U.S. NUCLEAR REGULATORY COMMISSION

REGION III

Report No. 50-461/OL 86-02

Docket No. 50-461 License No. CPPR-137

Licensee: Illinois Power Company
ATTN: Mr. W. C. Gerstner
Executive Vice President
500 South 27th Street
Decatur, IL 62525

Facility Name: Clinton Nuclear Power Station

Examination Administered At: Clinton Nuclear Power Station

Examination Conducted: April 28-30, 1986

Examiners: J. I. McMillen — Date: 5/22/86

T M Burdick for
K. E. Brockman — Date: 5/23/86

T M Burdick for
J. F. Munro — Date: 5/23/86

T M Burdick for
C. Castro — Date: 5/23/86

Thomas M. Burdick
Approved By: Thomas M. Burdick, Chief
Operating Licensing Section — Date: 5/23/86

Examination Summary

Examination administered on April 28-30, 1986 (Report No. 50-461/OL 86-02)
Written examinations were administered to five senior reactor candidates on April 28, 1986, Operating examinations were administered to four senior reactor and two reactor operator candidates on April 29 and 30, 1986.
Results: Four senior operator candidates passed the written examination, and two operator and two senior operator candidates passed the operating examination.

REPORT DETAILS

1. Examiners

J. I. McMillen, Region III
K. E. Brockman, Region II
C. Castro, Region II
J. F. Munro, Region II

2. Examination Review Meeting

At the completion of the written examination, a copy of the questions and answer key was left with facility training personnel. They were requested to provide written comments on the examination and answer key within five working days. Those comments and the resolution of the comments is attached to this report.

3. Exit Meeting

J. Munro, K. Brockman, and C. Castro met with M. Lyons of Illinois Power Company at the conclusion of the operating examination and informed Mr. Lyons that both steam flow annunciators would alarm when only one channel was down scale. This caused confusion among the operators.

Senior Operator Examination Comments and Resolutions

Questions

5.4:

Facility Comment: Answer is correct; however, candidate may respond with critical point vs critical temperature.

Resolution: Credit was given to responses that indicated an understanding of concept. The words "critical temperature" were not required for credit.

5.5:

Facility Comment: Answer is correct; however, the term "parameter" is misleading. Both power and neutron flux distribution are used by the process computer to calculate APF and RPF. Therefore, core thermal power, neutron flux distribution and local peaking factor should be also considered as an acceptable answer. (Reference, G.E. SNE Manual).

Resolution: Credit was given for responses that indicated an understanding of concept. All candidates answered correctly.

5.10:

Facility Comment: The answer is partially correct; however, this effect on core-beta is negligible. The overwhelming effect on core-beta is due to the difference in delayed neutron fractions of U-235 and Pu-239. The difference in delayed neutron energies is negligible (0.432 MeV for U-235 vs 0.433 MeV for Pu-239). Therefore, the difference in leakage is also negligible. Beta (U-235)=0.006¢ vs Beta (Pu-239)=0.0021 is the major reason for the change in core-beta over core life (Reference: Glasstone and Sesonski, "Nuclear Reactor Engineering," Van Nostrand Rienhold Co. 1967 page 93).

Resolution: Comment accepted, but full credit was not given unless the concept given in the answer key was part of the answer given by the candidate.

5.15

Facility Comment: The answer for part "a" should be 3; e.g., as level increases in the reactor, the pressure differential across the level transmitter will decrease.

Resolution: Comment accepted. Answer key corrected.

5.17

Facility Comment: Answer correct; however, please consider adding the following to list of acceptable answers: 5. Increase in the amount of fission product poisons present (Reference: PCIOMR Implementation Procedures, Revision 5, NEDE-21493, February 1982, page 1.0-1).

Resolution: Comment accepted, but no candidate gave that as part of their answer.

6.1

Facility Comment: a.1 The CRD FCV will fail shut on loss of air. (Reference: CPS 10P3214.015 Step 8.2.2.1.7). a.4 There is no TCV on VP chiller; however, student answer will probably be per answer key as the damper will close and system will shutdown. a.5 This valve will fail closed (Reference M05-1057 Sheet 1, Revision L).

Resolution: a.1. Comment accepted answer key changed.
a.4. This part of the question was deleted since there is no such valve in system. Points were distributed among four answers.

6.2b

Facility Comment: Answer is correct; however, candidates may list: Mode switch in refuel; one rod withdrawn, another (not the one withdrawn) rod selected.

Resolution: Comment accepted: Credit given for answers which indicated knowledge of system operation without using exact words in answer key.

6.3

Facility Comment: Answer is correct; however, CPS has no MSCV's or LPSCV's.

Resolution: Comment noted. All candidates answered correctly.

6.7

Facility Comment: Answers in blocks E, F and H are simultaneous interlocks and therefore, should be interchangeable. The same comment applies for blocks B and G.

Resolutions: Comment rejected. Chart was presented so that candidates did not have to memorize every step and should be able to fill in blocks in proper sequence.

6.8

Facility Comment: B or C should be considered as a correct response. It should be noted that the CCW pumps are not powered from the ESF buses. (Reference: E02-1AP03 Revision C).

Resolution: Comment accepted. Answer key changed to accept either answer.

6.9

Facility Comment: Answer is correct; however, students may respond with the following: RHR System A or B; Drywell Equipment Drain Sumps or Drywell Floor Drain Sumps vs Drywell Sumps; Cent. Equipment Drain Sumps or Containment Floor Drain Sumps vs Cent. Sumps. (Reference: M05-1045sh12 Revision M).

Resolution Comment accepted. Answers given that indicated knowledge of sumps were given credit.

6.10

Facility Comment: The key is incorrect. Procedure 3314.01 Revision 3 page 5 of 12, a note states, "An SLC pump will not start until its associated suction valve has cycled to the full open position. The suction valve will not automatically open unless the Test Tank Suction Valve is fully closed. . . therefore, the correct response should be D. F001 does not open SBLC pump A does not start (Reference 3314.01 Revision 3 page 5 of 12).

Resolution: Comment accepted. Answer key changed.

6.11

Facility Comment: The correct response should be, slow in the clockwise direction.

Resolution: Comment accepted. Slow in the fast direction was also an acceptable answer. Answer key changed.

6.12a

Facility Comment: The answer is correct; however, the RCIC system will isolate on High Room Temperature or Differential Temperature on steam escaping into the room after a period of time.

Resolution: Comment accepted and credit given for additional answers. Key corrected.

6.14

Facility Comment: Answer 4 should reference H13-P634 or P639 (Reference: CPS 4009.0 Revision 3 Step 3.2).

Resolution: Comment noted. Panel numbers were not needed to receive full credit for answers, but if given had to be correct and candidates only gave panel numbers for SRV position indication.

7.1

Facility Comment: Procedure 4404.01 is titled Reactivity Control Emergency vice Reactor Scram. Immediate operator action is not specified; however, operator action is and the answer should include the following: (4) If main turbine is on-line and MSIV's are open, then runback recirc flow to minimum; (5) activate the Backup ARI/RPT. (Reference 4404.01). Answer 4 should be prior to 3.

Procedure 4100.01 "Reactor Scram" immediate actions are:

1. Place Mode switch in shutdown.
2. Verify appropriate auto actions occur, manually perform any that do not.
3. If relief valves lift, or if lifting is imminent, evacuate containment.
4. Verify all control rods fully inserted.
5. Verify reactor power decreasing.

6. If two feed pumps are operating and level is increasing, then secure one feed pump and control level in the normal band.
7. Shift Feedwater control to single element auto as per CPS 3103.01 feedwater.

Resolution: Procedure 4404.01 refers to the Reactor Scram procedure and credit was given for answers that included those contained in the comments from the facility.

7.2
Facility Comment: Answer should say ". . .3 SRV's. . ." not 2 SRV's (Reference 4403.01, Revision 4).

Resolution: Comment accepted. Answer key changed.

7.3
Facility Comment: Answer is correct, however, 4403.01 cautions the "SRV operation in a sequence which results in uniform suppression pool heating per Frg 1. Then the procedure reference to MS Procedure 3101.01 which states to reduce pressure sufficiently to reduce the number of valve cycles.

Resolution: Comment noted. No change to answer key required since this was a multiple choice question.

7.4
Facility Comment: If the operator at the remote shutdown panel transfers RCIC controls to the RSP the RCIC trips/isolations are by passed and RCIC may be run. (Reference E02RS99, SR104 and E02R199 sh 8, 13,501)

Resolution: This question was deleted since it was a multiple choice question and based on additional review of the reference material the examination did not contain a correct answer.

7.5
Facility Comment: CPS OAP3302.01 RR states to take manual control of the FCV's and balance recirculation loop flows (Step 8.2.4) and Technical Specification requires the limits but CPS does not have CAF Procedures or Lesson Plans.

Resolution: CAF (Check at Facility) was a note to assure that facility personnel make sure the answer key was correct. All candidates answered correctly and the facility comment indicates that the answer key was correct.

7.6
Facility Comment: Answer A and B are incorrectly stated, a 20% power reduction vice 30% is called for and if at high power and high flow conditions (100% rod line) directs power rod insertion to maintain APRM scram margins (does not mention . . . monitored by APRM's) Reference OAP4005.01).

Resolution: Comment noted all candidates answered correctly. Answers A and B have been changed to 20%.

7.7a.
Facility Comment: This question does not apply to the Clinton Station . . . Technical Specification Suppression Pool Level (3.6.3.1) are: 8'11" (12'8 condition 4 and 5)
19'5"
Temperatures are: 95° maximum and Condition 1 and 2
105° Testing
110 Thermal Pwr $\pm$ 1%
120° MSIV shut after scram
All procedures required observance of the above limitations. Recommend throwing out the question. There is no information regarding this question in any CPS Procedure or CPS Training Manual.

Resolution: Facility comment states that all procedures require observance of the Technical Specification limits and the basis for the Technical Specifications state the reasons these limits must be maintained. Answer key changed to agree with Technical Specification limits.

7.8
Facility Comment: Answer is correct, however CPS Procedure 3304.01, Revision 1, Step 8.2.4.2 states "connect a hose from valve 107 to a floor drain," so another correct response would be when no water is observed draining from the hose (Reference CPS 3304.01, Revision 1).

Resolution: Comment accepted. Additional correct response would be no water observed draining from hose.

7.9.a.
Facility Comment: Answer is correct. Some candidates may reply that maintaining a level to promote natural circulation is only a concern with RR secured. This should be acceptable (Reference CPS OAP 3312.01).

Resolution: Comment noted. Additional information in answer, when correct, does not reduce the grade.

7.10
Facility Comment: Question states set points are not required. Answer 2 contains a typo. Should read from the generator with CO2. Answer 3 should be with Service Air or SIA. (Reference CPS 3111.01).

Resolution: Setpoints were not required. They were given in answer key for the benefit of the grader in case a candidate listed them in his answer. Typo in answer 2 corrected, answer 3 corrected. Credit was given to candidates for concept and sequence of events rather then for specific systems.

7.11
Facility Comment: B should be 3 rem (vice 25 rem) (Reference RA-03, Revision 1, Step 4.12).

Resolution: Comment accepted answer key changed.

7.12
Facility Comment: Tolerances for setpoints were not called for.

Resolution: Comment noted. Tolerances in answer key were for graders benefit.

7.13
Facility Comment: Either of the following answers should be acceptable, both are correct. CPS 4100.01 does not address a failure to isolate, however, per 4001.02, Automatic Isolation, Step 3.2 says verify all appropriate automatic actions occur and perform any which did not occur. In addition, CPS 4401.01, Revision 6, Condition requiring a MSIV isolation is an entry condition and the operator action this: (1) Place mode switch in shutdown, (2) Sound the containment evacuation alarm. (Reference 4401.01, Revision 6 and 4001.02).

Resolution: Comment accepted. Credit was given to reasonable answers that indicated an understanding of the requirements to place the facility in a stable condition.

7.15
Facility Comment: A.1. When both CRD pumps are declared inoperable (CPS 5068.08), A.2. When more than one accumulator in inoperable and one of the drives associated with the accumulators is withdrawn (3304.01, Revision 1). b. Delete ". . .and verify appropriate auto actions have occurred," This is part of 4100.01, vice 3304.01. (Reference 5068.08, 3304.01, Revision 1).

Resolution: Comment accepted. Answer key modified.

7.16
Facility Comment: This question is misleading, as we normally use condensate booster pumps at this stage. If the question asked why we minimize flow demand, then the answer would be as stated, "Per 3002.01 minimize flow to minimize thermal duty on the RV feedwater nozzles and CPS 3103.01 has a caution regarding increasing flow causing positive reactivity additions.

Resolution: Candidates interpreted question per the 3002.01 procedure. Credit was given for this answer. Question revised for future examinations.

7.17

Facility Comment: This question could be interpreted in two ways; (1) If all rod position indication (all 145 nods) is lost, then the answer is True per Technical Specification 3.1.4.2; (2) If all rod position indication on one rod is lost the answer is False. (Reference Technical Specification 3.1.4.2 and 3.1.3.5).

Resolution: Candidates assumed that question related to all rods. Credit was given for this answer. Question revised for future examinations.

7.18

Facility Comment: The answer should be: "Secure non-essential CCW loads, consideration should be given to transferring one or both FX HX's to SX cooling" (Reference 3203.02, Revision 2, Step 8.2.1.3.2). There are no immediate actions on partial loss of CCW. The abnormal operations section of the procedure states the following actions upon abnormal temperature on CCW Heat exchanger header outlet header.

1. Verify proper operation CCW heat exchanger temperature regulation valve controller. If necessary control temperature in manual or manual handwheel control.

2. Verify operating CCW pump-heat exchanger line up is consistent with plant heat loads.

3. If CCW heat exchanger outlet temperature remains high, proceed as follows:

   a. Vent heat exchangers

   b. Place additional CCW pumps/heat exchangers in service. Secure non-essential CCW loads. Consideration should be given to transferring one or both FC (fuel pool cooling) heat exchangers to Shutdown Service Water (SX) cooling.

Resolution: A partial loss of CCW would most likely give indications that would place the operator in the abnormal operations section of the procedure. Required actions as stated in facility comments per procedure received proper credit. Answer key wording revised.

8.4

Facility Comment: Answer is correct, however; some candidates may respond with viable methods/mechanisms listed in the EPG's to provide adequate core cooling; core submergence; spray cooling, steam cooling.

Expanded in our Emergency Procedures, students also could respond.

1. Water level maintained above TAF

2. Reactor flooded as determined by

   a. level unknown: injecting with at least 3 SRV's open and RPV pressure not decreasing and _ 68 psig. RPV pressure.
   b. Level known: injecting until RPV level is increasing.

3. Steam cooling in progress

4. HPCS or LPCS in spray cooling or simply Level restoration; RPV flooding; alternate RPV flooding; steam cooling.

Resolution: Comment noted: Alternate answers by candidates that indicate adequate understanding of procedure were given credit.

8.6

Facility Comment: Answer is correct, however, some students may apply the definition of operability conservatively by concluding that since the valve failed the surveillance 4.5.1.d, that this would make the system inoperable and require Hot S/D in six hours and at least cold S/D within the following 24 hours. Please consider this response to be acceptable as well. Additionally the requirement for steam dome pressure should be changed to 100 psig as penciled in an facility copy.

Resolution: Comment concerning change of pressure to 100 psig accepted. The other comment concerning the conservative answer is rejected, since the question asks for the action which most correctly details the allowance and/or limitation imposed by the Technical Specifications.

8.7

Facility Comment: Technical Specification total leakage as averaged over any 24 hour period per 3.4.3.2.c of attached Technical Specification supplied with exam is 25 gpm. Total average leakage is 25.4 gpm. This is in excess of the limit. (Key says 30 gpm), additionally the note to base the answer on the TS supplied with the exam is important as the 2 gpm increase from (0400-0800) is not included in recent set of Technical Specification.

Resolution: Answer key changed. Additional comment noted. No change necessary since answer was based on the Technical Specifications supplied to candidates.

8.8

Facility Comment: Service platform hoist fuel - loaded, should be excluded from key as service platform hoist cannot be used for fuel (3.9.6.1).

Resolution: Comment rejected in part, Service platform hoist loaded is one of the interlocks that is a possible answer key changed to delete the word "fuel."

8.13

Facility Comment: The reference does not exist at CPS, however, CPS Procedure 1405.01, Revision 4, Performance of operational activities states: Verification of circuit breaker position shall include a check of the following items.

1. Physical position of breaker in its compartment/cubicle.

2. The spring charging toggle switch is on, if so equipped. (4.16 KV breakers do not have this switch, however, they do have a plug showing springs are charged).

3. The control power fuses are installed.

Other acceptable responses may include

1. Power available indication

2. Protective relay flags reset

3. Lockout relay flags reset.

Resolution: Reference was CAF (Check at Facility) since examiner could not easily locate answer in facility material so key was based on general knowledge. Comment accepted and key changed according to Procedure 1405.01.

8.17.b

Facility Comment: Before issuing at job site. Name SSN, Dose Margin; Initials. At the job site, however, time, exposure in and time, exposure out to the nearest 5 mr.

Resolution: Comment accepted. Answer key changed.

MASTER COPY

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

FACILITY: CLINTON

REACTOR TYPE: BWR GE 6

DATE ADMINISTERED: April 28, 1986

EXAMINER: J. I. McMillen

APPLICANT: MASTER

INSTRUCTIONS TO APPLICANT:

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

Category Value	% of Total	Applicant's Score	% of Category Value	Category
25	25			5. Theory of Nuclear Power Plant Operation, Fluids, and Thermodynamics
26	26			6. Plant Systems Design, Control, and Instrumentation
~~24~~ 23	24			7. Procedures - Normal, Abnormal Emergency, and Radiological Control
~~25~~ 27	25			8. Administrative Procedures, Conditions, and Limitations
~~100~~ 101	~~100~~ 100			TOTALS

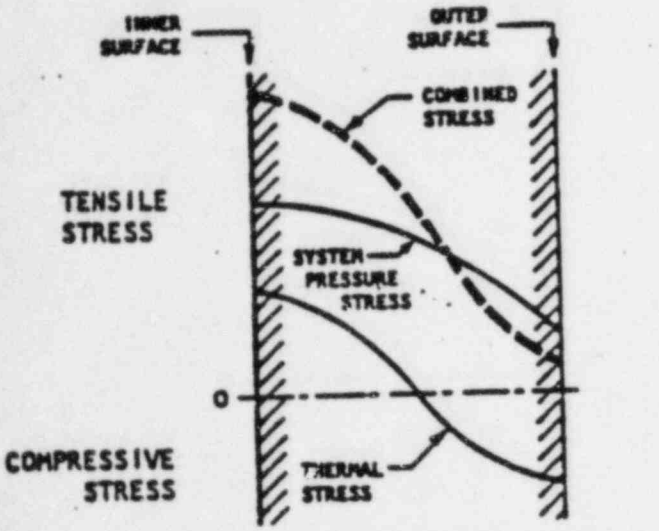
Final Grade _____ %

All work done on this exam is my own, I have neither given or received aid.

_____
Applicant's Signature

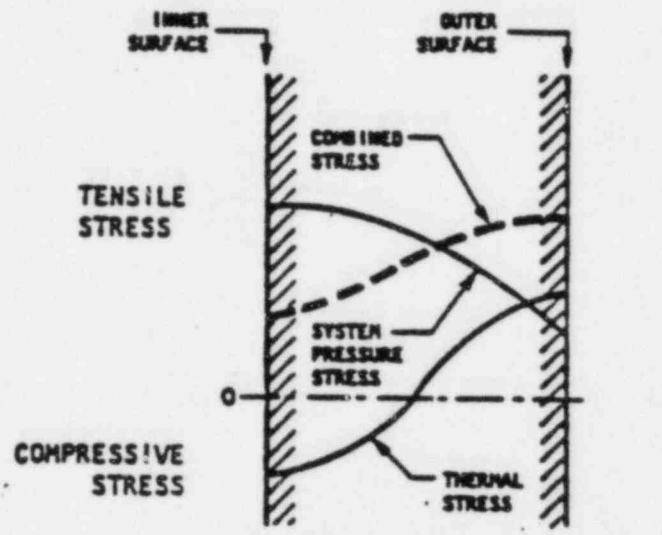
SECTION 5: THEORY OF NUCLEAR POWER PLANT OPERATION, FLUIDS AND THERMODYNAMICS

5.1 Select the diagram below (A or B) which indicates heat up stress. (1.0)



(CROSS-SECTION OF VESSEL WALL)

A



(CROSS-SECTION OF VESSEL WALL)

B

5.2 The convective heat transfer coefficient for boiling water is 300 - 9000. (Btu/hr ftsq°F). From the below list choose the values that represent the convective heat transfer coefficient for film boiling. [Choose either A, B, C, or D] (1.0)

Btu/hr ftsq°F

a. 5000 - 20,000

b. 300 - 9000

c. 50 - 3000

d. 5 - 20

5.3 From the selection of answers in Column 2, choose the correct number identifying the horizonal and vertical axis of the curve on the next page of this exam. (1.0)

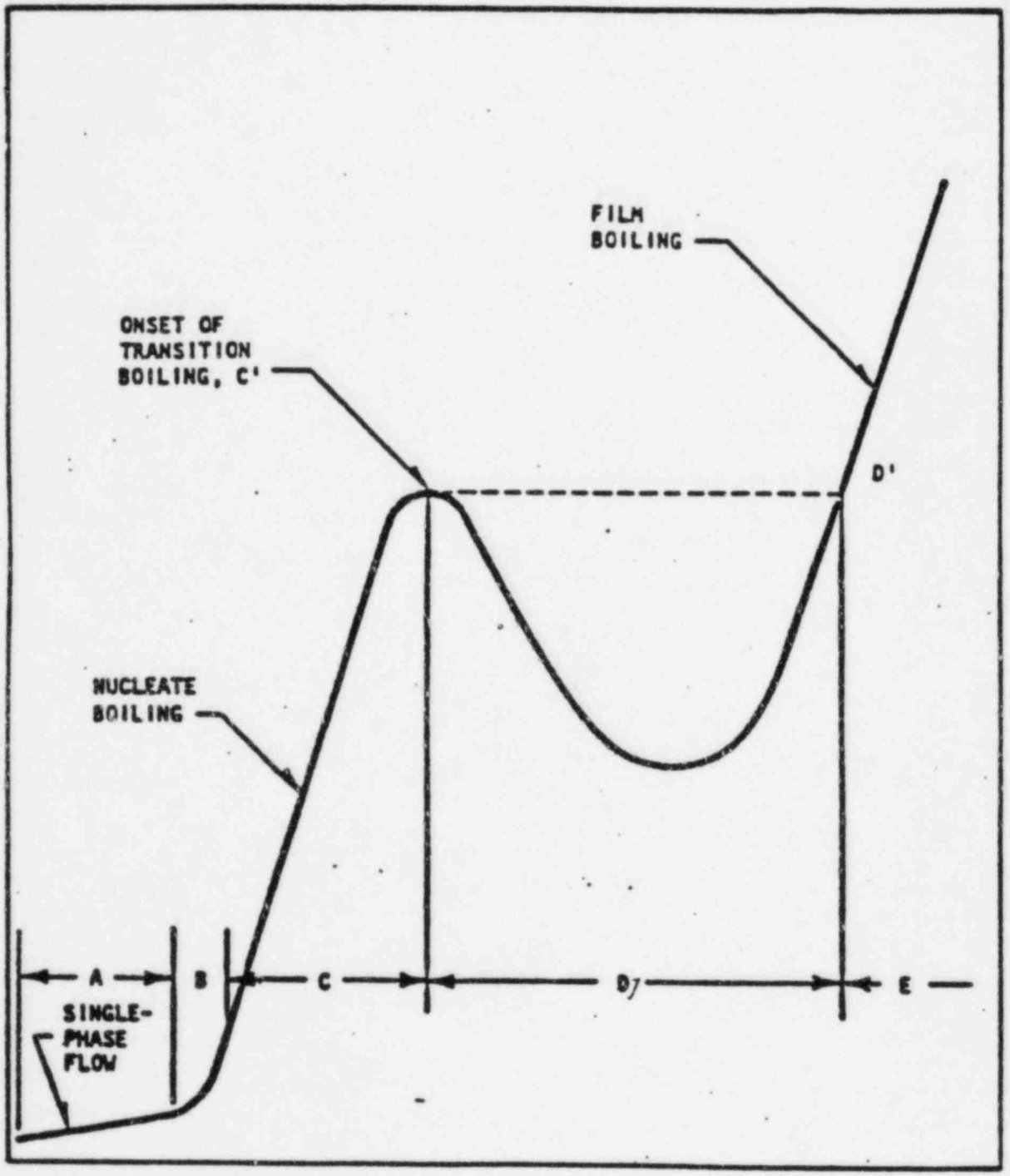
HORIZONAL = _____

VERTICAL = _____

COLUMN 2

1. delta temperature
2. delta pressure
3. log(T[clad] - T[coolant])
4. mass flow rate
5. log Q
6. change in entropy
7. % void fraction

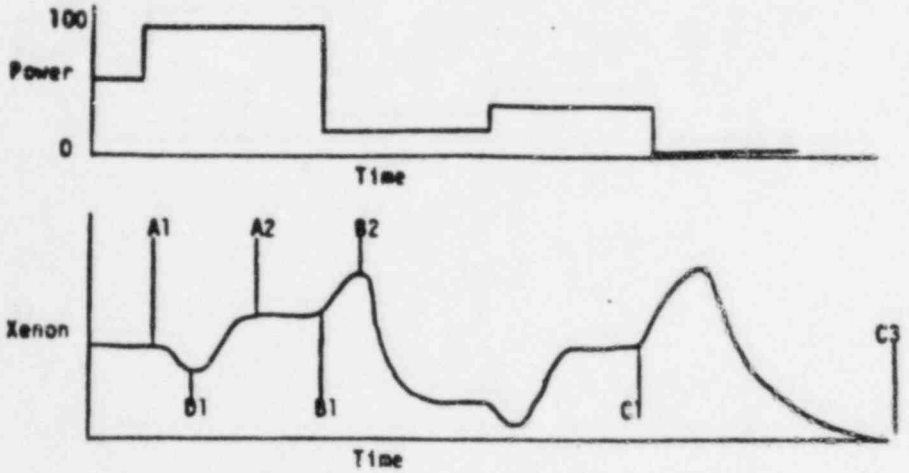
Figure 9.3 Heat Flux Versus Temperature Difference Between Cladding and Coolant



5.4 If a pressurized water system is operating at 705 F and 3400 psia, briefly explain what occurs in the system as temperature and pressure are increased at a rate of 10 units per minute. Assume no physical restraints on the system. (1.0)

5.5 A representative value for a BWR TOTAL PEAKING FACTOR is 2.43. What three parameters are used to determine the total peaking factor? (1.0)

5.6 Using the following figures, choose the correct answer for each of the three (3) questions asked below:



a. What is the approximate time from A1 to A2? (1.0)

1. 10 hours
2. 30 hours
3. 50 hours
4. 70 hours

b. What is the approximate time from B1 to B2? (1.0)

1. 1-3 hours
2. 3-6 hours
3. 6-9 hours
4. 9-12 hours

c. Why does Xe concentration decrease from A1 to D1? (1.0)

1. Xenon decay is equal to iodine decay
2. Xenon burnout is equal to iodine decaying to Xenon
3. Xenon burnout is greater than iodine decaying to Xenon
4. Xenon decay is greater than iodine decay

5.7 Answer the following statements about the Doppler Coefficient, True or False

a. Doppler Coefficient becomes more negative from 0 to 100% power due to the increased overlapping of resonance peaks at higher fuel temperatures. (1.0)

b. Doppler Coefficient becomes more negative over core life due to the buildup of Pu-240 and fission products with large resonances in the epithermal range. (1.0)

5.8 Which of the below best define, "power density?" (1.0)

a. reactor power in kw divided by the total surface area of the active fuel rods.

b. reactor power in kw divided by uranium loaded in the core.

c. reactor power in kw divided by core volume

d. reactor power in kw divided by the active length of fuel pins in the core.

5.9 The effective multiplication for a cold, xenon free reactor with its strongest control rod withdrawn is calculated to be 0.899. What is the reactors shutdown margin? Must include units in answer! (1.5)

5.10 Why does the presence of Pu-239 late in core life cause beta effective to decrease? (1.0)

5.11 There are several intrinsic sources in a reactor. List three of these in order of their contributions at the BOL. (1.5)

5.12 In which of the following situations is the control rod worth greater? EXPLAIN the reason for your selection. (Include comparison with the situation you did not select). (2.5)

SITUATION ONE
All control rods are fully inserted and the center rod is then fully withdrawn.

SITUATION TWO
All control rods are fully withdrawn and the center rod is then fully inserted.

5.13 Define the following terms:

a. Void fraction (1.0)

b. steam quality (1.0)

5.14 For the following MATCH the cause of failure with its associated limiting parameter. (1.5)

Cause of Failure	Limiting Parameter
1. Fuel Pellet Expansion	A. FLPD
	B. CPR
	C. APLHGR
2. Loss of Nucleate Boiling around cladding	D. MARRAT
	E. LHGR
3. Decay heat and stored heat following LOCA	

5.15 Differential pressure measurements can be used to determine level, pressure, and flow. For each of the following in COLUMN A, select the appropriate type of relationship that exists, from COLUMN B. (1.0)

COLUMN A (Item)	COLUMN B (Relationship)
a. Level	1. Proportional to differential pressure plus a constant
b. Flow	2. Proportional to differential pressure alone
	3. Proportional to the inverse differential pressure
	4. Proportional to the square of differential pressure
	5. Proportional to the square root of differential pressure.

5.16 Which of the following is NOT CORRECT as applies to the impact of delayed neutrons on reactor operation? (1.0)

a. When calculating reactor period, the delayed neutron term may be considered INSIGNIFICANT if the reactivity addition is GREATER than Beta.

(*** QUESTION 5.16 CONTINUES ON NEXT PAGE ***)

b. The magnitude of the effective delayed neutron fraction (Beta-bar) is GREATER at EOL than at BOL.

c. The delayed neutron fraction (Beta) is the RATIO of the number of delayed neutrons produced to the number of fission neutrons produced.

d. The presence of delayed neutron causes the average neutron generation time (1-bar) to increase.

5.17 The THRESHOLD power below which PCI failures do not occur is known to DECREASE with fuel burnup. State two (2) reasons for this decrease in the PCI threshold. (1.0)

5.18 A reactor heat balance was performed (by hand) during the 0000 to 0800 shift due to the process computer being out of service. The GAF's were computed, but the APRM GAIN ADJUSTMENTS HAVE NOT BEEN MADE. Which of the following statements is true concerning reactor power? (SELECT ONLY ONE ANSWER) (1.0)

a. If the feedwater temperature used in the heat balance calculation was LOWER than actual feedwater temperature, then the actual power is HIGHER than the currently calculated power.

b. If the reactor recirculation pump heat input used in the heat balance calculation was OMITTED, then the actual power is LOWER than the currently calculated power.

c. If the steam flow used in the heat balance calculation was LOWER than the actual steam flow, than the actual power is LOWER than the currently calculated power.

d. If the RWCU return temperature used in the heat balance calculation was HIGHER than the actual RWCU return temperature, then the actual power is LOWER than the currently calculated power.

(*** END OF SECTION 5 ***)

SECTION 6: PLANT SYSTEMS DESIGN, CONTROL, AND INSTRUMENTATION

6.1 Consider an Off-Normal Event in which Instrument Air System pressure is lost.

a. How will the following valves Fail? (CLOSED, OPEN, AS IS) (2.5)

1. CRD FCV
2. RFP Minimum Flow Valve
3. Feedwater Startup Flow Control Valve
4. Drywell Chillers Temperature Control Valves - Chilled H2O o. Cooling H2O
5. TBCW Make-up Valve

delete

b. EXPLAIN the cause of the potential High Radiation levels in the Off-Gas Building. (0.5)

6.2 Describe the condition(s) which will generate EACH of the following indications on the operator control module.

a. Channel disagree (0.5)

b. Insert required (0.5)

6.3 The plant is operating at 100% RTP with Recirc Flow control in "Flux Manual." An operator inadvertently DECREASES the "Pressure Reference Set" on the EHC Turbine Control System by 5 psig.

ASSUME: 1. No further operator action.

2. All other EHC control settings are normal.

3. Starting Parameters:

-TCVs (MSCV & LPSCVs)	-100% Steam Flow Position
-BPCVs	- 0% Steam Flow Position
-Rx Power	-100% Rated Thermal Power
-Rx Pressure	-1025 psig
-Load Demand/Load Limit	-1310 MWe

NOTES: All valve %s are in % Steam Flow Position.

See attached figures for information.

Which of the following most accurately describes both the INITIAL RESPONSE and FINAL STATUS of the different parameters and components? (2.0)

(*** QUESTION 6.3 CONTINUES ON NEXT PAGE ***)

	a	b	c	d
INITIAL RESPONSE				
-TCVs	Partial Close (<100%)	Partial Close (<100%	No Change	No Change
-BPCVs	No Change	Partial Open (>0%)	Partial Open (>0%)	Open (>0%)
-Rx Power	Increase	No Change	Decrease	Decrease
-Rx Pressure	Increase	No Change	Decrease	Decrease
FINAL STATUS				
-TCVs	~100%	Partial Close (<100%)	0% (MSIV SHUT)	~100%
-BPCVs	0%	Partial Open (>0%)	0% (MSIV SHUT)	0%
-Rx Power	>100%	>100%	~0%	<100%
-Rx Pressure	>1025 psig	>1025 psig	As controlled by SRVs &RCIC	<1025 psig

ONLY ONE ANSWER - READ ENTIRE COLUMN FOR BOTH INITIAL AND FINAL RESPONSES.

6.4 EXPLAIN the functioning of the Feedwater Control System "Setpoint Setdown Mode" feature from actuation to a reset condition. Ensure that your explanation addresses the following: (2.0)

- all applicable setpoint(s)
- specific effect(s)
- reset method(s)

6.5 Regarding the Control Rod Drive (CRD) and CRD Hydraulics

a. Why is the hydraulic system Flow Control Valve mechanically blocked from going completely closed during a scram? (1.0)

b. Scramming a CRD with the over piston flow path isolated (scram discharge valve closed or the area manual valve closed) will result in: (Select the <u>best</u> answer) (1.0)

1. The CRD staying at the position it was prior to the scram.

2. Extremely high pressures being generated in the over piston volumes.

3. Graphitor seal damage

4. High CRD temperature

6.6 The RHR-LPCI System has received a valid initiation signal. The system automatically initiated. The initiation signal is still present.

RHR-LPCI "A" flow is diverted to initiate Suppression Pool Cooling by use of the TEST RETURN LINE VALVE (F024A) MANUAL OVERRIDE function.

LIST the condition(s) that would defeat/inhibit this manual override signal to F024A. (1.0)

6.7 Consider the Recirc Pump Slow speed starting sequence logic depicted on the attached figure. List the nine (9) permissives that are left blank and lettered. (2.5)

6.8 The plant is operating at power with "A" and "C" CCW pumps running and the "B" CCW pump selected for STANDBY operation. A Loss of Power occurs and the diesels start and tie in normally. Which one of the following most accurately describes how the CCW system will respond during this transient? (1.0)

a. The "B" CCW pump will auto start on ESF power after the bus is reenergized.

b. Both the "A" and "C" CCW pumps can be started manually on ESF power after the buses are reenergized.

c. The "B" CCW pump will not auto start, but can be manually started by the operator on ESF power after the bus is reenergized.

d. The "B" CCW pump will auto start on a low CCW pressure signal after the ESF bus is reenergized.

6.9 The post accident sampling system station located on the 737' elevation of the Diesel Generator building provides a central location for monitoring and grab sampling several fluid systems? List three of these systems. (1.5)

6.10 SBLC System A is in a normal STANDBY lineup with one systematic deviation - the TEST TANK OUTLET VALVE (F031) is OPEN.

Which of the following most accurately describes the effects on the STORAGE TANK OUTLET VALVE (F001) and SBLC PUMP A of placing the SBLC Keylock Control Switch for Pump A to START. (1.0)

a. Valve F001 Opens - SBLC Pump A Starts after the valve reaches its Full Open position.

b. Valve F001 Opens - SBLC Pump A Starts concurrently with the valve opening.

c. Valve F001 does Not Open - SBLC Pump A Starts

d. Valve F001 does Not Open - SBLC Pump A does Not Start

6.11 A diesel generator is the sole supply to an ESF Bus. When paralleling the Normal Power supply back to the Bus the synchroscope should be turning (a) in the (b) direction. (0.5)

6.12 For each of the RCIC (Reactor Core Isolation Cooling) System component failures listed below, state whether or not RCIC will AUTO inject into the reactor vessel. If it will not inject, state why, and if it will inject, provide one (1) potential adverse effect or consequence of system operation when the component is in the failed condition at the time RCIC receives the AUTO initiation signal. Consider each item separately.

a. The Gland Seal Compressor fails to operate. (1.0)

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

c. The RCIC pump discharge flow element output signal (to the RCIC flow controller) is failed at its maximum output. (1.0)

6.13 The reactor is operating at 80% of full power when a relief valve suddenly fails open. Recirculation flow control is in Master Manual.

a. Will this result in a feed flow-steam flow mismatch? Explain. (1.0)

b. What happens to MWe? Explain. (0.5)

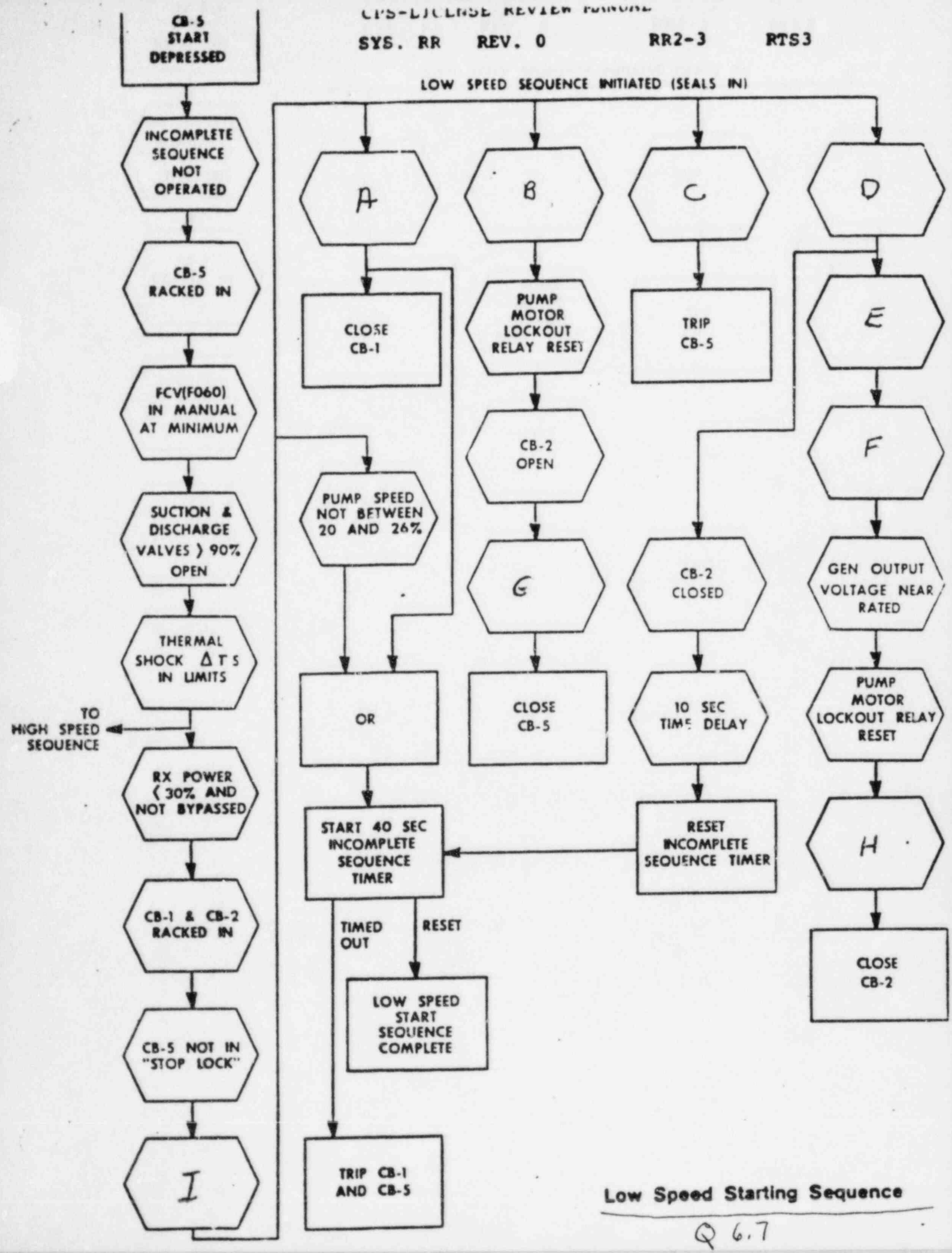
c. What is the initial response of reactor pressure? Explain. (0.5)

d. Where will power end up relative to the power at the beginning of the transient? Explain. (1:0)

e. How would your answer in part (d) differ if Recirculation flow control had been in Master-AUTO? Explain. (0.5)

6.14 While operating at 80% power, a Safety Relief Valve opens and remains open. List four (4) methods available to the operator to determine <u>which</u> SRV has opened. (2.0)

(*** END OF SECTION 6 ***)



Low Speed Starting Sequence

Q 6.7

SECTION 7: PROCEDURES - NORMAL, ABNORMAL, EMERGENCY, AND RADIOLOGICAL CONTROL

7.1 A reactor SCRAM has occurred, but NOT all of the control rods have inserted to less than the 06 position. Reactor power is indicated as 3% on the APRM's. LIST the three (3) immediate operator action steps that are required per CPS 4404.01 "Reactor Scram." (1.5)

7.2 Assume that adequate core cooling CANNOT be maintained and "Alternate Shutdown Cooling" must be established per 4403.01 DESCRIBE the RPV cooling water flowpath that should be established by this procedure. (1.0)

NOTE: INCLUDE IN YOUR DESCRIPTION THE SYSTEMS/COMPONENTS WHICH ARE USED.

7.3 Per 4403.01, "Cooldown Emergency," which one of the following most accurately describes how SRV operation should be used to control pressure, if needed? (1.0)

NOTE: ASSUME THAT THE INSTRUMENT AIR SYSTEM IS OPERATING PROPERLY

a. Use numerous SRV's, with short pressure reductions (~ 50 psig) to equalize Suppression Pool heatup.

b. Use fewer SRV blowdowns, with increased pressure reductions to minimize SRV cyclic stresses.

c. Depressurize with a sustained SRV opening to maximize the emergency cooldown rate.

d. Allow the SRV's to operate by mechanical actuation to ensure design pressure control and heat dispersion.

7.4 The Control Room is declared uninhabitable and evacuated. The immediate operator actions for "Remote Shutdown," are completed. RCIC then ISOLATES. Level subsequently decreases to Level 2. Restoration of level USING RCIC requires which of the following? (1.0)

delete

ASSUME THAT THE CONDITIONS NEEDED FOR RESETTING AN ISOLATION, "AUTOMATIC ISOLATION," HAVE BEEN MET.

a. No Operator Action. RCIC will restart automatically.

b. Operator Action. Close RCIC TURB FLO CONT in manual at minimum setting; Re-open RCIC TURB TRIP/THROT VLV and establish flow.

c. Operator Action. Close RCIC TURB TRIP/THROT VLV; reset RCIC TURB TRIP logic; RCIC will now restart automatically.

d. NONE OF THE ABOVE. RCIC cannot be restarted from the Remote Shutdown Panel after isolation.

7.5 "Reactor Recirculation," directs operator actions for an unexpected decrease in reactor coolant system flow rate.

FILL IN THE BLANKS

(After the unexpected decrease), if both recirculation loops are still operating, transfer the FCV's to ____ (a) ____. Balance loop flows to within ____ (b) ____at less than 70% core flow, or to within ____ (c) ____ at greater than 70% core flow. (1.5)

7.6 The unit is operating at 70% RTP; you notice power start to increase with NO CHANGE in recirculation flow or rod position. You suspect a "Loss of Feedwater Heating." Which of the following is required/appropriate per CPS 4005.01 (1.0)

a. A ~~30%~~ 20% reduction in Recirc Flow, monitored by Recirc Flow indication.

b. A ~~30%~~ 20% Power Reduction, using Recirc Flow, monitored by APRM's.

c. Insertion of Shallow Rods, to maintain proper flux shape, prior to reducing Recirc Flow.

d. Insertion of Power Rods, to maintain proper flux shape, prior to reducing Recirc. Flow.

7.7 Procedures associated with operation of HPCS, LPCS, RHR and/or RCIC caution the operator to observe certain limitations on Suppression Pool Level and Temperature when operating these systems. (1.5)

a. COMPLETE THE FOLLOWING:

Suppression Pool Level shall not be less than ____(1)____.

Suppression Pool Temperature shall not exceed ____(2)____ during HPCS, LPCS, and/or RHR operation; it shall not exceed ____(3)____ during RCIC operation.

b. STATE the basis for these temperature/level limitations on the Suppression Pool.

7.8 You are conducting a shutdown of the CRDH system, per 3304.01 you open drain valve 107 to drain the water accumulators. State the indication which should be used to determine that the accumulator is fully drained. (0.5)

7.9 Regarding the RHR Procedure, when operating in the shutdown cooling mode:

a. You are cautioned to NOT allow reactor vessel level to decrease below 44 inches on the shutdown range. Why is this level of concern? (1.0)

b. You are also cautioned to avoid opening the RHR test return line valve or the minimum flow bypass line valve. Why must these valves remain closed. (1.0)

7.10 DESCRIBE the steps that must be performed in order to take the Main Generator from its normal operating status to a status where maintenance can be performed on the generator after a shutdown. (1.5)

NOTE: LIMIT YOUR RESPONSES TO THE GAS SYSTEMS REQUIRED TO EFFECT THE PURIFICATION. SET POINTS NOT REQUIRED.

7.11 FILL IN THE BLANKS;

Clinton Power Station Emergency Plan authorizes exposures to a MAXIMUM emergency dose to the whole body of ____(a)____ when taking measures to protect plant safety systems. Lifesaving actions which may result in doses in excess of ___(b)___ shall be ____(c)____ in nature and should not exceed ____(d)____. (1.5)

7.12 List five (5) entry conditions for Containment Control-Emergency. (2.5)

7.13 A single MSIV closes and you determine that a high flow condition was reached in the other steam lines. Given that a Group 1 Isolation DID NOT OCCUR - STATE your Immediate Actions. (1.0)

7.14 Per the "Containment Combustible Gas Control," List two (2) conditions which require the operator to start the HYDROGEN IGNITERS. (1.5)

7.15 Per "CRD Malfunction," if NO CRD Pumps are running and NO CRD Pumps will restart:

a. STATE WHEN immediate corrective action must be initiated. (0.5)

b. STATE the Immediate Action(s) required. (0.5)

7.16 You are in the Reactor Heatup and pressurization phase of Procedure 3002.01. Reactor Pressure is 300 psig. Why should the use of a condensate booster pump at low ~~pressure~~ flow be minimized? (1.0)

7.17 True or False

re write question

If all rod position indication is lost, on one rod rod insertion is the only allowable rod motion. (i.e., Insert or Scram) (1.0)

7.18 Per procedure for Component Cooling Water System (CCW), state the immediate actions required for a Partial loss of CCW. (2.0)

(*** END OF SECTION 7 ***)

SECTION 8: ADMINISTRATIVE PROCEDURES, CONDITIONS AND LIMITATIONS

8.1 FILL IN THE BLANK with one of the following TS terms:

"A _____ shall be the injection of a simulated signal into the channel as close to the sensor as practicable to verify OPERABILITY including alarm and/or trip functions and channel failure trips." (1.0)

a. Channel Calibration

b. Channel Check

c. Channel Functional Test

d. Logic System Functional Test

8.2 FILL IN THE BLANK FOR THE FOLLOWING:

In accordance with 10 CFR 55, "if a licensee has not been actively performing the functions of an operator or senior operator for a period of ____(1)____ months, or longer, he shall, prior to resuming activities licensed pursuant to this part, demonstrate to the Commission that his knowledge and understanding of facility operation and administration are satisfactory. (0.5)

8.3 Technical Specifications define SHUTDOWN MARGIN as. . .

"SHUTDOWN MARGIN shall be the amount of reactivity by which the reactor is subcritical or would be subcritical assuming. . . and the reactor is in the shutdown condition;. . ."

LIST the plant conditions which complete the definition of SHUTDOWN MARGIN. (1.5)

8.4 ADEQUATE CORE COOLING must be assured prior to securing an ECCS system that has automatically initiated. LIST four (4) plant conditions (per Level Control-Emergency) which will assure that Adequate Core Cooling exists. (2.0)

8.5 During a Reactor Startup with the plant in Operational Condition 2, a Channel Functional Test on the EOC-RPT system is determined to be UNSATISFACTORY. The UNSAT condition affects no other TS systems.

a. STATE whether it is allowable to enter Operational Condition 1. JUSTIFY your response. (1.0)

b. DESCRIBE the physical phenomenon which necessitates the EOC-RPT system. (i.e., the Bases for EOC-RPT) (1.0)

8.6 The Unit is in Operational Condition 1, at 75% RTP, with one outstanding deficiency:

ADS 1 ADS Valve INOP (1 Day)

The Auto - swap of the HPCS suction upon receiving CST low level is determined to be UNSATISFACTORY. One channel of the swap-over logic is tripped, the suction is MANUALLY switched to the Suppression Pool, and the suction to the CST is ISOLATED.

Which one of the following actions most correctly details the allowance and/or limitations imposed by the Technical Specifications in this instance? (1.0)

NOTE: APPLICABLE TS's ARE ENCLOSED FOR REFERENCE

a. . . .no new limitations or TS Operational Condition restrictions are initiated by this re-alignment.

b. . . .be in at least HOT SHUTDOWN within 12 hours and reduce reactor steam dome pressure to less than or equal to ~~150~~ 100 psig within the following 24 hours.

c. . . .be in at least HOT SHUTDOWN within six hours and COLD SHUTDOWN within the following 30 hours.

d. . .be in at least HOT SHUTDOWN within six hours and reduce reactor steam dome pressure to less than or equal to ~~150~~ 100 psig within the next 30 hours.

8.7 a. The following data was derived during a single day of operation at Operational Condition 1. The unit has been in Operational Condition 1 for two weeks. Only FINAL DATA is presented; Preliminary data is not supplied.

Answer/T.S. ... attached

	SHIFTS		
	00-04	04-08	08-12
Floor Drain Leakage	2.52 gpm	4.58 gpm	3.75 gpm

(*** QUESTION 8.7 CONTINUES ON NEXT PAGE ***)

3.0

Equipment Drain Leakage	20.91 gpm	20.58 gpm	21.00 gpm
Total Leakage	23.43 gpm	25.16 gpm	24.75 gpm
		SHIFTS	
	12-16	16-20	20-24
Floor Drain Leakage	4.30 gpm	4.25 gpm	4.60 gpm
Equipment Drain Leakage	22.25 gpm	24.33 gpm	19.33 gpm
Total Leakage	26.55 gpm	28.58 gpm	23.93 gpm

NOTE: THE DRYWELL LEAKAGE CALCULATIONS ARE THE TOTAL LEAKAGES WHICH WERE CALCULATED DURING THE INDICATED PERIODS. THUS, DAILY TOTALS WOULD BE ATTAINED BY ADDING THE 6 4-HOUR PERIOD TOTALS.

EVALUATE FOR EACH of the four (4) TS Leakage LCO limits applicable in this plant condition whether the limit was exceeded, or not. (Disregard the Reactor Coolant System Pressure Isolation Valve Limit as defined in TS Table 3.4.3.2-1) (2.0)

b. DEFINE "Pressure Boundary Leakage." (1.0)

8.8 With the Mode Switch locked in the Refuel position:

"CORE ALTERATIONS shall not be performed using equipment associated with a Refuel position interlock unless at least four associated Refuel position interlocks are OPERABLE for such equipment."

LIST three (3) Refuel Position Interlocks. (1.5)

8.9 All Fuel is removed from the core; however, Fuel Loading is scheduled to commence. TWO (2) Control Rods are removed from the core under the allowances of the Technical Specifications. (1.0

Which of the following actions most accurately details the allowances and/or limitations imposed by the Technical Specifications in this instance?

NOTE: APPLICABLE TECHNICAL SPECIFICATIONS ARE ENCLOSED FOR REFERENCE

a. Fuel Loading may not commence until all Control Rods are inserted.

b. Fuel Loading may commence and continue as long as the Shutdown Margin requirements of TS 3.1.1 are satisfied.

(*** QUESTION 8.9 CONTINUES ON NEXT PAGE ***)

55

c. Fuel Loading may commence - however the four fuel assemblies surrounding the removed Control Rods may not be loaded.

d. Fuel Loading may commence AFTER one of the Control Rods is inserted. The four fuel assemblies surrounding the removed Control Rod may not be loaded.

8.10 Which of the following choices will correctly complete the blanks for the MCPR LCO listed below? (2.0)

The MCPR shall be equal to or ____(1)____ than ____(2)____ MCPR(f) ____(3)____ MCPR(p) limits at indicated core flow and THERMAL POWER as shown in Figures 3.2.3-1 and 3.2.3-2.

NOTE: Figures 3.2.3-1 and 3.2.3-2 are enclosed for reference.

	(1)	(2)	(3)
a.	greater;	the smaller of the;	or
b.	less;	the larger of the;	or
c.	greater;	both;	and
d.	less;	both;	and

8.11 The Unit is in COLD SHUTDOWN during a reactor startup with no outstanding deficiencies. Hydrogen Recombiner A becomes INOP. It is anticipated that repairs will be complete within two (2) weeks.

Which of the following actions most accurately details the allowances and/or limitations imposed by the Technical Specifications in this instance? (1.0)

a. Operational Condition 4 must be maintained (Entry into Operational Condition 5 is acceptable)

b. Startup activities may continue; Operational Condition 3 may be entered, but not exceeded.

c. Startup activities may continue; Operational Condition 2 may be entered, but not exceeded; Oxygen concentration shall be maintained < 2 v/o.

d. Startup activities may continue; Operational Condition 1 and/or 2 may be entered, but the Recombiner must be returned to an OPERABLE status within 30 days.

NOTE: APPLICABLE TS's ARE ENCLOSED FOR REFERENCE

30

8.12 The Technical Specification 3.4.4 established the following conductivity and chloride limits

Plant Condition	Conductivity Limit	Chloride Limit
1	1 umho/cm	0.2 ppm.
2 and 3	2 umho/cm	0.1 ppm.

Per the Technical Specification basis, WHY is the chloride limit more restrictive at the lower steaming rate than at power? (1.0)

8.13 With the exception of breaker position, what THREE (3) items should an operator check on a breaker, if applicable during the performance of a system lineup checksheet per Control and Use of Operations Section Directives, 02-S-02-2? Consider Local checks only, and a 4.16 KV I.T.E. Circuit Breaker as an example. (1.5)

8.14 The APRM Trip Setpoint Formula is (.66W+48%)*T. Which of the following choices correctly details the definition of "T" AND when it is applied? (1.0)

a. T = FRTP/MFLPD; T applied if < 1.0

b. T = MFLPD/FRTP; T applied if < 1.0

c. T = FRTP/MFLPD; T applied if > 1.0

d. T = MFLPD/FRTP: T applied if > 1.0

8.15 Per the Technical Specifications, COMPLETE THE FOLLOWING TABLE: (2.0)

MINIMUM SHIFT CREW COMPOSITION

POSITION	NUMBER OF INDIVIDUALS REQUIRED TO FILL POSITION	
	CONDITIONS 1, 2, & 3	CONDITIONS 4 & 5
SS	_____(a)_____	_____(f)_____
SRO	_____(b)_____	_____(g)_____
RO	_____(c)_____	_____(h)_____
AO	_____(d)_____	_____(i)_____
STA	_____(e)_____	_____(j)_____

8.16 In OPERATIONAL CONDITION 1 or 2 a reactor water isotopic analysis for iodine is required when the off gas level at the (a) increases by more than (b) in (c) during steady state operation at release rates (d) than (e). (Fill in the blanks.) (2.5)

8.17 Concerning Radiation Work Permits (RWP)

a. Whose permission is required to commence work covered by an RWP? (0.5)

b. What information is an individual required to enter on the RWP Access Log when entering/exiting the job site? (2.0)

(*** END OF SECTION 8 ***)

Table 1. Saturated Steam: Temperature Table

Temp Fahr t	Abs Press Lb per Sq In. p	Specific Volume Sat. Liquid v_f	Specific Volume Evap v_{fg}	Specific Volume Sat Vapor v_g	Enthalpy Sat. Liquid h_f	Enthalpy Evap h_{fg}	Enthalpy Sat Vapor h_g	Entropy Sat. Liquid s_f	Entropy Evap s_{fg}	Entropy Sat. Vapor s_g	Temp Fahr t
32.0°	0.08859	0.016022	3304.7	3304.7	−0.0179	1075.5	1075.5	0.0000	2.1873	2.1873	32.0°
34.0	0.09600	0.016021	3061.9	3061.9	1.996	1074.4	1076.4	0.0041	2.1762	2.1802	34.0
36.0	0.10395	0.016020	2839.0	2839.0	4.008	1073.2	1077.2	0.0081	2.1651	2.1732	36.0
38.0	0.11249	0.016019	2634.1	2634.2	6.018	1072.1	1078.1	0.0122	2.1541	2.1663	38.0
40.0	0.12163	0.016019	2445.8	2445.8	8.027	1071.0	1079.0	0.0162	2.1432	2.1594	40.0
42.0	0.13143	0.016019	2272.4	2272.4	10.035	1069.8	1079.9	0.0202	2.1325	2.1527	42.0
44.0	0.14192	0.016019	2112.8	2112.8	12.041	1068.7	1080.7	0.0242	2.1217	2.1459	44.0
46.0	0.15314	0.016020	1965.7	1965.7	14.047	1067.6	1081.6	0.0282	2.1111	2.1393	46.0
48.0	0.16514	0.016021	1830.0	1830.0	16.051	1066.4	1082.5	0.0321	2.1006	2.1327	48.0
50.0	0.17796	0.016023	1704.8	1704.8	18.054	1065.3	1083.4	0.0361	2.0901	2.1262	50.0
52.0	0.19165	0.016024	1589.2	1589.2	20.057	1064.2	1084.2	0.0400	2.0798	2.1197	52.0
54.0	0.20625	0.016026	1482.4	1482.4	22.058	1063.1	1085.1	0.0439	2.0695	2.1134	54.0
56.0	0.22183	0.016028	1383.6	1383.6	24.059	1061.9	1086.0	0.0478	2.0593	2.1070	56.0
58.0	0.23843	0.016031	1292.2	1292.2	26.060	1060.8	1086.9	0.0516	2.0491	2.1008	58.0
60.0	0.25611	0.016033	1207.6	1207.6	28.060	1059.7	1087.7	0.0555	2.0391	2.0946	60.0
62.0	0.27494	0.016036	1129.2	1129.2	30.059	1058.5	1088.6	0.0593	2.0291	2.0885	62.0
64.0	0.29497	0.016039	1056.5	1056.5	32.058	1057.4	1089.5	0.0632	2.0192	2.0824	64.0
66.0	0.31626	0.016043	989.0	989.1	34.056	1056.3	1090.4	0.0670	2.0094	2.0764	66.0
68.0	0.33889	0.016046	926.5	926.5	36.054	1055.2	1091.2	0.0708	1.9996	2.0704	68.0
70.0	0.36292	0.016050	868.3	868.4	38.052	1054.0	1092.1	0.0745	1.9900	2.0645	70.0
72.0	0.38844	0.016054	814.3	814.3	40.049	1052.9	1093.0	0.0783	1.9804	2.0587	72.0
74.0	0.41550	0.016058	764.1	764.1	42.046	1051.8	1093.8	0.0821	1.9708	2.0529	74.0
76.0	0.44420	0.016063	717.4	717.4	44.043	1050.7	1094.7	0.0858	1.9614	2.0472	76.0
78.0	0.47461	0.016067	673.8	673.9	46.040	1049.5	1095.6	0.0895	1.9520	2.0415	78.0
80.0	0.50683	0.016072	633.3	633.3	48.037	1048.4	1096.4	0.0932	1.9426	2.0359	80.0
82.0	0.54093	0.016077	595.5	595.5	50.033	1047.3	1097.3	0.0969	1.9334	2.0303	82.0
84.0	0.57702	0.016082	560.3	560.3	52.029	1046.1	1098.2	0.1006	1.9242	2.0248	84.0
86.0	0.61518	0.016087	527.5	527.5	54.026	1045.0	1099.0	0.1043	1.9151	2.0193	86.0
88.0	0.65551	0.016093	496.8	496.8	56.022	1043.9	1099.9	0.1079	1.9060	2.0139	88.0
90.0	0.69813	0.016099	468.1	468.1	58.018	1042.7	1100.8	0.1115	1.8970	2.0086	90.0
92.0	0.74313	0.016105	441.3	441.3	60.014	1041.6	1101.6	0.1152	1.8881	2.0033	92.0
94.0	0.79062	0.016111	416.3	416.3	62.010	1040.5	1102.5	0.1188	1.8792	1.9980	94.0
96.0	0.84072	0.016117	392.9	392.9	64.006	1039.3	1103.3	0.1224	1.8704	1.9928	96.0
98.0	0.89356	0.016123	370.9	370.9	66.003	1038.2	1104.2	0.1260	1.8617	1.9876	98.0
100.0	0.94924	0.016130	350.4	350.4	67.999	1037.1	1105.1	0.1295	1.8530	1.9825	100.0
102.0	1.00789	0.016137	331.1	331.1	69.995	1035.9	1105.9	0.1331	1.8444	1.9775	102.0
104.0	1.06965	0.016144	313.1	313.1	71.992	1034.8	1106.8	0.1366	1.8358	1.9725	104.0
106.0	1.1347	0.016151	296.16	296.18	73.99	1033.6	1107.6	0.1402	1.8273	1.9675	106.0
108.0	1.2030	0.016158	280.28	280.30	75.98	1032.5	1108.5	0.1437	1.8188	1.9626	108.0
110.0	1.2750	0.016165	265.37	265.39	77.98	1031.4	1109.3	0.1472	1.8105	1.9577	110.0
112.0	1.3505	0.016173	251.37	251.38	79.98	1030.2	1110.2	0.1507	1.8021	1.9528	112.0
114.0	1.4299	0.016180	238.21	238.22	81.97	1029.1	1111.0	0.1542	1.7938	1.9480	114.0
116.0	1.5133	0.016188	225.84	225.85	83.97	1027.9	1111.9	0.1577	1.7856	1.9433	116.0
118.0	1.6009	0.016196	214.20	214.21	85.97	1026.8	1112.7	0.1611	1.7774	1.9386	118.0
120.0	1.6927	0.016204	203.25	203.26	87.97	1025.6	1113.6	0.1646	1.7693	1.9339	120.0
122.0	1.7891	0.016213	192.94	192.95	89.96	1024.5	1114.4	0.1680	1.7613	1.9293	122.0
124.0	1.8901	0.016221	183.23	183.24	91.96	1023.3	1115.3	0.1715	1.7533	1.9247	124.0
126.0	1.9959	0.016229	174.08	174.09	93.96	1022.2	1116.1	0.1749	1.7453	1.9202	126.0
128.0	2.1068	0.016238	165.45	165.47	95.96	1021.0	1117.0	0.1783	1.7374	1.9157	128.0
130.0	2.2230	0.016247	157.32	157.33	97.96	1019.8	1117.8	0.1817	1.7295	1.9112	130.0
132.0	2.3445	0.016256	149.64	149.66	99.95	1018.7	1118.6	0.1851	1.7217	1.9068	132.0
134.0	2.4717	0.016265	142.40	142.41	101.95	1017.5	1119.5	0.1884	1.7140	1.9024	134.0
136.0	2.6047	0.016274	135.55	135.57	103.95	1016.4	1120.3	0.1918	1.7063	1.8980	136.0
138.0	2.7438	0.016284	129.09	129.11	105.95	1015.2	1121.1	0.1951	1.6986	1.8937	138.0
140.0	2.8892	0.016293	122.98	123.00	107.95	1014.0	1122.0	0.1985	1.6910	1.8895	140.0
142.0	3.0411	0.016303	117.21	117.22	109.95	1012.9	1122.8	0.2018	1.6534	1.8852	142.0
144.0	3.1997	0.016312	111.74	111.76	111.95	1011.7	1123.6	0.2051	1.6759	1.8810	144.0
146.0	3.3653	0.016322	106.58	106.59	113.95	1010.5	1124.5	0.2084	1.6684	1.8769	146.0
148.0	3.5381	0.016332	101.68	101.70	115.95	1009.3	1125.3	0.2117	1.6610	1.8727	148.0
150.0	3.7184	0.016343	97.05	97.07	117.95	1008.2	1126.1	0.2150	1.6536	1.8686	150.0
152.0	3.9065	0.016353	92.66	92.68	119.95	1007.0	1126.9	0.2183	1.6463	1.8646	152.0
154.0	4.1025	0.016363	88.50	88.52	121.95	1005.8	1127.7	0.2216	1.6390	1.8606	154.0
156.0	4.3068	0.016374	84.56	84.57	123.95	1004.6	1128.6	0.2248	1.6318	1.8566	156.0
158.0	4.5197	0.016384	80.82	80.83	125.96	1003.4	1129.4	0.2281	1.6245	1.8526	158.0
160.0	4.7414	0.016395	77.27	77.29	127.96	1002.2	1130.2	0.2313	1.6174	1.8487	160.0
162.0	4.9722	0.016406	73.90	73.92	129.96	1001.0	1131.0	0.2345	1.6103	1.8448	162.0
164.0	5.2124	0.016417	70.70	70.72	131.96	999.8	1131.8	0.2377	1.6032	1.8409	164.0
166.0	5.4623	0.016428	67.67	67.68	133.97	998.6	1132.6	0.2409	1.5961	1.8371	166.0
168.0	5.7223	0.016440	64.78	64.80	135.97	997.4	1133.4	0.2441	1.5892	1.8333	168.0
170.0	5.9926	0.016451	62.04	62.06	137.97	996.2	1134.2	0.2473	1.5822	1.8295	170.0
172.0	6.2736	0.016463	59.43	59.45	139.98	995.0	1135.0	0.2505	1.5753	1.8258	172.0
174.0	6.5656	0.016474	56.95	56.97	141.98	993.8	1135.8	0.2537	1.5684	1.8221	174.0
176.0	6.8690	0.016486	54.59	54.61	143.99	992.6	1136.6	0.2568	1.5616	1.8184	176.0
178.0	7.1840	0.016498	52.35	52.36	145.99	991.4	1137.4	0.2600	1.5548	1.8147	178.0

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

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

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

Temp Fahr t	Abs Press Lb per Sq In p	Specific Volume Sat Liquid v_f	Evap v_{fg}	Sat Vapor v_g	Enthalpy Sat Liquid h_f	Evap h_{fg}	Sat Vapor h_g	Entropy Sat Liquid s_f	Evap s_{fg}	Sat Vapor s_g	Temp Fahr t
460.0	466.87	0.01961	0.97463	0.99424	441.5	763.2	1204.8	0.6405	0.5799	1.4704	460.0
464.0	485.56	0.01969	0.93588	0.95557	446.1	758.6	1204.7	0.6454	0.5713	1.4667	464.0
468.0	504.83	0.01976	0.89885	0.91862	450.7	754.0	1204.6	0.6502	0.5627	1.4629	468.0
472.0	524.67	0.01984	0.86345	0.88329	455.2	749.3	1204.5	0.6551	0.5542	1.4592	472.0
476.0	545.11	0.01992	0.82958	0.84950	459.9	744.5	1204.3	0.6599	0.5456	1.4555	476.0
480.0	566.15	0.02000	0.79716	0.81717	464.5	739.6	1204.1	0.6648	0.5371	1.4518	480.0
484.0	587.81	0.02009	0.76613	0.78622	469.1	734.7	1203.8	0.6696	0.5285	1.4481	484.0
488.0	610.10	0.02017	0.73641	0.75658	473.8	729.7	1203.5	0.6745	0.5200	1.4444	488.0
492.0	633.03	0.02026	0.70794	0.72820	478.5	724.6	1203.1	0.6793	0.5114	1.4407	492.0
496.0	656.61	0.02034	0.68065	0.70100	483.2	719.5	1202.7	0.6842	0.5028	1.4370	496.0
500.0	680.86	0.02043	0.65448	0.67492	487.9	714.3	1202.2	0.6890	0.4943	1.4333	500.0
504.0	705.78	0.02053	0.62938	0.64991	492.7	709.0	1201.7	0.6939	0.4857	1.4296	504.0
508.0	731.40	0.02062	0.60530	0.62592	497.5	703.7	1201.1	0.6987	0.4771	1.4258	508.0
512.0	757.72	0.02072	0.58218	0.60289	502.3	698.2	1200.5	0.7036	0.4685	1.4221	512.0
516.0	784.76	0.02081	0.55997	0.58079	507.1	692.7	1199.8	0.7085	0.4599	1.4183	516.0
520.0	812.53	0.02091	0.53864	0.55956	512.0	687.0	1199.0	0.7133	0.4513	1.4146	520.0
524.0	841.04	0.02102	0.51814	0.53916	516.9	681.3	1198.2	0.7182	0.4426	1.4108	524.0
528.0	870.31	0.02112	0.49843	0.51955	521.8	675.5	1197.3	0.7231	0.4339	1.4070	528.0
532.0	900.34	0.02123	0.47947	0.50070	526.8	669.6	1196.4	0.7280	0.4252	1.4032	532.0
536.0	931.17	0.02134	0.46123	0.48257	531.7	663.6	1195.4	0.7329	0.4165	1.3993	536.0
540.0	962.79	0.02146	0.44367	0.46513	536.8	657.5	1194.3	0.7378	0.4077	1.3954	540.0
544.0	995.22	0.02157	0.42677	0.44834	541.8	651.3	1193.1	0.7427	0.3989	1.3915	544.0
548.0	1028.49	0.02169	0.41048	0.43217	546.9	645.0	1191.9	0.7476	0.3900	1.3876	548.0
552.0	1062.59	0.02182	0.39479	0.41660	552.0	638.5	1190.6	0.7525	0.3811	1.3837	552.0
556.0	1097.55	0.02194	0.37966	0.40160	557.2	632.0	1189.2	0.7575	0.3722	1.3797	556.0
560.0	1133.38	0.02207	0.36507	0.38714	562.4	625.3	1187.7	0.7625	0.3632	1.3757	560.0
564.0	1170.10	0.02221	0.35099	0.37320	567.6	618.5	1186.1	0.7674	0.3541	1.3716	564.0
568.0	1207.72	0.02235	0.33741	0.35975	572.9	611.5	1184.5	0.7725	0.3450	1.3675	568.0
572.0	1246.26	0.02249	0.32429	0.34678	578.3	604.5	1182.7	0.7775	0.3359	1.3634	572.0
576.0	1285.74	0.02264	0.31162	0.33426	583.7	597.2	1180.9	0.7825	0.3266	1.3592	576.0
580.0	1326.17	0.02279	0.29937	0.32216	589.1	589.9	1179.0	0.7876	0.3173	1.3550	580.0
584.0	1367.7	0.02295	0.28753	0.31048	594.6	582.4	1176.9	0.7927	0.3080	1.3507	584.0
588.0	1410.0	0.02311	0.27608	0.29919	600.1	574.7	1174.8	0.7978	0.2985	1.3464	588.0
592.0	1453.3	0.02328	0.26499	0.28827	605.7	566.8	1172.6	0.8030	0.2890	1.3420	592.0
596.0	1497.8	0.02345	0.25425	0.27770	611.4	558.8	1170.2	0.8082	0.2793	1.3375	596.0
600.0	1543.2	0.02364	0.24384	0.26747	617.1	550.6	1167.7	0.8134	0.2696	1.3330	600.0
604.0	1589.7	0.02382	0.23374	0.25757	622.9	542.2	1165.1	0.8187	0.2597	1.3284	604.0
608.0	1637.3	0.02402	0.22394	0.24796	628.8	533.6	1162.4	0.8240	0.2497	1.3238	608.0
612.0	1686.1	0.02422	0.21442	0.23865	634.8	524.7	1159.5	0.8294	0.2396	1.3190	612.0
616.0	1735.9	0.02444	0.20516	0.22960	640.8	515.6	1156.4	0.8348	0.2294	1.3141	616.0
620.0	1786.9	0.02466	0.19615	0.22081	646.9	506.3	1153.2	0.8403	0.2189	1.3092	620.0
624.0	1839.0	0.02489	0.18737	0.21226	653.1	496.6	1149.8	0.8458	0.2083	1.3041	624.0
628.0	1892.4	0.02514	0.17880	0.20394	659.5	486.7	1146.1	0.8514	0.1974	1.2988	628.0
632.0	1947.0	0.02539	0.17044	0.19583	665.9	476.4	1142.2	0.8571	0.1864	1.2934	632.0
636.0	2002.8	0.02566	0.16226	0.18792	672.4	465.7	1138.1	0.8628	0.1751	1.2879	636.0
640.0	2059.9	0.02595	0.15427	0.18021	679.1	454.6	1133.7	0.8686	0.1634	1.2821	640.0
644.0	2118.3	0.02625	0.14644	0.17269	685.9	443.1	1129.0	0.8746	0.1515	1.2761	644.0
648.0	2178.1	0.02657	0.13876	0.16534	692.9	431.1	1124.0	0.8806	0.1393	1.2699	648.0
652.0	2239.2	0.02691	0.13124	0.15816	700.0	418.7	1118.7	0.8868	0.1267	1.2634	652.0
656.0	2301.7	0.02728	0.12387	0.15115	707.4	405.7	1113.1	0.8931	0.1137	1.2567	656.0
660.0	2365.7	0.02768	0.11663	0.14431	714.9	392.1	1107.0	0.8995	0.1002	1.2498	660.0
664.0	2431.1	0.02811	0.10947	0.13757	722.9	377.7	1100.6	0.9064	0.0861	1.2425	664.0
668.0	2498.1	0.02858	0.10229	0.13087	731.5	362.1	1093.5	0.9137	0.0710	1.2347	668.0
672.0	2566.6	0.02911	0.09514	0.12424	740.2	345.7	1085.9	0.9212	0.0554	1.2766	672.0
676.0	2636.8	0.02970	0.08799	0.11769	749.2	328.5	1077.6	0.9287	0.0392	1.2179	676.0
680.0	2708.6	0.03037	0.08080	0.11117	758.5	310.1	1068.5	0.9365	0.0220	1.2086	680.0
684.0	2782.1	0.03114	0.07349	0.10463	768.2	290.2	1058.4	0.9447	0.0037	1.1984	684.0
688.0	2857.4	0.03204	0.06595	0.09799	778.8	268.2	1047.0	0.9535	-0.0157	1.1872	688.0
692.0	2934.5	0.03313	0.05797	0.09110	790.5	243.1	1033.6	0.9634	-0.0370	1.1744	692.0
696.0	3013.4	0.03455	0.04916	0.08371	804.4	212.8	1017.2	0.9749	-0.0611	1.1591	696.0
700.0	3094.3	0.03662	0.03857	0.07519	822.4	172.7	995.2	0.9901	-0.0910	1.1390	700.0
702.0	3135.5	0.03824	0.03173	0.06997	835.0	144.7	979.7	1.0006	-0.1106	1.1252	702.0
704.0	3177.2	0.04108	0.02192	0.06300	854.2	102.0	956.2	1.0169	-0.1376	1.1046	704.0
705.0	3198.3	0.04427	0.01304	0.05730	873.0	61.4	934.4	1.0329	-0.1627	1.0856	705.0
705.47*	3208.2	0.05078	0.00000	0.05078	906.0	0.0	906.0	1.0612	-0.2000	1.0612	705.47*

*Critical temperature

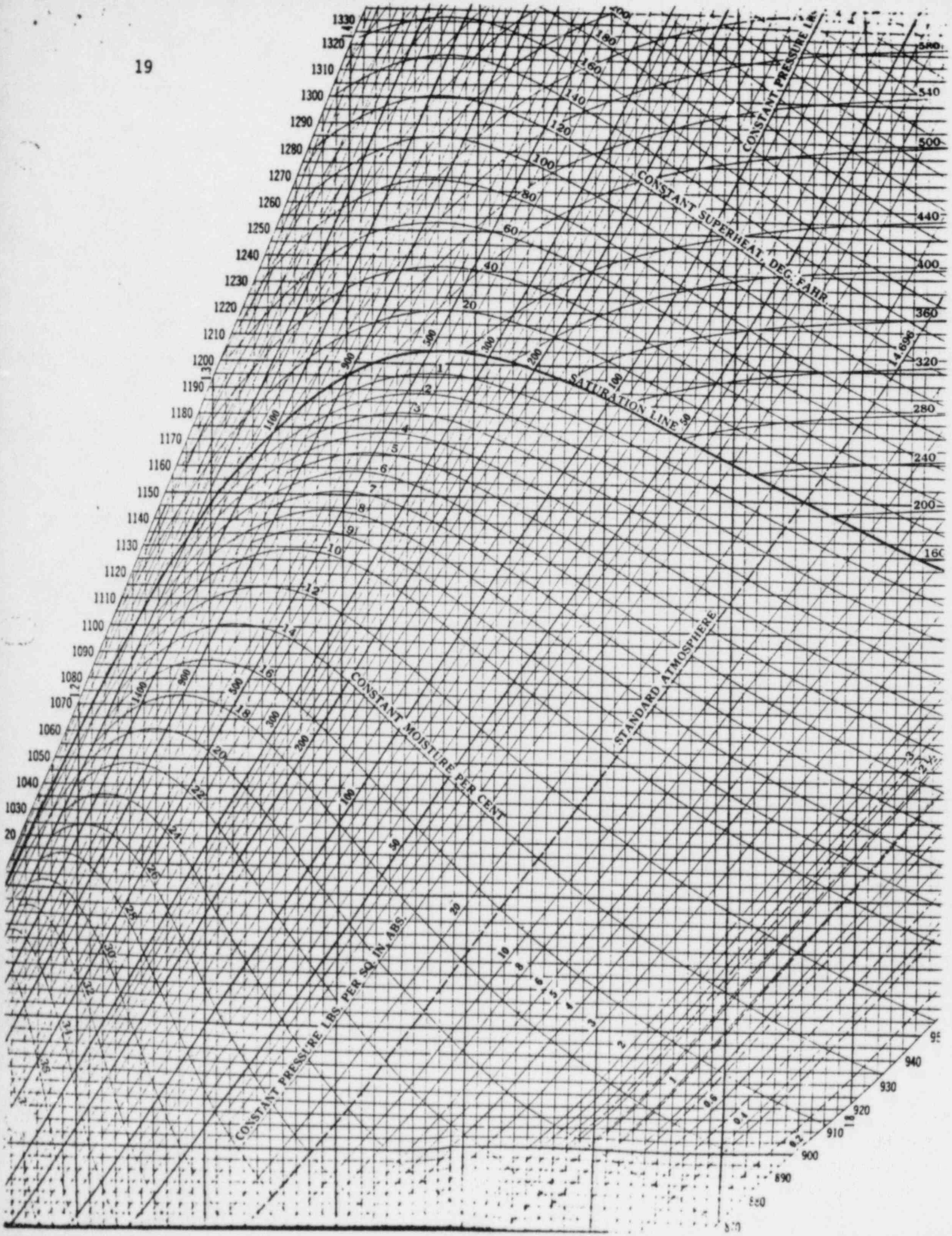

CONSTANT PRESSURE IN
CONSTANT SUPERHEAT, DEG. FAHR.
SATURATION LINE
14.696
STANDARD ATMOSPHERE
CONSTANT MOISTURE PER CENT
CONSTANT PRESSURE LBS. PER SQ. IN. ABS.

Table 2: Saturated Steam: Pressure Table

Abs Press Lb/Sq In p	Temp Fahr t	Specific Volume Sat Liquid v_f	Specific Volume Evap v_{fg}	Specific Volume Sat Vapor v_g	Enthalpy Sat Liquid h_f	Enthalpy Evap h_{fg}	Enthalpy Sat Vapor h_g	Entropy Sat Liquid s_f	Entropy Evap s_{fg}	Entropy Sat Vapor s_g	Abs Press Lb/Sq In p
0.08865	32.018	0.016022	3302.4	3302.4	0.0003	1075.5	1075.5	0.0000	2.1872	2.1872	0.08865
0.25	59.323	0.016032	1235.5	1235.5	27.382	1060.1	1087.4	0.0542	2.0425	2.0967	0.25
0.50	79.586	0.016071	641.5	641.5	47.623	1048.6	1096.3	0.0925	1.9446	2.0370	0.50
1.0	101.74	0.016136	333.59	333.60	69.73	1036.1	1105.8	0.1326	1.8455	1.9781	1.0
5.0	162.24	0.016407	73.515	73.532	130.20	1000.9	1131.1	0.2349	1.6094	1.8443	5.0
10.0	193.21	0.016592	38.404	38.420	161.26	982.1	1143.3	0.2836	1.5043	1.7879	10.0
14.696	212.00	0.016719	26.782	26.799	180.17	970.3	1150.5	0.3121	1.4447	1.7568	14.696
15.0	213.03	0.016726	26.274	26.290	181.21	969.7	1150.9	0.3137	1.4415	1.7552	15.0
20.0	227.96	0.016834	20.070	20.087	196.27	960.1	1156.3	0.3358	1.3962	1.7320	20.0
30.0	250.34	0.017009	13.7266	13.7436	218.9	945.2	1164.1	0.3682	1.3313	1.6995	30.0
40.0	267.25	0.017151	10.4794	10.4965	236.1	933.6	1169.8	0.3921	1.2844	1.6765	40.0
50.0	281.02	0.017274	8.4967	8.5140	250.2	923.9	1174.1	0.4112	1.2474	1.6586	50.0
60.0	292.71	0.017383	7.1562	7.1736	262.2	915.4	1177.6	0.4273	1.2167	1.6440	60.0
70.0	302.93	0.017482	6.1875	6.2050	272.7	907.8	1180.6	0.4411	1.1905	1.6316	70.0
80.0	312.04	0.017573	5.4536	5.4711	282.1	900.9	1183.1	0.4534	1.1675	1.6208	80.0
90.0	320.28	0.017659	4.8779	4.8953	290.7	894.6	1185.3	0.4643	1.1470	1.6113	90.0
100.0	327.82	0.017740	4.4133	4.4310	298.5	888.6	1187.2	0.4743	1.1284	1.6027	100.0
110.0	334.79	0.01782	4.0306	4.0484	305.8	883.1	1188.9	0.4834	1.1115	1.5950	110.0
120.0	341.27	0.01789	3.7097	3.7275	312.6	877.8	1190.4	0.4919	1.0960	1.5879	120.0
130.0	347.33	0.01796	3.4364	3.4544	319.0	872.8	1191.7	0.4998	1.0815	1.5813	130.0
140.0	353.04	0.01803	3.2010	3.2190	325.0	868.0	1193.0	0.5071	1.0681	1.5752	140.0
150.0	358.43	0.01809	2.9958	3.0139	330.6	863.4	1194.1	0.5141	1.0554	1.5695	150.0
160.0	363.55	0.01815	2.8155	2.8336	336.1	859.0	1195.1	0.5206	1.0435	1.5641	160.0
170.0	368.42	0.01821	2.6556	2.6738	341.2	854.8	1196.0	0.5269	1.0322	1.5591	170.0
180.0	373.08	0.01827	2.5129	2.5312	346.2	850.7	1196.9	0.5328	1.0215	1.5543	180.0
190.0	377.53	0.01833	2.3847	2.4030	350.9	846.7	1197.6	0.5384	1.0113	1.5498	190.0
200.0	381.80	0.01839	2.2689	2.2873	355.5	842.8	1198.3	0.5438	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	409.8	794.2	1204.0	0.6059	0.8909	1.4968	350.0
400.0	444.60	0.01934	1.14162	1.16095	424.2	780.4	1204.6	0.6217	0.8630	1.4847	400.0
450.0	456.28	0.01954	1.01224	1.03179	437.3	767.5	1204.8	0.6360	0.8378	1.4738	450.0
500.0	467.01	0.01975	0.90787	0.92762	449.5	755.1	1204.7	0.6490	0.8148	1.4639	500.0
550.0	476.94	0.01994	0.82183	0.84177	460.9	743.3	1204.3	0.6611	0.7936	1.4547	550.0
600.0	486.20	0.02013	0.74962	0.76975	471.7	732.0	1203.7	0.6723	0.7738	1.4461	600.0
650.0	494.89	0.02032	0.68811	0.70843	481.9	720.9	1202.8	0.6829	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
3208.2*	705.47	0.05078	0.00000	0.05078	906.0	0.0	906.0	1.0612	0.0000	1.0612	3208.2*

*Critical pressure

STEAM TABLE

PROPERTIES OF SATURATED STEAM AND SATURATED WATER (TEMPERATURE)

Temp F	Press. psia	Volume, ft³/lb			Enthalpy, Btu/lb			Entropy, Btu/lb x F			Temp F
		Water v_f	Evap v_{fg}	Steam v_g	Water h_f	Evap h_{fg}	Steam h_g	Water s_f	Evap s_{fg}	Steam s_g	
32	0.08859	0.01602	3305	3305	−0.02	1075.5	1075.5	0.0000	2.1873	2.1873	32
35	0.09991	0.01602	2948	2948	3.00	1073.8	1076.8	0.0061	2.1706	2.1767	35
40	0.12163	0.01602	2446	2446	8.03	1071.0	1079.0	0.0162	2.1432	2.1594	40
45	0.14744	0.01602	2037.7	2037.8	13.04	1068.1	1081.2	0.0262	2.1164	2.1426	45
50	0.17796	0.01602	1704.8	1704.8	18.05	1065.3	1083.4	0.0361	2.0901	2.1262	50
60	0.2561	0.01603	1207.6	1207.6	28.06	1059.7	1087.7	0.0555	2.0391	2.0946	60
70	0.3629	0.01605	868.3	868.4	38.05	1054.0	1092.1	0.0745	1.9900	2.0645	70
80	0.5068	0.01607	633.3	633.3	48.04	1048.4	1096.4	0.0932	1.9426	2.0359	80
90	0.6981	0.01610	468.1	468.1	58.02	1042.7	1100.8	0.1115	1.8970	2.0086	90
100	0.9492	0.01613	350.4	350.4	68.00	1037.1	1105.1	0.1295	1.8530	1.9825	100
110	1.2750	0.01617	265.4	265.4	77.98	1031.4	1109.3	0.1472	1.8105	1.9577	110
120	1.6927	0.01620	203.25	203.26	87.97	1025.6	1113.6	0.1646	1.7693	1.9339	120
130	2.2230	0.01625	157.32	157.33	97.96	1019.8	1117.8	0.1817	1.7295	1.9112	130
140	2.8892	0.01629	122.98	123.00	107.95	1014.0	1122.0	0.1985	1.6910	1.8895	140
150	3.718	0.01634	97.05	97.07	117.95	1008.2	1126.1	0.2150	1.6536	1.8686	150
160	4.741	0.01640	77.27	77.29	127.96	1002.2	1130.2	0.2313	1.6174	1.8487	160
170	5.993	0.01645	62.04	62.06	137.97	996.2	1134.2	0.2473	1.5822	1.8295	170
180	7.511	0.01651	50.21	50.22	148.00	990.2	1138.2	0.2631	1.5480	1.8111	180
190	9.340	0.01657	40.94	40.96	158.04	984.1	1142.1	0.2787	1.5148	1.7934	190
200	11.526	0.01664	33.62	33.64	168.09	977.9	1146.0	0.2940	1.4824	1.7764	200
210	14.123	0.01671	27.80	27.82	178.15	971.6	1149.7	0.3091	1.4509	1.7600	210
212	14.696	0.01672	26.78	26.80	180.17	970.3	1150.5	0.3121	1.4447	1.7568	212
220	17.186	0.01678	23.13	23.15	188.23	965.2	1153.4	0.3241	1.4201	1.7442	220
230	20.779	0.01685	19.364	19.381	198.33	958.7	1157.1	0.3388	1.3902	1.7290	230
240	24.968	0.01693	16.304	16.321	208.45	952.1	1160.6	0.3533	1.3609	1.7142	240
250	29.825	0.01701	13.802	13.819	218.59	945.4	1164.0	0.3677	1.3323	1.7000	250
260	35.427	0.01709	11.745	11.762	228.76	938.6	1167.4	0.3819	1.3043	1.6862	260
270	41.856	0.01718	10.042	10.060	238.95	931.7	1170.6	0.3960	1.2769	1.6729	270
280	49.200	0.01726	8.627	8.644	249.17	924.6	1173.8	0.4098	1.2501	1.6599	280
290	57.550	0.01736	7.443	7.460	259.4	917.4	1176.8	0.4236	1.2238	1.6473	290
300	67.005	0.01745	6.448	6.466	269.7	910.0	1179.7	0.4372	1.1979	1.6351	300
310	77.67	0.01755	5.609	5.626	280.0	902.5	1182.5	0.4506	1.1726	1.6232	310
320	89.64	0.01766	4.896	4.914	290.4	894.8	1185.2	0.4640	1.1477	1.6116	320
340	117.99	0.01787	3.770	3.788	311.3	878.8	1190.1	0.4902	1.0990	1.5892	340
360	153.01	0.01811	2.939	2.957	332.3	862.1	1194.4	0.5161	1.0517	1.5678	360
380	195.73	0.01836	2.317	2.335	353.6	844.5	1198.0	0.5416	1.0057	1.5473	380
400	247.26	0.01864	1.8444	1.8630	375.1	825.9	1201.0	0.5667	0.9607	1.5274	400
420	308.78	0.01894	1.4808	1.4997	396.9	806.2	1203.1	0.5915	0.9165	1.5080	420
440	381.54	0.01926	1.1976	1.2169	419.0	785.4	1204.4	0.6161	0.8729	1.4890	440
460	466.9	0.0196	0.9746	0.9942	441.5	763.2	1204.8	0.6405	0.8299	1.4704	460
480	566.2	0.0200	0.7972	0.8172	464.5	739.6	1204.1	0.6648	0.7871	1.4518	480
500	680.9	0.0204	0.6545	0.6749	487.9	714.3	1202.2	0.6890	0.7443	1.4333	500
520	812.5	0.0209	0.5386	0.5596	512.0	687.0	1199.0	0.7133	0.7013	1.4146	520
540	962.8	0.0215	0.4437	0.4651	536.8	657.5	1194.3	0.7378	0.6577	1.3954	540
560	1133.4	0.0221	0.3651	0.3871	562.4	625.3	1187.7	0.7625	0.6132	1.3757	560
580	1326.2	0.0228	0.2994	0.3222	589.1	589.9	1179.0	0.7876	0.5673	1.3550	580
600	1543.2	0.0236	0.2438	0.2675	617.1	550.6	1167.7	0.8134	0.5196	1.3330	600
620	1786.9	0.0247	0.1962	0.2208	646.9	506.3	1153.2	0.8403	0.4689	1.3092	620
640	2059.9	0.0260	0.1543	0.1802	679.1	454.6	1133.7	0.8686	0.4134	1.2821	640
660	2365.7	0.0277	0.1166	0.1443	714.9	392.1	1107.0	0.8995	0.3502	1.2498	660
680	2708.6	0.0304	0.0808	0.1112	758.5	310.1	1068.5	0.9365	0.2720	1.2086	680
700	3094.3	0.0366	0.0386	0.0752	822.4	172.7	995.2	0.9901	0.1490	1.1390	700
705.5	3208.2	0.0508	0	0.0508	906.0	0	906.0	1.0612	0	1.0612	705.5

EQUATION SHEET

$f = ma$

$w = mg$

$E = mc^2$

$KE = 1/2\ mv^2$

$PE = mgh$

$V_f = V_o + at$

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

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

$\Delta E = 931\ \Delta m$

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

$Q = UA\Delta h$

$Pwr = W_f \Delta h$

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

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

$SUR = 26.06/T$

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

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

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

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

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

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

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

$\Sigma = \sigma N$

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

$v = s/t$

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

$a = (V_f - V_o)/t$

$w = \theta/t$

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

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

$\lambda = \ell n 2/t_{1/2} = 0.693/t_{1/2}$

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

$I = I_o e^{-Ex}$

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

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

$TVL = 1.3/\mu$

$HVL = -0.693/\mu$

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

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

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

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

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

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

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

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

$I_1 d_1 = I_2 d_2$

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

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

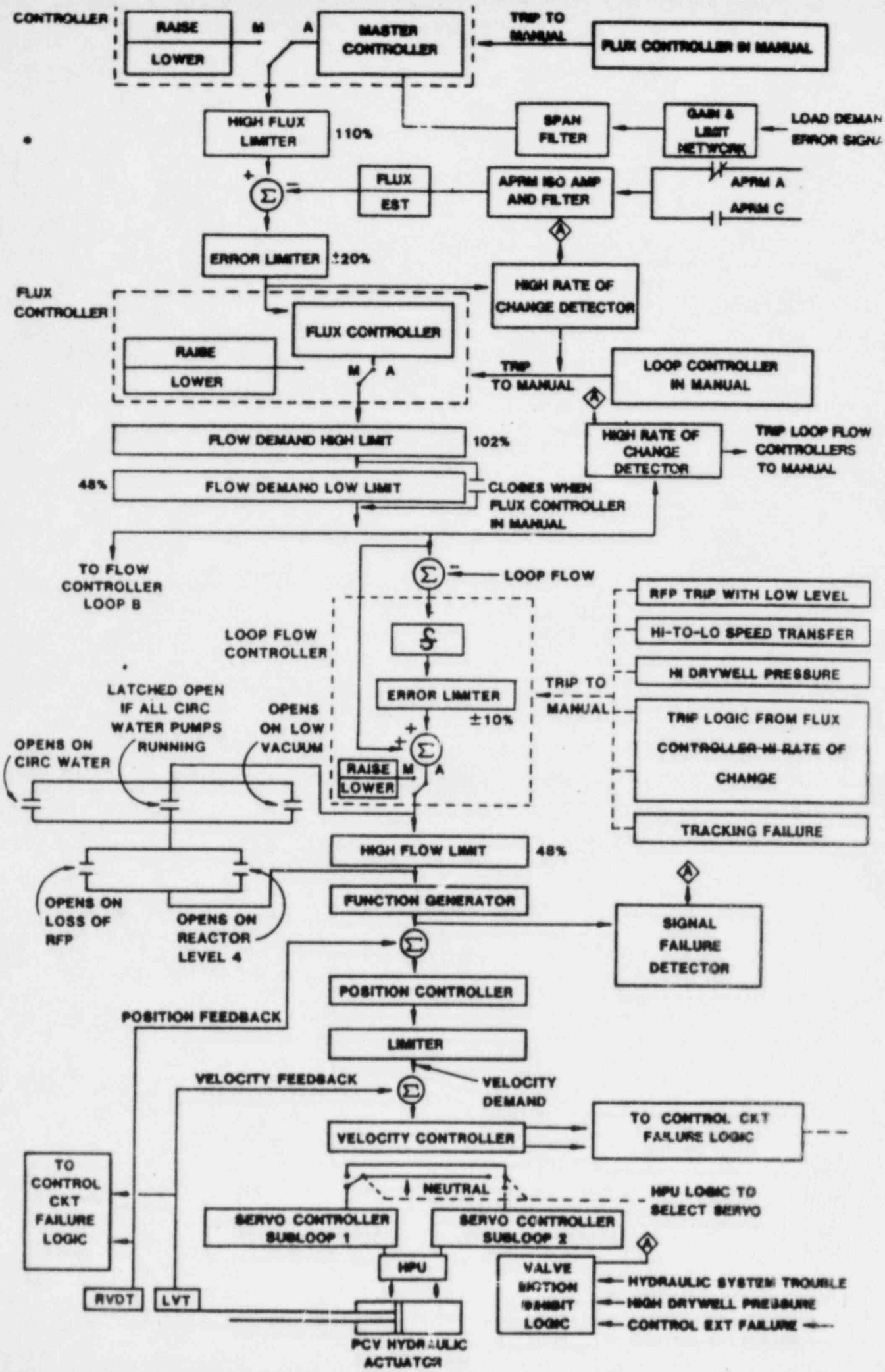
$R/hr = 6\ CE/d^2$ (feet)

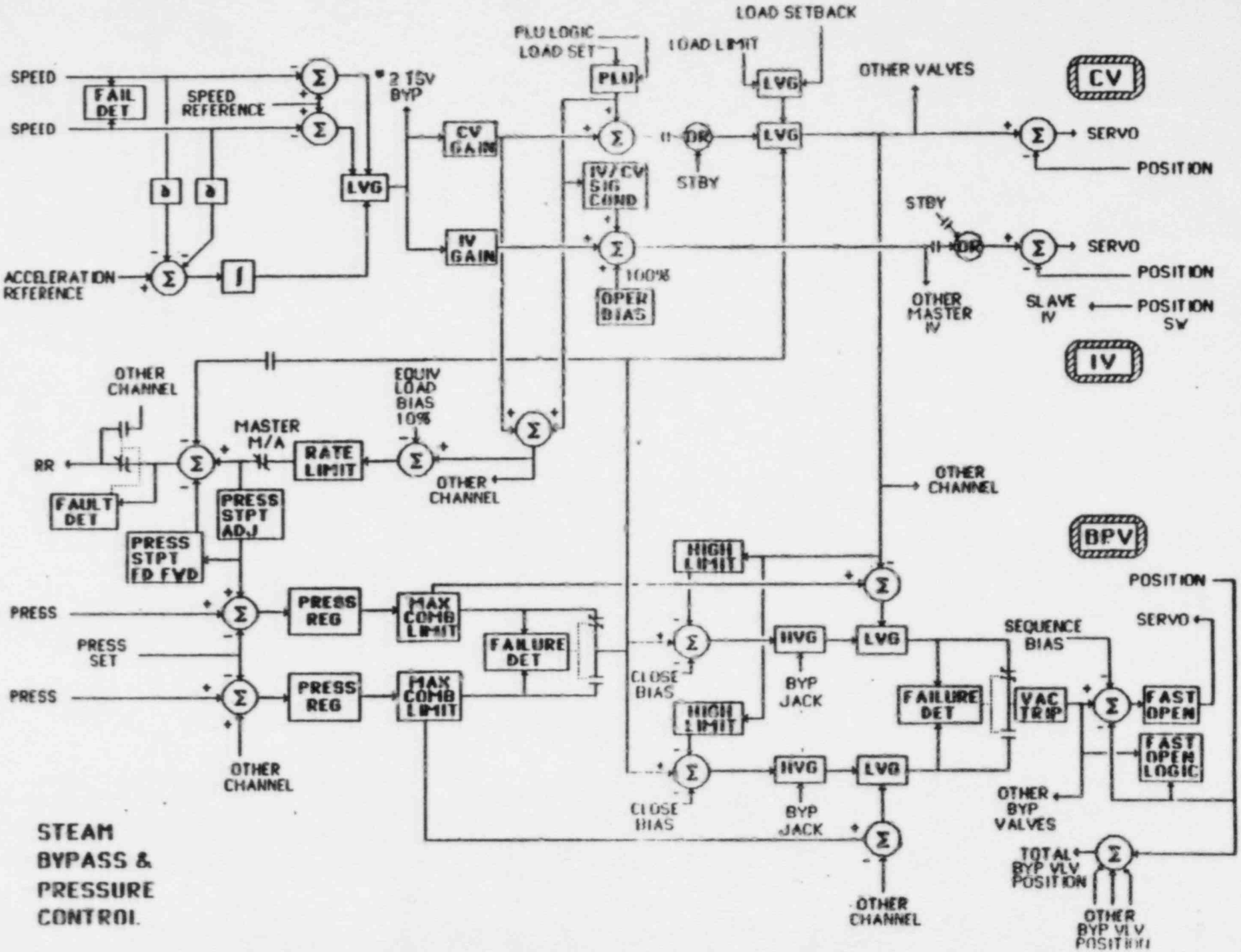
Water Parameters

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.

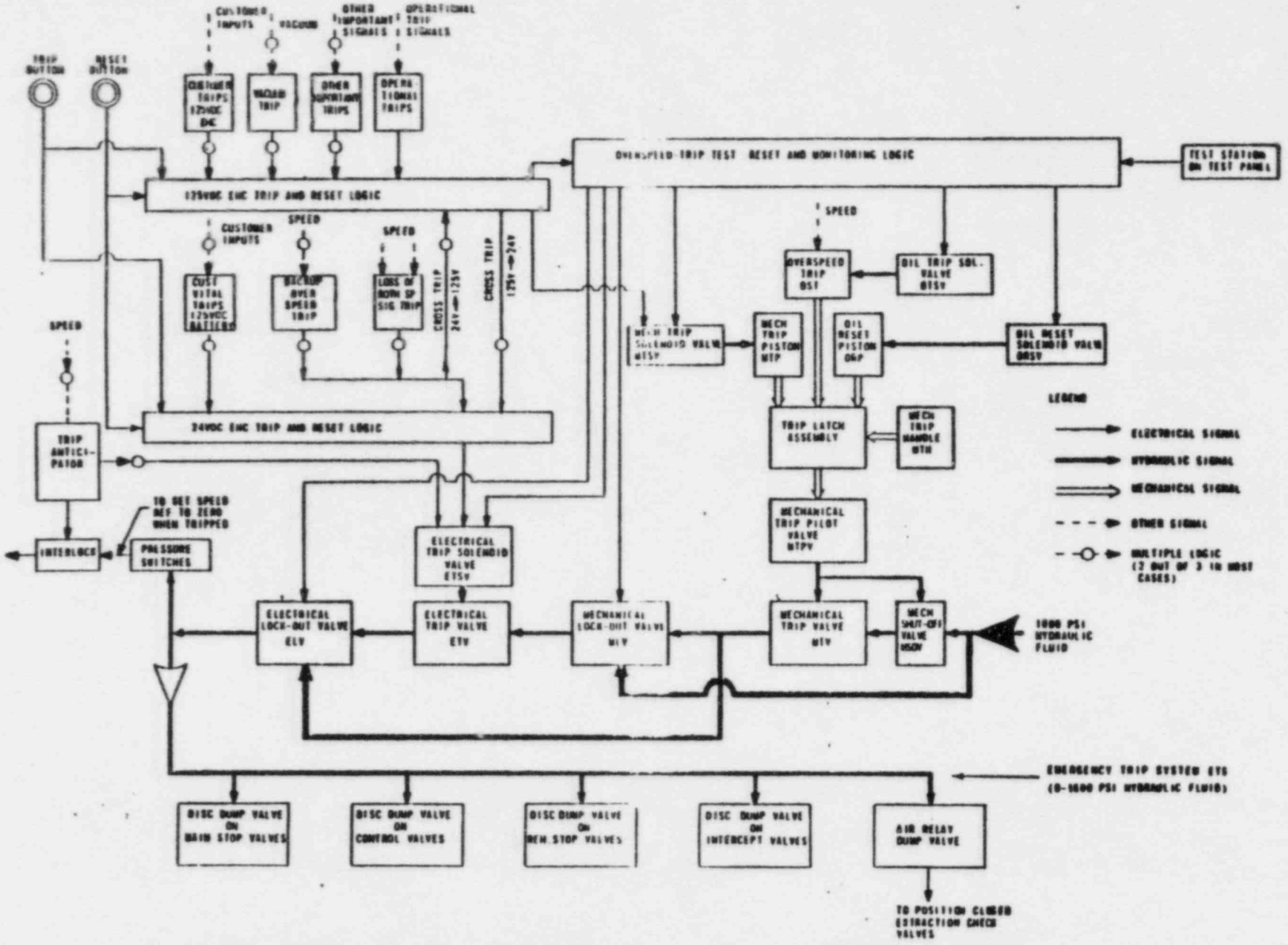
Miscellaneous Conversions

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


CONTROLLER
RAISE
LOWER
M
A
MASTER CONTROLLER
TRIP TO MANUAL
FLUX CONTROLLER IN MANUAL
HIGH FLUX LIMITER
110%
SPAN FILTER
GAIN & LIMIT NETWORK
LOAD DEMAN
ERROR SIGNA
FLUX EST
APRM ISO AMP AND FILTER
APRM A
APRM C
ERROR LIMITER
±20%
HIGH RATE OF CHANGE DETECTOR
FLUX CONTROLLER
FLUX CONTROLLER
RAISE
LOWER
M
A
TRIP TO MANUAL
LOOP CONTROLLER IN MANUAL
FLOW DEMAND HIGH LIMIT
102%
HIGH RATE OF CHANGE DETECTOR
TRIP LOOP FLOW CONTROLLERS TO MANUAL
48%
FLOW DEMAND LOW LIMIT
CLOSES WHEN FLUX CONTROLLER IN MANUAL
TO FLOW CONTROLLER LOOP B
LOOP FLOW
LOOP FLOW CONTROLLER
ERROR LIMITER
±10%
TRIP TO MANUAL
RFP TRIP WITH LOW LEVEL
HI-TO-LO SPEED TRANSFER
HI DRYWELL PRESSURE
TRIP LOGIC FROM FLUX CONTROLLER HI RATE OF CHANGE
TRACKING FAILURE
LATCHED OPEN IF ALL CIRC WATER PUMPS RUNNING
OPENS ON LOW VACUUM
OPENS ON CIRC WATER
RAISE
LOWER
M
A
HIGH FLOW LIMIT
48%
OPENS ON LOSS OF RFP
OPENS ON REACTOR LEVEL 4
FUNCTION GENERATOR
SIGNAL FAILURE DETECTOR
POSITION CONTROLLER
POSITION FEEDBACK
LIMITER
VELOCITY FEEDBACK
VELOCITY DEMAND
VELOCITY CONTROLLER
TO CONTROL CKT FAILURE LOGIC
TO CONTROL CKT FAILURE LOGIC
NEUTRAL
HPU LOGIC TO SELECT SERVO
SERVO CONTROLLER SUBLOOP 1
SERVO CONTROLLER SUBLOOP 2
HPU
VALVE MOTION INHIBIT LOGIC
HYDRAULIC SYSTEM TROUBLE
HIGH DRYWELL PRESSURE
CONTROL EXT FAILURE
RVDT
LVT
PCV HYDRAULIC ACTUATOR



STEAM BYPASS & PRESSURE CONTROL


TRIP BUTTON
RESET BUTTON
CUSTOMER INPUTS
VACUUM
OTHER IMPORTANT SIGNALS
OPERATIONAL TRIP SIGNALS
CUSTOMER TRIPS 125VDC ENC
VACUUM TRIP
OTHER IMPORTANT TRIPS
OPERATIONAL TRIPS
OVERSPEED TRIP TEST RESET AND MONITORING LOGIC
TEST STATION ON TEST PANEL
125VDC ENC TRIP AND RESET LOGIC
CUSTOMER INPUTS
SPEED
SPEED
CUST VITAL TRIPS 125VDC BATTERY
BACKUP OVER SPEED TRIP
LOSS OF BOTH SP SIG TRIP
CROSS TRIP 24V→125V
CROSS TRIP 125V→24V
SPEED
OVERSPEED TRIP OST
OIL TRIP SOL. VALVE OTSV
MECH TRIP SOLENOID VALVE MTSV
MECH TRIP PISTON MTP
OIL RESET PISTON ORP
OIL RESET SOLENOID VALVE ORSV
SPEED
TRIP ANTICI-PATOR
24VDC ENC TRIP AND RESET LOGIC
TRIP LATCH ASSEMBLY
MECH TRIP HANDLE MTH
LEGEND
ELECTRICAL SIGNAL
HYDRAULIC SIGNAL
MECHANICAL SIGNAL
OTHER SIGNAL
MULTIPLE LOGIC (2 OUT OF 3 IN MOST CASES)
TO SET SPEED REF TO ZERO WHEN TRIPPED
INTERLOCK
PRESSURE SWITCHES
ELECTRICAL TRIP SOLENOID VALVE ETSV
MECHANICAL TRIP PILOT VALVE MTPV
ELECTRICAL LOCK-OUT VALVE ELV
ELECTRICAL TRIP VALVE ETV
MECHANICAL LOCK-OUT VALVE MLV
MECHANICAL TRIP VALVE MTV
MECH SHUT-OFF VALVE MSOV
1000 PSI HYDRAULIC FLUID
EMERGENCY TRIP SYSTEM ETS (0-1600 PSI HYDRAULIC FLUID)
DISC DUMP VALVE ON MAIN STOP VALVES
DISC DUMP VALVE ON CONTROL VALVES
DISC DUMP VALVE ON REH STOP VALVES
DISC DUMP VALVE ON INTERCEPT VALVES
AIR RELAY DUMP VALVE
TO POSITION CLOSED EXTRACTION CHECK VALVES

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3/4.5 EMERGENCY CORE COOLING SYSTEMS

3/4.5.1 ECCS - OPERATING

LIMITING CONDITION FOR OPERATION

3.5.1 ECCS divisions 1, 2 and 3 shall be OPERABLE with:

a. ECCS division 1 consisting of:

1. The OPERABLE low pressure core spray (LPCS) system with a flow path capable of taking suction from the suppression pool and transferring the water through the spray sparger to the reactor vessel.

2. The OPERABLE low pressure coolant injection (LPCI) subsystem "A" of the RHR system with a flow path capable of taking suction from the suppression pool and transferring the water to the reactor vessel.

3. 7 OPERABLE ADS valves.

b. ECCS division 2 consisting of:

1. The OPERABLE low pressure coolant injection (LPCI) subsystems "B" and "C" of the RHR system, each with a flow path capable of taking suction from the suppression pool and transferring the water to the reactor vessel.

2. 7 OPERABLE ADS valves.

c. ECCS division 3 consisting of the OPERABLE high pressure core spray (HPCS) system with a flow path capable of taking suction from the suppression pool and transferring the water through the spray sparger to the reactor vessel.

APPLICABILITY: OPERATIONAL CONDITION 1, 2*,# and 3*.

*The ADS is not required to be OPERABLE when reactor steam dome pressure is less than or equal to 100 psig.

#See Special Test Exception 3.10.5.

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LIMITING CONDITION FOR OPERATION

ACTION:

a. For ECCS division 1, provided that ECCS divisions 2 and 3 are OPERABLE:

1. With the LPCS system inoperable, restore the inoperable LPCS system to OPERABLE status within 7 days.

2. With LPCI subsystem "A" inoperable, restore the inoperable LPCI subsystem "A" to OPERABLE status within 7 days.

3. With the LPCS system inoperable and LPCI subsystem "A" inoperable, restore at least the inoperable LPCI subsystem "A" or the inoperable LPCS system to OPERABLE status within 72 hours.

4. Otherwise, be in at least HOT SHUTDOWN within the next 12 hours and in COLD SHUTDOWN within the following 24 hours.

b. For ECCS division 2, provided that ECCS divisions 1 and 3 are OPERABLE:

1. With either LPCI subsystem "B" or "C" inoperable, restore the inoperable LPCI subsystem "B" or "C" to OPERABLE status within 7 days.

2. With both LPCI subsystems "B" and "C" inoperable, restore at least the inoperable LPCI subsystem "B" or "C" to OPERABLE status within 72 hours.

3. Otherwise, be in at least HOT SHUTDOWN within the next 12 hours and in COLD SHUTDOWN within the following 24 hours*.

c. For ECCS division 3, provided that ECCS divisions 1 and 2 and the RCIC system are OPERABLE:

1) With ECCS division 3 inoperable, restore the inoperable division to OPERABLE status within 14 days.

2) Otherwise, be in at least HOT SHUTDOWN within the next 12 hours and in COLD SHUTDOWN within the following 24 hours.

*Whenever two or more RHR subsystems are inoperable, if unable to attain COLD SHUTDOWN as required by this ACTION, maintain reactor coolant temperature as low as practical by use of alternate heat removal methods.

APR 19 198

LIMITING CONDITION FOR OPERATION (Continued)

ACTION: (Continued)

d. For ECCS divisions 1 and 2, provided that ECCS division 3 is OPERABLE:

1) With LPCI subsystem "A" and either LPCI subsystem "B" or "C" inoperable, restore at least the inoperable LPCI subsystem "A" or inoperable LPCI subsystem "B" or "C" to OPERABLE status within 72 hours.

2) With the LPCS system inoperable and either LPCI subsystems "B" or "C" inoperable, restore at least the inoperable LPCS system or inoperable LPCI subsystem "B" or "C" to OPERABLE status within 72 hours.

3) Otherwise, be in at least HOT SHUTDOWN within the next 12 hours and in COLD SHUTDOWN within the following 24 hours**.

e. For ECCS divisions 1 and 2, provided that ECCS division 3 is OPERABLE and divisions 1 and 2 are otherwise OPERABLE:

1. With one of the above required ADS valves inoperable, restore the inoperable ADS valve to OPERABLE status within 14 days or be in at least HOT SHUTDOWN within the next 12 hours and reduce reactor steam dome pressure to $\leq$ 100 psig within the next 24 hours.

2. With two or more of the above required ADS valves inoperable, be in at least HOT SHUTDOWN within 12 hours and reduce reactor steam dome pressure to $\leq$ 100 psig within the next 24 hours.

f. In the event an ECCS system is actuated and injects water into the Reactor Coolant System, a Special Report shall be prepared and submitted to the Commission pursuant to Specification 6.9.2 within 90 days describing the circumstances of the actuation and the total accumulated actuation cycles to date. The current value of the useage factor for each affected safety injection nozzle shall be provided in this Special Report whenever its value exceeds 0.70.

**whenever two or more RHR subsystems are inoperable, if unable to attain COLD SHUTDOWN as required by this ACTION, maintain reactor coolant temperature as low as practical by use of alternate heat removal methods.

SURVEILLANCE REQUIREMENTS

4.5.1 ECCS division 1, 2 and 3 shall be demonstrated OPERABLE by:

a. At least once per 31 days for the LPCS, LPCI and HPCS systems:

1. Verifying by venting at the high point vents that the system piping from the pump discharge valve to the system isolation valve is filled with water.

2. Verifying that each valve (manual, power operated or automatic) in the flow path that is not locked, sealed, or otherwise secured in position, is in its correct position.

b. Verifing that (when tested pursuant to Specification 4.0.5) (at least once per 92 days when tested each) each:

1. LPCS pump develops a flow of at least 5010 gpm against a test line pressure greater than or equal to (119) psid.

2. LPCI pump develops a flow of at least 5050 gpm against a test line pressure greater than or equal to (119) psid.

3. HPCS pump develops a flow of at least 5010 gpm against a test line pressure greater than or equal to (490) psid.

c. For the LPCS, LPCI and HPCS systems, at least once per 18 months performing a system functional test which includes simulated automatic actuation of the system throughout its emergency operating sequence and verifying that each automatic valve in the flow path actuates to its correct position. Actual injection of coolant into the reactor vessel may be excluded from this test.

d. For the HPCS system, at least once per 18 months, verifying that the suction is automatically transferred from the RCIC storage tank to the suppression pool on a RCIC storage tank low water level signal and on a suppression pool high water level signal.

e. At least once per 18 months for the ADS by:

1. Performing a system functional test which includes simulated automatic actuation of the system throughout its emergency operating sequence, but excluding actual valve actuation.

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SURVEILLANCE REQUIREMENTS (Continued)

2. Manually opening each ADS valve when the reactor steam dome pressure is greater than or equal to 100 psig* and observing that either:

   a. The control valve or bypass valve position responds accordingly, or

   b. There is a corresponding change in the measured stream flow.

*The provisions of Specification 4.0.4 are not applicable provided the surveillance is performed within 12 hours after reactor steam pressure is adequate to perform the test.

APR 19 1985

3/4 5.2 ECCS - SHUTDOWN

LIMITING CONDITION FOR OPERATION

3.5.2 At least two of the following shall be OPERABLE:

a. The low pressure core spray (LPCS) system with a flow path capable of taking suction from the suppression pool and transferring the water through the spray sparger to the reactor vessel.

b. Low pressure coolant injection (LPCI) subsystem "A" of the RHR system with a flow path capable of taking suction from the suppression pool and transferring the water to the reactor vessel.

c. Low pressure coolant injection (LPCI) subsystem "B" of the RHR system with a flow path capable of taking suction from the suppression pool and transferring the water to the reactor vessel.

d. Low pressure coolant injection (LPCI) subsystem "C" of the RHR system with a flow path capable of taking suction from the suppression pool and transferring the water to the reactor vessel.

e. The high pressure core spray (HPCS) system with a flow path capable of taking suction from the RCIC storage tank or the suppression pool and transferring the water through the spray sparger to the reactor vessel.

APPLICABILITY: OPERATIONAL CONDITION 4 and 5*.

ACTION:

a. With one of the above required subsystems/systems inoperable, restore at least two subsystems/systems to OPERABLE status within 4 hours or suspend all operations that have a potential for draining the reactor vessel.

b. With both of the above required subsystems/systems inoperable, suspend CORE ALTERATIONS and all operations that have a potential for draining the reactor vessel. Restore at least one subsystem/system to OPERABLE status within 4 hours or establish PRIMARY CONTAINMENT INTEGRITY within the next 8 hours.

*The ECCS is not required to be OPERABLE provided that the reactor vessel head is removed, the cavity is flooded, the reactor vessel to steam dryer pool gates are removed and water level is maintained within the limits of Specification 3.9.8 and 3.9.9.

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SURVEILLANCE REQUIREMENTS

4.5.2.1 At least the above required ECCS shall be demonstrated OPERABLE per Surveillance Requirement 4.5.1.

4.5.2.2 The HPCS system shall be determined OPERABLE at least once per 12 hours by verifying the RCIC storage tank required volume when the RCIC storage tank is required to be OPERABLE per Specification 3.5.2.e.

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REACTOR COOLANT SYSTEM

OPERATIONAL LEAKAGE

LIMITING CONDITION FOR OPERATION

3.4.3.2 Reactor coolant system leakage shall be limited to:

a. No PRESSURE BOUNDARY LEAKAGE.

b. 5 gpm UNIDENTIFIED LEAKAGE.

c. 25 gpm total leakage (averaged over any 24-hour period).

d. 1 gpm leakage at a reactor coolant system pressure of 1000 ± 10 psig from any reactor coolant system pressure isolation valve specified in Table 3.4.3.2-1.

e. 2 gpm increase in UNIDENTIFIED LEAKAGE within any 4-hour period.

APPLICABILITY: OPERATIONAL CONDITIONS 1, 2 and 3.

ACTION:

a. With any PRESSURE BOUNDARY LEAKAGE, be in at least HOT SHUTDOWN within 12 hours and in COLD SHUTDOWN within the next 24 hours.

b. With any reactor coolant system leakage greater than the limits in b and/or c, above, reduce the leakage rate to within the limits within 4 hours or be in at least HOT SHUTDOWN within the next 12 hours and in COLD SHUTDOWN within the following 24 hours.

c. With any reactor coolant system pressure isolation valve leakage greater than the above limit, isolate the high pressure portion of the affected system from the low pressure portion within 4 hours by use of at least two other closed manual or deactivated automatic valves, or be in at least HOT SHUTDOWN within the next 12 hours and in COLD SHUTDOWN within the following 24 hours.

d. With any reactor coolant system UNIDENTIFIED LEAKAGE increase greater than 2 gpm within any 4-hour period, identify the source of leakage increase as not service sensitive Type 304 or 316 austenitic stainless steel within 4 hours or be in at least HOT SHUTDOWN within the next 12 hours and in COLD SHUTDOWN within the following 24 hours.

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3/4.9.10 CONTROL ROD REMOVAL

SINGLE CONTROL ROD REMOVAL

LIMITING CONDITION FOR OPERATION

3.9.10.1 One control rod and/or the associated control rod drive mechanism may be removed from the core and/or reactor pressure vessel provided that at least the following requirements are satisfied until a control rod and associated control rod drive mechanism are reinstalled and the control rod is fully inserted in the core.

a. The reactor mode switch is OPERABLE and locked in the Shutdown position or in the Refuel position per Table 1.2 and Specification 3.9.1.

b. The source range monitors (SRM) are OPERABLE per Specification 3.9.2.

c. The SHUTDOWN MARGIN requirements of Specification 3.1.1 are satisfied, except that the control rod selected to be removed;

   1. May be assumed to be the highest worth control rod required to be assumed to be fully withdrawn by the SHUTDOWN MARGIN test, and

   2. Need not be assumed to be immovable or untrippable.

d. All other control rods in a five-by-five array centered on the control rod being removed are inserted and electrically or hydraulically disarmed or the four fuel assemblies surrounding the control rod or control rod drive mechanism to be removed from the core and/or reactor vessel are removed from the core cell.

e. All other control rods are inserted.

APPLICABILITY: OPERATIONAL CONDITION 4 and 5.

ACTION:

With the requirements of the above specification not satisfied, suspend removal of the control rod and/or associated control rod drive mechanism from the core and/or reactor pressure vessel and initiate action to satisfy the above requirements.

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SURVEILLANCE REQUIREMENTS

4.9.10.1 Within 4 hours prior to the start of removal of a control rod and/or the associated control rod drive mechanism from the core and/or reactor pressure vessel and at least once per 24 hours thereafter until a control rod and associated control rod drive mechanism are reinstalled and the control rod is inserted in the core, verify that:

a. The reactor mode switch is OPERABLE per Surveillance Requirement 4.3.1.1 or 4.9.1.2, as applicable, and locked in the Shutdown position or in the Refuel position with the "one rod out" Refuel position interlock OPERABLE per Specification 3.9.1.

b. The SRM channels are OPERABLE per Specification 3.9.2.

c. The SHUTDOWN MARGIN requirements of Specification 3.1.1 are satisfied per Specification 3.9.10.1.c.

d. All other control rods in a five-by-five array centered on the control rod being removed are inserted and electrically or hydraulically disarmed or the four fuel assemblies surrounding the control rod or control rod drive mechanism to be removed from the core and/or reactor vessel are removed from the core cell.

e. All other control rods are inserted.

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MULTIPLE CONTROL ROD REMOVAL

LIMITING CONDITION FOR OPERATION

3.9.10.2 Any number of control rods and/or control rod drive mechanisms may be removed from the core and/or reactor pressure vessel provided that at least the following requirements are satisfied until all control rods and control rod drive mechanisms are reinstalled and all control rods are inserted in the core.

a. The reactor mode switch is OPERABLE and locked in the Shutdown position or in the Refuel position per Specification 3.9.1, except that the Refuel position "one-rod-out" interlock may be bypassed, as required, for those control rods and/or control rod drive mechanisms to be removed, after the fuel assemblies have been removed as specified below.

b. The source range monitors (SRM) are OPERABLE per Specification 3.9.2.

c. The SHUTDOWN MARGIN requirements of Specification 3.1.1 are satisfied.

d. All other control rods are either inserted or have the surrounding four fuel assemblies removed from the core cell.

e. The four fuel assemblies surrounding each control rod or control rod drive mechanism to be removed from the core and/or reactor vessel are removed from the core cell.

APPLICABILITY: OPERATIONAL CONDITION 5.

ACTION:

With the requirements of the above specification not satisfied, suspend removal of control rods and/or control rod drive mechanisms from the core and/or reactor pressure vessel and initiate action to satisfy the above requirements.

DRAFT

SURVEILLANCE REQUIREMENTS

4.9.10.2.1 Within 4 hours prior to the start of removal of control rods and/or control rod drive mechanisms from the core and/or reactor pressure vessel and at least once per 24 hours thereafter until all control rods and control rod drive mechanisms are reinstalled and all control rods are inserted in the core, verify that:

a. The reactor mode switch is OPERABLE per Surveillance Requirement 4.3.1.1 or 4.9.1.2, as applicable, and locked in the Shutdown position or in the Refuel position per Specification 3.9.1.

b. The SRM channels are OPERABLE per Specification 3.9.2.

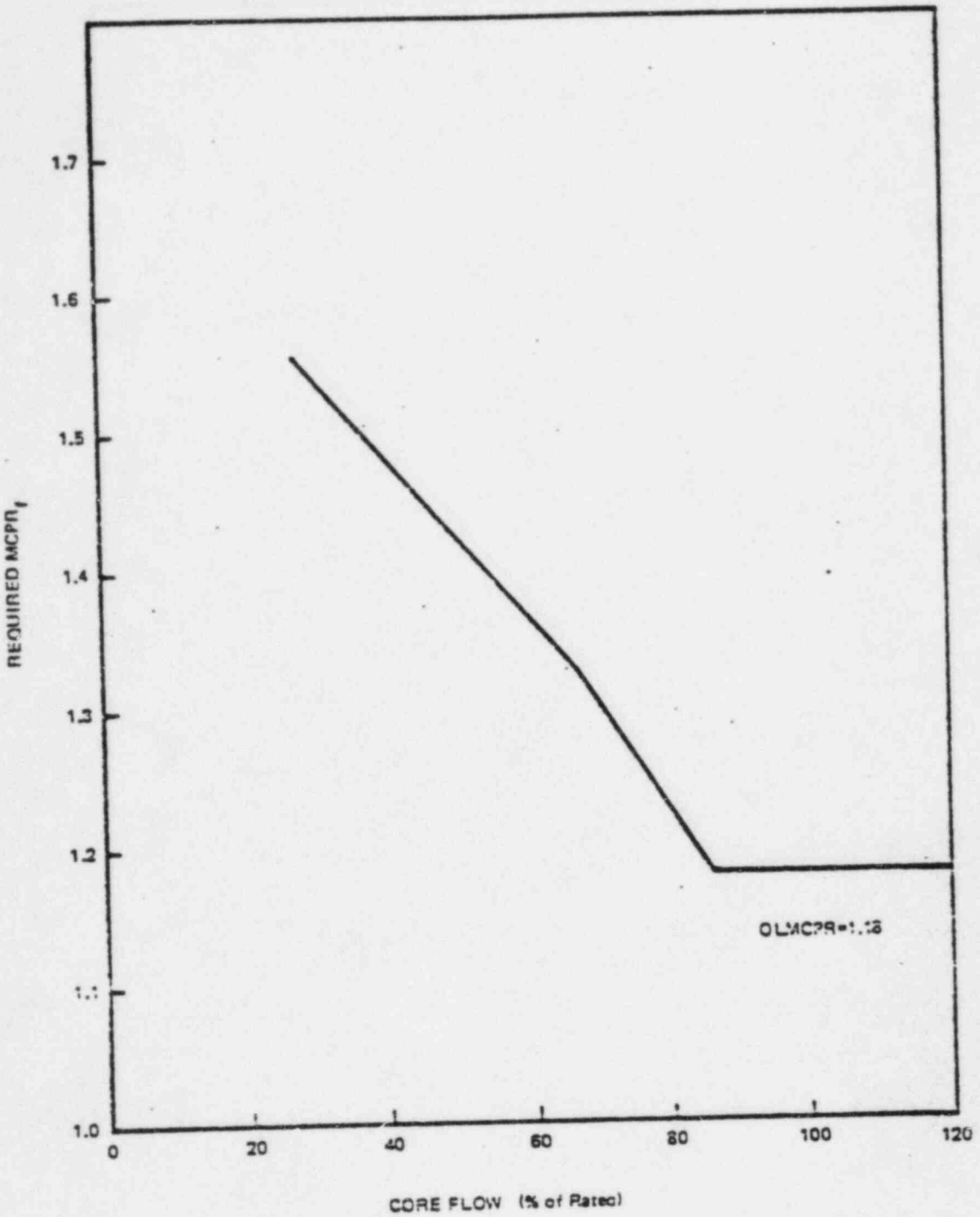
c. The SHUTDOWN MARGIN requirements of Specification 3.1.1 are satisfied.

d. All other control rods are either inserted or have the surrounding four fuel assemblies removed from the core cell.

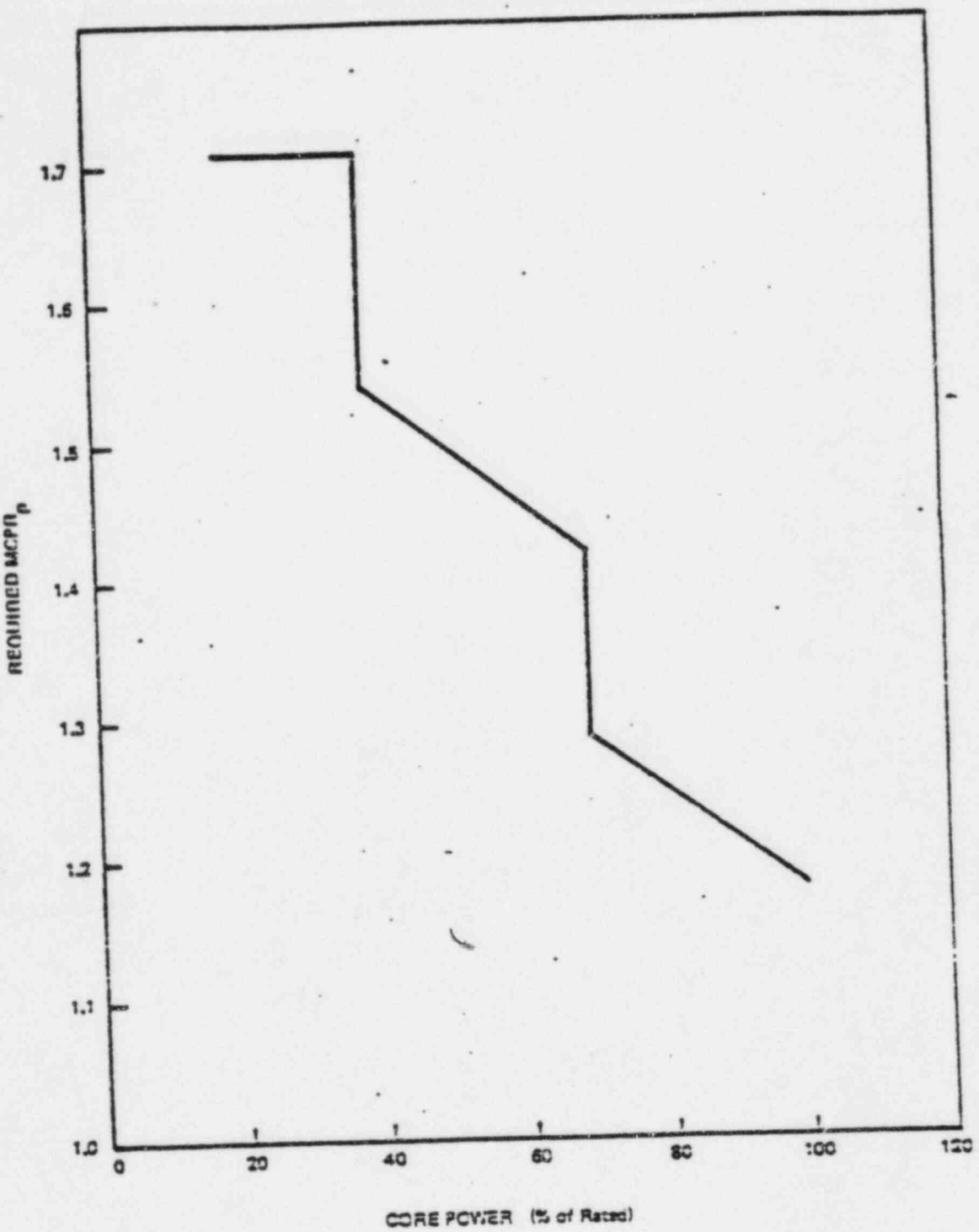
e. The four fuel assemblies surrounding each control rod and/or control rod drive mechanism to be removed from the core and/or reactor vessel are removed from the core cell.

f. All fuel loading operations are suspended unless all control rods are inserted in the core.

4.9.10.2.2 Following replacement of all control rods and/or control rod drive mechanisms removed in accordance with this specification, perform a functional test of the "one-rod-out" Refuel position interlock, if this function had been bypassed.



Clinton MCPR$_f$ (K_f) Versus Core Flow
Figure 3.2.3-1



Clinton MCPR$_p$ (K_p) Versus Power
Figure 3.2.3-2

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3/4.0 APPLICABILITY

LIMITING CONDITION FOR OPERATION

3.0.1 Compliance with the Limiting Conditions for Operation contained in the succeeding Specifications is required during the OPERATIONAL CONDITIONS or other conditions specified therein; except that upon failure to meet the Limiting Conditions for Operation, the associated ACTION requirements shall be met.

3.0.2 Noncompliance with a Specification shall exist when the requirements of the Limiting Condition for Operation and associated ACTION requirements are not met within the specified time intervals. If the Limiting Condition for Operation is restored prior to expiration of the specified time intervals, completion of the Action requirements is not required.

3.0.3 When a Limiting Condition for Operation is not met, except as provided in the associated ACTION requirements, within one hour action shall be initiated to place the unit in an OPERATIONAL CONDITION in which the Specification does not apply by placing it, as applicable, in:

1. At least STARTUP within the next 6 hours,
2. At least HOT SHUTDOWN within the following 6 hours, and
3. At least COLD SHUTDOWN within the subsequent 24 hours.

Where corrective measures are completed that permit operation under the ACTION requirements, the ACTION may be taken in accordance with the specified time limits as measured from the time of failure to meet the Limiting Condition for Operation. Exceptions to these requirements are stated in the individual Specifications.

This Specification is not applicable in OPERATIONAL CONDITIONS 4 or 5.

3.0.4 Entry into an OPERATIONAL CONDITION or other specified condition shall not be made unless the conditions for the Limiting Condition for Operation are met without reliance on provisions contained in the ACTION requirements. This provision shall not prevent passage through or to OPERATIONAL CONDITIONS as required to comply with ACTION requirements. Exceptions to these requirements are stated in the individual Specifications.

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3/4.6.7 ATMOSPHERE CONTROL

CONTAINMENT HYDROGEN RECOMBINER SYSTEMS

LIMITING CONDITION FOR OPERATION

3.6.7.1 Two independent containment hydrogen recombiner systems shall be OPERABLE.

APPLICABILITY: OPERATIONAL CONDITIONS 1 and 2.

ACTION:

With one containment and/or drywell hydrogen recombiner system inoperable, restore the inoperable system to OPERABLE status within 30 days or be in at least HOT SHUTDOWN within the next 12 hours.

SURVEILLANCE REQUIREMENTS

4.6.7.1 Each containment hydrogen recombiner system shall be demonstrated OPERABLE:

a. At least once per 6 months by verifying during a recombiner system functional test that the heater sheath temperature increases to greater than or equal to (600)°F within (60) minutes. (Upon reaching (700)°F, increase the power setting to maximum power for (2) minutes and verify that the power meter reads greater than or equal to (60) kW. Maintain $\geq$ (700)°F for at least (2) hours.)

b. At least once per 18 months by:

   1. Performing a CHANNEL CALIBRATION of all recombiner instrumentation and control circuits.

   2. Verifying through a visual examination that there is no evidence of abnormal conditions within the recombiner enclosure; i.e, loose wiring or structural connections, deposits of foreign materials, etc.

   3. Verifying the integrity of all heater electrical circuits by performing a resistance to ground test following the above required functional test. The resistance to ground for any heater phase phase shall be greater than or equal to (10,000) ohms.

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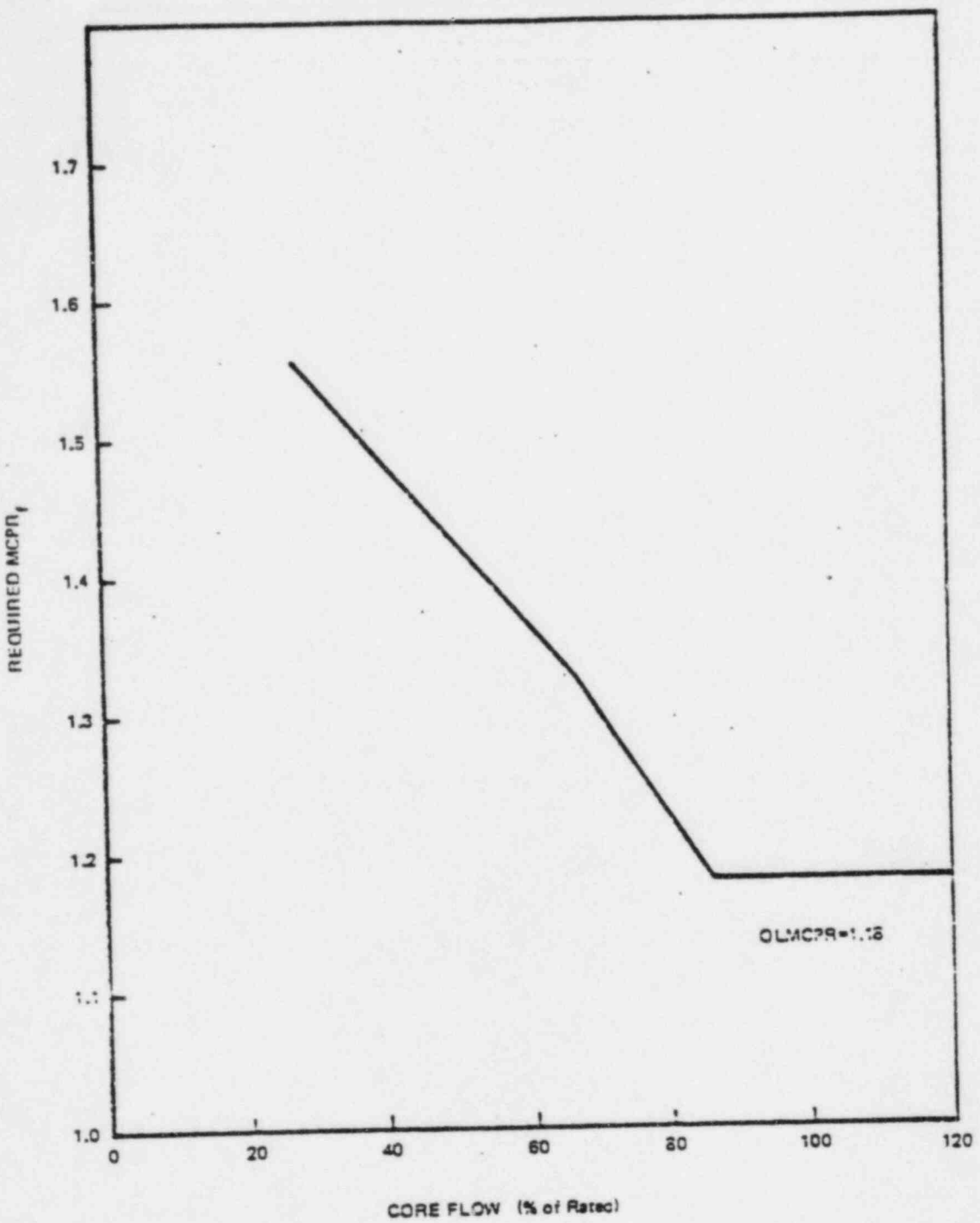
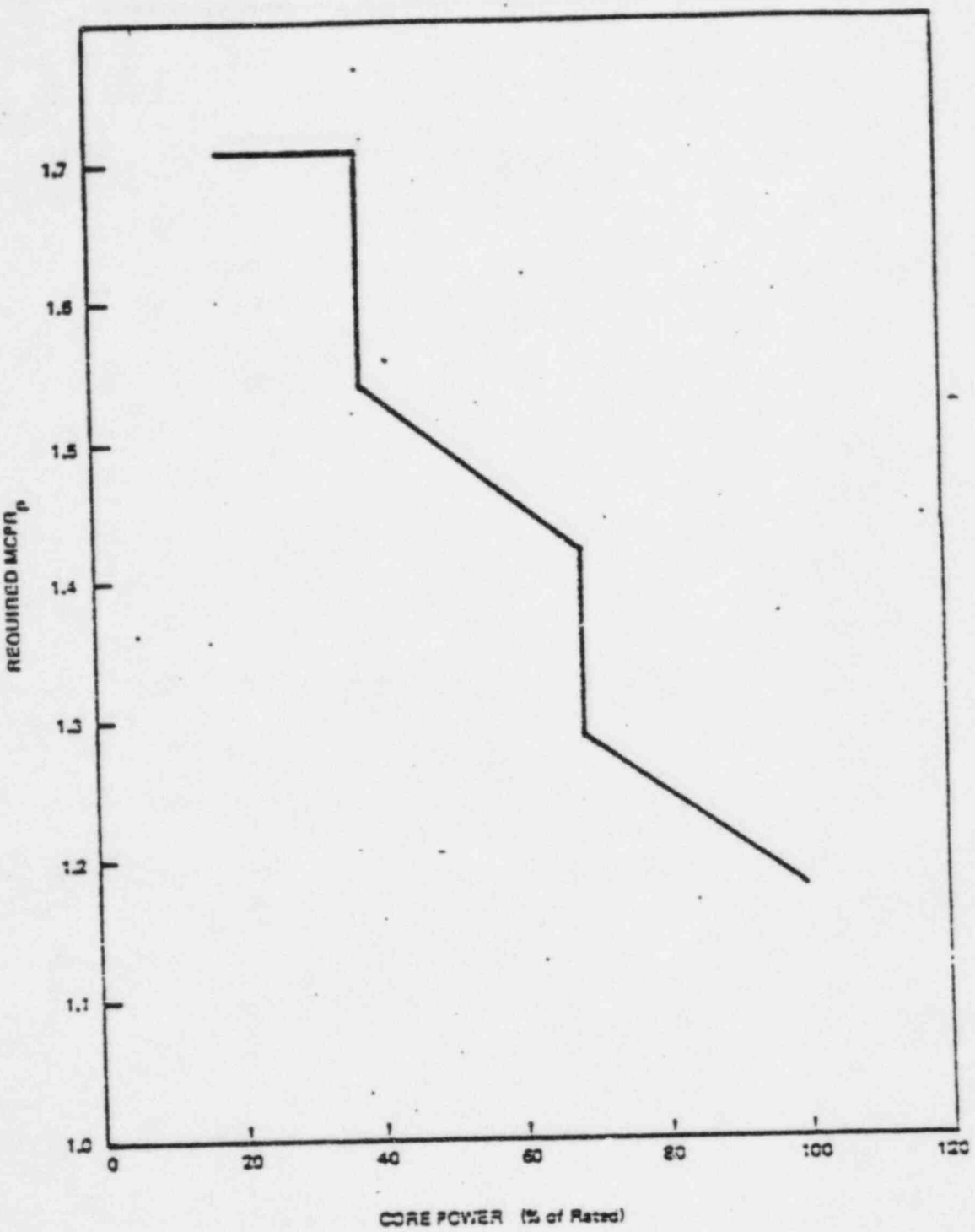


Clinton MCPR$_f$ (K_f) Versus Core Flow
Figure 3.2.3-1



Clinton MCPR$_p$ (K_p) Versus Power
Figure 3.2.3-2

ANSWER KEY
SECTION 5

5.1 B

Reference: CPS Nuclear Power Plant Thermal Science, Chapter 5, page 5-10

5.2 D

Reference: CPS Nuclear Power Plant Thermal Science, Chapter 5, page 5-29; Chapter 9, page 9-4

5.3 Horizontal 3

Vertical 5

Reference: CPS Nuclear Power Plant Thermal Science, Chapter 9, page 9-6

5.4 Temperature can only increase to 705.5°F and maintain the water in a liquid state. The critical temperature of water is 705.5°F. (Candidate must identify change of state or refer to critical temperature to receive full credit.

Reference: CPS Nuclear Power Plant Thermal Science, Chapter 3, page 3-13

5.5 Radial, Local and Axial peaking factors

Reference: CPS Nuclear Power Plant thermal Science, Chapter 10, page 10-21

5.6 a. 3

b. 2

c. 3

Reference: CPS Reactor Theory, pages 83-87

5.7 a. False

b. True

Reference: CPS Reactor Theory, pages 68 and 69

5.8 c

Reference: CPS Nuclear Power Plant Thermal Science, Chapter 10, page 10-4

5.9 $SDM = \frac{1-K(eff)}{K(eff)}$

SDM = 1-0.899/0.899 = 0.112 ΔK/K = 11.2% ΔK/K
1.0 (~~0.55~~ points for correct math)
0.5 (~~1.0~~ points for correct answer)

5.10 The delayed neutrons from Pμ-239 are born at a higher energy then those of U-235 (0.5). Therefore, the slowing down length increases for delayed neutrons over core life, more neutrons leakout, and fewer delayed fast neutrons reach thermal energies (0.5)

Reference: CPS Reactor Theory, page 49

11
5.~~10~~ 1. Spontaneous fission of U-238

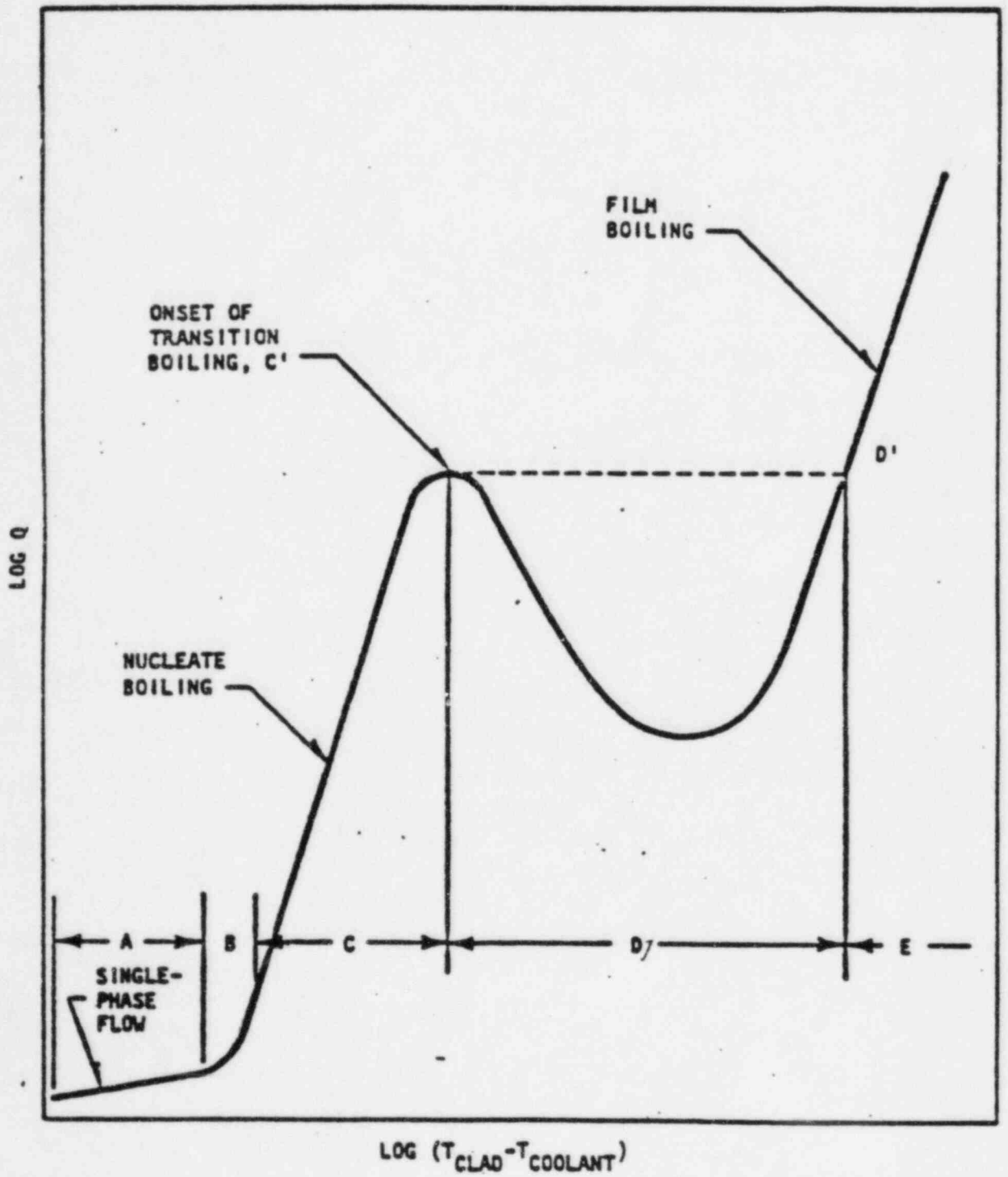
2. Gamma n reaction with D_2O

3. Alpha n reaction with O 18
(must be in proper order to receive full credit)

Reference: CPS Reactor Theory, page 96

5.12 SITUATION ONE [0.5] Control rod worth is proportional to the square of local flux. [0.5] With all rods inserted and the reactor shutdown the average core flux is very small. If the center rod is fully withdrawn, the flux in the area of the withdrawn rod increases substantially [0.5], and core multiplication increases. Because this rod causes the value of (local flux / average flux) squared to be large. Therefore, the worth for this rod is quite large [0.5].

Figure 9.3 Heat Flux Versus Temperature Difference Between Cladding and Coolant



Inserting the same rod from the fully withdrawn position with all other rods fully withdrawn, the flux depression caused by the insertion will result in a small change in the value of (local flux / average flux) squared [0.5]. (2.5)

Reference: CPS Reactor Theory, pages 80-83

5.13 a. void fraction is the volume fraction of steam in a steam-water mixture

$$\text{void fraction} = \frac{\text{volume of steam}}{\text{volume of steam} + \text{volume of water}} \quad (1.0)$$

b. steam quality is the weight fraction of steam in steam-water mixture

$$\text{steam quality} = \frac{\text{weight of steam}}{\text{weight of steam} + \text{weight of water}} \quad (1.0)$$

Reference: CPS Nuclear Power Plant Thermal Science, Chapter 9, page 9-20

5.14 1. E (LHGR)

2. B (CPR)

3. C (APLHGR)

Reference: CPS Nuclear Power Plant Thermal Science, Chapter 12, page 12-2

5.15 a - 23

b - 5

Reference: CPS Nuclear Power Plant Thermal Science, Chapter 16

5.16 b

Reference: CPS Reactor Theory, pages 48-53

5.17 1. Neutron embrittlement of the cladding

2. Thermally induced pellet growth

3. Inward motion of the cladding walls (creep down)

4. Clad weakening from (thermal) cyclic stress

Reference: CPS Nuclear Power Plant Thermal Science, Chapter 10, page 10-16

5.18 b

Reference: First Law of Thermodynamics
CPS Nuclear Power Plant Thermal Science, Chapter 11, pages 11-6 through 11

(*** END OF SECTION 5 ***)

ANSWER KEY
SECTION 6

6.1 a. 1. ~~FAI~~ FC
2. FO
3. FC
~~4. FC~~ delete points redistribute
5. ~~FO~~ FC

~~(0.5 each)~~ (.062 each)

b. Valve stem air to off gas system is lost (0.5)

Reference: CPS No. 10P3214.01S

6.2 a. Indication that the RGDS (Rod gang drive system) finds disagreement between the signals received from the 2 RACS (Rod action control system).

b. Indication that the withdrawn rod must be fully inserted before any other control rod can be moved. Mode switch in refuel. (0.5 each)

Reference: CPS 3304.02

6.3 d

Reference: EHC Lesson Plan; Recirc System Lesson Plan

6.4 - Auto initiated at Level 3 (+8.9") (0.5)
- Level signal increased to +55" (0.3) for 10 seconds (0.2)
- After 10 seconds (0.2), +55" replaced by +18" signal (0.3)
- No Reset until operator actuation of "Setpoint Setdown Reset" (0.5)

Reference: Feedwater Control Lesson Plan

6.5 a. To minimize thermal shock to the CRD when the scram is reset. (a minimum cooling flow is maintained while recharging the scram accumulators)

b. 2

Reference: CPS Question 6.06

6.6 Containment Spray Initiation

Reference: RHR Description, Page 13

6.7 See attached

6.8 c or B

Reference: 3203.01; 4200.01

6.9 1. Reactor water

2. RWCU system water

3. CRD system water

4. Drywell sumps

5. Containment drains

Reference: CPS No. 1890.34

6.10 ~~a~~ D charged per facility comment

Reference: CPS No. 3314.01

6.11 a. Slow

b. ~~Counter~~clockwise or fast

Reference: Standard Diesel Generator Operations

6.12 a. Will inject. Turbine seal leakage resulting in potential airborne activity in the RCIC room, high temp or high ΔT.

b. Will inject. Pump overheating and seal damage result during low or non-flow conditions.

c. Will not inject. Maximum signal from the flow element will result in the flow controller keeping the turbine speed at minimum.

Reference: CPS Question Bank (6.14)

6.13 a. No. The SRV's are downstream of elbow taps (flow input to Feedwater Level Control). Therefore, all steam flow is sensed.

b. The generated megawatts will decrease a small amount because the Turbine Control System will close down the turbine control valves to maintain reactor pressure.

c. Reactor pressure will initially decrease due to increased steam flow until the Turbine Control System has a chance to adjust pressure upward by closing down on the TCV's.

d. Reactor power will end up at approximately the same as when the transient started.

e. Recirculation flow would increase resulting in a reactor power increase.

Reference: CPS 4009.01

6.14 1. Discharge line temperature recorder on (1H13-P614)

2. SRV flow monitor on (1H13-P866)

3. SRV position indication on (1H13-P601, P642 or DCS display)

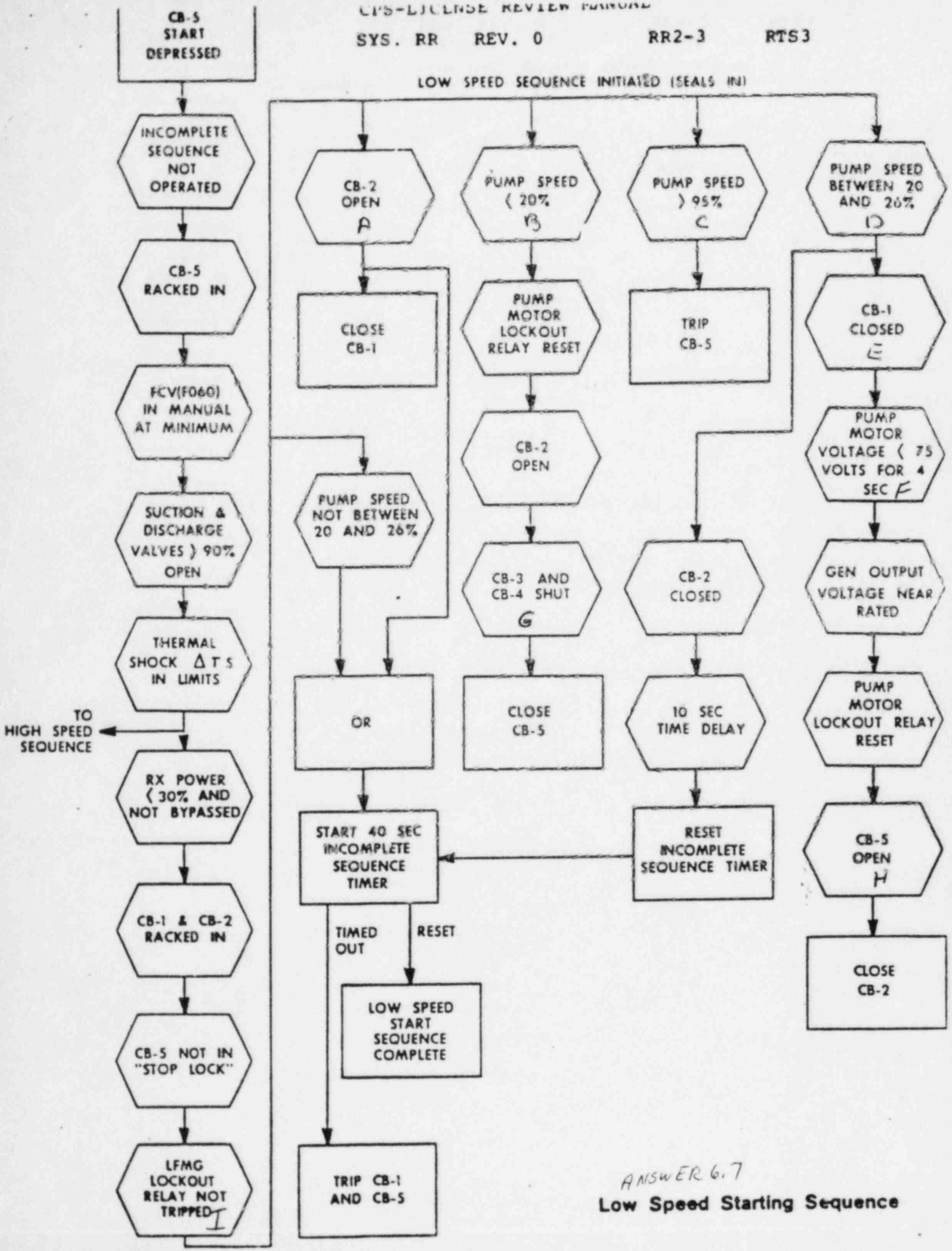
4. Suppression pool temperature recorder on (1H13-P~~601~~ 634 or P 639)

5. ACOUSTIC MONITORS

NOTE: Panel numbers not needed for full credit but if given must be correct.

Reference: CPS 4009.01

(*** END OF SECTION 6 ***)



ANSWER 6.7

Low Speed Starting Sequence

ANSWER KEY
SECTION 7

7.1 1. Place the Mode Switch in Shutdown

2. Insert a manual scram

3. Trip both recirc pumps (0.5 each)

Reference: CPS 4404.01

7.2 Establish LPCS or LPCI flow from the Suppression Pool with injection to the RPV (0.5) and open ~~two (2)~~ three SRV's to establish return flow to the Suppression Pool. (0.5)

Reference: CPS No. 4403.01

7.3 b

Reference: 4403.01

7.4 d

Reference: 4401.01 (CAF) RCIC License Review Manual

7.5 a. Loop Manual
b. 10%
c. 5%

Reference: 330.2.01 (CAF) (4008.01)(CAF) Recirc Flow Control System Lesson Plan

7.6 b

Reference: 4005.01

7.7 a. 1. ~~14.5 feet~~ 18'11"
2. ~~212 deg F~~ 95°
3. ~~140 deg~~ F 105° – 110° or 120°

b. To ensure that there is adequate NPSH for the respective ECCS pumps & adequate heat sink

Reference: CPS 3310.01, 3312.01, 3313.01, T.S. 3.6.3.1

7.8 Gas Pressure remains constant; no water draining from hose

Reference: CPS No. 3304.01

7.9 a. This level promotes natural circulation in the reactor vessel.

b. The valves should remain closed to prevent allowing reactor water to flow to the suppression pool.

Reference: 3312.01

7.10 1. Vent the hydrogen pressure (to 2-5 psig)

2. Purge the hydrogen from the generation with CO-2 (to a CO-2 purity of 95%)

3. Purge the CO-2 from the generator with ~~instrument air~~ service air or SIA. (to a CO-2 purity of 0%)

Reference: 3111.01

7.11 a. 25 REM

b. ~~25 rem~~. 3 rem.

c. Voluntary

d. 75 REM

Reference: CPS Emergency Plan, Section 4.3.1.2, page 4-10

7.12

1.	Drywell Pressure > 1.68 psig	(+-0 psig)	
2.	Drywell Temperature > 135 deg F	(+0 deg)	
3.	Suppression Pool Temperature > 95 deg F	(+-0 deg)	
4.	Suppression Pool Level > 19 ft 5 inches	(+-0 ft)	
5.	Suppression Pool Level < 18 ft 11 inches	(+-0 ft)	
6.	Containment Temperature > 120 deg F	(+-0 deg)	(5 @ 0.5 each)

Reference: CPS 4402.01

7.13 1. Place the Mode Switch in Shutdown (only 0.25 credit for scram the Reactor)

2. Close all Group 1 Isolation Valves

Reference: 4100.01

7.14 a. Reactor water level is unknown or cannot be determined to be above TAF and H_2 concentration is less than 6% and O_2 concentration is less than 5%.

b. Drywell or containment H_2 concentration is greater than 1% and less than 6% and oxygen concentration is less than 5%.

c. Containment H_2 concentration is greater than 1% and containment H_2 concentration is less than 6% or containment O_2 concentration is less than 5%.

Reference: CPS License Review Manual, Combustible Gas Control System

7.15 a. When both pumps are declared inoperable (0.25) or ~~low accumulator pressure for a withdrawn alarms begin appearing~~ more than one accumulator and one of the rods associated with that group accumulator is withdrawn (0.5)

b. Place the Mode Switch in Shutdown (0.35 for Scram the Reactor) ~~and verify appropriate auto actions have occurred~~. (0.5)

Reference: 4100.01

7.16 Due to the excess delta pressure developed across the Startup Level Control Valve level instabilities may result. minimum thermal shock to FW nozzles

Reference: Feedwater Control System Lesson Plan

7.17 False or True.

Reference: 3304.02

7.18. 1. Verify the Standby Pump Starts

2. Isolate the Fuel Pool Heat Exchanger (0.25) ~~(CCW side also) (0.25)~~ or transfer to SX cooling

3. ~~Isolate RWCU (0.25) (CCW side also)~~ (0.25) Place additional RCW pumps & Heat Exchangers in service verify system lineup.

4. ~~Monitor Reactor Recirculation Systems~~ (0.5 each)

Reference: 3203.01

(*** END OF SECTION 7 ***)

ANSWER KEY
SECTION 8

8.1 c

Reference: TS definition, page 1-1

8.2 4 months

Reference: 10 CFR 55.31e

8.3 1. All rods fully inserted except for the single control rod of highest reactivity worth which is assumed to be fully withdrawn

2. Cold (68 deg. F)

3. Xenon free (0.5 each)

Reference: TS Definition, page 1-7

8.4 1. Reactor Water Level maintained > TAF.

2. Core being sprayed by HPCS.

3. Core being sprayed by LPCS.

4. Reflooding flow of 1 LPCI pump injecting into the core with reactor water level high enough to produce 2-phase flow through the core.

5. Steam flow of (later) through the core. (4 @ 0.5 each)

Reference: CPS No. 4401.01

8.5 a. YES (0.5) TS 3.0.4 does not preclude a mode shift since no Action Requirements are, or will, be relied on immediately upon shifting into Operational Condition 1. (EOC-RPT is not applicable until Rated Thermal Power is >- 40%) (0.5) (1.0)

b. Void reactivity feedback due to a pressurization transient (0.5) could add positive reactivity at a faster rate than the Control Rods can add negative reactivity late in core life. (1.0)

Reference: TS 3/4.3.4.2, 3.04

8.6 a

Reference: TS 3/4.5.1 and 3/4.5.2

8.7 a. PRESSURE BOUNDARY LEAKRATE - Not Exceeded
UNIDENTIFIED LEAKAGE (5 GPM) - Not Exceeded
TOTAL LEAKAGE (~~30~~ GPM) 25 gpm - ~~Not~~ Exceeded
UNIDENTIFIED LEAKAGE (2 GPM INCREASE) - Exceeded (0.5 each)
(0400-0800) 0.1- ID
0.4- Eval)

b. Pressure Boundary Leakage shall be leakage through a nonisolable fault (0.5) in a reactor coolant system component body, pipe wall, or vessel wall. (0.5) (1.0)

Reference: TS 3.4.3.2

8.8 1. One rod out (all rods in)

2. Refuel platform Position

3. Refuel Platform Main Hoist Fuel-loaded

4. Service Platform hoist ~~Unl~~ - loaded

Reference: TS 3/4.9.1

8.9 a

Reference: TS 3/4.9.10

8.10 c

Reference: TS 3.2.3

8.11 b

Reference: TS 3.04., 3.6.7

8.12 Because the dissolved oxygen content of the reactor coolant is typically higher during low steaming rates (e.g., Startup or Hot Standby).

Reference: TS 3.4.4

8.13 The following checks should be made:

- ~~Breaker charging springs charged.~~ Physical Position Flag shows spring charged (0.5)
- ~~Charging motor disconnect switch on.~~ ~~Toggle switch on~~ (0.5)
- ~~Control power on.~~ Power fuses installed (0.5)

Reference: CAF (Check at Facility)
1405.01 Step 8.2.7.

8.14 a

Reference: TS 3.2.2

8.15

a.	1	f.	1
b.	1	g.	0 (n/a)
c.	2	h.	1
d.	2	i.	1
e.	1	j.	0 (n/a)

(0.2 each)

Reference: TS Table 6.2.2-1

8.16 a. SJAE

b. 10,000 microcuries/sec - OR - 15%

c. one hour

d. less - OR - greater

e. 75,000 microcuries/sec

NOTE: Answers to b and d must agree for full credit

Reference: TS 3.4.5.c

8.17 a. Shift/Assistant Shift Supervisor

b. ~~Initials, Date~~, time, Dosimeter Reading IN
Dose on left

Reference: CPS 1905.10

(*** END OF SECTION 8 ***)