** END OF CATEGORY 04 *****)
(************* END OF EXAMINATION ***************)



BF3
"B"
Z
70% of NORMAL
"A"
+1950 VDC
TEST SIGNAL
PULSE AMP & DISCRIMINATOR
ISOL AMP
"C"
PULSE SHAPER
PULSE DRIVER
LOG PULSE INTEGRATOR
LEVEL AMP
"D"
PLANT COMPUTER
ISOL AMP
MCB METER
5 x BACKGROUND
FLUX DOUBLING
NR-45 RECORDER
REACTOR TRIP
"E"
BDPS
COUNT RATE NIS PANEL
BLOCKING SWITCH
CONTAINMENT EVACUATION ALARM

FIGURE 3-1

EQUATION SHEET

$f = ma$

$w = mg$

$E = mC^2$

$KE = ½mv^2$

$PE = mgh$

$W = v\Delta P$

$\Delta E = 931\Delta m$

$\dot{Q} = \dot{m}C_p\Delta T$

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

$Pwr = W_f \dot{m}$

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

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

$SUR = 26.06/T$

$T = 1.44\ DT$

$SUR = 26 \left(\frac{\lambda_{eff}\rho}{\bar{\beta} - \rho}\right)$

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

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

$T = (\bar{\beta} - \rho)/\lambda_{eff}\rho$

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

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

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

$\Sigma = N\sigma$

$v = s/t$

$s = v_o t + ½at^2$

$a = (v_f - v_o)/t$

$v_f = v_o + at$

$\omega = \theta/t$

$\text{Cycle efficiency} = \frac{\text{Net Work (out)}}{\text{Energy (in)}}$

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

$\lambda = \ln 2/t_{½} = 0.693/t_{½}$

$t_{½}(eff) = \frac{(t_{½})(t_b)}{(t_{½} + t_b)}$

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

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

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

$TVL = 1.3/\mu$

$HVL = 0.693/\mu$

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

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

$CR_1(1 - K_{eff})_1 = CR_2(1 - K_{eff})_2$

$M = 1/(1 - K_{eff}) = CR_1/CR_0$

$M = (1 - K_{eff})_0/(1 - K_{eff})_1$

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

$\ell^* = 1 \times 10^{-5}$ seconds

$\lambda_{eff} = 0.1\ \text{seconds}^{-1}$

$I_1d_1 = I_2d_2$

$I_1d_1^2 = I_2d_2^2$

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

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

WATER PARAMETERS

1 gal. = 8.345 lbm

1 gal. = 3.78 liters

1 ft^3 = 7.48 gal.

Density = 62.4 lbm/ft^3

Density = 1 gm/cm^3

Heat of vaporization = 970 Btu/lbm

Heat of fusion = 144 Btu/lbm

1 Atm = 14.7 psi = 29.9 in. Hg

1 ft. H_2O = 0.4335 lbf/in^2

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 Btu = 778 ft-lbf

1 inch = 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	1.12163	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	227.5	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	2.0056	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

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
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	0.1[illegible]30	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	6.8630	0.016486	54.59	54.61	143.99	992.6	1136.6	0.2568	1.5616	1.8184	176.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.2600	1.5548	1.8147	[illegible]

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	18.189	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	[illegible]	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

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
300.0	67.005	0.01745	6.4483	6.4658	269.7	910.0	1179.7	0.4372	1.1979	1.6351	300.0
304.0	71.119	0.01749	6.0955	6.1130	273.8	907.0	1180.9	0.4426	1.1877	1.6303	304.0
308.0	75.433	0.01753	5.7655	5.7830	278.0	904.0	1182.0	0.4479	1.1776	1.6256	308.0
312.0	79.953	0.01757	5.4566	5.4742	282.1	901.0	1183.1	0.4533	1.1676	1.6209	312.0
316.0	84.688	0.01761	5.1673	5.1849	286.3	897.9	1184.1	0.4586	1.1576	1.6162	316.0
320.0	89.643	0.01766	4.8961	4.9138	290.4	894.8	1185.2	0.4640	1.1477	1.6116	320.0
324.0	94.826	0.01770	4.6418	4.6595	294.6	891.6	1186.2	0.4692	1.1378	1.6071	324.0
328.0	100.245	0.01774	4.4030	4.4208	298.7	888.5	1187.2	0.4745	1.1280	1.6025	328.0
332.0	105.907	0.01779	4.1788	4.1966	302.9	885.3	1188.2	0.4798	1.1183	1.5981	332.0
336.0	111.820	0.01783	3.9681	3.9859	307.1	882.1	1189.1	0.4850	1.1086	1.5936	336.0
340.0	117.992	0.01787	3.7699	3.7878	311.3	878.8	1190.1	0.4902	1.0990	1.5892	340.0
344.0	124.430	0.01792	3.5834	3.6013	315.5	875.5	1191.0	0.4954	1.0894	1.5849	344.0
348.0	131.142	0.01797	3.4078	3.4258	319.7	872.2	1191.1	0.5006	1.0799	1.5806	348.0
352.0	138.138	0.01801	3.2423	3.2603	323.9	868.9	1192.7	0.5058	1.0705	1.5763	352.0
356.0	145.424	0.01806	3.0863	3.1044	328.1	865.5	1193.6	0.5110	1.0611	1.5721	356.0
360.0	153.010	0.01811	2.9392	2.9573	332.3	862.1	1194.4	0.5161	1.0517	1.5678	360.0
364.0	160.903	0.01816	2.8002	2.8184	336.5	858.6	1195.2	0.5212	1.0424	1.5637	364.0
368.0	169.113	0.01821	2.6691	2.6873	340.8	855.1	1195.9	0.5263	1.0332	1.5595	368.0
372.0	177.648	0.01826	2.5451	2.5633	345.0	851.6	1196.7	0.5314	1.0240	1.5554	372.0
376.0	186.517	0.01831	2.4279	2.4462	349.3	848.1	1197.4	0.5365	1.0148	1.5513	376.0
380.0	195.729	0.01836	2.3170	2.3353	353.6	844.5	1198.0	0.5416	1.0057	1.5473	380.0
384.0	205.294	0.01842	2.2120	2.2304	357.9	840.8	1198.7	0.5466	0.9966	1.5432	384.0
388.0	215.220	0.01847	2.1126	2.1311	362.2	837.2	1199.3	0.5516	0.9876	1.5392	388.0
392.0	225.516	0.01853	2.0184	2.0369	366.5	833.4	1199.9	0.5567	0.9786	1.5352	392.0
396.0	236.193	0.01858	1.9291	1.9477	370.8	829.7	1200.4	0.5617	0.9696	1.5313	396.0
400.0	247.259	0.01864	1.8444	1.8630	375.1	825.9	1201.0	0.5667	0.9607	1.5274	400.0
404.0	258.725	0.01870	1.7640	1.7827	379.4	822.0	1201.5	0.5717	0.9518	1.5234	404.0
408.0	270.600	0.01875	1.6877	1.7064	383.8	818.2	1201.9	0.5766	0.9429	1.5195	408.0
412.0	282.894	0.01881	1.6152	1.6340	388.1	814.2	1202.4	0.5816	0.9341	1.5157	412.0
416.0	295.617	0.01887	1.5463	1.5651	392.5	810.2	1202.8	0.5866	0.9253	1.5118	416.0
420.0	308.780	0.01894	1.4808	1.4997	396.9	806.2	1203.1	0.5915	0.9165	1.5080	420.0
424.0	322.391	0.01900	1.4184	1.4374	401.3	802.2	1203.5	0.5964	0.9077	1.5042	424.0
428.0	336.463	0.01906	1.3591	1.3782	405.7	798.0	1203.7	0.6014	0.8990	1.5004	428.0
432.0	351.00	0.01913	1.30266	1.32179	410.1	793.9	1204.0	0.6063	0.8903	1.4966	432.0
436.0	366.03	0.01919	1.24887	1.26806	414.6	789.7	[illegible]	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	[illegible]	1.4890	440.0
444.0	397.56	0.01933	1.14874	1.16806	[illegible]	781.1	1204.6	0.6210	0.8643	1.4853	444.0

Temp Fahr t	Abs Press. Lb per Sq In. p	Specific Volume			Enthalpy			Entropy			Temp Fahr t
		Sat. Liquid v_f	Evap v_{fg}	Sat. Vapor v_g	Sat. Liquid h_f	Evap h_{fg}	Sat. Vapor h_g	Sat. Liquid s_f	Evap s_{fg}	Sat. Vapor s_g	
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

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
600.0	1543.2	0.02364	0.24384	0.2674[illegible]	617.1	550.6	1167.7	0.8134	0.5196	1.3330	600.0
604.0	1589.7	0.02382	0.23374	0.257[illegible]7	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
616.6	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	4[illegible]6.6	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	666.0
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	0.029[illegible]1	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*

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	0.3632	1.3313	1.6995	30.0
40.0	267.25	0.017151	10.4794	10.4965	236.1	933.6	1169.8	0.3921	1.2844	1.6765	40.0
50.0	281.02	0.017274	8.4967	8.5140	250.2	923.9	1174.1	0.4112	1.2474	1.6586	50.0
60.0	292.71	0.017383	7.1562	7.1736	262.2	915.4	1177.6	0.4273	1.2167	1.6440	60.0
70.0	302.93	0.017482	6.1875	6.2050	272.7	907.8	1180.6	0.4411	1.1905	1.6316	70.0
80.0	312.04	0.017573	5.4536	5.4711	282.1	900.9	1183.1	0.4534	1.1675	1.6208	80.0
90.0	320.28	0.017659	4.8779	4.8953	290.7	894.6	1185.3	0.4643	1.1470	1.6113	90.0
100.0	327.82	0.017740	4.4133	4.4310	298.5	888.6	1187.2	0.4743	1.1284	1.6027	100.0
110.0	334.79	0.01782	4.0306	4.0484	305.8	883.1	1188.9	0.4834	1.1115	1.5950	110.0
120.0	341.27	0.01789	3.7097	3.7275	312.6	877.8	1190.4	0.4919	1.0960	1.5879	120.0
130.0	347.33	0.01796	3.4364	3.4544	319.0	872.8	1191.7	0.4998	1.0815	1.5813	130.0
140.0	353.04	0.01803	3.2010	3.2190	325.0	868.0	1193.0	0.5071	1.0681	1.5752	140.0
150.0	358.43	0.01809	2.9958	3.0139	330.6	863.4	1194.1	0.5141	1.0554	1.5695	150.0
160.0	363.55	0.01815	2.8155	2.8336	336.1	859.0	1195.1	0.5206	1.0435	1.5641	160.0
170.0	368.42	0.01821	2.6556	2.6738	341.2	854.8	1196.0	0.5269	1.0322	1.5591	170.0
180.0	373.08	0.01827	2.5129	2.5312	346.2	850.7	1196.9	0.5328	1.0215	1.5543	180.0
190.0	377.53	0.01833	2.3847	2.4030	350.9	846.7	1197.6	0.5384	1.0113	1.5498	190.0
200.0	381.80	0.01839	2.2689	2.2873	355.5	842.8	1198.3	0.5438	1.0016	1.5454	200.0
210.0	385.91	0.01844	2.16373	2.18217	359.9	839.1	1199.0	0.5490	0.9923	1.5413	210.0
220.0	389.88	0.01850	2.06779	2.08629	364.2	835.4	1199.6	0.5540	0.9834	1.5374	220.0
230.0	393.70	0.01855	1.97991	1.99846	368.3	831.8	1200.1	0.5588	0.9748	1.5336	230.0
240.0	397.39	0.01860	1.89909	1.91769	372.3	828.4	1200.6	0.5634	0.9665	1.5299	240.0
250.0	400.97	0.01865	1.82452	1.84317	376.1	825.0	1201.1	0.5679	0.9585	1.5264	250.0
260.0	404.44	0.01870	1.75548	1.77418	379.9	821.6	1201.5	0.5722	0.9508	1.5230	260.0
270.0	407.80	0.01875	1.69137	1.71013	383.6	818.3	1201.9	0.5764	0.9433	1.5197	270.0
280.0	411.07	0.01880	1.63169	1.65049	387.1	815.1	1202.3	0.5805	0.9361	1.5166	280.0
290.0	414.25	0.01885	1.57597	1.59482	390.6	812.0	1202.6	0.5844	0.9291	1.5135	290.0
300.0	417.35	0.01889	1.52384	1.54274	394.0	808.9	1202.9	0.5882	0.9223	1.5105	300.0
350.0	431.73	0.01912	1.30642	1.32554	400.8	794.2	1204.0	0.6059	0.8909	1.4968	350.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Abs Press. Lb/Sq In. p	Temp Fahr t	Specific Volume Sat. Liquid v_f	Evap v_{fg}	Sat. Vapor v_g	Enthalpy Sat. Liquid h_f	Evap h_{fg}	Sat. Vapor h_g	Entropy Sat. Liquid s_f	Evap s_{fg}	Sat. Vapor s_g	Abs Press. Lb/Sq In. p
450.0	456.28	0.01954	1.01224	1.03179	437.3	767.5	1204.8	0.6360	0.8378	1.4738	450.0
500.0	467.01	0.01975	0.90787	0.92762	449.5	755.1	1204.7	0.6490	0.8148	1.4639	500.0
550.0	476.94	0.01994	0.82183	0.84177	460.9	743.3	1204.3	0.6611	0.7936	1.4547	550.0
600.0	486.20	0.02013	0.74962	0.76975	471.7	732.0	1203.7	0.6723	0.7738	1.4461	600.0
650.0	494.89	0.02032	0.68811	0.70843	481.9	720.9	1202.8	0.6828	0.7552	1.4381	650.0
700.0	503.08	0.02050	0.63505	0.65556	491.6	710.2	1201.8	0.6928	0.7377	1.4304	700.0
750.0	510.84	0.02069	0.58880	0.60949	500.9	699.8	1200.7	0.7022	0.7210	1.4232	750.0
800.0	518.21	0.02087	0.54809	0.56896	509.8	689.6	1199.4	0.7111	0.7051	1.4163	800.0
850.0	525.24	0.02105	0.51197	0.53302	518.4	679.5	1198.0	0.7197	0.6899	1.4096	850.0
900.0	531.95	0.02123	0.47968	0.50091	526.7	669.7	1196.4	0.7279	0.6753	1.4032	900.0
950.0	538.39	0.02141	0.45064	0.47205	534.7	660.0	1194.7	0.7358	0.6612	1.3970	950.0
1000.0	544.58	0.02159	0.42436	0.44596	542.6	650.4	1192.9	0.7434	0.6476	1.3910	1000.0
1050.0	550.53	0.02177	0.40047	0.42224	550.1	640.9	1191.0	0.7507	0.6344	1.3851	1050.0
1100.0	556.28	0.02195	0.37863	0.40058	557.5	631.5	1189.1	0.7578	0.6216	1.3794	1100.0
1150.0	561.82	0.02214	0.35859	0.38073	564.8	622.2	1187.0	0.7647	0.6091	1.3738	1150.0
1200.0	567.19	0.02232	0.34013	0.36245	571.9	613.0	1184.8	0.7714	0.5969	1.3683	1200.0
1250.0	572.38	0.02250	0.32306	0.34556	578.8	603.8	1182.6	0.7780	0.5850	1.3630	1250.0
1300.0	577.42	0.02269	0.30722	0.32991	585.6	594.6	1180.2	0.7843	0.5733	1.3577	1300.0
1350.0	582.32	0.02288	0.29250	0.31537	592.3	585.4	1177.8	0.7906	0.5620	1.3525	1350.0
1400.0	587.07	0.02307	0.27871	0.30178	598.8	576.5	1175.3	0.7966	0.5507	1.3474	1400.0
1450.0	591.70	0.02327	0.26584	0.28911	605.3	567.4	1172.8	0.8026	0.5397	1.3423	1450.0
1500.0	596.20	0.02346	0.25372	0.27719	611.7	558.4	1170.1	0.8085	0.5288	1.3373	1500.0
1550.0	600.59	0.02366	0.24235	0.26601	618.0	549.4	1167.4	0.8142	0.5182	1.3324	1550.0
1600.0	604.87	0.02387	0.23159	0.25545	624.2	540.3	1164.5	0.8199	0.5076	1.3274	1600.0
1650.0	609.05	0.02407	0.22143	0.24551	630.4	531.3	1161.6	0.8254	0.4971	1.3225	1650.0
1700.0	613.13	0.02428	0.21178	0.23607	636.5	522.2	1158.6	0.8309	0.4867	1.3176	1700.0
1750.0	617.12	0.02450	0.20263	0.22713	642.5	513.1	1155.6	0.8363	0.4765	1.3128	1750.0
1800.0	621.02	0.02472	0.19390	0.21861	648.5	503.8	1152.3	0.8417	0.4662	1.3079	1800.0
1850.0	624.83	0.02495	0.18558	0.21052	654.5	494.6	1149.0	0.8470	0.4561	1.3030	1850.0
1900.0	628.56	0.02517	0.17761	0.20278	660.4	485.2	1145.6	0.8522	0.4459	1.2981	1900.0
1950.0	632.22	0.02541	0.16999	0.19540	666.3	475.8	1142.0	0.8574	0.4358	1.2931	1950.0
2000.0	635.80	0.02565	0.16266	0.18831	672.1	466.2	1138.3	0.8625	0.4256	1.2881	2000.0
2100.0	642.76	0.02615	0.14885	0.17501	683.8	446.7	1130.5	0.8727	0.4053	1.2780	2100.0
2200.0	649.45	0.02669	0.13603	0.16272	695.5	426.7	1122.2	0.8828	0.3848	1.2676	2200.0
2300.0	655.89	0.02727	0.12406	0.15133	707.2	406.0	1113.2	0.8929	0.3640	1.2569	2300.0
2400.0	662.11	0.02790	0.11287	0.14076	719.0	384.8	1103.7	0.9031	0.3430	1.2460	2400.0
2500.0	668.11	0.02859	0.10209	0.13068	731.7	361.6	1093.3	0.9139	0.3206	1.2345	2500.0
2600.0	673.91	0.02938	0.09172	0.12110	744.5	337.6	1082.0	0.9247	0.2977	1.2225	2600.0
2700.0	679.53	0.03029	0.08165	0.11194	757.3	312.3	1069.7	0.9356	0.2741	1.2097	2700.0
2800.0	684.96	0.03134	0.07171	0.10305	770.7	285.1	1055.8	0.9468	0.2491	1.1958	2800.0
2900.0	690.22	0.03262	0.06158	0.09420	785.1	254.7	1039.8	0.9588	0.2215	1.1803	2900.0
3000.0	695.33	0.03428	0.05073	0.08500	801.8	218.4	1020.3	0.9728	0.1891	1.1619	3000.0
3100.0	700.28	0.03681	0.03771	0.07452	824.0	169.3	993.3	0.9914	0.1460	1.1373	3100.0
3200.0	705.08	0.04472	0.01191	0.05663	875.5	56.1	931.6	1.0351	0.0482	1.0832	3200.0
[illegible]08.2*	705.47	0.05078	0.00000	0.05078	90[illegible]	0.0	906.0	1.0612	0.0000	1.0612	[illegible]08.2*

Table 3. Superheated Steam

Abs Press Lb/Sq In (Sat Temp)		Sat Water	Sat Steam	200	250	300	350	400	450	500	600	700	800	900	1000	1100	1200
				Temperature – Degrees Fahrenheit													
1 (101.74)	Sh			98.26	148.26	198.26	248.26	298.26	348.26	398.26	498.26	598.26	698.26	798.26	898.26	998.26	1098.26
	v	0.01614	333.6	392.5	422.4	452.3	482.1	511.9	541.7	571.5	631.1	690.7	750.3	809.8	869.4	929.0	988.6
	h	69.73	1105.8	1150.2	1172.9	1195.7	1218.7	1241.8	1265.1	1288.6	1336.1	1384.5	1433.7	1483.8	1534.9	1586.8	1639.7
	s	0.1326	1.9781	2.0509	2.0841	2.1152	2.1445	2.1722	2.1985	2.2237	2.2708	2.3144	2.3551	2.3934	2.4296	2.4640	2.4969
5 (162.24)	Sh			37.76	87.76	137.76	187.76	237.76	287.76	337.76	437.76	537.76	637.76	737.76	837.76	937.76	1037.76
	v	0.01641	73.53	78.14	84.21	90.24	96.25	102.24	108.23	114.21	126.15	138.08	150.01	161.94	173.86	185.78	197.70
	h	130.20	1131.1	1148.6	1171.7	1194.8	1218.0	1241.3	1264.7	1288.2	1335.9	1384.3	1433.6	1483.7	1534.7	1586.7	1639.6
	s	0.2349	1.8443	1.8716	1.9054	1.9369	1.9664	1.9943	2.0208	2.0460	2.0932	2.1369	2.1776	2.2159	2.2521	2.2866	2.3194
10 (193.21)	Sh			6.79	56.79	106.79	156.79	206.79	256.79	306.79	406.79	506.79	606.79	706.79	806.79	906.79	1006.79
	v	0.01659	38.42	38.84	41.93	44.98	48.02	51.03	54.04	57.04	63.03	69.00	74.98	80.94	86.91	92.87	98.84
	h	161.26	1143.3	1146.6	1170.2	1193.7	1217.1	1240.6	1264.1	1287.8	1335.5	1384.0	1433.4	1483.5	1534.6	1586.6	1639.5
	s	0.2836	1.7879	1.7928	1.8273	1.8593	1.8892	1.9173	1.9439	1.9692	2.0166	2.0603	2.1011	2.1394	2.1757	2.2101	2.2430
14.696 (212.00)	Sh				38.00	88.00	138.00	188.00	238.00	288.00	388.00	488.00	588.00	688.00	788.00	888.00	988.00
	v	.0167	26.799		28.42	30.52	32.60	34.67	36.72	38.77	42.86	46.93	51.00	55.06	59.13	63.19	67.25
	h	180.17	1150.5		1168.8	1192.6	1216.3	1239.9	1263.6	1287.4	1335.7	1383.8	1432.7	1483.4	1534.5	1586.5	1639.4
	s	.3121	1.7568		1.7833	1.8158	1.8459	1.8743	1.9010	1.9265	1.9739	2.0177	2.0585	2.0969	2.1332	2.1676	2.2005
15 (213.03)	Sh				36.97	86.97	136.97	186.97	236.97	286.97	386.97	486.97	586.97	686.97	786.97	886.97	986.97
	v	0.01673	26.290		27.837	29.899	31.939	33.963	35.977	37.985	41.986	45.978	49.964	53.946	57.926	61.905	65.887
	h	181.21	1150.9		1168.7	1192.5	1216.2	1239.9	1263.6	1287.3	1335.2	1383.8	1433.2	1483.4	1534.5	1586.5	1639.4
	s	0.3137	1.7552		1.7809	1.8134	1.8437	1.8720	1.8988	1.9242	1.9717	2.0155	2.0563	2.0946	2.1309	2.1653	2.1982
20 (227.96)	Sh				22.04	72.04	122.04	172.04	222.04	272.04	372.04	472.04	572.04	672.04	772.04	872.04	972.04
	v	0.01683	20.087		20.788	22.356	23.900	25.428	26.946	28.457	31.466	34.465	37.458	40.447	43.435	46.420	49.405
	h	196.27	1156.3	–	1167.1	1191.4	1215.4	1239.2	1263.0	1286.9	1334.9	1383.5	1432.9	1483.2	1534.3	1586.3	1639.3
	s	0.3358	1.7320		1.7475	1.7805	1.8111	1.8397	1.8666	1.8921	1.9397	1.9836	2.0244	2.0628	2.0991	2.1336	2.1665
25 (240.07)	Sh				9.93	59.93	109.93	159.93	209.93	259.93	359.93	459.93	559.93	659.93	759.93	859.93	959.93
	v	0.01693	16.301		16.558	17.829	19.076	20.307	21.527	22.740	25.153	27.557	29.954	32.348	34.740	37.130	39.518
	h	208.52	1160.6		1165.6	1190.2	1214.5	1238.5	1262.5	1286.4	1334.5	1383.1	1432.7	1483.0	1534.2	1586.2	1639.2
	s	0.3535	1.7141		1.7212	1.7547	1.7856	1.8145	1.8415	1.8672	1.9149	1.9588	1.9997	2.0381	2.0744	2.1089	2.1418
30 (250.34)	Sh					49.66	99.66	149.66	199.66	249.66	349.66	449.66	549.66	649.66	749.66	849.66	949.66
	v	0.01701	13.744			14.810	15.859	16.892	17.914	18.929	20.945	22.951	24.952	26.949	28.943	30.936	32.927
	h	218.93	1164.1			1189.0	1213.6	1237.8	1261.9	1286.0	1334.2	1383.0	1432.5	1482.8	1534.0	1586.1	1639.0
	s	0.3682	1.6995			1.7334	1.7647	1.7937	1.8210	1.8467	1.8946	1.9386	1.9795	2.0179	2.0543	2.0888	2.1217
35 (259.29)	Sh					40.71	90.71	140.71	190.71	240.71	340.71	440.71	540.71	640.71	740.71	840.71	940.71
	v	0.01708	11.896			12.654	13.562	14.453	15.334	16.207	17.939	19.662	21.379	23.092	24.803	26.512	28.220
	h	228.03	1167.1			1187.8	1212.7	1237.1	1261.3	1285.5	1333.9	1382.8	1432.3	1482.7	1533.9	1586.0	1638.9
	s	0.3809	1.6872			1.7152	1.7468	1.7761	1.8035	1.8294	1.8774	1.9214	1.9624	2.0009	2.0372	2.0717	2.1046
40 (267.25)	Sh					32.75	82.75	132.75	182.75	232.75	332.75	432.75	532.75	632.75	732.75	832.75	932.75
	v	0.01715	10.497			11.036	11.838	12.624	13.398	14.165	15.685	17.195	18.699	20.199	21.697	23.194	24.689
	h	236.14	1169.8			1186.6	1211.7	1236.4	1260.8	1285.0	1333.6	1382.5	1432.1	1482.5	1533.7	1585.8	1638.8
	s	0.3921	1.6765			1.6992	1.7312	1.7608	1.7883	1.8143	1.8624	1.9065	1.9476	1.9860	2.0224	2.0569	2.0899
45 (274.44)	Sh					25.56	75.56	125.56	175.56	225.56	325.56	425.56	525.56	625.56	725.56	825.56	925.56
	v	0.01721	9.399			9.777	10.497	11.201	11.892	12.577	13.932	15.276	16.614	17.950	19.282	20.613	21.943
	h	243.49	1172.1			1185.4	1210.4	1235.7	1260.7	1284.6	1333.3	1382.3	1431.9	1482.3	1533.6	1585.7	1638.7
	s	0.4021	1.6671			1.6849	1.7173	1.7471	1.7748	1.8010	1.8492	1.8934	1.9345	1.9730	2.0093	2.0439	2.0768
50 (281.02)	Sh					18.98	68.98	118.98	168.98	218.98	318.98	418.98	518.98	618.98	718.98	818.98	918.98
	v	0.01727	8.514			8.769	9.424	10.062	10.688	11.306	12.529	13.741	14.947	16.150	17.350	18.549	19.746
	h	250.21	1174.1			1184.1	1209.9	1234.9	1259.6	1284.1	1332.9	1382.0	1431.7	1482.2	1533.4	1585.6	1638.6
	s	0.4112	1.6586			1.6720	1.7048	1.7349	1.7628	1.7890	1.8374	1.8816	1.9227	1.9613	1.9977	2.0322	2.0652
55 (287.07)	Sh					12.93	62.93	112.93	162.93	212.93	312.93	412.93	512.93	612.93	712.93	812.93	912.93
	v	0.01733				7.945	8.546	9.130	9.702	10.267	11.381	12.485	13.583	14.677	15.769	16.859	17.948
	h	256.41				1182.9	1208.9	1234.2	1259.1	1283.6	1332.6	1381.8	1431.5	1482.0	1533.3	1585.5	1638.5
	s	0.4196				1.6601	1.6933	1.7237	1.7518	1.7781	1.8266	1.8710	1.9121	1.9507	1.987	2.022	2.055
60 (292.71)	Sh					7.29	57.29	107.29	157.29	207.29	307.29	407.29	507.29	607.29	707.29	807.29	907.29
	v	0.01738	7.174			7.257	7.815	8.354	8.881	9.400	10.425	11.438	12.446	13.450	14.452	15.452	16.450
	h	262.21	1177.6			1181.6	1208.0	1233.5	1258.5	1283.2	1332.3	1381.5	1431.3	1481.8	1533.2	1585.3	1638.4
	s	0.4273	1.6440			1.6492	1.6829	1.7134	1.7417	1.7681	1.8168	1.8612	1.9024	1.9410	1.9774	2.0120	2.0450
65 (297.98)	Sh					2.02	52.02	102.02	152.02	202.02	302.02	402.02	502.02	602.02	702.02	802.02	902.02
	v	0.01743	6.653			6.675	7.195	7.697	8.186	8.667	9.615	10.552	11.484	12.412	13.337	14.261	15.183
	h	267.63	1179.1			1180.3	1207.0	1232.7	1257.9	1282.7	1331.9	1381.3	1431.1	1481.6	1533.0	1585.2	1638.3
	s	0.4344	1.6375			1.6390	1.6731	1.7040	1.7324	1.7590	1.8077	1.8522	1.8935	1.9321	1.9685	2.0031	2.0361
70 (302.93)	Sh						47.07	97.07	147.07	197.07	297.07	397.07	497.07	597.07	697.07	797.07	897.07
	v	0.01748	6.205				6.664	7.133	7.590	8.039	8.922	9.793	10.659	11.522	12.382	13.240	14.097
	h	272.74	1180.6				1206.0	1232.0	1257.3	1282.2	1331.6	1381.0	1430.9	1481.5	1532.9	1585.1	1638.2
	s	0.4411	1.6316				1.6640	1.6951	1.7237	1.7504	1.7993	1.8439	1.8852	1.9238	1.9603	1.9949	2.0279
75 (307.61)	Sh						42.39	92.39	142.39	192.39	292.39	392.39	492.39	592.39	692.39	792.39	892.39
	v	0.01753	5.814				6.204	6.645	7.074	7.494	8.320	9.135	9.945	10.750	11.553	12.355	13.155
	h	277.56	1181.9				1205.0	1231.2	1256.7	1281.7	1331.3	1380.7	1430.7	1481.3	1532.7	1585.0	1638.1
	s	0.4474	1.6260				1.6554	1.6868	1.7156	1.7424	1.7915	1.8361	1.8774	1.9161	1.9526	1.9872	2.0202

Sh = superheat, F
v = specific volume, cu ft per lb
h = enthalpy, Btu per lb
s = entropy, Btu per R per lb

Table 3 Superheated Steam – Continued

Abs Press Lb/Sq In (Sat Temp)		Sat Water	Sat Steam	350	400	450	500	550	600	700	800	900	1000	1100	1200	1300	1400
				Temperature – Degrees Fahrenheit													
80 (312.04)	Sh			37.96	87.96	137.96	187.96	237.96	287.96	387.96	487.96	587.96	687.96	787.96	887.96	987.96	1087.96
	v	0.01757	5.471	5.801	6.218	6.627	7.018	7.408	7.794	8.560	9.319	10.075	10.829	11.581	12.331	13.081	13.829
	h	282.15	1183.1	1204.0	1230.5	1256.1	1281.3	1306.2	1330.9	1380.5	1430.5	1481.1	1532.6	1584.9	1638.0	1692.0	1746.8
	s	0.4534	1.6208	1.6473	1.6790	1.7080	1.7349	1.7602	1.7842	1.8289	1.8702	1.9089	1.9454	1.9800	2.0131	2.0446	2.0750
85 (316.26)	Sh			33.74	83.74	133.74	183.74	233.74	283.74	383.74	483.74	583.74	683.74	783.74	883.74	983.74	1083.74
	v	0.01762	5.167	5.445	5.840	6.223	6.597	6.966	7.330	8.052	8.768	9.480	10.190	10.898	11.604	12.310	13.014
	h	286.52	1184.2	1203.0	1229.7	1255.5	1280.8	1305.8	1330.6	1380.2	1430.3	1481.0	1532.4	1584.7	1637.9	1691.9	1746.8
	s	0.4590	1.6159	1.6396	1.6716	1.7008	1.7279	1.7532	1.7772	1.8220	1.8634	1.9021	1.9386	1.9733	2.0063	2.0379	2.0682
90 (320.28)	Sh			29.72	79.72	129.72	179.72	229.72	279.72	379.72	479.72	579.72	679.72	779.72	879.72	979.72	1079.72
	v	0.01766	4.895	5.128	5.505	5.869	6.223	6.572	6.917	7.600	8.277	8.950	9.621	10.290	10.958	11.625	12.293
	h	290.69	1185.3	1202.0	1228.9	1254.9	1280.3	1305.4	1330.2	1380.0	1430.1	1480.8	1532.3	1584.6	1637.8	1691.8	1745.7
	s	0.4643	1.6113	1.6323	1.6646	1.6940	1.7212	1.7467	1.7707	1.8156	1.8570	1.8957	1.9323	1.9669	2.0000	2.0316	2.0619
95 (324.13)	Sh			25.87	75.87	125.87	175.87	225.87	275.87	375.87	475.87	575.87	675.87	775.87	875.87	975.87	1075.87
	v	0.01770	4.651	4.845	5.205	5.551	5.889	6.221	6.548	7.196	7.838	8.477	9.113	9.747	10.380	11.012	11.643
	h	294.70	1186.2	1200.9	1228.1	1254.3	1279.8	1305.0	1329.9	1379.7	1429.9	1480.6	1532.1	1584.5	1637.7	1691.7	1746.6
	s	0.4694	1.6069	1.6253	1.6580	1.6876	1.7149	1.7404	1.7645	1.8094	1.8509	1.8897	1.9262	1.9609	1.9940	2.0256	2.0559
100 (327.82)	Sh			22.18	72.18	122.18	172.18	222.18	272.18	372.18	472.18	572.18	672.18	772.18	872.18	972.18	1072.18
	v	0.01774	4.431	4.590	4.935	5.266	5.588	5.904	6.216	6.833	7.443	8.050	8.655	9.258	9.860	10.460	11.060
	h	298.54	1187.2	1199.9	1227.4	1253.7	1279.3	1304.6	1329.6	1379.5	1429.7	1480.4	1532.0	1584.4	1637.6	1691.6	1745.5
	s	0.4743	1.6027	1.6187	1.6516	1.6814	1.7088	1.7344	1.7586	1.8036	1.8451	1.8839	1.9205	1.9552	1.9883	2.0199	2.0502
105 (331.37)	Sh			18.63	68.63	118.63	168.63	218.63	268.63	368.63	468.63	568.63	668.63	768.63	868.63	968.63	1068.63
	v	0.01778	4.231	4.359	4.690	5.007	5.315	5.617	5.915	6.504	7.086	7.665	8.241	8.816	9.389	9.961	10.532
	h	302.24	1188.0	1198.8	1226.6	1253.1	1278.8	1304.2	1329.2	1379.2	1429.4	1480.3	1531.8	1584.2	1637.5	1691.5	1745.4
	s	0.4790	1.5988	1.6122	1.6455	1.6755	1.7031	1.7288	1.7530	1.7981	1.8396	[illegible]	1.9151	1.9498	1.9828	2.0145	2.0448
110 (334.79)	Sh			15.21	65.21	115.21	165.21	215.21	265.21	365.21	465.21	565.21	665.21	765.21	865.21	965.21	1065.21
	v	0.01782	4.048	4.149	4.468	4.772	5.068	5.357	5.642	6.205	6.761	7.314	7.865	8.413	8.961	9.507	10.053
	h	305.80	1188.9	1197.7	1225.8	1252.5	1278.3	1303.8	1328.9	1379.0	1429.2	1480.1	1531.7	1584.1	1637.4	1691.4	1745.4
	s	0.4834	1.5950	1.6061	1.6396	1.6698	1.6975	1.7233	1.7476	1.7928	1.8344	1.8732	1.9099	1.9446	1.9777	2.0093	2.0397
115 (338.08)	Sh			11.92	61.92	111.92	161.92	211.92	261.92	361.92	461.92	561.92	661.92	761.92	861.92	961.92	1061.92
	v	0.01785	3.881	3.957	4.265	4.558	4.841	5.119	5.392	5.932	6.465	6.994	7.521	8.046	8.570	9.093	9.615
	h	309.25	1189.6	1196.7	1225.0	1251.8	1277.9	1303.3	1328.6	1378.7	1429.0	1479.9	1531.6	1584.0	1637.2	1691.4	1745.3
	s	0.4877	1.5913	1.6001	1.6340	1.6644	1.6922	1.7181	1.7425	1.7877	1.8294	1.8682	1.9049	1.9396	1.9727	2.0044	2.0347
120 (341.27)	Sh			8.73	58.73	108.73	158.73	208.73	258.73	358.73	458.73	558.73	658.73	758.73	858.73	958.73	1058.73
	v	0.01789	3.7275	3.7815	4.0786	4.3610	4.6341	4.9009	5.1637	5.6813	6.1928	6.7006	7.2060	7.7096	8.2119	8.7130	9.2134
	h	312.58	1190.4	1195.6	1224.1	1251.2	1277.4	1302.9	1328.2	1378.4	1428.8	1479.8	1531.4	1583.9	1637.1	1691.3	1745.2
	s	0.4919	1.5879	1.5943	1.6286	1.6592	1.6872	1.7132	1.7376	1.7829	1.8246	1.8635	1.9001	1.9349	1.9680	1.9996	2.0300
130 (347.33)	Sh			2.67	52.67	102.67	152.67	202.67	252.67	352.67	452.67	552.67	652.67	752.67	852.67	952.67	1052.67
	v	0.01796	3.4544	3.4699	3.7489	4.0129	4.2672	4.5151	4.7589	5.2384	5.7118	6.1814	6.6486	7.1140	7.5781	8.0411	8.5033
	h	318.95	1191.7	1193.4	1222.5	1249.9	1276.4	1302.1	1327.5	1377.9	1428.4	1479.4	1531.1	1583.6	1636.9	1691.1	1745.1
	s	0.4998	1.5813	1.5833	1.6182	1.6493	1.6775	1.7037	1.7283	1.7737	1.8155	1.8545	1.8911	1.9259	1.9591	1.9907	2.0211
140 (353.04)	Sh				46.96	96.96	146.96	196.96	246.96	346.96	446.96	546.96	646.96	746.96	846.96	946.96	1046.96
	v	0.01803	3.2190		3.4661	3.7143	3.9526	4.1844	4.4119	4.8588	5.2995	5.7364	6.1709	6.6036	7.0349	7.4652	7.8946
	h	324.96	1193.0		1220.8	1248.7	1275.3	1301.3	1326.8	1377.4	1428.0	1479.1	1530.8	1583.4	1636.7	1690.9	1745.9
	s	0.5071	1.5752		1.6085	1.6400	1.6686	1.6949	1.7196	1.7652	1.8071	1.8461	1.8828	1.9176	1.9508	1.9825	2.0129
150 (358.43)	Sh				41.57	91.57	141.57	191.57	241.57	341.57	441.57	541.57	641.57	741.57	841.57	941.57	1041.57
	v	0.01809	3.0139		3.2208	3.4555	3.6799	3.8978	4.1112	4.5298	4.9421	5.3507	5.7568	6.1612	6.5642	6.9661	7.3671
	h	330.65	1194.1		1219.1	1247.4	1274.3	1300.5	1326.1	1376.9	1427.6	1478.7	1530.5	1583.1	1636.5	1690.7	1745.7
	s	0.5141	1.5695		1.5993	1.6313	1.6602	1.6867	1.7115	1.7573	1.7992	1.8383	1.8751	1.9099	1.9431	1.9748	2.0052
160 (363.55)	Sh				36.45	86.45	136.45	186.45	236.45	336.45	436.45	536.45	636.45	736.45	836.45	936.45	1036.45
	v	0.01815	2.8336		3.0060	3.2288	3.4413	3.6469	3.8480	4.2420	4.6295	5.0132	5.3945	5.7741	6.1522	6.5293	6.9055
	h	336.07	1195.1		1217.4	1246.0	1273.3	1299.6	1325.4	1376.4	1427.2	1478.4	1530.3	1582.9	1636.3	1690.5	1745.6
	s	0.5206	1.5641		1.5906	1.6231	1.6522	1.6790	1.7039	1.7499	1.7919	1.8310	1.8678	1.9027	1.9359	1.9676	1.9980
170 (368.42)	Sh				31.58	81.58	131.58	181.58	231.58	331.58	431.58	531.58	631.58	731.58	831.58	931.58	1031.58
	v	0.01821	2.6738		2.8162	3.0288	3.2306	3.4255	3.6158	3.9879	4.3536	4.7155	5.0749	5.4325	5.7888	6.1440	6.4983
	h	341.24	1196.0		1215.6	1244.7	1272.2	1298.8	1324.7	1375.8	1426.8	1478.0	1530.0	1582.6	1636.1	1690.4	1745.4
	s	0.5269	1.5591		1.5823	1.6152	1.6447	1.6717	1.6968	1.7428	1.7850	1.8241	1.8610	1.8959	1.9291	1.9608	1.9913
180 (373.08)	Sh				26.92	76.92	126.92	176.92	226.92	326.92	426.92	526.92	626.92	726.92	826.92	926.92	1026.92
	v	0.01827	2.5312		2.6474	2.8508	3.0433	3.2286	3.4093	3.7621	4.1084	4.4508	4.7907	5.1289	5.4657	5.8014	6.1363
	h	346.19	1196.9		1213.8	1243.4	1271.2	1297.9	1324.0	1375.3	1426.3	1477.7	1529.7	1582.4	1635.9	1690.2	1745.3
	s	0.5328	1.5543		1.5743	1.6078	1.6376	1.6647	1.6900	1.7362	1.7784	1.8176	1.8545	1.8894	1.9227	1.9545	1.9849
190 (377.53)	Sh				22.47	72.47	122.47	172.47	222.47	322.47	422.47	522.47	622.47	722.47	822.47	922.47	1022.47
	v	0.01833	2.4030		2.4961	2.6915	2.8756	3.0525	3.2246	3.5601	3.8889	4.2140	4.5365	4.8572	5.1766	5.4949	5.8124
	h	350.94	1197.6		1212.0	1242.0	1270.1	1297.1	1323.3	1374.8	1425.9	1477.4	1529.4	1582.1	1635.7	1690.0	1745.1
	s	0.5384	1.5498		1.5667	1.6006	1.6307	1.6581	1.6835	1.7299	1.7722	1.8115	1.8484	1.8834	1.9166	1.9484	1.9789
200 (381.80)	Sh				18.20	68.20	118.20	168.20	218.20	318.20	418.20	518.20	618.20	718.20	818.20	918.20	1018.20
	v	0.01839	2.2873		2.3598	2.5480	2.7247	2.8939	3.0583	3.3783	3.6915	4.0008	4.3077	4.6128	4.9165	5.2191	5.5209
	h	355.51	1198.3		1210.1	1240.6	1269.0	1296.2	1322.6	1374.3	1425.5	1477.0	1529.1	1581.9	1635.4	1689.8	1745.0
	s	0.5436	1.5454		1.5593	1.5938	1.6242	1.6518	1.6773	1.7239	1.7663	1.8057	1.8426	1.8776	1.9109	1.9427	1.9732

Sh = superheat, F
v = specific volume, cu ft per lb
h = enthalpy, Btu per lb
s = entropy, Btu per F per lb

Table 3. Superheated Steam – *Continued*

Abs Press Lb/Sq in (Sat Temp)		Sat Water	Sat Steam	Temperature – Degrees Fahrenheit 400	450	500	550	600	700	800	900	1000	1100	1200	1300	1400	1500
	Sh			14.09	64.09	114.09	164.09	214.09	314.09	414.09	514.09	614.09	714.09	814.09	914.09	1014.09	1114.09
210 (385.91)	v	0.01844	2.1822	2.2364	2.4181	2.5880	2.7504	2.9078	3.2137	3.5128	3.8080	4.1007	4.3915	4.6811	4.9695	5.2571	5.5440
	h	359.91	1199.0	1208.02	1239.2	1268.0	1295.3	1321.9	1373.7	1425.1	1476.7	1528.8	1581.6	1635.2	1689.6	1744.8	1800.8
	s	0.5490	1.5413	1.5522	1.5872	1.6180	1.6458	1.6715	1.7182	1.7607	1.8001	1.8371	1.8721	1.9054	1.9372	1.9677	1.9970
	Sh			10.12	60.12	110.12	160.12	210.12	310.12	410.12	510.12	610.12	710.12	810.12	910.12	1010.12	1110.12
220 (389.88)	v	0.01850	2.0863	2.1240	2.2999	2.4638	2.6199	2.7710	3.0642	3.3504	3.6327	3.9125	4.1905	4.4671	4.7426	5.0173	5.2913
	h	364.17	1199.6	1206.3	1237.8	1266.9	1294.5	1321.2	1373.2	1424.7	1476.3	1528.5	1581.4	1635.0	1689.4	1744.7	1800.6
	s	0.5540	1.5374	1.5453	1.5808	1.6120	1.6400	1.6658	1.7128	1.7553	1.7948	1.8318	1.8668	1.9002	1.9320	1.9625	1.9919
	Sh			6.30	56.30	106.30	156.30	206.30	306.30	406.30	506.30	606.30	706.30	806.30	906.30	1006.30	1106.30
230 (393.70)	v	0.01855	1.9985	2.0212	2.1919	2.3503	2.5008	2.6461	2.9276	3.2020	3.4726	3.7406	4.0068	4.2717	4.5355	4.7984	5.0606
	h	368.28	1200.1	1204.4	1236.3	1265.7	1293.6	1320.4	1372.7	1424.2	1476.0	1528.2	1581.1	1634.8	1689.3	1744.5	1800.5
	s	0.5588	1.5336	1.5385	1.5747	1.6062	1.6344	1.6604	1.7075	1.7502	1.7897	1.8268	1.8618	1.8952	1.9270	1.9576	1.9869
	Sh			2.61	52.61	102.61	152.61	202.61	302.61	402.61	502.61	602.61	702.61	802.61	902.61	1002.61	1102.61
240 (397.39)	v	0.01860	1.9177	1.9268	2.0928	2.2462	2.3915	2.5316	2.8024	3.0661	3.3259	3.5831	3.8385	4.0926	4.3456	4.5977	4.8492
	h	372.27	1200.6	1202.4	1234.9	1264.6	1292.7	1319.7	1372.1	1423.8	1475.6	1527.9	1580.9	1634.6	1689.1	1744.3	1800.4
	s	0.5634	1.5299	1.5320	1.5687	1.6006	1.6291	1.6552	1.7025	1.7452	1.7848	1.8219	1.8570	1.8904	1.9223	1.9528	1.9822
	Sh				49.03	99.03	149.03	199.03	299.03	399.03	499.03	599.03	699.03	799.03	899.03	999.03	1099.03
250 (400.97)	v	0.01865	1.8432		2.0016	2.1504	2.2909	2.4262	2.6872	2.9410	3.1909	3.4382	3.6837	3.9278	4.1709	4.4131	4.6546
	h	376.14	1201.1		1233.4	1263.5	1291.8	1319.0	1371.6	1423.4	1475.3	1527.6	1580.6	1634.4	1688.9	1744.2	1800.2
	s	0.5679	1.5264		1.5629	1.5951	1.6239	1.6502	1.6976	1.7405	1.7801	1.8173	1.8524	1.8858	1.9177	1.9482	1.9776
	Sh				45.56	95.56	145.56	195.56	295.56	395.56	495.56	595.56	695.56	795.56	895.56	995.56	1095.56
260 (404.44)	v	0.01870	1.7742		1.9173	2.0619	2.1981	2.3289	2.5808	2.8256	3.0663	3.3044	3.5408	3.7758	4.0097	4.2427	4.4750
	h	379.90	1201.5		1231.9	1262.4	1290.9	1318.2	1371.1	1423.0	1474.9	1527.3	1580.4	1634.2	1688.7	1744.0	1800.1
	s	0.5722	1.5230		1.5573	1.5899	1.6189	1.6453	1.6930	1.7359	1.7756	1.8128	1.8480	1.8814	1.9133	1.9439	1.9732
	Sh				42.20	92.20	142.20	192.20	292.20	392.20	492.20	592.20	692.20	792.20	892.20	992.20	1092.20
270 (407.80)	v	0.01875	1.7101		1.8391	1.9799	2.1171	2.2388	2.4824	2.7186	2.9509	3.1806	3.4084	3.6349	3.8603	4.0849	4.3087
	h	383.56	1201.9		1230.4	1261.2	1290.0	1317.5	1370.5	1422.6	1474.6	1527.1	1580.1	1634.0	1688.5	1743.9	1800.0
	s	0.5764	1.5197		1.5518	1.5848	1.6140	1.6406	1.6885	1.7315	1.7713	1.8085	1.8437	1.8771	1.9090	1.9396	1.9690
	Sh				38.93	88.93	138.93	188.93	288.93	388.93	488.93	588.93	688.93	788.93	888.93	988.93	1088.93
280 (411.07)	v	0.01880	1.6505		1.7665	1.9037	2.0322	2.1551	2.3909	2.6194	2.8437	3.0655	3.2855	3.5042	3.7217	3.9384	4.1543
	h	387.12	1202.3		1228.8	1260.0	1289.1	1316.8	1370.0	1422.1	1474.2	1526.8	1579.9	1633.8	1688.4	1743.7	1799.8
	s	0.5805	1.5166		1.5464	1.5798	1.6093	1.6361	1.6841	1.7273	1.7671	1.8043	1.8395	[illegible]	1.9050	1.9356	1.9649
	Sh				35.75	85.75	135.75	185.75	285.75	385.75	485.75	585.75	685.75	785.75	[illegible]	985.75	1085.75
290 (414.25)	v	0.01885	1.5948		1.6988	1.8327	1.9578	2.0772	2.3058	2.5269	2.7440	2.9585	3.1711	3.3824	3.5926	3.8019	4.0106
	h	390.60	1202.6		1227.3	1258.9	1288.1	1316.0	1369.5	1421.7	1473.9	1526.5	1579.6	1633.5	1688.2	1743.6	1799.7
	s	0.5844	1.5135		1.5412	1.5750	1.6048	1.6317	1.6799	1.7232	1.7630	1.8003	1.8356	1.8690	1.9010	1.9316	1.9610
	Sh				32.65	82.65	132.65	182.65	282.65	382.65	482.65	582.65	682.65	782.65	882.65	982.65	1082.65
300 (417.35)	v	0.01889	1.5427		1.6356	1.7665	1.8883	2.0044	2.2263	2.4407	2.6509	2.8585	3.0643	3.2688	3.4721	3.6746	3.8764
	h	393.99	1202.9		1225.7	1257.7	1287.2	1315.2	1368.9	1421.3	1473.6	1526.2	1579.4	1633.3	1688.0	1743.4	1799.6
	s	0.5882	1.5105		1.5351	1.5703	1.6003	1.6274	1.6758	1.7192	1.7591	1.7964	1.8317	1.8652	1.8972	1.9278	1.9572
	Sh				29.64	79.64	129.64	179.64	279.64	379.64	479.64	579.64	679.64	779.64	879.64	979.64	1079.64
310 (420.36)	v	0.01894	1.4939		1.5763	1.7044	1.8233	1.9363	2.1520	2.3600	2.5638	2.7650	2.9644	3.1625	3.3594	3.5555	3.7509
	h	397.30	1203.2		1224.1	1256.5	1286.3	1314.5	1368.4	1420.9	1473.2	1525.9	1579.2	1633.1	1687.8	1743.3	1799.4
	s	0.5920	1.5076		1.5311	1.5657	1.5960	1.6233	1.6719	1.7153	1.7553	1.7927	1.8280	1.8615	1.8935	1.9241	1.9536
	Sh				26.69	76.69	126.69	176.69	276.69	376.69	476.69	576.69	676.69	776.69	876.69	976.69	1076.69
320 (423.31)	v	0.01899	1.4480		1.5207	1.6462	1.7623	1.8725	2.0823	2.2843	2.4821	2.6774	2.8708	3.0628	3.2538	3.4438	3.6332
	h	400.53	1203.4		1222.5	1255.2	1285.3	1313.7	1367.8	1420.5	1472.9	1525.6	1578.9	1632.9	1687.6	1743.1	1799.3
	s	0.5956	1.5048		1.5261	1.5612	1.5918	1.6192	1.6680	1.7116	1.7516	1.7890	1.8243	1.8579	1.8899	1.9206	1.9500
	Sh				23.82	73.82	123.82	173.82	273.82	373.82	473.82	573.82	673.82	773.82	873.82	973.82	1073.82
330 (426.18)	v	0.01903	1.4048		1.4684	1.5915	1.7050	1.8125	2.0168	2.2132	2.4054	2.5950	2.7828	2.9692	3.1545	3.3389	3.5227
	h	403.70	1203.6		1220.9	1254.0	1284.4	1313.0	1367.3	1420.0	1472.5	1525.3	1578.7	1632.7	1687.5	1742.9	1799.2
	s	0.5991	1.5021		1.5213	1.5568	1.5876	1.6153	1.6643	1.7079	1.7480	1.7855	1.8208	1.8544	1.8864	1.9171	1.9466
	Sh				21.01	71.01	121.01	171.01	271.01	371.01	471.01	571.01	671.01	771.01	871.01	971.01	1071.01
340 (428.99)	v	0.01908	1.3640		1.4191	1.5399	1.6511	1.7561	1.9552	2.1463	2.3333	2.5175	2.7000	2.8811	3.0611	3.2402	3.4186
	h	406.80	1203.8		1219.2	1252.8	1283.4	1312.2	1366.7	1419.6	1472.2	1525.0	1578.4	1632.5	1687.3	1742.8	1799.0
	s	0.6026	1.4994		1.5165	1.5525	1.5836	1.6114	1.6606	1.7044	1.7445	1.7820	1.8174	1.8510	1.8831	1.9138	1.9432
	Sh				18.27	68.27	118.27	168.27	268.27	368.27	468.27	568.27	668.27	768.27	868.27	968.27	1068.27
350 (431.73)	v	0.01912	1.3255		1.3725	1.4913	1.6002	1.7028	1.8970	2.0832	2.2652	2.4445	2.6219	2.7980	2.9730	3.1471	3.3205
	h	409.83	1204.0		1217.5	1251.5	1282.4	1311.4	1366.2	1419.2	1471.8	1524.7	1578.2	1632.3	1687.1	1742.6	1798.9
	s	0.6059	1.4968		1.5119	1.5483	1.5797	1.6077	1.6571	[illegible]	1.7411	1.7787	1.8141	1.8477	1.8798	1.9105	1.9400
	Sh				15.59	65.59	115.59	165.59	265.59	365.59	465.59	565.59	665.59	765.59	865.59	965.59	1065.59
360 (434.41)	v	0.01917	1.2891		1.3285	1.4454	1.5521	1.6525	1.8421	2.0237	2.2009	2.3755	2.5482	2.7196	2.8898	3.0592	3.2279
	h	412.81	1204.1		1215.8	1250.3	1281.5	1310.6	1365.6	1418.7	1471.5	1524.4	1577.9	1632.1	1686.9	1742.5	1798.8
	s	0.6092	1.4943		1.5073	1.5441	1.5758	1.6040	1.6536	1.6976	1.7379	1.7754	1.8109	1.8445	1.8766	1.9073	1.9368
	Sh				10.39	60.39	110.39	160.39	260.39	360.39	460.39	560.39	660.39	760.39	860.39	960.39	1060.39
380 (439.61)	v	0.01925	1.2218		1.2472	1.3606	1.4635	1.5598	1.7410	1.9139	2.0825	2.2484	2.4124	2.5750	2.7366	2.8973	3.0572
	h	418.59	1204.4		1212.4	1247.7	1279.5	1309.0	1364.5	1417.9	1470.8	1523.8	1577.4	1631.6	1686.5	1742.2	1798.5
	s	0.6156	1.4894		1.4982	1.5360	1.5683	1.5969	1.6470	1.6911	1.7315	1.7692	1.8047	1.8384	1.8705	1.9012	1.9307

Sh = superheat, F
v = specific volume, cu ft per lb
h = enthalpy, Btu per lb
s = entropy, Btu per R per lb

Table 3. Superheated Steam—*Continued*

Abs Press. Lb/Sq In (Sat. Temp)		Sat. Water	Sat. Steam	Temperature—Degrees Fahrenheit 450	500	550	600	650	700	800	900	1000	1100	1200	1300	1400	1500
400 (444.60)	Sh			5.40	55.40	105.40	155.40	205.40	255.40	355.40	455.40	555.40	655.40	755.40	855.40	955.40	1055.40
	v	0.01934	1.1610	1.1738	1.2841	1.3836	1.4763	1.5646	1.6499	1.8151	1.9759	2.1339	2.2901	2.4450	2.5987	2.7515	2.9037
	h	424.17	1204.6	1208.8	1245.1	1277.5	1307.4	1335.9	1363.4	1417.0	1470.1	1523.3	1576.9	1631.2	1686.2	1741.9	1798.2
	s	0.6217	1.4847	1.4894	1.5282	1.5611	1.5901	1.6163	1.6406	1.6850	1.7255	1.7632	1.7988	1.8325	1.8647	1.8955	1.9250
420 (449.40)	Sh			.60	50.60	100.60	150.60	200.60	250.60	350.60	450.60	550.60	650.60	750.60	850.60	950.60	1050.60
	v	0.01942	1.1057	1.1071	1.2148	1.3113	1.4007	1.4856	1.5676	1.7258	1.8795	2.0304	2.1795	2.3273	[illegible]	2.6196	2.7647
	h	429.56	1204.7	1205.2	1242.4	1275.4	1305.8	1334.5	1362.3	1416.2	1469.4	1522.7	1576.4	1630.8	[illegible]	1741.6	1798.0
	s	0.6276	1.4802	1.4808	1.5206	1.5542	1.5835	1.6100	1.6345	1.6791	1.7197	1.7575	1.7932	1.8269	1.8591	1.8899	1.9195
440 (454.03)	Sh				45.97	95.97	145.97	195.97	245.97	345.97	445.97	545.97	645.97	745.97	845.97	945.97	1045.97
	v	0.01950	1.0554		1.1517	1.2454	1.3319	1.4138	1.4926	1.6445	1.7918	1.9363	2.0790	2.2203	2.3605	2.4998	2.6384
	h	434.77	1204.8		1239.7	1273.4	1304.2	1333.2	1361.1	1415.3	1468.7	1522.1	1575.9	1630.4	1685.5	1741.2	1797.7
	s	0.6332	1.4759		1.5132	1.5474	1.5772	1.6040	1.6286	1.6734	1.7142	1.7521	1.7878	1.8216	1.8538	1.8847	1.9143
460 (458.50)	Sh				41.50	91.50	141.50	191.50	241.50	341.50	441.50	541.50	641.50	741.50	841.50	941.50	1041.50
	v	0.01959	1.0092		1.0939	1.1852	1.2691	1.3482	1.4242	1.5703	1.7117	1.8504	1.9872	2.1226	2.2569	2.3903	2.5230
	h	439.83	1204.8		1236.9	1271.3	1302.5	1331.8	1360.0	1414.4	1468.0	1521.5	1575.4	1629.9	1685.1	1740.9	1797.4
	s	0.6387	1.4718		1.5060	1.5409	1.5711	1.5982	1.6230	1.6680	1.7089	1.7469	1.7826	1.8165	1.8488	1.8797	1.9093
480 (462.82)	Sh				37.18	87.18	137.18	187.18	237.18	337.18	437.18	537.18	637.18	737.18	837.18	937.18	1037.18
	v	0.01967	0.9668		1.0409	1.1300	1.2115	1.2881	1.3615	1.5023	1.6384	1.7716	1.9030	2.0330	2.1619	2.2900	2.4173
	h	444.75	1204.8		1234.1	1269.1	1300.8	1330.5	1358.8	1413.6	1467.3	1520.9	1574.9	1629.5	1684.7	1740.6	1797.2
	s	0.6439	1.4677		1.4990	1.5346	1.5652	1.5925	1.6176	1.6628	1.7038	1.7419	1.7777	1.8116	1.8439	1.8748	1.9045
500 (467.01)	Sh				32.99	82.99	132.99	182.99	232.99	332.99	432.99	532.99	632.99	732.99	832.99	932.99	1032.99
	v	0.01975	0.9276		0.9919	1.0791	1.1584	1.2327	1.3037	1.4397	1.5708	1.6992	1.8256	1.9507	2.0746	2.1977	2.3200
	h	449.52	1204.7	—	1231.2	1267.0	1299.1	1329.1	1357.7	1412.7	1466.6	1520.3	1574.4	1629.1	1684.4	1740.3	1796.9
	s	0.6490	1.4639		1.4921	1.5284	1.5595	1.5871	1.6123	1.6578	1.6990	1.7371	1.7730	1.8069	1.8393	1.8702	1.8998
520 (471.07)	Sh				28.93	78.93	128.93	178.93	228.93	328.93	428.93	528.93	628.93	728.93	828.93	928.93	1028.93
	v	0.01982	0.8914		0.9466	1.0321	1.1094	1.1816	1.2504	1.3819	1.5085	1.6323	1.7542	1.8746	1.9940	2.1125	2.2302
	h	454.18	1204.5		1228.3	1264.8	1297.4	1327.7	1356.5	1411.8	1465.9	1519.7	1573.9	1628.7	1684.0	1740.0	1796.7
	s	0.6540	1.4601		1.4853	1.5223	1.5539	1.5818	1.6072	1.6530	1.6943	1.7325	1.7684	1.8024	1.8348	1.8657	1.8954
540 (475.01)	Sh				24.99	74.99	124.99	174.99	224.99	324.99	424.99	524.99	624.99	724.99	824.99	924.99	1024.99
	v	0.01990	0.8577		0.9045	0.9884	1.0640	1.1342	1.2010	1.3284	1.4508	1.5704	1.6880	1.8042	1.9193	2.0336	2.1471
	h	458.71	1204.4		1225.3	1262.5	1295.7	1326.3	1355.3	1410.9	1465.1	1519.1	1573.4	1628.2	1683.6	1739.7	1796.4
	s	0.6587	1.4565		1.4786	1.5164	1.5485	1.5767	1.6023	1.6483	1.6897	1.7280	1.7640	1.7981	1.8305	1.8615	1.8911
560 (478.84)	Sh				21.16	71.16	121.16	171.16	221.16	321.16	421.16	521.16	621.16	721.16	821.16	921.16	1021.16
	v	0.01998	0.8264		0.8653	0.9479	1.0217	1.0902	1.1552	1.2787	1.3972	1.5129	1.6266	1.7388	1.8500	1.9603	2.0699
	h	463.14	1203.2		1222.2	1260.3	1293.9	1324.9	1354.2	1410.0	1464.4	1518.6	1572.9	1627.8	1683.3	1739.4	1796.1
	s	0.6634	1.4529		1.4720	1.5106	1.5431	1.5717	1.5975	1.6438	1.6853	1.7237	1.7598	1.7939	1.8263	1.8573	1.8870
580 (482.57)	Sh				17.43	67.43	117.43	167.43	217.43	317.43	417.43	517.43	617.43	717.43	817.43	917.43	1017.43
	v	0.02006	0.7971		0.8287	0.9100	0.9824	1.0492	1.1125	1.2324	1.3473	1.4593	1.5693	1.6780	1.7855	1.8921	1.9980
	h	467.47	1203.9		1219.1	1258.0	1292.1	1323.4	1353.0	1409.2	1463.7	1518.0	1572.4	1627.4	1682.9	1739.1	1795.9
	s	0.6679	1.4495		1.4654	1.5049	1.5380	1.5668	1.5929	1.6394	1.6811	1.7196	1.7556	1.7898	1.8223	1.8533	1.8831
600 (486.20)	Sh				13.80	63.80	113.80	163.80	213.80	313.80	413.80	513.80	613.80	713.80	813.80	[illegible]	1013.80
	v	0.02013	0.7697		0.7944	0.8746	0.9456	1.0109	1.0726	1.1892	1.3008	1.4093	1.5160	1.6211	1.7252	[illegible]	1.9309
	h	471.70	1203.7		1215.9	1255.6	1290.3	1322.0	1351.8	1408.3	1463.0	1517.4	1571.9	1627.0	[illegible]	[illegible]	1795.6
	s	0.6723	1.4461		1.4590	1.4993	1.5329	1.5621	1.5884	1.6351	1.6769	1.7155	1.7517	1.7859	1.8184	[illegible]	1.8792
650 (494.89)	Sh				5.11	55.11	105.11	155.11	205.11	305.11	405.11	505.11	605.11	705.11	805.11	905.11	1005.11
	v	0.02032	0.7084		0.7173	0.7954	0.8634	0.9254	0.9835	1.0929	1.1969	1.2979	1.3969	1.4944	1.5909	1.6864	1.7813
	h	481.89	1202.8		1207.6	1249.6	1285.7	1318.3	1348.7	1406.0	1461.2	1515.9	1570.7	1625.9	1681.6	1738.0	1794.9
	s	0.6828	1.4381		1.4430	1.4858	1.5207	1.5507	1.5775	1.6249	1.6671	1.7059	1.7422	1.7765	1.8092	1.8403	1.8701
700 (503.08)	Sh					46.92	96.92	146.92	196.92	296.92	396.92	496.92	596.92	696.92	796.92	896.92	996.92
	v	0.02050	0.6556			0.7271	0.7928	0.8520	0.9072	1.0102	1.1078	1.2023	1.2948	1.3858	1.4757	1.5647	1.6530
	h	491.60	1201.8			1243.4	1281.0	1314.6	1345.6	1403.7	1459.4	1514.4	1569.4	1624.8	1680.7	1737.2	1794.3
	s	0.6928	1.4304			1.4726	1.5090	1.5399	1.5673	1.6154	1.6580	1.6970	1.7335	1.7679	1.8006	1.8318	1.8617
750 (510.84)	Sh					39.16	89.16	139.16	189.16	289.16	389.16	489.16	589.16	689.16	789.16	889.16	989.16
	v	0.02069	0.6095			0.6676	0.7313	0.7882	0.8409	0.9386	1.0306	1.1195	1.2063	1.2916	1.3759	1.4592	1.5419
	h	500.89	1200.7			1236.9	1276.1	1310.7	1342.5	1401.5	1457.6	1512.9	1568.2	1623.8	1679.8	1736.4	1793.6
	s	0.7022	1.4232			1.4598	1.4977	1.5296	1.5577	1.6065	1.6494	1.6886	1.7252	1.7598	1.7926	1.8239	1.8538
800 (518.21)	Sh					31.79	81.79	131.79	181.79	281.79	381.79	481.79	581.79	681.79	781.79	881.79	981.79
	v	0.02087	0.5690			0.6151	0.6774	0.7323	0.7828	0.8759	0.9631	1.0470	1.1289	1.2093	1.2885	1.3669	1.4446
	h	509.81	1199.4			1230.1	1271.1	1306.8	1339.3	1399.1	1455.8	1511.4	1566.9	1622.7	1678.9	1735.7	1792.9
	s	0.7111	1.4163			1.4472	1.4869	1.5198	1.5484	1.5980	1.6413	1.6807	1.7175	1.7522	1.7851	1.8164	1.8464
850 (525.24)	Sh					24.76	74.76	124.76	174.76	274.76	374.76	474.76	574.76	674.76	774.76	874.76	974.76
	v	0.02105	0.5330			0.5683	0.6296	0.6829	0.7315	0.8205	0.9034	0.9830	1.0606	1.1366	1.2115	1.2855	1.3588
	h	518.40	1198.0			1223.0	1265.9	1302.8	1336.0	1396.8	1454.0	1510.0	1565.7	1621.6	1678.0	1734.9	1792.3
	s	0.7197	1.4096			1.4347	1.4763	1.5102	1.5396	1.5899	1.6336	1.6733	1.7102	1.7450	1.7780	1.8094	1.8395
900 (531.95)	Sh					18.05	68.05	118.05	168.05	268.05	368.05	468.05	568.05	668.05	768.05	868.05	968.05
	v	0.02123	0.5009			0.5263	0.5869	0.6388	0.6858	0.7713	0.8504	0.9262	0.9998	1.0720	1.1430	1.2131	1.2875
	h	526.70	1196.4			1215.5	1260.6	1298.6	1332.7	1394.4	1452.2	1508.5	1564.4	1620.6	1677.1	1734.1	1791.6
	s	0.7279	1.4032			1.4223	1.4659	1.5010	1.5311	1.5822	1.6263	1.6662	1.7033	1.7382	1.7713	1.8028	1.8329

Sh = superheat, F
v = specific volume, cu ft per lb
h = enthalpy, Btu per lb
s = entropy, Btu per F per lb

Table 3. Superheated Steam – Continued

Abs Press Lb/Sq In (Sat Temp)		Sat Water	Sat Steam	550	600	650	700	750	800	850	900	1000	1100	1200	1300	1400	1500
	Sh			11.61	61.61	111.61	161.61	211.61	261.61	311.61	361.61	461.61	561.61	661.61	761.61	861.61	961.61
850	v	0.02141	0.4721	0.4883	0.5485	0.5993	0.6449	0.6871	0.7272	0.7656	0.8030	0.8753	0.9455	1.0142	1.0817	1.1484	1.2143
(538.39)	h	534.74	1194.7	1207.6	1255.1	1294.4	1329.3	1361.5	1392.0	1421.5	1450.3	1507.0	1563.2	1619.5	1675.2	1733.3	[illegible]
	s	0.7358	1.3970	1.4098	1.4557	1.4921	1.5228	1.5500	1.5748	1.5977	1.6193	1.6595	1.6967	1.7317	1.7649	1.7965	1.8267
	Sh			5.42	55.42	105.42	155.42	205.42	255.42	305.42	355.42	455.42	555.42	655.42	755.42	855.42	[illegible]
1000	v	0.02159	0.4460	0.4535	0.5137	0.5636	0.6080	0.6489	0.6875	0.7245	0.7603	0.8295	0.8966	0.9622	1.0266	1.0901	[illegible]
(544.58)	h	542.55	1192.9	1199.3	1249.3	1290.1	1325.9	1358.7	1389.6	1419.4	1448.5	1505.4	1561.9	1618.4	1675.3	1732.5	[illegible]
	s	0.7434	1.3910	1.3973	1.4457	1.4833	1.5149	1.5426	1.5677	1.5908	1.6126	1.6530	1.6905	1.7256	1.7589	1.7905	1.8207
	Sh				49.47	99.47	149.47	199.47	249.47	299.47	349.47	449.47	549.47	649.47	749.47	849.47	949.47
1050	v	0.02177	0.4222		0.4821	0.5312	0.5745	0.6142	0.6515	0.6872	0.7216	0.7881	0.8524	0.9151	0.9767	1.0373	1.0973
(550.53)	h	550.15	1191.0		1243.4	1285.7	1322.4	1355.8	1387.2	1417.3	1446.6	1503.9	1560.7	1617.4	1674.4	1731.8	1789.5
	s	0.7507	1.3851		1.4358	1.4748	1.5072	1.5354	1.5608	1.5842	1.6062	1.6469	1.6845	1.7197	1.7531	1.7848	1.8151
	Sh				43.72	93.72	143.72	193.72	243.72	293.72	343.72	443.72	543.72	643.72	743.72	843.72	943.72
1100	v	0.02195	0.4006		0.4531	0.5017	0.5440	0.5826	0.6188	0.6533	0.6865	0.7505	0.8121	0.8723	0.9313	0.9894	1.0468
(556.28)	h	557.55	1189.1		1237.3	1281.2	1318.8	1352.9	1384.7	1415.2	1444.7	1502.4	1559.4	1616.3	1673.5	1731.0	1789.0
	s	0.7578	1.3794		1.4259	1.4664	1.4996	1.5284	1.5542	1.5779	1.6000	1.6410	1.6787	1.7141	1.7475	1.7793	1.8097
	Sh				39.18	89.18	139.18	189.18	239.18	289.18	339.18	439.18	539.18	639.18	739.18	839.18	939.18
1150	v	0.02214	0.3807		0.4263	0.4746	0.5162	0.5538	0.5889	0.6223	0.6544	0.7161	0.7754	0.8332	0.8899	0.9456	1.0007
(561.82)	h	564.78	1187.0		1230.9	1276.6	1315.2	1349.9	1382.2	1413.0	1442.8	1500.9	1558.1	1615.2	1672.6	1730.2	1788.3
	s	0.7647	1.3738		1.4160	1.4582	1.4923	1.5216	1.5478	1.5717	1.5941	1.6353	1.6732	1.7087	1.7422	1.7741	1.8045
	Sh				32.81	82.81	132.81	182.81	232.81	282.81	332.81	432.81	532.81	632.81	732.81	832.81	932.81
1200	v	0.02232	0.3624		0.4016	0.4497	0.4905	0.5273	0.5615	0.5939	0.6250	0.6845	0.7418	0.7974	0.8519	0.9055	0.9594
(567.19)	h	571.85	1184.8	–	1224.2	1271.8	1311.5	1346.9	1379.7	1410.8	1440.9	1499.4	1556.9	1614.2	1671.6	1729.4	1787.6
	s	0.7714	1.3683		1.4061	1.4501	1.4851	1.5150	1.5415	1.5658	1.5883	1.6298	1.6679	1.7035	1.7371	1.7691	1.7995
	Sh				22.58	72.58	122.58	172.58	222.58	272.58	322.58	422.58	522.58	622.58	722.58	822.58	922.58
1300	v	0.02269	0.3299		0.3570	0.4052	0.4451	0.4804	0.5129	0.5436	0.5729	0.6287	0.6822	0.7341	0.7847	0.8345	0.8835
(577.42)	h	585.58	1180.2		1209.9	1261.9	1303.9	1340.8	1374.6	1406.4	1437.1	1496.3	1554.3	1612.0	1669.8	1727.9	1786.3
	s	0.7843	1.3577		1.3860	1.4340	1.4711	1.5022	1.5296	1.5544	1.5773	1.6194	1.6578	1.6937	1.7275	1.7596	1.7902
	Sh				12.93	62.93	112.93	162.93	212.93	262.93	312.93	412.93	512.93	612.93	712.93	812.93	912.93
1400	v	0.02307	0.3018		0.3176	0.3667	0.4059	0.4400	0.4712	0.5004	0.5282	0.5809	0.6311	0.6798	0.7272	0.7737	0.8195
(587.07)	h	598.83	1175.3		1194.1	1251.4	1296.1	1334.5	1369.3	1402.0	1433.2	1493.2	1551.8	1609.9	1668.0	1726.3	1785.0
	s	0.7966	1.3474		1.3652	1.4181	1.4575	1.4900	1.5182	1.5436	1.5670	1.6096	1.6484	1.6845	1.7185	1.7508	1.7815
	Sh				3.80	53.80	103.80	153.80	203.80	253.80	303.80	403.80	503.80	603.80	703.80	803.80	[illegible]
1500	v	0.02346	0.2772		0.2820	0.3328	0.3717	0.4049	0.4350	0.4629	0.4894	0.5394	0.5869	0.6327	0.6773	0.7210	[illegible]
(596.20)	h	611.68	1170.1		1176.3	1240.2	1287.9	1328.0	1364.0	1397.4	1429.2	1490.1	1549.2	1607.7	1666.2	1724.8	1781.7
	s	0.8085	1.3373		1.3431	1.4022	1.4443	1.4782	1.5073	1.5333	1.5572	1.6004	1.6395	1.6759	1.7101	1.7425	1.7734
	Sh					45.13	95.13	145.13	195.13	245.13	295.13	395.13	495.13	595.13	695.13	795.13	895.13
1600	v	0.02387	0.2555			0.3026	0.3415	0.3741	0.4032	0.4301	0.4555	0.5031	0.5482	0.5915	0.6336	0.6748	0.7153
(604.87)	h	624.20	1164.5			1228.3	1279.4	1321.4	1358.5	1392.8	1425.2	1486.9	1546.6	1605.6	1664.3	1723.2	1782.3
	s	0.8199	1.3274			1.3861	1.4312	1.4667	1.4968	1.5235	1.5478	1.5916	1.6312	1.6678	1.7022	1.7347	1.7657
	Sh					36.87	86.87	136.87	186.87	236.87	286.87	386.87	486.87	586.87	686.87	786.87	886.87
1700	v	0.02428	0.2361			0.2754	0.3147	0.3468	0.3751	0.4011	0.4255	0.4711	0.5140	0.5552	0.5951	0.6341	0.6724
(613.13)	h	636.45	1158.6			1215.3	1270.5	1314.5	1352.9	1388.1	1421.2	1483.8	1544.0	1603.4	1662.5	1721.7	1781.0
	s	0.8309	1.3176			1.3697	1.4183	1.4555	1.4867	1.5140	1.5388	1.5833	1.6232	1.6601	1.6947	1.7274	1.7585
	Sh					28.98	78.98	128.98	178.98	228.98	278.98	378.98	478.98	578.98	678.98	778.98	878.98
1800	v	0.02472	0.2186			0.2505	0.2906	0.3223	0.3500	0.3752	0.3988	0.4426	0.4836	0.5229	0.5609	0.5980	0.6343
(621.02)	h	648.49	1152.3			1201.2	1261.1	1307.4	1347.2	1383.3	1417.1	1480.6	1541.4	1601.2	1660.7	1720.1	1779.7
	s	0.8417	1.3079			1.3526	1.4054	1.4446	1.4768	1.5049	1.5302	1.5753	1.6156	1.6528	1.6876	1.7204	1.7516
	Sh					21.44	71.44	121.44	171.44	221.44	271.44	371.44	471.44	571.44	671.44	771.44	871.44
1900	v	0.02517	0.2028			0.2274	0.2687	0.3004	0.3275	0.3521	0.3749	0.4171	0.4565	0.4940	0.5303	0.5656	0.6002
(628.56)	h	660.36	1145.6			1185.7	1251.3	1300.2	1341.4	1378.4	1412.9	1477.4	1538.8	1599.1	1658.8	1718.6	1778.4
	s	0.8522	1.2981			1.3346	1.3925	1.4338	1.4672	1.4960	1.5219	1.5677	1.6084	1.6458	1.6808	1.7138	1.7451
	Sh					14.20	64.20	114.20	164.20	214.20	264.20	364.20	464.20	564.20	664.20	764.20	864.20
2000	v	0.02565	0.1883			0.2056	0.2488	0.2805	0.3072	0.3312	0.3534	0.3947	0.4320	0.4680	0.5027	0.5365	0.5695
(635.80)	h	672.11	1138.3			1168.3	1240.9	1292.6	1335.4	1373.5	1408.7	1474.1	1536.2	1596.9	1657.0	1717.0	1771.1
	s	0.8625	1.2881			1.3154	1.3794	1.4231	1.4578	1.4874	1.5138	1.5603	1.6014	1.6391	1.6743	1.7075	1.7389
	Sh					7.24	57.24	107.24	157.24	207.24	257.24	357.24	457.24	557.24	657.24	757.24	857.24
2100	v	0.02615	0.1750			0.1847	0.2304	0.2621	0.2888	0.3123	0.3339	0.3734	0.4099	0.4445	0.4778	0.5101	0.5418
(642.76)	h	683.79	1130.5			1148.5	1229.8	1284.9	1329.3	1368.4	1404.4	1470.9	1533.6	1594.7	1655.2	1715.4	1775.7
	s	0.8727	1.2780			1.2942	1.3661	1.4125	1.4486	1.4790	1.5060	1.5532	1.5948	1.6327	1.6681	1.7014	1.7330
	Sh					0.55	50.55	100.55	150.55	200.55	250.55	350.55	450.55	550.55	650.55	750.55	850.55
2200	v	0.02669	0.1627			0.1636	0.2134	0.2458	0.2720	0.2950	0.3161	0.3545	0.3897	0.4231	0.4551	0.4862	0.5165
(649.45)	h	695.46	1122.2			1123.9	1218.0	1276.8	1323.1	1363.3	1400.0	1467.6	1530.9	1592.5	1653.3	1713.9	1774.4
	s	0.8828	1.2676			1.2691	1.3523	1.4020	1.4395	1.4708	1.4984	1.5463	1.5883	1.6266	1.6622	1.6956	1.7273
	Sh						44.11	94.11	144.11	194.11	244.11	344.11	444.11	544.11	644.11	744.11	844.11
2300	v	0.02727	0.1513				0.1975	0.2305	0.2566	0.2793	0.2999	0.3372	0.3714	0.4035	0.4344	0.4643	0.4935
(655.89)	h	707.18	1113.2				1205.3	1268.4	1315.7	1358.1	1395.7	1464.2	1528.3	1590.3	1651.5	1712.3	1773.1
	s	0.8929	1.2569				1.3381	1.3914	1.4305	1.4628	1.4910	1.5397	1.5821	1.6207	1.6565	1.6901	1.7219

Sh = superheat, F
v = specific volume, cu ft per lb
h = enthalpy, Btu per lb
s = entropy, Btu per R per lb

Table 3. Superheated Steam – *Continued*

Abs Press Lb/Sq In (Sat Temp)		Sat Water	Sat Steam	Temperature – Degrees Fahrenheit 700	750	800	850	900	950	1000	1050	1100	1150	1200	1300	1400	1500
2400 (662.11)	Sh			37.89	87.89	137.89	187.89	237.89	287.89	337.89	387.89	437.89	487.89	537.89	637.89	737.89	837.89
	v	0.02790	0.1408	0.1824	0.2164	0.2424	0.2648	0.2850	0.3037	0.3214	0.3382	0.3545	0.3703	0.3856	0.4155	0.4443	0.4724
	h	718.95	1103.7	1191.6	1259.7	1310.1	1352.8	1391.2	1426.9	1460.9	1493.7	1525.6	1557.0	1588.1	1649.6	1710.8	1771.8
	s	0.9031	1.2460	1.3232	1.3808	1.4217	1.4549	1.4837	1.5095	1.5332	1.5553	1.5761	1.5959	1.6149	1.6509	1.6847	1.7167
2500 (668.11)	Sh			31.89	81.89	131.89	181.89	231.89	281.89	331.89	381.89	431.89	481.89	531.89	631.89	731.89	831.89
	v	0.02859	0.1307	0.1681	0.2032	0.2293	0.2514	0.2712	0.2896	0.3068	0.3232	0.3390	0.3543	0.3692	0.3980	0.4259	[illegible]
	h	731.71	1091.3	1176.7	1250.6	1303.4	1347.4	1386.7	1423.1	1457.5	1490.7	1522.9	1554.6	1585.9	1647.8	1709.2	1770.4
	s	0.9139	1.2345	1.3076	1.3701	1.4129	1.4472	1.4766	1.5029	1.5269	1.5492	1.5703	1.5903	1.6094	1.6456	1.6796	1.7116
2600 (673.91)	Sh			26.09	76.09	126.09	176.09	226.09	276.09	326.09	376.09	426.09	476.09	526.09	626.09	726.09	826.09
	v	0.02938	0.1211	0.1544	0.1909	0.2171	0.2390	0.2585	0.2765	0.2933	0.3093	0.3247	0.3395	0.3540	0.3819	0.4088	0.4350
	h	744.47	1082.0	1160.2	1241.1	1296.5	1341.9	1382.1	1419.2	1454.1	1487.7	1520.2	1552.2	1583.7	1646.0	1707.7	1769.1
	s	0.9247	1.2225	1.2908	1.3592	1.4042	1.4395	1.4696	1.4964	1.5208	1.5434	1.5646	1.5848	1.6040	1.6405	1.6746	1.7068
2700 (679.53)	Sh			20.47	70.47	120.47	170.47	220.47	270.47	370.47	370.47	420.47	470.47	520.47	620.47	720.47	820.47
	v	0.03029	0.1119	0.1411	0.1794	0.2058	0.2275	0.2468	0.2644	0.2809	0.2965	0.3114	0.3259	0.3399	0.3670	0.3931	0.4184
	h	757.34	1069.7	1147.0	1231.1	1289.5	1336.3	[illegible]	1415.2	1450.7	1484.6	1517.5	1549.8	1581.5	1644.1	1706.1	1767.8
	s	0.9356	1.2097	1.2727	1.3481	1.3954	1.4319	[illegible]	1.4900	1.5148	1.5376	1.5591	1.5794	1.5988	1.6355	1.6697	1.7021
2800 (684.96)	Sh			15.04	65.04	115.04	165.04	215.04	265.04	315.04	365.04	415.04	465.04	515.04	615.04	715.04	815.04
	v	0.03134	0.1030	0.1278	0.1685	0.1952	0.2168	0.2358	0.2531	0.2693	0.2845	0.2991	0.3132	0.3262	0.3532	0.3785	0.4030
	h	770.69	1055.8	1121.2	1220.6	1282.2	1330.7	1372.8	1411.2	1447.2	1481.6	1514.8	1547.3	1579.3	1642.2	1704.5	1766.5
	s	0.9468	1.1958	1.2527	1.3368	1.3867	1.4245	1.4561	1.4838	1.5089	1.5321	1.5537	1.5742	1.5938	1.6306	1.6651	1.6975
2900 (690.22)	Sh			9.78	59.78	109.78	159.78	209.78	259.78	309.78	359.78	409.78	459.78	509.78	609.78	709.78	809.78
	v	0.03262	0.0942	0.1138	0.1581	0.1853	0.2068	0.2256	0.2427	0.2585	0.2734	0.2877	0.3014	0.3147	0.3403	0.3649	0.3887
	h	785.13	1039.8	1095.7	1209.6	1274.7	1324.9	1368.0	1407.2	1443.7	1478.5	1512.1	1544.9	1577.0	1640.4	1703.0	1765.2
	s	0.9588	1.1803	1.2283	1.3251	1.3780	1.4171	1.4494	1.4777	1.5032	1.5266	1.5485	1.5692	1.5889	1.6259	1.6605	1.6931
3000 (695.33)	Sh			4.67	54.67	104.67	154.67	204.67	254.67	304.67	354.67	404.67	454.67	504.67	604.67	704.67	804.67
	v	0.03428	0.0850	0.0982	0.1483	0.1759	0.1975	0.2161	0.2329	0.2484	0.2630	0.2770	0.2904	0.3033	0.3282	0.3522	0.3751
	h	801.84	1020.3	1060.5	1197.9	1267.0	1319.0	1363.2	1403.1	1440.2	1475.4	1509.4	1542.4	1574.8	1638.5	1701.4	1763.8
	s	0.9728	1.1619	1.1966	1.3131	1.3692	1.4097	1.4429	1.4717	1.4976	1.5213	1.5434	1.5642	1.5841	1.6214	1.6561	1.6888
3100 (700.28)	Sh				49.72	99.72	149.72	199.72	249.72	299.72	349.72	399.72	449.72	499.72	599.72	699.72	799.72
	v	0.03681	0.0745		0.1389	0.1671	0.1887	0.2071	0.2237	0.2390	0.2533	0.2670	0.2800	0.2927	0.3170	0.3403	0.3628
	h	823.97	993.3		1185.4	1259.1	1313.0	1358.4	1399.0	1436.7	1472.3	1506.6	1539.9	1572.6	1636.7	1699.8	1762.5
	s	0.9914	1.1373		1.3007	1.3604	1.4024	1.4364	1.4658	1.4920	1.5161	1.5384	1.5594	1.5794	1.6169	1.6518	1.6847
3200 (705.08)	Sh				44.92	94.92	144.92	194.92	244.92	294.92	344.92	394.92	444.92	494.92	594.92	694.92	794.92
	v	0.04472	0.0566		0.1300	0.1588	0.1804	0.1987	0.2151	0.2301	0.2442	0.2576	0.2704	0.2827	0.3065	0.3291	0.3510
	h	875.54	931.6		1177.3	1250.9	1306.9	1353.4	1394.9	1433.1	1469.2	1503.8	1537.4	1570.3	1634.8	1698.3	1761.2
	s	1.0351	1.0832		1.2877	1.3515	1.3951	1.4300	1.4600	1.4866	1.5110	1.5335	1.5547	1.5749	1.6126	1.6477	1.6806
3300	Sh																
	v				0.1213	0.1510	0.1727	0.1908	0.2070	0.2218	0.2357	0.2488	0.2613	0.2734	0.2966	0.3187	0.3400
	h				1158.2	1242.5	1300.7	1348.4	1390.7	1429.5	1466.1	1501.0	1534.9	1568.1	1632.9	1696.7	1759.9
	s				1.2742	1.3425	1.3879	1.4237	1.4542	1.4813	1.5059	1.5287	1.5501	1.5704	1.6084	1.6436	1.6767
3400	Sh																
	v				0.1129	0.1435	0.1653	0.1834	0.1994	0.2140	0.2276	0.2405	0.2528	0.2646	0.2872	0.3088	0.3296
	h				1143.2	1233.7	1294.3	1343.4	1386.4	1425.9	1462.9	1498.3	1532.4	1565.8	1631.1	1695.1	1758.5
	s				1.2600	1.3334	1.3807	1.4174	1.4486	1.4761	1.5010	1.5240	1.5456	1.5660	1.6042	1.6396	1.6728
3500	Sh																
	v				0.1048	0.1354	0.1583	0.1764	0.1922	0.2066	0.2200	0.2326	0.2447	0.2563	0.2784	0.2995	0.3198
	h				1127.1	1224.6	1287.8	1338.2	1382.2	1422.2	1459.7	1495.5	1529.9	1563.6	1629.2	1693.6	1757.2
	s				1.2450	1.3242	1.3734	1.4112	1.4430	1.4709	1.4962	1.5194	1.5412	1.5618	1.6002	1.6358	1.6691
3600	Sh																
	v				0.0966	0.1296	0.1517	0.1697	0.1854	0.1996	0.2128	0.2252	0.2371	0.2485	0.2702	0.2908	0.3106
	h				1108.6	1215.3	1281.2	1333.0	1377.9	1418.6	1456.5	1492.6	1527.4	1561.3	1627.3	1692.0	1755.9
	s				1.2281	1.3148	1.3662	1.4050	1.4374	1.4658	1.4914	1.5149	1.5369	1.5576	1.5962	1.632	1.6654
3800	Sh																
	v				0.0799	0.1169	0.1395	0.1574	0.1729	0.1868	0.1996	0.2116	0.2231	0.2340	0.2549	0.2746	0.2936
	h				1064.2	1195.5	1267.6	1322.4	1369.1	1411.2	1450.1	1487.0	1522.4	1556.8	1623.6	1688.9	1753.2
	s				1.1888	1.2955	1.3517	1.3928	1.4265	1.4558	1.4821	1.5061	1.5284	1.5495	1.5886	1.6247	1.6584
4000	Sh																
	v				0.0631	0.1052	0.1284	0.1463	0.1616	0.1752	0.1877	0.1994	0.2105	0.2210	0.2411	0.2601	0.2783
	h				1007.4	1174.3	1253.4	1311.6	1360.2	1403.6	1443.6	1481.3	1517.3	1552.2	1619.8	1685.7	1750.6
	s				1.1396	1.2754	1.3371	1.3807	1.4158	1.4461	1.4730	1.4976	1.5203	1.5417	1.5812	1.6177	1.6516
4200	Sh																
	v				0.0498	0.0945	0.1193	0.1362	0.1513	0.1647	0.1769	0.1883	0.1991	0.2093	0.2287	0.2470	0.2645
	h				950.1	1151.6	1238.6	1300.4	1351.2	1396.0	1437.1	1475.5	1512.2	1547.6	1616.1	1682.6	1748.0
	s				1.0905	1.2544	1.3223	1.3686	1.4053	1.4366	1.4642	1.4893	1.5124	1.5341	1.5742	1.6109	1.6452
4400	Sh																
	v				0.0471	0.0846	0.1090	0.1270	0.1470	0.1552	0.1671	0.1782	0.1887	0.1996	0.2174	0.2351	0.2519
	h				909.5	1127.3	1223.3	1289.0	1347.0	1388.3	1430.4	1469.7	1507.1	1543.0	1612.3	1679.4	1745.3
	s				1.0556	1.2325	1.3073	1.3566	1.3949	1.4272	1.4556	1.4812	1.5048	1.5268	1.5673	1.6044	1.6383

Sh = superheat, F
v = specific volume, cu ft per lb
h = enthalpy, Btu per lb
s = entropy, Btu per R per lb

Table 3. Superheated Steam – *Continued*

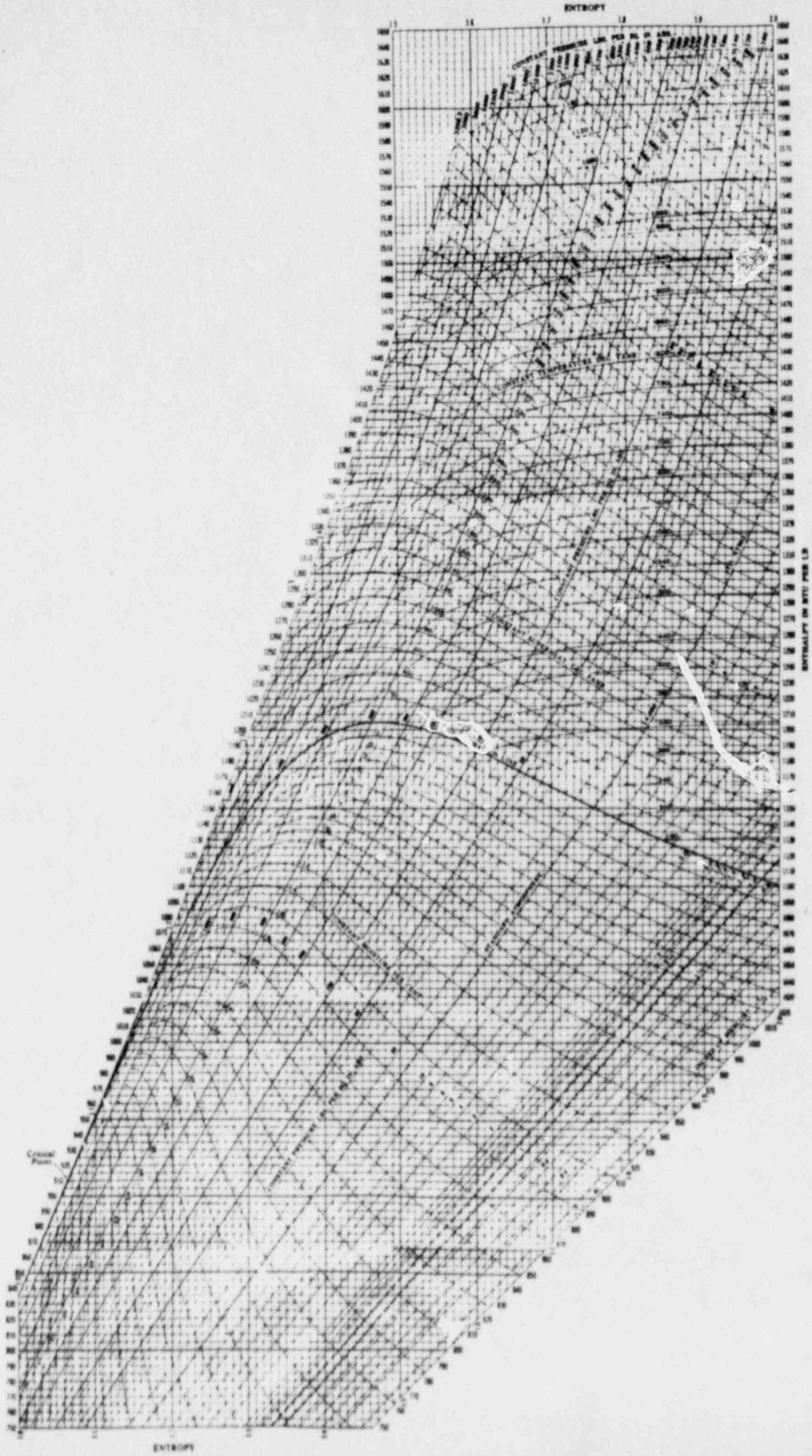
Abs Press Lb/Sq In (Sat Temp)		Sat Water	Sat Steam	750	800	850	900	950	1000	1050	1100	1150	1200	1250	1300	1400	1500
				Temperature – Degrees Fahrenheit													
4600	Sh																
	v			0.0380	0.0751	0.1005	0.1186	0.1335	0.1465	0.1582	0.1691	0.1792	0.1889	0.1982	0.2071	0.2242	0.2404
	h			883.8	1100.0	1207.3	1277.2	1332.6	1380.5	1423.7	1463.9	1501.9	1538.4	1573.8	1608.5	1676.3	1742.7
	s			1.0331	1.2084	1.2922	1.3446	1.3847	1.4181	1.4472	1.4734	1.4974	1.5197	1.5407	1.5607	1.5982	1.6330
4800	Sh																
	v			0.0355	0.0665	0.0927	0.1109	0.1257	0.1385	0.1500	0.1606	0.1706	0.1800	0.1890	0.1977	0.2142	0.2299
	h			866.9	1071.2	1190.7	1265.2	1323.1	1372.6	1417.0	1458.0	1496.7	1533.5	1569.7	1604.7	1673.1	1740.0
	s			1.0180	1.1835	1.2768	1.3327	1.3745	1.4090	1.4390	1.4657	1.4901	1.5128	1.5341	1.5543	1.5921	1.6272
5000	Sh																
	v			0.0338	0.0591	0.0855	0.1038	0.1185	0.1312	0.1425	0.1529	0.1626	0.1718	0.1806	0.1890	0.2050	0.2203
	h			854.9	1042.9	1173.6	1252.9	1313.5	1364.6	1410.2	1452.1	1491.5	1529.1	1565.5	1600.9	1670.0	1737.4
	s			1.0070	1.1593	1.2612	1.3207	1.3645	1.4001	1.4309	1.4582	1.4831	1.5061	1.5277	1.5481	1.5863	1.6216
5200	Sh																
	v			0.0326	0.0531	0.0789	0.0973	0.1119	0.1244	0.1356	0.1458	0.1553	0.1642	0.1728	0.1810	0.1966	0.2114
	h			845.8	1016.9	1156.0	1240.4	1303.7	1356.6	1403.4	1446.2	1486.3	1524.5	1561.3	1597.2	1666.8	1734.7
	s			0.9985	1.1370	1.2455	1.3088	1.3545	1.3914	1.4229	1.4509	1.4762	1.4995	1.5214	1.5420	1.5806	1.6161
5400	Sh																
	v			0.0317	0.0483	0.0728	0.0912	0.1058	0.1182	0.1292	0.1392	0.1485	0.1572	0.1656	0.1736	0.1888	0.2031
	h			838.5	994.3	1138.1	1227.7	1293.7	1348.4	1396.5	1440.3	1481.1	1519.8	1557.1	1593.4	1663.7	1732.1
	s			0.9915	1.1175	1.2296	1.2969	1.3446	1.3827	1.4151	1.4437	1.4694	1.4931	1.5153	1.5362	1.5750	1.6109
5600	Sh																
	v			0.0309	0.0447	0.0672	0.0856	0.1001	0.1124	0.1232	0.1331	0.1422	0.1508	0.1589	0.1667	0.1815	0.1954
	h			832.4	975.0	1119.9	1214.8	1283.7	1340.2	1389.6	1434.3	1475.9	1515.2	1552.9	1589.6	1660.5	1729.5
	s			0.9855	1.1008	1.2137	1.2850	1.3348	1.3742	1.4075	1.4366	1.4628	1.4869	1.5093	1.5304	1.5697	1.6058
5800	Sh																
	v			0.0303	0.0419	0.0672	0.0805	0.0949	0.1070	0.1177	0.1274	0.1363	0.1447	0.1527	0.1603	0.1747	0.1883
	h			827.3	958.8	1101.8	1201.8	1273.6	1312.0	1382.6	1428.3	1470.5	1510.5	1548.7	1585.8	1657.4	1726.8
	s			0.9803	1.0867	1.1981	1.2732	1.3250	1.3658	1.3999	1.4297	1.4564	1.4808	1.5035	1.5248	1.5644	1.6008
6000	Sh																
	v			0.0298	0.0397	0.0579	0.0757	0.0900	0.1020	0.1126	0.1221	0.1309	0.1391	0.1469	0.1544	0.1684	0.1817
	h			822.9	945.1	1084.6	1188.8	1263.4	1323.6	1375.7	1422.3	1465.4	1505.9	1544.6	1582.0	1654.2	1724.2
	s			0.9758	1.0746	1.1833	1.2615	1.3154	1.3574	1.3925	1.4229	1.4500	1.4748	1.4978	1.5194	1.5593	1.5960
6500	Sh																
	v			0.0287	0.0358	0.0495	0.0655	0.0793	0.0909	0.1012	0.1104	0.1188	0.1266	0.1340	0.1411	0.1544	0.1669
	h			813.9	919.5	1046.7	1156.3	1237.8	1302.7	1358.1	1407.3	1452.2	1494.2	1534.1	1572.5	1646.4	1717.6
	s			0.9661	1.0515	1.1506	1.2328	1.2917	1.3370	1.3743	1.4064	1.4347	1.4604	1.4841	1.5062	1.5471	1.5844
7000	Sh																
	v			0.0279	0.0334	0.0438	0.0573	0.0704	0.0816	0.0915	0.1004	0.1085	0.1160	0.1231	0.1298	0.1424	0.1542
	h			806.9	901.8	1016.5	1124.9	1212.6	1281.7	1340.5	1392.2	1439.1	1482.6	1523.7	1563.1	1638.6	1711.1
	s			0.9582	1.0350	1.1243	1.2055	1.2689	1.3171	1.3567	1.3904	1.4200	1.4466	1.4710	1.4938	1.5355	1.5735
7500	Sh																
	v			0.0272	0.0318	0.0399	0.0512	0.0631	0.0737	0.0833	0.0918	0.0996	0.1068	0.1136	0.1200	0.1321	0.1433
	h			801.3	889.0	992.9	1097.7	1188.3	1261.0	1322.9	1377.2	1426.0	1471.0	1513.3	1553.7	1630.8	1704.6
	s			0.9514	1.0224	1.1033	1.1818	1.2473	1.2980	1.3397	1.3751	1.4059	1.4335	1.4586	1.4819	1.5245	1.5632
8000	Sh																
	v			0.0267	0.0306	0.0371	0.0465	0.0571	0.0671	0.0762	0.0845	0.0920	0.0989	0.1054	0.1115	0.1230	0.1338
	h			796.6	879.1	974.4	1074.3	1165.4	1241.0	1305.5	1362.2	1413.0	1459.6	1503.1	1544.5	1623.1	1698.1
	s			0.9455	1.0122	1.0864	1.1613	1.2271	1.2798	1.3233	1.3603	1.3924	1.4208	1.4467	1.4705	1.5140	1.5533
8500	Sh																
	v			0.0262	0.0296	0.0350	0.0429	0.0522	0.0615	0.0701	0.0780	0.0853	0.0919	0.0982	0.1041	0.1151	0.1254
	h			792.7	871.2	959.8	1054.5	1144.0	1221.9	1288.5	1347.5	1400.2	1448.2	1492.9	1535.3	1615.4	1691.7
	s			0.9402	1.0037	1.0727	1.1437	1.2084	1.2627	1.3076	1.3460	1.3793	1.4087	1.4352	1.4597	1.5040	1.5439
9000	Sh																
	v			0.0258	0.0288	0.0335	0.0402	0.0483	0.0568	0.0649	0.0724	0.0794	0.0858	0.0918	0.0975	0.1081	0.1179
	h			789.3	864.7	948.0	1037.6	1125.4	1204.1	1272.1	1333.0	1387.5	1437.1	1482.9	1526.3	1607.9	1685.3
	s			0.9354	0.9964	1.0613	1.1285	1.1918	1.2468	1.2926	1.3323	1.3667	1.3970	1.4243	1.4492	1.4944	1.5349
9500	Sh																
	v			0.0254	0.0282	0.0322	0.0380	0.0451	0.0528	0.0603	0.0675	0.0742	0.0804	0.0862	0.0917	0.1019	0.1113
	h			786.4	859.2	938.3	1023.4	1108.9	1187.7	1256.6	1318.9	1375.1	1426.1	1473.1	1517.3	1600.4	1679.0
	s			0.9310	0.9900	1.0516	1.1153	1.1771	1.2320	1.2785	1.3191	1.3546	1.3858	1.4137	1.4392	1.4851	1.5263
10000	Sh																
	v			0.0251	0.0276	0.0312	0.0362	0.0425	0.0495	0.0565	0.0633	0.0697	0.0757	0.0812	0.0865	0.0963	0.1054
	h			783.8	854.5	930.2	1011.3	1094.2	1172.6	1242.0	1305.3	1362.9	1415.3	1463.4	1508.6	1593.1	1672.8
	s			0.9270	0.9842	1.0432	1.1039	1.1638	1.2185	1.2652	1.3065	1.3429	1.3749	1.4035	1.4295	1.4763	1.5180
10500	Sh																
	v			0.0248	0.0271	0.0303	0.0347	0.0404	0.0467	0.0532	0.0595	0.0656	0.0714	0.0768	0.0818	0.0913	0.1001
	h			781.5	850.5	923.4	1001.0	1081.3	1158.9	1228.4	1292.4	1351.1	1404.7	1453.9	1500.0	1585.8	1666.7
	s			0.9232	0.9790	1.0358	1.0939	1.1519	1.2060	1.2529	1.2946	1.3371	1.3644	1.3937	1.4202	1.4677	1.5100

Sh = superheat, F
v = specific volume, cu ft per lb
h = enthalpy, Btu per lb
s = entropy, Btu per F per lb

Table 3. Superheated Steam – *Continued*

Abs Press Lb/Sq In (Sat Temp)		Sat Water	Sat Steam	750	800	850	900	950	1000	1050	1100	1150	1200	1250	1300	1400	1500
11000	v			0.0245	0.0267	0.0296	0.0335	0.0386	0.0443	0.0503	0.0562	0.0620	0.0676	0.0727	0.0776	0.0864	0.0952
	h			779.5	846.9	917.5	992.1	1069.9	1146.3	1215.9	1280.2	1339.7	1394.4	1444.6	1491.5	1578.7	1660.6
	s			0.9196	0.9742	1.0292	1.0851	1.1417	1.1945	1.2414	1.2833	1.3209	1.3544	1.3842	1.4112	1.4595	1.5023
11500	v			0.0243	0.0263	0.0290	0.0325	0.0370	0.0423	0.0478	0.0534	0.0588	0.0641	0.0691	0.0739	0.0827	0.0909
	h			777.7	843.8	912.4	984.5	1059.8	1134.9	1204.3	1268.7	1328.8	1384.4	1435.5	1483.2	1571.8	1654.2
	s			0.9163	0.9698	1.0232	1.0777	1.1316	1.1840	1.2308	1.2727	1.3107	1.3446	1.3750	1.4025	1.4515	1.4949
12000	v			0.0241	0.0260	0.0284	0.0317	0.0357	0.0405	0.0456	0.0508	0.0560	0.0610	0.0659	0.0704	0.0790	0.0869
	h			776.1	841.0	907.9	977.8	1050.9	1124.5	1193.7	1258.0	1318.5	1374.7	1426.6	1475.1	1564.9	1648.8
	s			0.9131	0.9657	1.0177	1.0701	1.1229	1.1742	1.2209	1.2627	1.3010	1.3353	1.3662	1.3941	1.4438	1.4877
12500	v			0.0238	0.0256	0.0279	0.0309	0.0346	0.0390	0.0437	0.0486	0.0535	0.0583	0.0629	0.0673	0.0756	0.0832
	h			774.7	838.6	903.9	971.9	1043.1	1115.2	1184.1	1247.9	1308.8	1365.4	1418.0	1467.2	1558.2	1643.1
	s			0.9101	0.9618	1.0127	1.0637	1.1151	1.1653	1.2117	1.2534	1.2918	1.3264	1.3576	1.3860	1.4363	1.4808
13000	v			0.0236	0.0253	0.0275	0.0302	0.0136	0.0176	0.0420	0.0466	0.0512	0.0558	0.0602	0.0645	0.0775	0.0799
	h			771.5	836.3	900.4	966.8	1036.7	1106.7	1174.8	1238.5	1299.6	1356.5	1409.6	1459.4	1551.6	1637.4
	s			0.9073	0.9582	1.0080	1.0578	1.1079	1.1571	1.2030	1.2445	1.2831	1.3179	1.3494	1.3781	1.4291	1.4741
13500	v			0.0235	0.0251	0.0271	0.0297	0.0328	0.0364	0.0405	0.0448	0.0492	0.0535	0.0577	0.0619	0.0696	0.0768
	h			772.3	834.4	897.2	962.2	1030.0	1099.1	1166.3	1229.7	1291.0	1348.1	1401.5	1451.8	1545.7	1631.9
	s			0.9045	0.9548	1.0037	1.0524	1.1014	1.1495	1.1948	1.2361	1.2749	1.3098	1.3415	1.3705	1.4221	1.4675
14000	v			0.0233	0.0248	0.0267	0.0291	0.0320	0.0354	0.0392	0.0432	0.0474	0.0515	0.0555	0.0595	0.0670	0.0740
	h			771.3	832.6	894.3	958.0	1024.5	1092.3	1158.5	1221.4	1283.0	1340.2	1393.8	1444.4	1538.8	1626.5
	s			0.9019	0.9515	0.9996	1.0473	1.0953	1.1426	1.1872	1.2282	1.2671	1.3021	1.3339	1.3631	1.4153	1.4612
14500	v			0.0231	0.0246	0.0264	0.0287	0.0314	0.0345	0.0380	0.0418	0.0458	0.0496	0.0534	0.0573	0.0646	0.0714
	h			770.4	831.0	891.7	954.3	1019.6	1086.2	1151.4	1213.8	1275.4	1332.9	1386.4	1437.3	1537.6	1621.1
	s			0.8994	0.9484	0.9957	1.0426	1.0897	1.1362	1.1801	1.2208	1.2597	1.2949	1.3266	1.3560	1.4087	1.4551
15000	v			0.0230	0.0244	0.0261	0.0282	0.0308	0.0337	0.0369	0.0405	0.0443	0.0479	0.0516	0.0552	0.0624	0.0690
	h			769.6	829.5	889.3	950.9	1015.1	1080.6	1144.9	1206.8	1268.1	1326.0	1379.4	1430.3	1526.4	1615.9
	s			0.8970	0.9455	0.9920	1.0382	1.0846	1.1302	1.1735	1.2139	1.2525	1.2880	1.3197	1.3491	1.4022	1.4491
15500	v			0.0228	0.0242	0.0258	0.0278	0.0302	0.0329	0.0360	0.0393	0.0429	0.0464	0.0499	0.0534	0.0603	0.0668
	h			768.9	[illegible]	887.7	947.8	1011.1	1075.7	1139.0	1200.3	1261.1	1319.6	1372.8	1423.6	1520.4	1610.8
	s			0.8946	0.9427	0.9886	1.0340	1.0797	1.1247	1.1674	1.2073	1.2457	1.2815	1.3131	1.3424	1.3959	1.4433

Sh = superheat, F
v = specific volume, cu ft per lb
h = enthalpy, Btu per lb
s = entropy, Btu per R per lb


ENTROPY
Critical Point
ENTHALPY IN BTU PER LB
ENTROPY

ANSWER 1.01 (1.00)

d.

REFERENCE
Westinghouse, Fundamentals of Nuclear Reactor Physics, 1983, p. 7-21.
192003K106 ...(KA'S)

ANSWER 1.02 (1.00)

a.

REFERENCE
Westinghouse, Fundamentals of Nuclear Reactor Physics, 1983, p. 5-52.
192002K108 ...(KA'S)

ANSWER 1.03 (1.00)

c.

REFERENCE
BW PWR Operation Fundamentals-Reactor Theory p. 5-17 to 5-20
Westinghouse, Reactor Core Control for Large PWR's, 1983, p.5-13 thru 5-18.

192004K109 ...(KA'S)

ANSWER 1.04 (2.00)

a. FALSE
b. TRUE
c. TRUE
d. TRUE

REFERENCE
BW S.D. PWR. Operations, Unit 1/2 Differences p. 12 to 16.
035010K402 035010K503 ...(KA'S)

ANSWER 1.05 (1.00)

b.

REFERENCE
BW PWR Operations Fundamentals-Instrumentation and Control p. 1-33
Westinghouse, Thermal-Hydraulic Principles and Applications to the PWR, Vol. 2, 1982, p.11-29.
191002K109 ...(KA'S)

ANSWER 1.06 (1.00)

c.

REFERENCE
BW PWR Operations S.D. p.27-18
Westinghouse, Mitigating Core Damage, 1984, p. 6.26
Westinghouse, Thermal-Hydraulic Principles and Applications to the PWR, Vol. 2, 1982, p. 11-19, 11-20.
191002K102 ...(KA'S)

ANSWER 1.07 (1.00)

d.

REFERENCE
Westinghouse, Fundamentals of Nuclear Reactor Physics, 1983, p. 8-54.
192008K103 ...(KA'S)

ANSWER 1.08 (1.00)

a.

REFERENCE
BW PWR Operations Fundamentals-Reactor Theory Ch.9;p.8 of 33
Westinghouse, Reactor Core Control for Large Pressurized Water Reactors, 1983, p. 9-10.
192008K104 ...(KA'S)

ANSWER 1.09 (1.50)

Reasonance energy neutrons travel further into the fuel pellet (0.5) (reduces self shielding) which ensures all neutrons with resonance energy are absorbed (0.5).

In addition neutrons with energies slightly above or below resonance energy have a greater probability of being absorbed in the fuel (0.5) (lost from the fission chain).

REFERENCE
BW PWR Operations Fundamentals-Reactor Theory p. 2-30 and 2-31.
Westinghouse, Reactor Core Control for Large PWRs, 1983, p.2-29.
192004K107 ...(KA'S)

ANSWER 1.10 (1.00)

a.

REFERENCE
BW PWR Fundamental Text-Instrumentation and Control p.1-42
Westinghouse, Mitigating Core Damage, 1984, p.8.9.
191002K114 ...(KA'S)

ANSWER 1.11 (1.00)

c.

REFERENCE
Westinghouse, Transient and Accident Analysis, Vol. 1, 1983, p.12-11 and 12-43.
BW PWR Fundamentals Text-Heat Transfer p. 9-25 and HT. 9-11.
193008K106 ...(KA'S)

ANSWER 1.12 (1.50)

a. TRUE
b. TRUE
c. TRUE

REFERENCE
BW PWR Fundamentals Text-Heat Transfer p. 1-64, 1-72, 1-94
193008K101 193008K103 ...(KA'S)

ANSWER 1.13 (1.00)

b.

REFERENCE
Westinghouse. Reactor Core Control for Large PWRs, 1983, p. 3-20 to 3-28.
BW PWR Fundamentals Text- Reactor Theory p. 3-17, 3-18.
192004K106 ...(KA'S)

ANSWER 1.14 (1.00)

a.

REFERENCE
BW PWR Operations Fundamentals-Reactor Theory p. 6-25.
Westinghouse, Reactor Core Control for Large PWRs, 1983, p. 6-30.
192005K115 ...(KA'S)

ANSWER 1.15 (1.00)

d.

REFERENCE
BW PWR Operations Fundamentals-Reactor Theory p. 7-14 to 7-17.
Westinghouse, Reactor Core Control For Large Pressurized Water Reactors, 1983, p. 7-31 thru 7-33.
192008K102 ...(KA'S)

ANSWER 1.16 (1.00)

d.

REFERENCE
BW PWR Operations Fundamentals-Reactor Theory p. 7-10.
Westinghouse, Reactor Core Control for Large PWRs, 1983, p. 9-18.
192008K120 ...(KA'S)

ANSWER 1.17 (1.00)

b.

REFERENCE
BW PWR Operations Fundamentals-Reactor Theory p. 7-6.
Westinghouse, Reactor Core Control For Large Pressurized Water Reactors, 1983, pages 7-21 thru 7-23.
192002K114 ...(KA'S)

ANSWER 1.18 (1.00)

Reactor power will increase (0.25) until it is turned by the heatup of the fuel (0.25) and coolant ~~(0.5)~~ (0.25) at which time startup rate decreases to near zero. (0.25)

REFERENCE
BW PWR Operations Fundamentals-Reactor Theory CH.9, p. 20 of 33.
Westinghouse, Reactor Core Control for Large PWRs, 1983, p. 9-17.
192008K117 ...(KA'S)

ANSWER 1.19 (1.00)

a.

REFERENCE
Westinghouse, Thermal-Hydraulic Principles and Applications to the PWR, Vol. 2, p. 13-62.
BW PWR Fundamentals Text-Heat Transfer, p.6-22.
193010K105 ...(KA'S)

ANSWERS -- BRAIDWOOD 1&2 -88/07/18-VICTOR, F.

I. part "a", additional acceptable answer for second sentence, ... "when pump suction pressure (0.25) is less than the minimum required NPSH (0.25)"...

ANSWER 1.20 (2.00)

a. Cavitation is the formation (0.25) and subsequent collapse (0.25) of vapor bubbles in a pump. When local pressure (0.25) decreases below fluid saturation pressure (0.25) bubbles form and then collapse as the bubbles move to regions of higher pressure (0.25).

b. (1) Fluctuation in pressure.
(2) Fluctuation in flow.
(3) Fluctuation in motor current.
(4) Temperature increasing on components served.

Any three at (0.25 each)

REFERENCE
BW PWR Fundamentals Text Fluid Flow p. 2-47.
191004K101 ...(KA'S)

ANSWER 1.21 (1.00)

c.

REFERENCE
BW PWR Operations Fundamentals-Reactor Theory p. 2-9
Westinghouse, Reactor Core Control for Large Pressurized Water Reactors, 1983, p. 2.7.
192002K109 ...(KA'S)

ANSWER 1.22 (1.00)

a.

REFERENCE
BW PWR Operations Fundamentals-Reactor Theory Ch.9, p.22 of 33.
Westinghouse, Reactor Core Control for Large PWRs, 1983, p.9-22.
Ch.9 Append D Q#5 ANS or why dilute- Power defect add negative reactivity-dilute to compensate.
192008K119 ...(KA'S)

ANSWER 2.01 (2.00)

a. loops 3 and 4 [0.2] cold legs [0.2] [0.4]

b. loop 4 [0.1] hotleg [0.1] [0.2]

c. hihead

SI

RHR

Accumulators

[all 4 @ 0.2 each] [0.8]

d. loop 1 or 2 - [0.2]

e. loop 3 [0.2]

f. all 4 [0.1] coldlegs [0.1] [0.2]

REFERENCE
Reactor Coolant System Lesson Plan, Chapter 12, p. 31 and 33
002000K106 002000K108 002000K109 ...(KA'S)

ANSWER 2.02 (2.00)

a. In order to close the RCP breaker [0.25] the hot leg and cold leg [0.25] must be open [0.25] or the cold leg shut [0.25] and the bypass open [0.25].

b. Component Cooling Water is lost [0.25] to the reactor coolant pump oil coolers [0.25] and the reactor coolant pump thermal barrier heat exchanger [0.25] on a phase B isolation signal.

REFERENCE
Reactor Coolant Pump Lesson Plan, Chapter 13, Rev. 5, p. 36
Reactor Coolant Pump System Description, Rev. 5, Para II.5., p. 13-36,
003000K112 003000K411 ...(KA'S)

ANSWER 2.03 (2.00)

a. Prevent excess cooling of the spray system

Limit effects of thermal shock on the spray nozzle

Equalize PZR and RCS chemistry

[all 3 @ 0.25 each] [0.75]

b. Primary makeup water pump

Pressurizer PORVs

Pressurizer safety valves

RCP seal water relief valve

Letdown Orifice relief valve

[all 5 @ 0.25 each] [1.25]

REFERENCE
Pressurizer Lesson Plan, Chapter 14, Rev. 3, Para II.c.2, p. 20
Pressurizer Pressure and Level Control System Description, Chapter 14, Rev. 4, Para II.7, p. 14-23 and 14-24,
010000K105 010000K401 ...(KA'S)

ANSWER 2.04 (2.50)

Provide surge capacity for RCS expansion not accommodated by the Pressurizer

Provide a means for oxygen control of the RCS by maintaining hydrogen in the RCS during normal operation

Provide sufficient net positive suction pressure for the charging pumps

Provide sufficient back pressure for the number one seal of the RCPs

Provide a place to makeup to the RCS

Place to remove dissolved gases to Waste Gas System

[equivalent wording accepted for full credit] [any 5 @ 0.5 each] [2.5]

REFERENCE
Chemical and Volume Control System Description, Chapter 15a, Rev. 6, Para II.A.1.m, p. 15a-27 and 15a-28
004000G007 ...(KA'S)

ANSWER 2.05 (2.00)

a. To prevent clogging of the VCT spray nozzle [0.5]

b. Blender output is directed to the VCT inlet [0.25] and outlet [0.25] [0.5]

Water directed to the VCT outlet is not degassed by the spray nozzle [0.5]

Water directed to the VCT outlet is not exposed to the hydrogen gas in the VCT and therefore is not allowed to absorb hydrogen [0.5]

[equivalent wording accepted for full credit]

REFERENCE
Reactor Makeup Control Lesson Plan, Chapter 15b, p.36
Reactor Makeup Control System Description, Chapter 15b, p. 15b-25 & 15b-26.

004000K106 ...(KA'S)

ANSWER 2.06 (2.50)

a. To limit pump runout [0.5]

To limit individual line flow on a downstream break [0.5]

b. CVCS system [Centrifugal charging pumps]
Safety injection system
Residual heat removal system
Component cooling water system
Essential service water system
Auxiliary feedwater system
Containment spray system

~~[all~~ 6 @ 0.25 each] [1.5]
any

REFERENCE
Emergency Core Cooling System Description, Chapter 58, Rev. 7, Para I.B., p. 58-8, Para III.D.1.a.2, p. 58-53.
006000A302 006050K402 ...(KA'S)

ANSWER 2.07 (3.00)

a. Containment Recirc Sump suction valves [SI8811A/B] must be fully open [0.5] to ensure a suction path to the CS pumps from the recirc sump is available [0.5] [1.0]

Residual Heat Removal hot leg suction valves [RH8701A(B)] must be fully closed [0.5] to prevent the CS pumps from inadvertently taking a suction from the RCS hot leg supply lines to RHR [0.25] and discharging the contents of the RCS into the containment atmosphere [0.25] [1.0]

[equivalent wording accepted for full credit]

b. Containment Spray Pump Recirc Sump Suction Isolation Valves [CS009A(B)] must be fully closed [0.5] to prevent inadvertently supplying a drain flowpath from the RWST to the recirc sumps [0.5]

[equivalent wording accepted for full credit] [1.0]

REFERENCE
Containment Spray System Description, Chapter 59, Rev. 2, Para II.C.2.&3., p. 59-25 and 59-26
026000K401 ...(KA'S)

ANSWER 2.08 (1.50)

2/3 [0.1] low steam line pressure in any line [0.2] 640 psig [0.1] when above P-11 [0.1] or SI not blocked below P-11 [0.1] [0.6]

high-high containment pressure [0.2] 8.2 psig [0.1] on 2/3 channels [0.1] [0.4]

2/3 [0.1] high negative steam pressure rate in any line [0.2]
100 psi/50 sec [0.1] when below P-11 and SI blocked ~~[0.1]~~ ,JH [0.5]
[0.05] JH [0.05] JH

REFERENCE
Main Steam System Description, Chapter 23, p.23-35
039000K405 ...(KA'S)

ANSWER 2.09 (1.00)

a.

REFERENCE
Steam Dump System Description, Chapter 24, Rev. 2, Para II.A.9., p. 24-12 and Para II.C.1.c., p. 24-14
041020K603 ...(KA'S)

ANSWER 2.10 (1.50)

low auxiliary feedwater pump suction pressure [0.2] 1.22" Hg VAC [0.1] coincident with one of the following signals:[0.1] [0.4]

2/4 [0.1] low-low steam generator level signals [0.2] from any steam generator [0.1] [0.4]

2/4 [0.1] reactor coolant pump busses [0.2] undervoltage [0.1] [0.4]

any SI [0.3] [0.3]

REFERENCE
Auxiliary Feedwater System Description, Chapter 26, Revision 4, Para II.C.1., p. 26-39
061000K401 ...(KA'S)

ANSWER 2.11 (1.00)

d.

REFERENCE
A.C. Electrical Power Distribution System Description, Chapter 4, Rev. 2, Para III.B., page 4-104, TPO #4.
062000K201 ...(KA'S)

ANSWER 2.12 (2.00)

Accommodate the expansion and contraction of the component cooling water resulting from the temperature changes during system operation

Provides an immediate source of makeup in the event of a component cooling system leak

Provide a suction head for the component cooling pumps

Accommodate the inflow of reactor coolant stemming from a RCP thermal barrier heat exchanger tube rupture for three minutes

[equivalent wording accepted for full credit]

[all 4 @ 0.5 each] [2.0]

REFERENCE
Component Cooling Water System Description, Chapter 19, Rev. 2, Para II.A.3., p. 19-15
008000G007 ...(KA'S)

ANSWER 3.01 (2.00)

1. c. [VCT level will go to zero] [1.0 each ans.]

2. d. [VCT level will be maintained in the normal operating range]

REFERENCE
Chemical and Volume Control System Description, Chapter 15a, Rev. 6, Para II.B.1.k., p. 15a-54&55
004020A104 ...(KA'S)

ANSWER 3.02 ~~(1.50)~~ JH (0.50)

a. Manual rod motion stops

-[0.25 each ans.]

Auto rod motion stops

~~b. Regulation failure~~ Part "b" deleted JH

~~Phase failure~~

~~Logic error~~

~~Multiplexing error~~

~~Loose or missing card [any 4 at 0.25 each]~~

REFERENCE
Rod Control System Description, Chapter 28, Rev. 5, Para II.B.2.a., p.28-65 through 28-67
001050K401 ...(KA'S)

ANSWER 3.03 ~~(2.00)~~ JH (1.00)

a. C-5 [turbine first stage pressure] [0.25] <15% [0.15] 1/1 [0.1]

C-11 [control bank D] [0.25] 223 steps [0.25]

~~b. C-1 [intermediate range nuclear overpower] [0.25] current equal to 20% power [0.15] 1/2 [0.1]~~ Part "b" deleted. JH

~~C-2 [power range nuclear power] [0.25] 103% [0.15] 1/4 [0.1]~~

REFERENCE
Rod Control System Description, Chapter 28, Rev. 5, Para C.1., p. 28-72 and 28-73
001000K408 ...(KA'S)

ANSWER 3.04 (1.00)

The digital rod position indication system [0.25] senses actual rod position using coils mounted around the rod drive pressure housing[0.25].

The demand position indication system [0.25] determines rod position by counting the number of steps demanded by the rod control system[0.25].

REFERENCE
Rod Position Indication System Description, Chapter 29, Rev. 5, Para I.B., p. 29-5
014000A102 ...(KA'S)

ANSWER 3.05 (2.00)

Rod control

Steam dumps

Pressurizer level program [all 5 @ 0.4 each]

RIL

Deviation alarms [loop Tavg or Tref]

REFERENCE
Reactor Coolant System Description, Chapter 12, Rev. 2, Para II.B.1., p. 12-22 through 12-24
016000K403 ...(KA'S)

ANSWER 3.06 (1.50)

The loss of load controller [0.5] would generate a Tavg-Tref mismatch signal [0.5], however the dump valves would not open since they are not armed [0.5].

REFERENCE
Steam Dump System Description, Chapter 24, Rev. 2, Para II.A.7., p. 24-11

041020A408 C41020K411 ...(KA'S)

ANSWER 3.07 (2.50)

Pressure decreases because PORV opens momentarily and shuts [0.5] all heaters turn off [0.5] while both spray valves open and remain open [0.5]. [A reactor trip and] safety injection occur which raises pressure after the pressurize is filled soild [0.5]. Final pressure will be determined by cycling of the PORV [0.5].

[equivalent wording accepted for full credit]

REFERENCE
Pressurizer Pressure and Level Control System Description, Chapter 14, Rev. 3, Para II.C.1., p. 14-38 through 14-41
010000K103 ...(KA'S)

ANSWER 3.08 (3.00)

a. When a Reactor Trip Breaker [0.25] and it's Bypass Breaker [0.25] are both open [0.25] [in either train.]

b. 1. Actuates turbine trip. [0.5]

   2. Closes the main feedwater valves [0.25] on Tavg < 564 [0.25]

   3. Prevents opening of main feedwater valves which were closed [0.25] by safety injection [0.25] or high-high steam generator water level [0.25].

   4. Allows manual block [0.25] of the automatic reactuation of safety injection [0.25]

REFERENCE
Reactor Protection System Description, Chapter 60b, Rev. 3, Para II.C.1., p. 60b-21
012000K610 ...(KA'S)

ANSWER 3.09 (2.00)

A. PREAMP

B. LOSS OF DETECTOR VOLTAGE ALARM

C. AUDIO COUNT RATE

D. SUR CIRCUIT

E. HI FLUX AT SHUTDOWN

[0.4 for each ans.]

REFERENCE
Source Range NI'S System Description, Chapter 31, Rev. 3, Figure 31-7
015000G007 015000K603 ...(KA'S)

ANSWER 3.10 (2.25)

a. Reactor coolant loop pressure sensors

Reactor vessel level indication system [RVLIS]

Core exit thermocouples [all 3 @ 0.25 each]]

b. 1. Loss of fluid subcooling prior to the occurrence of saturation conditions in the coolant [equivalent wording accepted] [0.5]

2. Decreasing coolant inventory within the upper plenum [from the top of the vessel to the top of the active fuel] [0.5]

3. Increasing core exit temperature produced by uncovery of the core [0.5]

REFERENCE
Inadequate Core Cooling System Description, Chapter 34b, Rev. 2,. Para I.B, p. 34b-4 through 34b-6
016000G015 017020K601 ...(KA'S)

ANSWER 3.11 (2.25)

a. When a high radiation level is detected, one of the charcoal booster fans [0.25] (OVA04CA or B) starts [0.25]. The filter bypass damper closes [0.25] and flow is directed through the filter [0.25]. Once one of the booster fans starts [0.25] the other is locked out and prevented from starting [0.25].

b. When a high radiation level is detected, automatically the outside air intake B dampers close [0.25], the makeup area unit fan (OVC03CB) starts [0.25] and the main control room turbine building air intake "B" dampers open [0.25].

REFERENCE
Radiation Monitoring System Description, Chapter 49, Rev. 2, Para II.C.1.&2
p. 49-64 through 49-67
072000K402 073000K101 ...(KA'S)

3.12, Part "a" : Change third sentence to read... "Essential Service Water to the Primary Containment Refrigeration Unit is isolated [0.4] ...

ANSWER 3.12 (3.00)

a. All RCFC fans operating in HIGH speed will trip. [0.40] After a 20 second time delay [0.4] (with power available) all fans will start in LOW speed. [0.4] Essential Service Water to the ~~chilled water coils~~ is isolated [0.4] (resulting in the chill water pump tripping.) The RCFC unit is interlocked with the Essential Service Water outlet isolation valves [0.4] (such that isolation valves automatically open when fan motors start and close when fan motors stop.)

b. The P-14 interlock is generated by Hi-Hi Steam Generator Level [0.1] with 2/4 detectors [0.1] on 1/4 Steam Generators [0.1] above 81.4% NR [0.1]. The P-14 interlock closes all feedwater control valves [0.2], trips the MFW pumps [0.2] and actuates a turbine trip [0.2].

REFERENCE
Engineered Safety Features System Description, Chapter 61, Rev. 2, Para II.C.14. p. 61-34
Containment Ventilation and Purge System Description, Chapter 42, Rev. 2
Para II.C.1 & 2 p. 42-38 through 42-40
013000G004 013000K113 ...(KA'S)

ANSWER 4.01 (1.50)

A reactor trip is necessary to prevent low S/G levels (0.5) since the Feedwater Regulating Valves (0.5) and Feedwater Bypass Valves (0.5) fail closed on loss of either DC bus.

REFERENCE
BW Rev.2 S.D. Chapt.8a p.8a-22
BW Procedure 1BWOA ELECT-1 p. 2 of 28
000058K302 ...(KA'S)

ANSWER 4.02 (1.50)

The operator must have the procedures immediately present (0.5)(as they are used) and steps are signed off on a flow chart (0.5) as the steps are performed. (0.5)

REFERENCE
BW Procedure BWAP 340-1, Rev. 52, p.2
194001A102 ...(KA'S)

ANSWER 4.03 (2.00)

When aligning the RHR system to supply the SI system (0.5) the SI Pump miniflow valves must be shut (to prevent coolant from entering the RWST.) (0.5) With RCS pressure above 1590 psig the SI pumps will be operating at their shutoff head pressure.(0.5) Operating the SI pumps at shutoff head pressure with no recirculation (miniflow) could damage the pumps.(0.5)

REFERENCE
BW Procedure 1 BWEP, ES-1.3 p.4
BW Systems Lesson Plan ECCS Ch.58, p. 44 of 81
006000K402 006000K406 ...(KA'S)

ANSWERS -- BRAIDWOOD 1&2 -88/07/18-VICTOR, F.

ANSWER 4.04 (1.50)

1. The Containment Atmosphere Particulate Radioactive Monitoring System.

2. The Containment Floor Drain and Reactor Cavity Flow Monitoring System.

3. The Containment Gaseous Radioactivity Monitoring System. (0.5 each ans.)

REFERENCE
BW Technical Specifications p. 3/4 4-20.
000009A210 000009A211 ...(KA'S)

ANSWER 4.05 (1.50)

a. Rod bottom lights-LIT.
Reactor trip and bypass breakers-OPEN
Neutron Flux-Decreasing (0.125 each ans.)

b. FW pumps-TRIPPED
FW pumps discharge valves-CLOSED - 1FW002 A/B/C/D
FW reg valves-CLOSED 1FW 510/520/530/540
FW reg byp valves-CLOSED 1FW 510A/520A/530A/540A
FW isol valves-CLOSED 1FW 009 A/B/C/D
FW temprng flow cont valves-CLOSED 1FW 034 A/B/C/D
FW temprng isol valves-CLOSED 1FW 035 A/B/C/D
FW prehtr byp isol valves-CLOSED 1FW 039 A/B/C/D
FWIV byp isol valves-CLOSED 1FW 043 A/B/C/D (0.125 each ans.)

REFERENCE
BW Procedure 1BWEP-0 p.3 of 31, 6 of 31, 7 of 31
000005G010 000007A206 ...(KA'S)

ANSWER 4.06 (2.00)

a. With rod control in manual, exercise the bank (with the failed rod) by inserting rods 5 steps (0.5) and then withdrawing rods 5 steps (0.5) to determine if all rods move.
b. A rod misaligned high is driven in to match its group (0.5) while a rod misaligned low has the group driven in to match the misaligned rod. (0.5)

REFERENCE
BW Procedure 1BWOA, ROD-3 p.3 of 6, 6 of 6
000005K306 ...(KA'S)

ANSWER 4.07 (1.50)

a. Personnel dosimeters are worn near each other (0.25) on the front part (0.125) of the body at or above the waist level (0.125) ~~(0.25)~~.

b. The individual shall leave the work area (0.125) and report to his supervisor (0.125) ~~(0.25)~~ and then to Radiation/Chemistry immediately(0.25).

c. Whole body dose limit shall not exceed 75 rem.(0.25) Extremities dose limit shall not exceed 200 rem.(0.25)

REFERENCE
BW Procedure BWRP 1000-A1 p.26,33
194001K103 194001K104 ...(KA'S)

ANSWER 4.08 (1.00)

First --Place an OOS card on the remote control switch.
Next ---Place an OOS card on the power supply for the valve.
Last ---Place an OOS card on the valve. (0.33 each ans.)

REFERENCE
BW Procedure BWAP 330-1 p.3; BWAP 330-6 p.1
194001K102 ...(KA'S)

ANSWER 4.09 (2.00)

1. #1 seal leakoff flow high
2. #1 seal leakoff flow low
3. #1 seal outlet temperature high
4. RCP vibration
5. #1 seal low delta-p (Any 4 at 0.5 each)

REFERENCE
BW Procedure 1BWOA, RCP-1 p.1 of 14
003000G015 ...(KA'S)

ANSWER 4.10 (1.00)

If you discover a fire that is so small that you are sure you can put it out with extinguishers readily available, extinguish it at once [0.25] and then dial extension 2211 and report the fire [0.25].If in doubt summon aid before fighting the fire.[0.25] Report the use of any fire equipment to the Fire Marshal as soon as possible.[0.25]

REFERENCE
BW Administrative Procedure BWAP 1100-1 p.13
000067G001 194001K116 ...(KA'S)

ANSWER 4.11 (2.00)

a. 1. Emergency borate using emergency borate valve(1CV8104).
   2. Emergency borate through the normal boration path.
   3. Emergency borate using RWST. (0.25 each; 0.25 for correct order)

b. Emergency boration using the manual boration valve (1CV8439) will only deliver 10 GPM of boration flow (0.5) which does not meet the flowrate required by Technical Specifications. (0.5)

REFERENCE
BW Procedure 1BWOA, PRI-2 p. 2 of 7 through 4 of 7.
000024K302 ...(KA'S)

ANSWER 4.12 (1.00)

1. Containment pressure (0.25) greater than 5 psig. (0.25)
2. Containment radiation level (0.25) greater than 100,000 R/HR.(0.25)

REFERENCE
BW Procedure 1BWEP-0 p.3 of 31
000009A210 000009A211 103000G015 ...(KA'S)

ANSWER 4.13 (1.50)

a. 2735, 550 (0.5 each)
b. (2) Identified Leakage (0.5)

REFERENCE
BRAIDWOOD T.S. p.1-3; 2-1; and 3/4 1-6
002000G005 010000G005 ...(KA'S)

ANSWER 4.14 (1.50)

Trip the RCPs when:
--CC Water to RCPs lost (0.25)
--Containment Phase B activated (0.25)
--Controlled cooldown not in progress (0.25) and RCS pressure less than 1370 psig (0.25) and High Head SI pump greater than 50 GPM (0.25) or SI pump(s) greater than 100 gpm. (0.25)

REFERENCE
BW Procedure 1BWEP-0 fold-out page.
000007A104 ...(KA'S)

ANSWER 4.15 (1.00)

a. 60
105
b. Demineralized water supply (0.25 each)
Reactor makeup water

REFERENCE
BW Precautions,Limitations and Set points p.90
008030G010 ...(KA'S)

ANSWER 4.16 (1.50)

a. FALSE
b. FALSE
c. TRUE

REFERENCE
BW Procedure BWAP 340-1, Rev.52 p.9
000011K011 ...(KA'S)

ANSWER 4.17 (1.00)

A mandatory in-hand procedure must be in the possession of the personnel on the job and each step is read (0.25) and understood (0.25) prior to performing the task. (0.25)
BWOP RD-5, Control Rod Drive MG Set Start Up and Paralleling. (0.25)

REFERENCE
BW Special Operating Order SO-ST-0014
194001A102 194001A103 ...(KA'S)