U.S. NUCLEAR REGULATORY COMMISSION

REGION III

Report No. 50-341/OL-88-01

Docket No. 50-341 License No. NPF-43

Licensee: The Detroit Edison Company
6400 North Dixie Highway
Newport, MI 48166

Facility Name: Fermi 2 Nuclear Plant

Examination Administered At: Fermi 2 Nuclear Plant, Michigan

Examination Conducted: August 2, 1988

Chief Examiner: G. M. Nejfelt
G. M. Nejfelt, Principal Examiner, Operator Licensing Section No. 1

August 31, 1988
Date

Approved By: M J Jordan
Michael Jordan, Chief
Operator Licensing Section No. 1

8/31/88
Date

Examination Summary

Examination administered on August 2, 1988 (Report No 50-341/OL-88-01)
One written examination was given to a reactor operator (RO) candidate as a retake.
Results: The candidate successfully passed this examination.

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REPORT DETAILS

1. Examiners

   G. Nejfelt, Chief Examiner

2. Exit Meeting

   At the conclusion of the site visit, the examiner met with facility training staff. The following personnel attended this exit meeting.

   Facility Representatives

   G. R. Overbeck, Director, Nuclear Training
   R. W. Bovinet, Work Leader, Operator Training Program

   NRC Representative

   G. M. Nejfelt, Chief Examiner

   The following items are discussed during the exit meeting on August 3, 1988:

   a. Timely submission of examination comments from the facility training staff. These comments were received in the Regional Office on August 19, 1988.

   b. Materials that were prepared for the tentatively scheduled Requalification Examinations starting the week of October 31, 1988 were discussed. Most of the written examination questions were found to be satisfactory, except for static simulator questions that could be answered without the use of the simulator. No Job Performance Measures (JPMs) were available for review.

3. Examination Review

   Responses to licensee's comments, concerning the written RO examination, are provided in Attachment 1. Minor changes made without facility comments by the examiner are provided in Attachment 2. Also, note that six comments were made concerning the examination materials provided (see Attachment 1 NRC Response to Questions 2.06.a, 2.07, 2.10.a, 3.02, 3.10, and 4.03).

Attachments:
1. RO Examination Comments and Resolutions
2. RO Answer Key Modification Without Facility Comment

ATTACHMENT 1

REACTOR OPERATOR (RO)

EXAMINATION COMMENTS AND RESOLUTIONS

FERMI 2 RO EXAMINATION OF AUGUST 2, 1988

The following represents the facility comments and the NRC resolution to those comments made as a result of the current examination review policy.

1.05.c

Facility Comment: Comment answer for Part (c) is 518 seconds . . . a math error was made in the answer key.

NRC Resolution: Comment is accepted. The answer key is changed from "318 seconds" to "518 seconds" to correct the typographical error.

2.01

Facility Comment: Correct answer for Part (c) of 2.01 should be 1153 +0/-20 psig and 441 +20/-0 psig. This licensing class was taught allowable values as listed in Technical Specifications.

References:
- Reactor Recirculation System Handout, Page 18
- Fermi 2 Technical Specification (TS), Section 3.3.3
- Fermi 2 TS, Section 3.3.4
- Pump Trip System Instrumentation

NRC Resolution: Comment is accepted, since the allowable maximum value agrees with the setpoint value and is more conservative than the setpoint value. The setpoint valves of 1133 psig and 441 have been changed to the allowable values and tolerances provided above.

2.02.a

Facility Comment: In Part (a), the answer states that the backup air supply for the inboard main steam isolation valves (MSIVs) and the normal air supply for the outboard MISVs is instrument [illegible] This answer could be misleading. The term used at [illegible] for this instrument air is called Control Air. Specifically, INTERRUPTIBLE CONTROL AIR (IAS).

References:
Student Handout, Main Steam System and Bypass System, Page 14.
Drawing 6m721-5730-5.

NRC Resolution: Comment is accepted. The use of the alternate names for instrument air (e.g., control air and Interruptible Control Air) are in addition to the answer as acceptable alternate wording.

2.02.b

Facility Comment: Part (b) answer should be "130 VDC and 120 VAC (RPS M-G Set)."

Reference:
Student Handout, Main Steam System and Bypass System, Page 14.

NRC Resolution: Comment is accepted. Typographical error is changed from "125 VDC . . ." to "130 VDC . . ."

2.02.d

Facility Comment: In Answer (d), the statement is made that the isolation will not reset. Assuming the isolation signal itself is clear pushing the RESET pushbutton without first pushing the close pushbuttons on the MISVs will cause the MISVs to open.

References:
Student Handout, Main Steam and Bypass, Page 14.
LER 50-341/87-037.
6I721-2095-14, 15, 17, and 18.

NRC Resolution: Comment is accepted, only if, the candidate stated that the solenoids for the MISV were deenergized and reenergized in an unorthodox manner (e.g., LER 50-341/87-037).

2.06.a

Facility Comment: On Part (a), the answer key should be changed to accept the power supplies to the RPS M-G Sets as correct actions for normal supplies. These would be:

1. DIV I (RPS M-G Set A) - 480 VAC Motor Control Center (MCC) 72B-4C Pos.
2. DIV II (RPS M-G Set B) - 480 VAC MCC 72E-5B Pos 1C-R.

References:
Nuc. Prod. Sys. Operati Proc. 23.316, Pages 8 and 9.
DECo Drawings 6I721-2151-1 and 2.

NRC Resolution: Comment is accepted for both the primary and alternate RPS power supplies, if the candidate's answer is in the same detail. Student Handout, RPS, PIC-C71, Revision 3, Page 4, substantiate the answer key as originally written.

2.06.b

Facility Comment: Part b should have four answers:

1. Process Radiation Monitoring System.
2. Power Range Monitoring System.
3. Nuclear Steam Supply Shutoff System.
4. Reactor Protection System.

Reference:
DECo Drawing 6I721-2151-1 and 2.

NRC Resolution: Comment is not accepted. The question asked for systems that received power from RPS. Also, if schematics are provided as supporting material, please ensure that the information is large enough and clear enough to be used without a tedious effort to extract the information.

2.07

Facility Comment: Using the reference given on Pages 8 and 14, there is no mention of High Reactor Pressure causing a Standby Gas Treatment (SBGT) System auto start. There is a misprint on Page 14 that may lead one to believe Part (a), High Radiation (ARM) on the Refuel floor, may be a correct response. 4.a.4 on Page 14 should be Fuel Pool Ventilation Exhaust Radiation High as shown by Page 8 of the SBGT system, Student Handout and Alarm Response Procedure 17D14. Therefore, the answer key should read:

will: b, g

will not: a, c, d, e, f, h

References:
Standby Gas Treatment System Student Handout, Pages 8 and 14.
Alarm Response Procedure 17D14.

NRC Resolution: Comment is accepted and the answer key modified as above. Revision of Student Handout, SBGT, T46-00, Revision 4, Page 14, is needed.

2.08

Facility Comment: Even though not listed in the given reference, the word chugging is often used to describe the condition of injecting the boron too fast. So an alternative phrase at the end of the answer would also be: Could Cause Power Chugging.

NRC Resolution: Comment is accepted. The word "chugging" is added to the answer key as an alternative wording.

2.10.a

Facility Comment: To be consistent with Question 2.01, the answer for (a) should be 441 +20/-0 psig.

NRC Resolution: Comment is accepted. The answer key is changed to the allowable value and tolerances provided above.

Note that the asterisk used in Table 4 of Student Handout, RHR, Revision 4, Page 48 is not defined.

2.10.c

Facility Comment: Part (c) should read:

F015A/B: Remove initiation signal and push Initiation Signal Reset Push Button and Leak Detection Line Break Push Button.

F017A/B: Five minutes after initiation signal is received.

Reference:
HRH Student Handout, Pages 32, 33, and 48.

NRC Resolution: Comments is not accepted. References did not support revising answer key.

2.10.d

Facility Comment: Part (d) should be changed to read:

F017A/B can be closed (throttled) to control injection flow (Reactor Level).

This is because the push button for closure of the valve (F017A/B) will allow full closure if pushed long enough. Also, the way the question is worded (close inhibit) would lead one to think along the lines of open/close not throttled.

References:
RHR Student Handout, Pages 32, 33, and 48.
Fermi 2 Technical Specification 3.3.3 Table 3.3.3-2.

NRC Resolution: Comment does not warrant changing answer key, since "throttling" can be considered synonymous with "closing" for this question.

3.02

Facility Comment: Using the Student Handout on RWM referenced, Fermi 2 Technical Specifications and Proposed Design Change (PDC) 7030 it is possible to answer Part "a" several different ways. The first way would be a word definition as stated in the answer key. The other way would be with specific numbers. Per the Student Text and Fermi 2 Technical Specification the MINIMUM allowable reset power level is 20% for the LPSP. The actual per PDC 7030 is 30%. the LPAP per the Student Handout is 35%. But per PDC 7030, the actual value set in the Control Room is 40%. Therefore, a suggested addition to the provided answer would be:

a. (1) . . . similar. Also accept 25 ± 5%.
b. (2) . . . similar. Also accept 35% to 40%.

References:
Rod Worth Minimizer Student Handout, Page 4.
Fermi 2 Technical Specifications 3.1.4.1 Rod Worth Minimizer
Proposed Design Change (PDC) 7030, Revision B.

NRC Resolution: Comment is partially accepted. The question elicited more than a numerical values for Low Power Point (LPSP) and Low Power Alarm Point (LPAP). Partial credit will be given for range of values stated above.

Training material is needed to be revised with plant changes.

3.04.c

Facility Comment: Using the referenced Automatic Depressurization System Handout, Figure 2 and Detroit Edison Drawings 6I721-2095-02 and 07 the correct answer for "c" should be ADS valves remain as is. The reason is that BOTH Core Spray Pumps in Division II must be running to satisfy the ADS logic.

Reference:
Automatic Depressurization Handout, Pages 7, 8, and Figure 2.
Detroit Edison Drawings 6I721-2095-02 and 07.

NRC Resolution: Comment is not accepted. With no 130 VDC, the solenoids for ADS valves will deenergize and close valves (e.g., remove fuses to shut stuck open SRV).

3.08

Facility Comment: Using the Power Range Monitor and Technical Specification reference plus Technical Specification Page 3/4 3-45 there are three parts of the answer that needs to be expounded.

1. For the information provided, Answer "c" could be YES or NO. True eight inops LPRM inputs to CHANNEL D APRM sill leave it with 14 operable inputs (minimum required to be operable). The questions of how many operable LPRM inputs per level is not addressed. Therefore since eight LPRM's are inop, it could be assumed there are < 2 operable per level which would make that ARPM inop per Technical Specification.

Regarding Answers "b" and "f." Technical Specifications Page 3/4 3-44 lists the allowable value of Reactor Coolant System Recirculation Flow Comparator as $\leq$ 11% flow deviation. Which is what the Student Handout on Power Range Monitor Page 13 used. The $\leq$ means that value has been set at or below this value per Tech Specs. So if the actuation is set at 11% (the Tech Spec allowable value class was instructed to memorize), there would not be a rod block flow reference off normal. Therefore Answers 6 and 7 could be NO.

References:
Power Range Monitor Student Handout Page 13
Technical Specification Pages 3/4 3-5 and 3/4 3-44.

NRC Resolution: For Item "c," your comment is accepted. Part "c" is deleted because of the question ambiguity; and the question point value is reduced from 3.00 points to 2.50 points.

For Items "b" and "f" your comment is not accepted. As stated above, the greater than or equal to 11% difference is signal between Flow Unit "A" and Flow Unit "B" was memorized by the licensing class. Unless the candidate clearly stated or assumed flow deviation less than 11%, no change to the answer key is made.

3.10

Facility Comment: Per the Recirculation Flow Control System Pages 10, 11, and 12, there are three flow limiters. No. 1 limiter first in line before the individual pump controller and Limiter 2 and 3 are after the Error Limiting Network and Individual Speed Controllers.

Their setpoints per Proposed Design Change 8294 are:

Limiter No. 1 - 30%
Limiter No. 2 - 42%
Limiter No. 3 - 48%

The individual pump controllers do not have any limits on them. The limiters are separate units. So Answer "a" should be as above. Also, Answer "b" for limiter No. 1 should be . . . not fully open OR feedwater . . . .

References:
Recirculation Flow Control Student Handout, Pages 10 through 12.
Detroit Edison Drawing 6I721-2105-7.
Proposed Design Change 8294.

NRC Resolution: For Part (a), comment is accepted. The answer key is revised to change the setpoint values and to added Limiter No. 3 based on Potential Design Change (PDC) No. 8294 that superseded Student Hardout, Recirculation Flow Control System (B31), Revision 4, which was used to prepare the question. Also, the point value for Part (a) was reduced from 1.00 point to 0.75 point with each limiter setpoint with 0.25 point.

For Part (b), comment is accepted based upon Schematic Drawing, 6I721-2105-7, Revision C1; and the answer key is changed from ". . . and . . ." to ". . . or . . ." with either answer worth 1.00 point. Student Handout Recirculation Flow Control System (B31), Revision 4, Section D.4.a(a) is in error.

3.11

Facility Comment: Using the Rod Sequence Control System Student Handout Pages 4 and 6. The answer in "2" would more correctly be: "Neither Sequence Groups B 1-2 and B 3-4 Control Rods are fully out, and."

The answer is more complete because it recognizes that A and B Sequences are broken into Groups A 1-2, A 3-4, B 1-2, and B 3-4 on the Rod Sequence Select Switch.

Reference:
Rod Sequence Control System Student Handout, Pages 4 and 6.

NRC Resolution: Comment is not accepted because it is moot. Nothing is gained by specifying the subgroups for the "A" and "B" Rod Control Sequence Groups.

4.01

Facility Comment: The answer in the above question was not specific. Therefore, answers should also include:

1. During plant startup (when RHR shutdown cooling is secured).
2. During plant shutdown (prior to RHR shutdown cooling being started).
3. During a loss of RHR shutdown (when RHR is not able to be restored)

References:

General Operating Procedures 22.000.03, Page 9 and 22.000.10, Page 11.
Abnormal Operating Procedures 20.205.01, Page 1.

NRC Resolution: Comment is accepted. The question could be construed for plant situations when operation of recirculation pumps may be required to operate. The answer and key point distribution are revised to read:

1. Preventing temperature stratification or in the Reactor Vessel (0.50).

2. Retaining solids in suspension until they can be removed (by the RWCU System to prevent their deposition in the bottom of the Reactor Vessel of the CRD mechanisms) (0.50).

3. During plant startup (0.25), when RHR shutdown cooling is secured (0.25).

4. During plant shutdown (0.25), prior to RHR shutdown cooling being started (0.25).

5. During a loss of RHR shutdown cooling (when RHR cannot be restored) (0.50).

(Note: Only two of the items above are required for full credit.)

4.03

Facility Comment: Although not listed as an indication in Section 3.0 of AOP 20.106.04, there is another indication listed in Step 2.1.1. This step has the operator check LRPM (POWER) as the Rod is moved to verify the rod is recoupled. This method could also be used prior to the rod reaching Position 48 by looking for no LPRM change during rod movement.

Reference:
AOP 20.106-04, Page 3.

NRC Resolution: Comment is partially accepted. POM 20.106.104, Revision 4, Section 2.1.1 must include the condition of Section 2.1.2. Therefore, the answer key is revised to read:

"4. Observe a response to the rod movement through Nuclear Instrumentation (NI) response (0.25).
and
Demonstrates that the Control Rod will not go to the withdraw overtravel position (0.25).
(Any three of the above for full credit)."

Note: Use of the NI response as an indication should be added to Section 3.0 of POM 20.106.04.

4.11

Facility Comment: Using the reference (AOP 20.710.01 Pages 1 and 2) the answer key should be expanded to include:

If Reactor Building Vent Exhaust Radiation Monitor upscale trip occur, verify the following automatic action occur:

1. Reactor Building Ventilation System tripped.

2. Reactor Building Divisions I and II Supply and Exhaust isolation valves close.

3. Pri Containment Purge and Vent Valves close.

4. SBGT System Auto Starts.

5. CCHVAC System aligns to Emergency Recirculation Mode.

Notify the NSS of the event, actions taken, and that it may be required to classify the event in accordance with Emergency Plan Implementing Procedure EP 101, "Classification of Emergencies."

Reference:
AOP 20.710.01 Refueling Floor High Radiation, Revision 5, Pages 1 and 2.

NRC Resolution: Comment is partially accepted. The notification of the Nuclear Shift Supervisor (NSS) is added to the answer key as an alternative answer. However, the question asked for immediate operator actions for the "Refueling Flow High Radiation alarm." Therefore no credit is given for the "Reactor Building Vent Exhaust Rod Monitor" upscale trip immediate operator actions.

4.13

Facility Comment: Per Tech Spec 1.36, Page 1-6 O-Rings, Bellows, and Welds should be acceptable for "Sealing Mechanism."

Reference:
Tech Spec 1.36, Page 1-6.

NRC Resolution: Comment is acceptable. Answer key Item 5 is revised with these examples to read:

"5. The sealing mechanism associated with each secondary containment penetration (e.g., welds, bellows, or O-rings) is operable."

ATTACHMENT 2

FERMI 2

REACTOR OPERATOR EXAMINATION

AUGUST 2, 1988

- CHANGES MADE TO ANSWER KEY WITHOUT PROMPTING FROM FACILITY -

Question Number	Comment
1.11	Answer key asterisk at point (0, 1) is deleted, as a typographical error. Also, the range for the allowable value on the x-axis is increased from "34-36" to "32-38," because the graphical accuracy intended would not be achieved without the use of graph paper and straight edge ruler.
1.12	Point value for Question 1.12 was erroneous given as "2.00 points." The point value for this question has been changed to "1.50 points" to agree with the answer key.
1.13	Point values redistributed between Parts (a) and (b) to reflect effort needed in response. Part (a) value was changed from "1.00 point" to "1.50 points" and Part (b) value was changed for "1.00 point" to "0.50 point."

ENCLOSURE (2)

U. S. NUCLEAR REGULATORY COMMISSION
REACTOR OPERATOR LICENSE EXAMINATION

FACILITY:	FERMI 2
REACTOR TYPE:	BWR-GE4
DATE ADMINSTERED:	88/08/02
EXAMINER:	E. A. HARE
CANDIDATE	

INSTRUCTIONS TO CANDIDATE:

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

CATEGORY VALUE	% OF TOTAL	CANDIDATE'S SCORE	% OF CATEGORY VALUE		CATEGORY
25.48 ~~25.00~~	~~25.75~~ ~~25.86~~ 25.88			1.	PRINCIPLES OF NUCLEAR POWER PLANT OPERATION, THERMODYNAMICS, HEAT TRANSFER AND FLUID FLOW
24.50 ~~25.00~~	~~24.88~~ ~~25.26~~ ~~24.88~~			2.	PLANT DESIGN INCLUDING SAFETY AND EMERGENCY SYSTEMS
~~23.99~~ ~~24.49~~ ~~24.99~~ 24.24	~~24.36~~ ~~24.27~~ 24.55 ~~24.87~~ ~~24.75~~			3.	INSTRUMENTS AND CONTROLS
24.50	~~24.29~~ ~~24.38~~ 24.12			4.	PROCEDURES - NORMAL, ABNORMAL, EMERGENCY AND RADIOLOGICAL CONTROL
~~98.47~~ ~~98.97~~ ~~100.0~~ 98.72		Final Grade	%		Totals

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

Candidate's Signature

MASTER COPY

NRC RULES AND GUIDELINES FOR LICENSE EXAMINATIONS

During the administration of this examination the following rules apply:

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

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

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

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

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

6. Use only the paper provided for answers.

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

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

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

10. Skip at least three lines between each answer.

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

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

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

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

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

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

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

18. When you complete your examination, you shall:

a. Assemble your examination as follows:

(1) Exam questions on top.

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

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

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

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

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

QUESTION 1.01 (1.50)

Increasing recirculation pump speed will cause WHAT change (INCREASE, DECREASE, or REMAIN THE SAME) in each of the following parameters? (Assume normal operating conditions) (1.5)

a. actual bundle power

b. critical power

c. critical power ratio

QUESTION 1.02 (1.98)

Match each of the power distribution limits [1, 2, & 3] with its associated FAILURE MECHANISM in Column A and its associated LIMITING CONDITION in Column B. (2.0)

1. Linear Heat Generation Rate (LHGR)

2. Average Planer Linear Heat Generation Rate (APLHGR)

3. Minimum Critical Power Ratio (MCPR)

Column A FAILURE MECHANISM	Column B LIMITING CONDITION
A1. FUEL CLAD CRACKING DUE TO LACK OF COOLING	B1. 1% PLASTIC STRAIN
A2. FUEL CLAD CRACKING DUE TO HIGH STRESS FROM PELLET EXPANSION	B2. PREVENT TRANSITION BOILING
A3. GROSS CLAD FAILURE DUE TO DECAY HEAT AND STORED HEAT FOLLOWING A LOCA	B3. LIMIT CLAD TEMP TO 2200 F

QUESTION 1.03 (1.00)

Using the steam tables, calculate a reactor cooldown rate (F/hr) for a reactor pressure decrease from 1000 psig to 250 psig in one hour and forty five minutes (105 minutes total) SHOW ALL WORK for full credit.

(***** CATEGORY 1 CONTINUED ON NEXT PAGE *****)

QUESTION 1.04 (2.50)

For each of the following events, state which COEFFICIENT of reactivity (fuel temperature, moderator temperature, void) would act FIRST to change reactivity.

a. Control rod drop at power (0.5)

b. SRV opening at power (0.5)

c. Loss of shutdown cooling when shutdown (0.5)

d. One recirc pump trips while at 50% power (0.5)

e. Loss of one feedwater heater at 100% power (extraction steam isolated) (0.5)

QUESTION 1.05 (2.50)

~~The reactor is brought critical at 40% on IRM range 2 with the shortest permissible stable positive period allowed by GOP 22.000.03 "Startup From Cold Shutdown to Rated Power". Reactor power is determined to be 40% on range 8 of IRM's.~~ SHOW ALL WORK.

Answer each of the following questions, concerning reactor period

a. What is the shortest permissible stable reactor period, as stated in the caution of POM 22.000.03, STARTUP FROM COLD SHUTDOWN TO RATED POWER? (0.5)

b. What is the doubling time for a constant reactor period of 2 minutes? (0.5).

c. How long will it take for power to reach the point of adding heat (i.e., 40% on Range 8 of IRMs) if a period of 75 seconds is maintained with reactor power initially determined to be 40% on Range 2 of IRMs. (1.5)

QUESTION 1.06 (2.00)

ANSWER each of the following questions given that the reactor is at 100% power and 1000 psig, when a relief valve inadvertently opens.

a. STATE the tailpipe temperature, assuming atmospheric pressure in the Suppression Pool and No Reactor Depressurization (0.5)

b. If the Suppression Pool Pressure were to INCREASE, STATE whether the Tailpipe Temperature would INCREASE, DECREASE, or REMAIN THE SAME. (0.5)

c. If the reactor starts to depressurize when the valve is opened, STATE whether the Tailpipe Temperature will INITIALLY INCREASE, DECREASE, or REMAIN THE SAME. (0.5)

d. STATE the Reactor Pressure at which the Tailpipe Temperature would be at its MAXIMUM value (during the depressurization). (0.5)

(ASSUME A SATURATED SYSTEM AND INSTANTANEOUS HEAT TRANSFER)

QUESTION 1.07 (1.00)

The reactor trips from full power, equilibrium XENON conditions. Twenty-four (24) hours later the reactor is brought critical and power level is maintained on range 5 of the IRMs for several hours. Which of the following statements is CORRECT. (1.0)

a. Rods will have to be withdrawn due to XENON build-in.

b. Rods will have to be rapidly inserted since the critical reactor will cause a high rate of XENON burnout.

c. Rods will have to be inserted since XENON will closely follows its normal decay rate.

d. Rods will approximately remain as is as the XENON establishes its equilibrium value for this power level.

QUESTION 1.08 (2.00)

Answer each of the following questions either TRUE or FALSE

A reactor heat balance was manually calculated during the midnight to 8 a.m. shift, because the Process Computer was inoperable. The gain adjustment factors were computed, but the APRM gain adjustments have not been made.

a. If the feedwater flow rate used in the heat balance calculation was LOWER than the actual feedwater flow rate, then the actual power is HIGHER than the currently calculated power. (0.5)

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. (0.5)

c. If the steam flow used in the heat balance calculation was LOWER than the actual steam flow, then the actual power is LOWER than the currently calculated power. (0.5)

d. If the RWCU return temperature used in the heat balance calculation was LOWER than the actual RWCU return temperature, then the actual power is HIGHER than the currently calculated power. (0.5)

QUESTION 1.09 (2.00)

Concerning the Net Positive Suction Head (NPSH):

a. DEFINE NPSH

b. For each of the following, INDICATE whether the available NPSH at the suction of the recirculation pump would INCREASE/DECREASE/REMAIN THE SAME: (1.5)

(1) The Feedwater Flow is INCREASED

(2) The Recirculation Flow is INCREASED

(3) The Vessel Pressure is INCREASED from 200 psig to 800 psig

(***** CATEGORY 1 CONTINUED ON NEXT PAGE *****)

QUESTION 1.10 (1.00)

SELECT the answer below that would typically coincide with the MAXIMUM Control Rod Worth, during a reactor startup (1.0)

a. Cold Shutdown prior to the startup

b. Heatup in Progress (approximately 1% Reactor Thermal Power (RTP))

c. Heatup Complete (approximately 1% RTP)

d. 50% RTP

e. 100% RTP

QUESTION 1.11 (2.00)

USE the 1/M plot and PREDICT the number of control rods required to be withdrawn to achieve criticality. *PLOT each data point given below on graph*

NOTES: 1. CR = Count Rate
2. USE THE FIGURE BELOW TO SKETCH YOUR SOLUTION

Each CR reading is recorded following a 5 rod withdrawal with CRD representing 100% rod density.

Number of Control Rods Withdrawn	Count Rate
0	40
5	50
10	89
15	129
20	191
25	333
30	800

```
           5    10    15    20    25    30    35    40    45    50    55
  1.0|----|----|----|----|----|----|----|----|----|----|----|---|1.0
     -                                                          -
  0.9-                                                          -0.9
     -                                                          -
  0.8-                                                          -0.8
     -                                                          -
  0.7-                                                          -0.7
     -                                                          -
1/M 0.6-                                                        -0.6
     -                                                          -
  0.5-                                                          -0.5
     -                                                          -
  0.4-                                                          -0.4
     -                                                          -
  0.3-                                                          -0.3
     -                                                          -
  0.2-                                                          -0.2
     -                                                          -
  0.1-                                                          -0.1
     -                                                          -
  0.0|----|----|----|----|----|----|----|----|----|----|----|---|
     0    5    10    15    20    25    30    35    40    45    50    55

                      Control Rods Withdrawn
```

QUESTION 1.12 (~~1.00~~) 1.50

An increase in void content in an operating reactor causes a negative reactivity insertion. DESCRIBE THREE (3) effects which cause the void reactivity coefficient (alpha-v) to be negative.

QUESTION 1.13 (2.00)

Concerning the effects of Control Rods on reactor power:

a. EXPLAIN how a control rod withdrawal at certain power levels could result in a reactor power decrease (reverse power effect). (1.5) ~~(1.0)~~

b. Which one of the following would be the rod movement sequence most likely to cause the reverse power effect? (0.5) ~~(1.0)~~

(1) Deep Rod - 10 notch movement

(2) Deep Rod - 1 or 2 notch movement

(3) Shallow Rod - 10 notch movement

(4) Shallow Rod - 1 or 2 notch movement

QUESTION 1.14 (1.00)

MULTIPLE CHOICE (Select the ONE correct answer.)

The Doppler Coefficient of Reactivity correlates the change in fuel temperature to a reactivity insertion.

Which statement is TRUE concerning Doppler Coefficient?

a. The coefficient becomes less negative with fuel burnup, and more negative with control rod withdrawal.

b. The coefficient becomes more negative with fuel temperature increase and less negative with void fraction increase.

c. The coefficient becomes less negative with control rod withdrawal, and more negative with fuel temperature increase.

d. The coefficient becomes more negative with void fraction increase and less negative with fuel temperature increase.

QUESTION 1.15 (1.50)

Suppose Beff over core life decrease from 0.0072 to 0.0055. With equal insertions of 0.001 dK/K of positive reactivity:

a. Calculate the change in the reactor period over core life. (1.0)

b. What is the cause for this change in Beff? (5.0)

(***** END OF CATEGORY 1 *****)

QUESTION 2.01 (~~2.50~~) 2.0

a. What will cause an RECIRC SYS A (B) STARTUP SEQUENCE INCOMPLETE annunicator when starting a recirculation pump? (~~1.0~~) 0.5

b. What automatic action occurs, if an incomplete start sequence is detected? (0.5)

c. Describe any automatic actions that occur in the recirculation system as a result of REACTOR PRESSURE. INCLUDE SETFOINTS/SEQUENCES AS APPLICABLE. (1.0)

QUESTION 2.02 (3.00)

Answer the following questions concerning the Main Steam Isolation Valves (MSIV)

a. State the applicable NORMAL and BACKUP pneumatic supplies to the Inboard MSIVs and to the Outboard MSIVs. (1.0)

b. What provides the power for the MSIV normal operating solenoids and logics? (1.0)

c. How does the loss of power to one of the MSIV solenoids affect opening and closing ability of that MSIV? (0.5)

d. An MSIV isolation (Group I) has occurred. The operator attempts to reset the isolation without depressing the MSIV close pushbuttons. Does the isolation reset, and if so, what happens to the MSIVs? (0.5)

QUESTION 2.03 (2.00)

Describe the feature(s) of the Safety/Relief Valves (SRV) that results in increasing the amount of energy released per SRV opening. (2.0)

QUESTION 2.04 (2.00)

a. The RCIC system has received a valid initiation signal and is ramping up in speed when the RCIC oil pump fails. HOW will the turbine respond (assuming the turbine does not trip on low oil pressure) and WHY? (1.0)

b. The HPCI system has received a valid initiation signal and its auxiliary oil pump fails to start. HOW will the turbine respond and WHY? (1.0)

QUESTION 2.05 (2.50)

The Control Rod Drive Hydraulic System interfaces with (interacts with) several in-plant systems/equipment. EXPLAIN the interaction with each of the following systems.

a. Control Air System

b. Reactor Building Closed Cooling Water

c. Recirculation Pumps

d. Reactor Protection System

e. Reactor Manual Control System

QUESTION 2.06 (2.50)

Answer each of the following questions concerning the Reactor Protection System (RPS)

a. STATE the normal and alternate power supplies to RPS (1.0)

b. List three (3) systems that receive electrical power from RPS (1.5)

(***** CATEGORY 2 CONTINUED ON NEXT PAGE *****)

QUESTION 2.07 (2.00)

State whether the following conditions or signals WILL or WILL NOT cause initiation of the Standby Gas Treatment System (SBGT) system: (2.0)

NOTE: Do not consider setpoints. If the indicated parameters will initiate the system, assume the setpoint has been reached.

a. High radiation (ARM) on the Refuel Floor

b. High radiation in the reactor building ventilation exhaust

c. High particulate activity in the drywell

d. Low flow in the offgas system

e. High reactor pressure

f. Low RPV pressure

g. Low RPV water level

h. Main Steam Line high radiation

QUESTION 2.08 (2.00)

The Standby Liquid Control System (SLC) injects sodium pentaborate solution into the reactor coolant. The pumps are designed to limit the boron injection rate. WHY (i.e. what is the basis) are there limits at which the solution must be injected (both upper and lower limits must be discussed for full credit)? (2.0)

QUESTION 2.09 (2.00)

a. What is the purpose of the Rod Block Monitoring System? (1.0)

b. The RBM gain change is done so that the RBM output will be equal to or greater than the reference APRM output. WHAT is the reason for changing the gain? (1.0)

QUESTION 2.10 (2.50)

In regards to the RHR loop injection valves, F015A/B and F017A/B:

a. WHAT interlock must be satisfied to open BOTH injection valves in a loop? (0.5)

b. WHAT is the purpose of this opening interlock? (0.5)

c. Following an automatic initiation, WHAT INTERLOCK(S) must be satisfied to close each of these valves? (1.0)

d. WHAT function is allowed after satisfying the close inhibit interlock(s)? (0.5)

QUESTION 2.11 (2.00)

Concerning the RWCU System:

a. LIST four (4) conditions that will automatically isolate the RWCU system. (SETPOINTS NOT REQUIRED) (1.0)

b. During startup, while blowing down the reactor, the rate of blowdown is limited. What limits the rate of blowdown and what is the reason for this limit. (1.0)

(***** END OF CATEGORY 2 *****)

QUESTION 3.01 (2.00)

State whether each of the following parameters directly initiates a scram, rod block, both, or neither. Setpoints are not required. (2.0)

a. Main steam line radiation
b. Neutron flux
c. Reactor vessel high level
d. Recirculation flow

QUESTION 3.02 (2.50)

Answer each of the following questions concerning the Rod Worth Minimizer (RWM) system

a. DEFINE or DESCRIBE (1.0)

(1) Low Power Set Point (LPSP)

(2) Low Power Alarm Point (LPAP)

b. Reactor power is 17% and the RWM is operable.

(1) How many withdraw errors will the RWM allow? (0.5)

(2) How many insert errors will the RWM allow? (0.5)

(3) What restrictions are imposed on rod movement if the allowable number of errors is exceeded? (0.5)

(***** CATEGORY 3 CONTINUED ON NEXT PAGE *****)

QUESTION 3.03 (3.99)

Assume the feedwater level control system is being operated in 3-element control using reactor level detector channel "A". Reactor power is at 85%, steady state. For each of the instrument or control signal failures listed below, state how reactor level will initially respond (increase, decrease, or remain constant) and briefly explain why, in terms of what is happening in the Level Control System and Feedwater System immediately following the failure. No SCRAM occurs.

NOTE: A block diagram of the feedwater level control system is attached (figure 1)

a. Channel "A" reactor level detector signal fails low.

b. Loss of signal to "B" feedwater control valve M/A transfer station.

c. "B" feedwater flow signal fails high.

QUESTION 3.04 (2.50)

For the following situations, state whether the Automatic Depressurization System (ADS) relief valves will OPEN, CLOSE or REMAIN AS IS. Consider each set of conditions separately.

a. ADS initiating signal sealed in, ADS valves open . . . . reactor water level then rises to 177 inches. (0.5)

b. ADS initiating signal sealed in, ADS valves open . . . . ADS timer reset buttons are then depressed. (0.5)

c. ADS initiating signal sealed in, ADS valves open . . . . then a DC power failure occurs that affects all busses supplying ADS valves. (0.5)

d. ADS initiating parameters present, a loss of the pneumatic supply to the drywell has occurred, 120 second timer timing out . . . . then the 120 second timer times out. (0.5)

e. ADS initiating parameters present, all ECCS pumps are secured except for CS pump B which is running with a discharge pressure of 195 psig, 120 second timer timing out . . . . then the 120 second timer times out. (0.5)

QUESTION 3.05 (2.50)

The Core Level Indicator (LI-R610) located on Control Room Panel H11-P601 has an indicating range from -150 to +50 inches.

a. WHAT is INSTRUMENT ZERO for this level sensor? (Provide the core component located at Instrument Zero.) (0.5)

b. Is this level sensor temperature compensated? (0.5)

c. MATCH the core conditions in Column 1 with the correct response of the core level indicator (LI-R610) in Column 2 . (1.5)

COLUMN 1	COLUMN 2
1. LPCI is the only system injecting into the vessel	a. Full Scale
2. No recirculation flow exists, no systems are injecting to the RPV, and the reactor is at atmospheric pressure	b. Downscale
3. Both recirculation pumps are at 45% speed	c. Actual Level
	d. 14 inches HIGHER than actual level
	e. 14 inches LOWER than actual level 1

QUESTION 3.06 (1.00)

HOW would an SRM detector respond to a pinhole leak which caused a gradual decrease in Argon gas pressure?

a. Gamma and neutron sensitivity would DECREASE.

b. Gamma sensitivity would DECREASE but neutron sensitivity would REMAIN THE SAME.

c. Gamma sensitivity would REMAIN THE SAME but neutron sensitivity would DECREASE.

d. BOTH gamma and neutron sensitivity would REMAIN THE SAME.

QUESTION 3.07 (1. 0)

LIST three (? ions and thei etpoints (if applicable) that will automatically station air compressors. (1.5)

QUESTION 3.08

Consider the following information:

- the Reactor is at 100% power
- APRM CHANNEL D is reading 102%
- FLOW UNIT A is reading 90%
- FLOW UNIT B is reading 100%
- 8 LPRM inputs to APRM CHANNEL D are bypassed

STATE whether each of the following will occur. (YES or NO) occur.

a) RPS DIV I trip (1/2 scram) (0.5)

b) Control Rod Withdrawal Block (0.5)

~~c) APRM D Inop~~ *deleted* (0.5)

d) APRM D upscale high (0.5)

e) APRM D upscale Hi Hi (0.5)

f) Flow Reference Off Normal (0.5)

QUESTION 3.09 (1.50)

a. WHAT automatic actions occur when the scram discharge volume high level scram bypass switch is placed in BYPASS and the scram is reset.

b. WHAT position(s) must the reactor mode switch be in to allow BYPASS of the scram discharge volume high level scram function?

c. WHAT additional protective function is inserted when the scram bypass switch is in the BYPASS position?

QUESTION 3.10 (3.00)

There are THREE (3) speed limiters in the Recirculation flow control system which function to limit the maximum speed demand.

a. WHAT is the maximum speed demand limit imposed by EACH limiter? (LIST EACH LIMITER AND THE APPLICABLE SETPOINT.) (1.0)

b. During what plant conditions are the #1 & #2 limiters in control and imposing limitations on Recirculation pump speed? (SETPOINTS REQUIRED) (2.0)

QUESTION 3.11 (1.50)

STATE three (3) conditions that would cause the Rod Sequence Control System Annunicator, ALL A/B SEQUENCE RODS NOT FULL OUT, to alarm.

(***** END OF CATEGORY 3 *****)

QUESTION 4.01 (1.00)

Operation of the Recirculation Pumps at a suction pressure below 300 psig should be minimized since such operations can contribute to shortening seal life. However, STATE two reasons that may require recirculation pump operations at low pressure.

QUESTION 4.02 (1.00)

STATE two (2) alternate methods of scramming the reactor per AOP 20.000.19, "Shutdown From Outside The Control Room".

QUESTION 4.03 (1.50)

During reactor startup, a control rod is to be withdrawn. LIST three possible indications that the control rod is uncoupled per AOP 20.106.04, "Uncoupled CRD".

QUESTION 4.04 (1.00)

SOP 23.202, "High Pressure Coolant Injection System", cautions not to defeat the automatic function of an ECCS by placing the controls in MANUAL or OFF unless confirmed by at least two independent indications. STATE these two (2) indications.

(***** CATEGORY 4 CONTINUED ON NEXT PAGE *****)

QUESTION 4.05 (2.00)

For each of the following conditions (a through d) INDICATE which of the corresponding procedures (1 through 4) would need to be entered. (More than one procedure may apply for each condition. If none of the procedures are required to be entered then state "NONE").

CONDITIONS

a. Drywell pressure has increased to 3 psig

b. Reactor water level cannot be determined

c. Reactor water level decreasing to +160"

d. Drywell Equipment Sump High Level Annunciator alarms

PROCEDURES

1. 29.000.01- Level/Pressure Control

2. 29.000.02- Cooldown

3. 29.000.03- Primary Containment Control

4. 29.000.04- Contingency For RPV Flooding

QUESTION 4.06 (2.00)

Per EOP 29.000.08, "Reactivity Control Procedure", if the MSIVs are open and the Main Condenser is available, the operator is to verify or manually runback the Reactor Recirculation Pumps to minimum speed before tripping them. Explain why these pumps are runback prior to tripping them. (2.0)

QUESTION 4.07 (1.50)

Answer the following TRUE or FALSE with regards to the Criteria for Standing Orders.

a. Standing Orders should be used to provide additional guidance on administrative matters.

b. Standing Orders may conflict with procedural requirements.

c. Standing Orders can be issued prior to approval by the OE or AOE.

(***** CATEGORY 4 CONTINUED ON NEXT PAGE *****)

QUESTION 4.08 (2.00)

Match the following tag descriptions (a through d) with the correct type of tag (1 through 4)

DESCRIPTION

a. May be placed to identify a short term condition or to explain limitations.

b. Used to warn against the operation of electrical or mechanical equipment which could injury personnel.

c. Used to mark the unsafe condition of equipment such as tools and ladders.

d. Used for the protection of equipment or when determined to be required be the NSS.

TYPE OF TAG

1. Red Tag

2. Safety Tag

3. Information Tag

4. Equipment Protection Tag

QUESTION 4.09 (2.00)

Per GOP 22.000.03, "Startup From Cold Shutdown To Rated Power", when the reactor is critical, four items must be logged in the Control Room Log Book. LIST these four (4) items (some "items" may include more than one entry).

(***** CATEGORY 4 CONTINUED ON NEXT PAGE *****)

QUESTION 4.10 (2.00)

LIST the following system/equipment in the order they are taken out of service during a reactor shutdown from rated power with MSIVs open per GOP 22.000.10 Shutdown From Rated Power To Cold Shutdown.

1. Off Gas System

2. Last Reactor Feed Pump

3. Last Heater Feed Pump

4. Steam Jet Air Ejectors

5. Main Turbine

QUESTION 4.11 (2.00)

A local Area Radiation Monitor ARM alarms on the refueling floor. Upon receiving indication or notification of a Refueling Floor high radiation condition, STATE the four (4) immediate operator actions in the control room?

(***** CATEGORY 4 CONTINUED ON NEXT PAGE *****)

QUESTION 4.12 (2.00)

Match the following Emergency Classifications (a - d) with the appropriate description of that event (1 - 4). (2.0)

a.	General Emergency	1.	Events which involve actual or imminent substantial core degradation or melting has occurred with a potential for loss of containment integrity.
b.	Site Emergency	2.	Any condition that involves an actual or potential substantial degradation of the level of safety of the plant.
c.	Alert	3.	Events which involve likely or actual major failures of plant functions needed for the protection of the public.
d.	Unusual Event	4.	Any station related event which indicates a potential degradation of the level of safety of the plant, but which is not likely to affect onsite personnel or the public or result in radioactive releases requiring offsite monitoring.

QUESTION 4.13 (2.50)

List five of the six conditions that must be met to establish Secondary Containment Integrity. (2.5)

QUESTION 4.14 (2.00)

TRUE or FALSE (2.0)

A General Radiation Work Permit (RWP) should be used for the following:

1. To enter posted Radiation Areas

2. To enter posted Contaminated Areas

3. To enter posted Airborne Radioactivity Area

4. To enter posted Neutron Radiation Area

(***** END OF CATEGORY 4 *****)
(*********** END OF EXAMINATION ***********)

ANSWER 1.01 (1.50)

a. increase (0.5)

b. increase (0.5)

c. decrease (0.5)

REFERENCE

GE Thermodynamic, Heat Transfer, and Fluid Flow Text pg.9-85, 9-86, 9-92
FERMI Nuclear Power Plant Thermal Sciences pg.10-10, 10-15
K/A 293009 K1.23 (2.8/3.2)
293009K123 ..(KA's)

ANSWER 1.02 (1.98)

	FAILURE MECHANISM	LIMITING CONDITION
1. LHGR	A2	B1
2. APLHGR	A3	B3
3. MCPR	A1	B2

(6 @ 0.33 each = 1.98)

REFERENCE

FERMI Nuclear Power Plant Thermal Sciences pg 10-10, 10-15
K/A 293009 K1.08 (3.0/3.4), K1.12 (2.9/3.5), K1.20 (3.1/3.6)
293009K120 293009K112 293009K108 ..(KA's)

ANSWER 1.03 (1.00)

Obtain corresponding temp. from the steam tables by interpolation
1000 psig = 546.3 deg F (.25)
250 psig = 406.0 deg F (.25)
Temp. change: 546.3 - 406.0 = 140.3 deg F (.25)
Rate of cooldown: 140.3/1.75 = 80.2 deg F/hr (.25)

(***** CATEGORY 1 CONTINUED ON NEXT PAGE *****)

REFERENCE

Steam Tables
K/A 293003 K1.23 (2.8/3.1)
239003K123 ..(KA's)

ANSWER 1.04 (2.50)

a. Doppler or fuel temperature
b. Void
c. Moderator temperature
d. Void
e. Moderator temperature
(5 at 0.5 each = 2.5)

REFERENCE

FERMI Reactor Theory Fundamental pg 7.5, 7.6
K/A 292004 K1.14 (3.3/3.3)
292004K114 ..(KA's)

ANSWER 1.05 (2.50)

a. From POM 22.000.03, shortest permissible stable period equals 50 (+/-5) seconds. (0.5)

b. Doubling time = (2 min)(60 s/1 min)/1.44 = 83.3 +/- 4 seconds. (0.5)

c. 40% range 2 is equal to 0.04% on range 8 (0.25)
P(0) = 0.04 P(t) = 40 Period = 75 seconds
P(t) = P(0) e ^(t/period)
40 = 0.04 e ^(t/75 sec)
Time = ~~010~~ 518 (+/- 20) seconds (1.25)

REFERENCE

GOP 22.000.03 rev 15 pg 13
FERMI Reactor Theory Fundamentals pg 10.9
K/A 292003 K1.08 (2.7/2.8)
292003K108 ..(KA's)

(***** CATEGORY 1 CONTINUED ON NEXT PAGE *****)

ANSWER 1.06 (2.00)

a. 296 deg F (+/- 15 deg F) (0.5)

b. Increase (0.5)

c. Increase (0.5)

d. 450 psia (+/- 50 psia) (0.5)

REFERENCE

Mollier diagram
Steam tables
System Book 1, 03-15-05, MS and Bypass System, Rev. 4, pg 31.
K/A 293003 K1.23 (2.8/3.1)
293003K123 ..(KA's)

ANSWER 1.07 (1.00)

c.

REFERENCE

FERMI Reactor Theory Fundamentals pg 9.8
K/A 292006 K1.07 (3.2/3.2)
292006K107 ..(KA's)

ANSWER 1.08 (2.00)

a. FALSE (0.5)
b. TRUE (0.5)
c. FALSE (0.5)
d. FALSE (0.5)

REFERENCE

FERMI Nuclear Power plant Thermal Sciences pg 11-9
K/A 293007 K1.13 (2.3/2.9)
293007K113 ..(KA's)

(***** CATEGORY 1 CONTINUED ON NEXT PAGE *****)

ANSWER 1.09 (2.00)

a. $P_{act} - P_{sat}$ (or pressured measured at the inlet of the pump) (0.5)

b. (1) INCREASE (More Subcooling at the pump suction)

(2) DECREASE (Reduced pressure at the eye of the pump results in being closer to saturation pressure)

(3) DECREASE (Further to saturation temperature and increased discharged fluid density causing less static head)
(3 at 0.5 each = 1.5)

REFERENCE

FERMI Nuclear Power Plant Thermal Sciences pg 17-20
K/A 293006 K1.10 (2.7/2.8, K1.08 (2.5/2.6)
293006K108 293006K110 ..(KA's)

ANSWER 1.10 (1.00)

c (1.0)

REFERENCE

General Electric Reactor Theory, Chapter 5
FERMI Reactor Theory Fundamentals pg 12.1
K/A 292005 K1.09 (2.5/2.6)
292005K109 ..(KA's)

ANSWER 1.11 (2.00)

Drawing a straight line between the last two *'s predicts ~~34-36~~ 32-38 control rods must be withdrawn.
(0.25 for each point plotted, 0.50 for line and prediction)

deleted

```
            5    10   15   20   25   30   35   40   45   50   55
    1.0*----|----|----|----|----|----|----|----|----|----|----|---|1.0
       -                                                          -
    0.9-                                                          -0.9
       -                                                          -
    0.8-    *                                                     -0.8
       -                                                          -
    0.7-                                                          -0.7
       -                                                          -
1/M 0.6-                                                          -0.6
       -                                                          -
    0.5-                                                          -0.5
       -         *                                                -
    0.4-                                                          -0.4
       -                                                          -
    0.3-              *                                           -0.3
       -                                                          -
    0.2-                   *                                      -0.2
       -                                                          -
    0.1-                        *                                 -0.1
       -                             *                            -
    0.0|----|----|----|----|----|----|----X----|----|----|----|---|
       0    5    10   15   20   25   30   35   40   45   50   55

                      Control Rods Withdrawn
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REFERENCE

GE BWR Academic Series, Reactor Theory, Chap. 3, pg. 13-15,
FERMI Reactor Theory Fund. pg 11.11
K/A 292008 K1.04 (3.3/3.4)
292008K104 ..(KA's)

(***** CATEGORY 1 CONTINUED ON NEXT PAGE *****)

ANSWER 1.12 (~~2.00~~ 1.50)

(1) More neutrons will be captured in the resonant peaks of the fuel (uranium and plutonium (0.5) (as the slowing down length increases).

(2) Thermal neutron leakage increases (0.5)

(3) Fast neutron leakage increases (0.5).

REFERENCE

FERMI Reactor Theory Fundamentals pg 5.13
K/A 292002 K1.03 (2.0/2.1) 292002 K1.04 (1.9/2.0) 292004 K1.03 (2.6/2.7)
292004 K1.10 (3.2/3.2)
292004K110 292004K104 292002K104 292002K103 ..(KA's)

ANSWER 1.13 (2.00)

a. The negative reactivity added by the increased voids generated by the rod withdrawal is greater than the positive reactivity added by the reduced rod absorption. (1.5) (~~1.0~~)

b. (4) (0.5) (~~1.0~~)

REFERENCE

FERMI Reactor Theory Fund. pg 12.1 - 3
K/A 292005 K1.04 (3.5/3.5)
292005K104 ..(KA's)

ANSWER 1.14 (1.00)

d [1.0]

REFERENCE

FERMI Reactor Theory Fundamentals pg 8.22
K/A 292004 K1.05 (2.9/2.9)
292004K105 ..(KA's)

(***** CATEGORY 1 CONTINUED ON NEXT PAGE *****)

ANSWER 1.15 (1.50)

a. BOL: t = B - P/u*P = (0.0072 - 0.001)/(0.1)(.001)
= 62 seconds (0.33)

EOL t = (0.0055 - 0.001)/(0.1)(.001) = 45 seconds (0.33)

CHANGE 62 - 45 = 17 seconds (0.34)

b. Buildup of Pu-239 coupled with the burnout of U-235 causes a decrease in the effective delayed neutron fraction (Beff). (0.5)

REFERENCE

FERMI Reactor Theory Fundamentals pg. 10.4, 10.12
K/A 292003 K1.06 (3.7/3.7)
292003K106 ..(KA's)

(***** END OF CATEGORY 1 *****)

ANSWER 2.01 (2.00 ~~2.50~~)

a. M-G set failed to complete startup sequence in <15 seconds 0.5 ~~(1.0)~~

b. The recirc M-G drive motor Lockout Relay trips (0.5)

c. The recirc pumps trip (0.25) on high reactor pressure of 1153 +0/-20 ~~1132~~ psig (0.25). The recirc pumps discharge valves shut (0.25) if a LPCI initiation signal is present (0.125) and reactor pressure decreases to 441 +20/-0 psig (0.125).

REFERENCE

Recirculation System, pg 10, table 3 and 4
K/A 202001 K1.12 (3.5/3.6), K1.27 (4.1/4.3), K4.07 (2.8/2.9)
K4.14 (4.0/4.1), K6.06 (3.1/3.1)
202001K606 202001K414 202001K407 202001K127 202001K112
..(KA's)

ANSWER 2.02 (3.00)

a. The pneumatic supply for the inboard MSIVs is Nitrogen (0.34) with a backup supply from instrument air (other names: control air and interruptible control air (IAS)) (0.33). The supply for the outboard MSIVs is instrument air (0.33).

b. 130 ~~125~~ VDC (0.5) and 120 VAC (0.5) (RPS acceptable for the 120 VAC)

c. The loss of one solenoid will not affect the ability of the valve to open or close (0.5). Both solenoids must de-energize to close the valve. If either is energized, the valve will open.

d. The isolation will not reset (0.5). (Other answers are possible, if the candidate clearly states assumptions made (e.g., unorthodox loss and restoration of power to MSIV solenoids, LER 50-341/87-037)).

REFERENCE

Main Steam System and Bypass System, Sys Bk 1, 03-15-05, Rev 4, pgs 14 & 20
K/A 239001 K1.12 (2.5/2.6), 2.01 (3.2/3.3), K4.01 (3.8/3.8),
K6.01 (3.1/3.3)
239001K601 239001K401 239001K201 239001K112 ..(KA's)

ANSWER 2.03 (2.00)

The logic (Low-Low Set) is armed by actuation of any SRV (0.5) and a high reactor pressure scram signal (0.5), the logic will lower the opening and closing setpoints of two SRVs (0.5). The valve blowdown is also increased (0.5)

REFERENCE

Main Steam System and Bypass System pg 10
K/A 239002 K4.01 (3.9/4.0), K4.02 (3.4/3.6)
239002K402 239002K401 ..(KA's)

ANSWER 2.04 (2.00)

a. The turbine will speed up and trip on overspeed (0.5) because the governor valve will fail open (0.5).

b. The turbine will not start (0.5) because the governor and stop valves require oil pressure to open (0.5) which is normally supplied by the auxiliary oil pump.

REFERENCE

RCIC, Figures 3 and 7
HPCI, Figures 4 and 7
K/A 217000 A2.07 (3.1/3.1), 206000 K4.14 (3.4/3.4), 206000 K5.05 (3.3/3.3)
206000K505 206000K414 217000A207 ..(KA's)

(***** CATEGORY 2 CONTINUED ON NEXT PAGE *****)

ANSWER 2.05 (2.50)

a. Services the flow control valves, scram valves and scram discharge volume vent and drain valves.

b. The CRD pumps are cooled by the Reactor Building Closed Cooling water system.

c. The CRD hydraulic system supplies recirculating pump seal purge water.

d. The RPS provides signals to energize or de-energize scram pilot and scram valves and backup scram valves (to insert rods on a scram.)

e. The Reactor Manual Control System provides signals to the hydraulic control unit, to position directional control valves to control rod motion.

(5 at 0.50 each = 2.5)

REFERENCE

CRDH System pg 23 and 24
K/A 201001 K1.03 (3.1/3.1), K1.06 (2.8/2.8), K1.07 (3.4/3.4)
K1.08 (3.4/3.4), K1.09 (3.1/3.2)
201001K109 201001K108 201001K107 201001K106 201001K103
..(KA's)

(DIV I (RPS M-G Set A) - 480 MCC, 72B-4C ~~Rm~~s)
(DIV II (RPS M-G Set B) - 480 MCC, ~~72E-4B Rm~~ 72E-5B).

ANSWER 2.06 (2.50)

a. Normal - RPS M-G sets (0.5)
Alternate - 480V MCC ~~(72C-2D POS 2 and 72-4A POS 2)~~s (0.5)

b.
1. Process Radiation Monitoring System (0.5)
2. Power Range Monitoring System (0.5)
3. Nuclear Steam Supply Shutoff System (0.5)

REFERENCE

RPS pg 5, 28
K/A 212000 A2.02 (3.7/3.9)
212000A202 ..(KA's)

(DIV I (RPS Alternate Transformer) -
480 VAC Dist Cabinet 72C-2D Pos.2)
(DIV II (RPS Alternate Transformer B) -
480 V/AC Dist. Cabinet 72F-4B Pos 2)

ANSWER 2.07 (2.00)

deleted

will: b, ~~e~~ g

will not: a, c, d,e,f, h
(0.25 each = 2.0)

REFERENCE

SBGT system pg 14
K/A 261000 K401 (3.7/3.8)
261000K401 ..(KA's)

ANSWER 2.08 (2.00)

The system discharge boron injection is limited such that the rate of increase in the concentration of natural boron in the primary coolant water is fast enough to ensure a negative reactivity insertion rate greater than positive reactivity addition rate due to plant cooldown (1.0), yet slow enough to ensure sufficient mixing so boron does not recirculate through the reactor core in uneven concentrations (could cause power cycling, chugging). (1.0). (2.0)

REFERENCE

SLC System pg 5
K/A 211000 K4.05 (3.4/3.6), A1.07 (4.3/4.4)
211000A107 211000K405 ..(KA's)

ANSWER 2.09 (2.00)

a. 1. To prevent local fuel damage that may result from a single rod withdrawal error. (0.5)

2. Provides a signal used by the operator to evaluate the change in local relative power level during control rod movement. (0.5)

b. The local power may be lower than the core average power. (1.0)

REFERENCE

RBM pg 4 and 7
K/A 215002 K1.02 (3.2/3.1), G004 (3.3/3.4)
215002G004 215002K102 ..(KA's)

ANSWER 2.10 (2.50)

+20/-0

a. Reactor Pressure less than 441 psig (0.5)

b. Prevent over pressurization of the low pressure piping upstream of the injection valves. (0.5)

c. F015A/B: Remove initiation signal (0.5)
F017A/B: 5 minutes after initiation signal is received (0.5)

d. F017A/B can be throttled to control injection flow (0.5)

REFERENCE

RHR pg 32
K/A 203000 K4.02 (3.3/3.4), K4.10 (3.9/4.1)
203000K410 203000K402 ..(KA's)

ANSWER 2.11 (2.00)

a. 1. Low reactor water level (level 2)
2. High temperature at outlet of the non-regenerative heat exchanger (140 deg F)
3. SLC initiation
4. High ambient temperature (>183 F)
5. High differential monitoring temperature (>53 F)
6. High differential flow comparison (>63.4 gpm) and 60 second time delay
(any 4 at 0.25 each = 1.0)

b. Non-regenerative heat exchanger outlet temperature <130 deg F (0.5)
To prevent damage to the ion exchange resin (0.5)

REFERENCE

RWCU pg 14 and 18
K/A 204000 K4.01 (2.5/2.5), K4.03 (2.9/2.9), K4.04 (3.5/3.6)
204000K404 204000K403 204000K401 ..(KA's)

(***** END OF CATEGORY 2 *****)

ANSWER 3.01 (2.00)

a. scram
b. both
c. neither
d. rod block
(4 at 0.5 each = 2.0)

REFERENCE

RPS, pg 6
RBM, pg 16
K/A 212000 K1.01 (3.7/3.9), K1.03 (3.4/3.6), K1.05 (3.3,3.6), K1.14 (3.6/3.7)
212000K114 212000K105 212000K103 212000K101 ..(KA's)

ANSWER 3.02 (2.50)

a. (1) The LPSP is defined as the power level (25+/-5%) below which the RWM program is enforcing adherence to the control rod movement as compared to the rod sequence (0.5) or similar. a

(2) The LPAP is the power level (375+/-2.5%) above which all RWM blocks, alarms, and error displays are discontinued (0.5) or similar. a

b. (1) 1 (0.5)
(2) 3 (0.5)
(3) Rod blocks will occur on all rods (0.25)except for the rod(s) required to correct the insert or withdraw errors (0.25).

REFERENCE

Rod Worth Minimizer, pg 4, 15
K/A 201006 K4.01 (3.4/3.5), K4.02 (3.5/3.5), K4.06 (3.2/3.4), K4.07 (3.1/3.2)
201006K407 201006K406 201006K402 201006K401 ..(KA's)

ANSWER 3.03 (3.99)

a. Causes reactor level to increase [0.33] due to the level control system having a level error, level set. indicated level [0.5] resulting in the feedwater control valves opening to match new higher level [0.5].

b. Reactor level should remain constant [0.33] because the "B" M/A transfer station will lock-up [0.5]. The "A" feedwater control valve will control level [0.5].

c. Causes reactor level to decrease [0.33] due to the level control system having a steam flow/feed flow error, steam flow < feed flow [0.5] resulting in the feedwater control valves to close to match new lower level [0.5].

REFERENCE

Reactor Vessel Level Control System pg 12, 13, and figure 1
K/A 259001 K1.08 (3.2/3.2), K1.09 (2.9/3.0), K3.01 (3.8/3.8)
K3.02 (3.7/3.7)
259001K302 259001K301 259001K109 259001K108 ..(KA's)

ANSWER 3.04 (2.50)

a. ADS valves remain as is (0.5)
b. ADS valves close (0.5)
c. ADS valves close (0.5)
d. ADS valves open (0.5)
e. ADS valves open (0.5)

REFERENCE

Automatic Depressurization System, pg 2, 8, 9, and figure 6
K/A 218000 K5.01 (3.3/3.8), K4.04 (3.5/3.[illegible]), A2.05 (3.4/3.6),
K6.02 (4.1/4.1), A1.05 (4.1/4.1)
218000K602 218000K501 218000K404 218000A205 218000A105
..(KA's)

ANSWER 3.05 (2.50)

a. Top of active fuel (0.50)

b. Yes (0.50)

c. 1. d
2. c
3. a

(3 at 0.5 each = 1.5)

REFERENCE

FERMI RPV Process Instrumentation pg 6.
K/A 216000 K1.05 (3.7/3.9), K1.22 (3.6/3.8), K1.23 (3.3/3.4)
K5.01 (3.1/3.2), K4.14 (3.3/3.4)
216000K123 216000K105 216000K414 216000K501 216000K122
..(KA's)

ANSWER 3.06 (1.00)

a

REFERENCE

SRM pg 17
K/A 291002 K1.22 (3.0/3.1), K1.19 (3.0/3.1), 215004 K5.01 (2.6/2.6)
215004K501 291002K119 291002K122 ..(KA's)

ANSWER 3.07 (1.50)

a. Motor overload (0.25); 175 % (0.25)

b. High frame oil temperature (0.25); 150 deg F (0.25)

c. Low lube oil pressure (0.25); 10 psig (0.25)

d. Ground fault (0.50)
(any three = 1.50)

(***** CATEGORY 3 CONTINUED ON NEXT PAGE *****)

REFERENCE

Compressed Air System pg 7
K/A 295019G011 (3.9/4.1), G009 (3.4/3.4)
295019G009 295019G001 ..(KA's)

ANSWER 3.08 ~~(3.00)~~ 2.50 gn

a) NO (0.5)

b) YES (0.5)

~~c) NO~~ deleted gn (0.5)

d) NO (0.5)

e) NO (0.5)

f) YES (0.5)

REFERENCE

Power Range Monitor (PRM) pg 13
FERMI Tech Specs pg 3/4 3-5
K/A 215005 K101 (4.0/4.0), K4.01 (3.7/3.7), K4.02 (4.1/4.2)
215005K402 215005K401 215005K101 ..(KA's)

ANSWER 3.09 (1.50)

a. Opens the scram discharge volume vent and drain valves (0.5)

b. Shutdown [0.25] or Refuel [0.25] (0.5)

c. Rod Withdrawal Block (0.5)

REFERENCE

CRD Hydraulics, pg 12
K/A 201001 A1.05 (3.3/3.4), K4.06 (3.8/3.9)
201001K406 201001A105 ..(KA's)

(***** CATEGORY 3 CONTINUED ON NEXT PAGE *****)

ANSWER 3.10 (~~3.00~~) 2.75

a. ~~Output of the individual pump controller [0.25] 80% [0.25] (0.5)~~
#1 Limiter <30% [0.25]
#2 Limiter <~~45%~~ 42% [0.25]
#3 Limiter <48% (0.25)

b. Limiter #1: Recirc. pump discharge valve [0.25] not fully open [0.25]
OR ~~and,~~ feedwater flow [0.25] <20% [0.25] (1.0)

Limiter #2: "A" or "B" Reactor feed pumps [0.25] not running rated flow [0.25] and a reactor vessel [0.25] level less than level 4 (192.5") [0.25] is received. (1.0)

REFERENCE

Recirculation Flow Control System pg 10-12; and PDC #8294.
K/A 202002 K4.02 (3.1/3.2), K4.07 (2.8/2.9)
202002K407 202002K402 ..(KA's)

ANSWER 3.11 (1.50)

1. Power less than 35%

2. Neither all A sequence control rods or all B sequence control rods are fully out, and

3. Power is greater than 30% (or the Reactor Mode Switch is in the REFUEL position)
(3 at 0.5 each = 1.5)

REFERENCE

Rod Sequence Control System pg 8
K/A 201004 G008 (3.7/3.4)
201004G008 ..(KA's)

(***** END OF CATEGORY 3 *****)

3. During plant startup [0.25], when RHR shutdown cooling is secured [0.25].
4. During plant shutdown [0.25] prior to RHR shutdown cooling being started [0.25].
5. During a loss of RHR shutdown cooling (when RHR cannot be restored) [0.50].

ANSWER 4.01 (1.00)

[NOTE: Only 2 of the items above are required for full credit].

1. Preventing temperature stratification in the Reactor Vessel. (0.5)

2. Retaining solids in suspension until they can be removed (by the RWCU system to prevent their deposition in the bottom of the Reactor Vessel of the CRD Mechanisms). (0.5)

REFERENCE

SOP 23.138.01 Rev. 21, Reactor Recirculation System, pg 7
K/A 202001 K1.05 (3.4/3.4), K4.12 (3.2/3.5)
202001K412 202001K105 ..(KA's)

ANSWER 4.02 (1.00)

1. Scram the reactor at H11-P608RR by taking one operable APRM's Mode switch out of OPERATE position in Div. I and DIV. II (0.5)

2. Trip the main turbine at H11-P632 by removing the relay cover from TTR1 or TTR2 and then push back on the relay trip coil bar at the top until the trip flag falls. (0.5)

REFERENCE

AOP 20.000.19, Shutdown From Outside The Control Room
K/A 295016 G006 (4.1/4.1), AK2.02 (4.0/4.1)
295016K202 295016G006 ..(KA's)

ANSWER 4.03 (1.50)

1. Control Rod Overtravel annunciator

2 Loss of position indication, (past position 48), when fully withdrawn

3. Control Rod Drift annunciator

4. Observe a response to the rod movement through Nuclear Instrumentation (NI) response [0.25]
AND
Demonstrate that the control rod will not go to the withdraw overtravel position [0.25].

[Any 3 of the above items for full credit].

REFERENCE

AOP 20.106.04, Uncoupled CRD
K/A 201003 G015 (3.8/3.9)
201003G015 ..(KA's)

(***** CATEGORY 4 CONTINUED ON NEXT PAGE *****)

ANSWER 4.04 (1.00)

1. Misoperation in automatic was initiated

2. Adequate core cooling is assured
(2 at 0.5 = 1.0)

REFERENCE

SOP 23.202, HPCI System pg 13
K/A 206000 A2.17 (3.9/4.3)
206000A217 ..(KA's)

ANSWER 4.05 (2.00)

a. 3

b. 4

c. 1

d. none
(4 at 0.5 each = 2.0)

REFERENCE

EOP 29.000.01 pg 1, 29.000.03 pg 1, 29.000.04 pg 1
K/A 295024 G011 (4.3/4.5), 295031 G011 (4.2/4.6), 295036 G011 (3.8/4.1)
295036G011 295031G011 295024G011 ..(KA's)

ANSWER 4.06 (2.00)

Running back the recirculation pumps prior to tripping them minimizes the heat load added to the suppression pool [1.0]. If the pumps were tripped at higher speeds it may cause a severe enough transient to trip the main turbine and lift the safety/relief valves which would add heat to the torus [1.0]. (2.00)

(***** CATEGORY 4 CONTINUED ON NEXT PAGE *****)

REFERENCE

EOP 29.000.08 rev 2, pg 2
OC&P Course: ATWAS Study Guide Section X
K/A 294001 K1.09 (3.4/3.8)
294001K109 ..(KA's)

ANSWER 4.07 (1.50)

a. True

b. False

c. False

REFERENCE

Admin Proc. 21.000.01, Conduct of Shift Operations, pg 12
K/A 294001 A1.03 (2.7/3.7)
294001A103 ..(KA's)

ANSWER 4.08 (2.00)

a. 3

b. 1

c. 2

d. 4

(4 at 0.5 each = 2.0)

REFERENCE

Admin Proc 12.000.012 rev 15, Tagging and Protective Barrier System, pg7
K/A 294001 K1.02 (3.9/4.3)
294001K102 ..(KA's)

(***** CATEGORY 4 CONTINUED ON NEXT PAGE *****)

ANSWER 4.09 (2.00)

1. Time

2. Rod Sequence, Rod Group, Rod, and Rod Position

3. Reactor Coolant Temperature (as indicated by RWCU inlet or Reactor Recirc. loop temperature)

4. Reactor period

(4 at 0.5 each = 2.0)

REFERENCE

GOP 22.000.03 rev 15, Startup From Cold Shutdown To Rated Power pg 1
K/A 294001 A1.06 (3.4/3.6)
294001A106 ..(KA's)

ANSWER 4.10 (2.00)

5, 2, 4, 1, 3
(0.4 each, subtract 0.4 for each one out of order up to the value 2.0)

REFERENCE

GOP 22.000.10 rev 6, pg 8, 10, 11
K/A 294001 A1.13 (4.5/4.3)
294001A113 ..(KA's)

ANSWER 4.11 (2.00)

1. Announce the event over the Hi-comm.

2. Sound the "Plant Area Alarm".

3. Notify Health Physics.

4. Notify Security.

~~(4 at 0.5 each = 2.0)~~

5. Notify Nuclear Shift Supervisor (NSS)

[Any 4 of the items above with each worth 0.50 point].

(***** CATEGORY 4 CONTINUED ON NEXT PAGE *****)

REFERENCE

AOP 20.710.01, Refueling Floor High Radiation rev 5, pg 1
K/A 295023 G010 (3.5/3.5)
295023G010 ..(KA's)

ANSWER 4.12 (2.00)

a. 1
b. 3
c. 2
d. 4
(0.5 each)

REFERENCE

EP 102, 103, 104, 105
K/A 294001 A1.16 (2.9/4.7)
294001A116 ..(KA's)

(***** CATEGORY 4 CONTINUED ON NEXT PAGE *****)

ANSWER 4.13 (2.50)

1. All secondary containment penetrations required to be closed during accident conditions are either:
   a. Capable of being closed by an operable containment automatic isolation system, or

   b. Closed by at least one manual valve, blind flange, or deactivated automatic damper secured in its closed position, (except as provided in Table 3.6.5.2-1 of Spec 3.6.5.2)

2. All secondary containment hatches and blowout panels are closed and sealed

3. The standby gas treatment system is operable (or in compliance with the requirements of Spec 3.6.5.3)

4. At least one door in each access to the secondary containment is closed.

5. The sealing mechanism associated with each secondary containment penetration (e.g., welds, bellows, or O-rings) is operable.

6. The pressure within the secondary containment is less than or equal to the value 0.125 inch of vacuum water gauge (required by Spec 4.6.5.1.a)

(any 5 at 0.5 each = 2.5)

REFERENCE

Tech Spec. 1.36 pg 1-6
K/A 290001 G011 (3.3/4.2)
290001G011 ..(KA's)

ANSWER 4.14 (2.00)

1. False

2. False

3. False

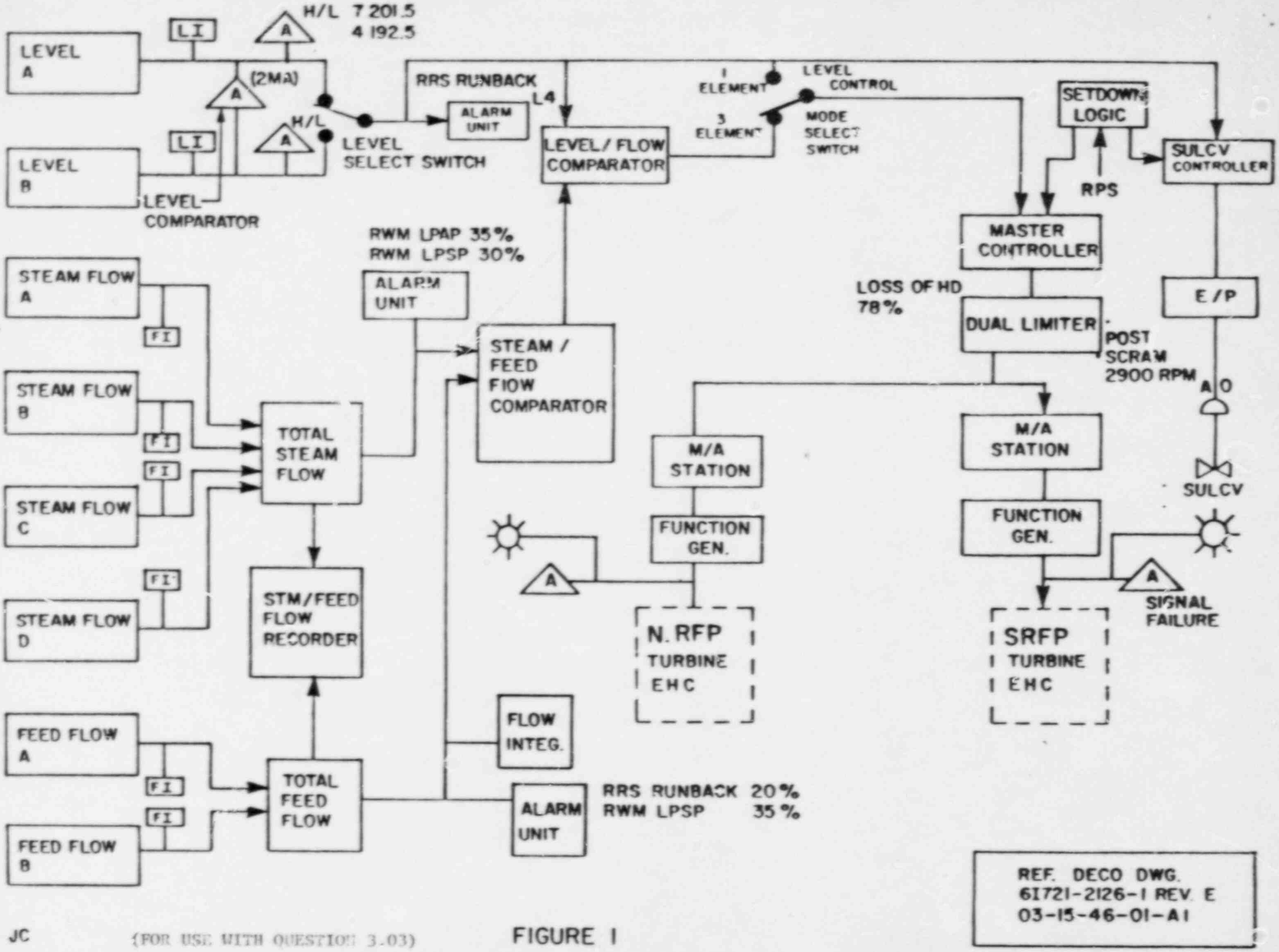
4. False
(4 at 0.5 each = 2.0)

(***** CATEGORY 4 CONTINUED ON NEXT PAGE *****)

REFERENCE

Admin Proc 12.000.013 rev 8, pg 7
K/A 294001 K1.03 (3.3/3.8)
294001K103 ..(KA's)

(***** END OF CATEGORY 4 *****)
(********** END OF EXAMINATION **********)



JC (FOR USE WITH QUESTION 3.03) FIGURE 1

REV. 4

DATA SHEET

REACTOR THEORY FORMULAS:

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

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

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

$$SUR = 26.06/\tau$$

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

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

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

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

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

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

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

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

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

$$\tau = \frac{1^*}{\rho}$$

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

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

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

DATA SHEET

THERMODYNAMICS AND FLUID MECHANICS FORMULAS:

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

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

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

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

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

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

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

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

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

$$\dot{Q} = \frac{A\,\Delta T_{total}}{\frac{\Delta X_a}{K_a} + \frac{\Delta X_b}{K_b} + \ldots + \frac{\Delta X_n}{K_n}}$$

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

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

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

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

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

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

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

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

DATA SHEET

CENTRIFUGAL PUMP LAWS:

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

RADIATION AND CHEMISTRY FORMULAS:

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

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

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

CONVERSIONS:

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

DATA SHEET

AVERAGE THERMAL CONDUCTIVITY (K)

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

MISCELLANEOUS INFORMATION:

$E = mc^2$

$KE = 1/2\ mv^2$

$PE = mgh$

$V_f = V_0 + at$

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

DATA SHEET

MISCELLANEOUS INFORMATION (continued):

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

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

Linear Absorption Coefficients μ (cm^{-1})

Energy (MEV)	Water	Concrete	Iron	Lead
0.5	0.090	0.21	0.63	1.7
1.0	0.067	0.15	0.44	0.77
1.5	0.057	0.13	0.40	0.57
2.0	0.048	0.11	0.33	0.51
2.5	0.042	0.097	0.31	0.49
3.0	0.038	0.088	0.30	0.47

Table 1. Saturated Steam: Temperature Table

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

*The states shown are metastable

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

Temp Fahr t	Abs Press Lb per Sq In p	Specific Volume Sat Liquid v_f	Specific Volume Evap v_{fg}	Specific Volume Sat Vapor v_g	Enthalpy Sat Liquid h_f	Enthalpy Evap h_{fg}	Enthalpy Sat Vapor h_g	Entropy Sat Liquid s_f	Entropy Evap s_{fg}	Entropy Sat Vapor s_g	Temp Fahr t
180.0	7.5110	0.016510	50.21	50.22	148.00	990.2	1138.2	0.2631	1.5480	1.8111	180.0
182.0	7.850	0.016522	48.172	48.189	150.01	989.0	1139.0	0.2662	1.5413	1.8075	182.0
184.0	8.203	0.016534	46.232	46.249	152.01	987.8	1139.8	0.2694	1.5346	1.8040	184.0
186.0	8.568	0.016547	44.383	44.400	154.02	986.5	1140.5	0.2725	1.5279	1.8004	186.0
188.0	8.947	0.016559	42.621	42.638	156.03	985.3	1141.3	0.2756	1.5213	1.7969	188.0
190.0	9.340	0.016572	40.941	40.957	158.04	984.1	1142.1	0.2787	1.5148	1.7934	190.0
192.0	9.747	0.016585	39.337	39.354	160.05	982.8	1142.9	0.2818	1.5082	1.7900	192.0
194.0	10.168	0.016598	37.808	37.824	162.05	981.6	1143.7	0.2848	1.5017	1.7865	194.0
196.0	10.605	0.016611	36.348	36.364	164.06	980.4	1144.4	0.2879	1.4952	1.7831	196.0
198.0	11.058	0.016624	34.954	34.970	166.08	979.1	1145.2	0.2910	1.4888	1.7798	198.0
200.0	11.526	0.016637	33.622	33.639	168.09	977.9	1146.0	0.2940	1.4824	1.7764	200.0
204.0	12.512	0.016664	31.135	31.151	172.11	975.4	1147.5	0.3001	1.4697	1.7698	204.0
208.0	13.568	0.016691	28.862	28.878	176.14	972.8	1149.0	0.3061	1.4571	1.7632	208.0
212.0	14.696	0.016719	26.782	26.799	180.17	970.3	1150.5	0.3121	1.4447	1.7568	212.0
216.0	15.901	0.016747	24.878	24.894	184.20	967.8	1152.0	0.3181	1.4323	1.7505	216.0
220.0	17.186	0.016775	23.131	23.148	188.23	965.2	1153.4	0.3241	1.4201	1.7442	220.0
224.0	18.556	0.016805	21.529	21.545	192.27	962.6	1154.9	0.3300	1.4081	1.7380	224.0
228.0	20.015	0.016834	20.056	20.073	196.31	960.0	1156.3	0.3359	1.3961	1.7320	228.0
232.0	21.567	0.016864	18.701	18.718	200.35	957.4	1157.8	0.3417	1.3842	1.7260	232.0
236.0	23.216	0.016895	17.454	17.471	204.40	954.8	1159.2	0.3476	1.3725	1.7201	236.0
240.0	24.968	0.016926	16.304	16.321	208.45	952.1	1160.6	0.3533	1.3609	1.7142	240.0
244.0	26.826	0.016958	15.243	15.260	212.50	949.5	1162.0	0.3591	1.3494	1.7085	244.0
248.0	28.796	0.016990	14.264	14.281	216.56	946.8	1163.4	0.3649	1.3379	1.7028	248.0
252.0	30.883	0.017022	13.358	13.375	220.62	944.1	1164.7	0.3706	1.3266	1.6972	252.0
256.0	33.091	0.017055	12.520	12.538	224.69	941.4	1166.1	0.3763	1.3154	1.6917	256.0
260.0	35.427	0.017089	11.745	11.762	228.76	938.6	1167.4	0.3819	1.3043	1.6862	260.0
264.0	37.894	0.017123	11.025	11.042	232.83	935.9	1168.7	0.3876	1.2933	1.6808	264.0
268.0	40.500	0.017157	10.358	10.375	236.91	933.1	1170.0	0.3932	1.2823	1.6755	268.0
272.0	43.249	0.017193	9.738	9.755	240.99	930.3	1171.3	0.3987	1.2715	1.6702	272.0
276.0	46.147	0.017228	9.162	9.180	245.08	927.5	1172.5	0.4043	1.2607	1.6650	276.0
280.0	49.200	0.017264	8.627	8.644	249.17	924.6	1173.8	0.4098	1.2501	1.6599	280.0
284.0	52.414	0.01730	8.1280	8.1453	253.3	921.7	1175.0	0.4154	1.2395	1.6548	284.0
288.0	55.795	0.01734	7.6634	7.6807	257.4	918.8	1176.2	0.4208	1.2290	1.6498	288.0
292.0	59.350	0.01738	7.2301	7.2475	261.5	915.9	1177.4	0.4263	1.2186	1.6449	292.0
296.0	63.084	0.01743	6.8259	6.8433	265.6	913.0	1178.6	0.4317	1.2082	1.6400	296.0
300.0	67.005	0.01745	6.4483	6.4658	269.7	910.0	1179.7	0.4372	1.1979	1.6351	300.0
304.0	71.119	0.01749	6.0955	6.1130	273.8	907.0	1180.9	0.4426	1.1877	1.6303	304.0
308.0	75.433	0.01753	5.7655	5.7830	278.0	904.0	1182.0	0.4479	1.1776	1.6256	308.0
312.0	79.953	0.01757	5.4566	5.4742	282.1	901.0	1183.1	0.4533	1.1676	1.6209	312.0
316.0	84.688	0.01761	5.1673	5.1849	286.3	897.9	1184.1	0.4586	1.1576	1.6162	316.0
320.0	89.643	0.01766	4.8961	4.9138	290.4	894.8	1185.2	0.4640	1.1477	1.6116	320.0
324.0	94.826	0.01770	4.6418	4.6595	294.6	891.6	1186.2	0.4692	1.1378	1.6071	324.0
328.0	100.245	0.01774	4.4030	4.4208	298.7	888.5	1187.2	0.4745	1.1280	1.6025	328.0
332.0	105.907	0.01779	4.1788	4.1966	302.9	885.3	1188.2	0.4798	1.1183	1.5981	332.0
336.0	111.820	0.01783	3.9681	3.9859	307.1	882.1	1189.1	0.4850	1.1086	1.5936	336.0
340.0	117.992	0.01787	3.7699	3.7878	311.3	878.8	1190.1	0.4902	1.0990	1.5892	340.0
344.0	124.430	0.01792	3.5834	3.6013	315.5	875.5	1191.0	0.4954	1.0894	1.5849	344.0
348.0	131.142	0.01797	3.4078	3.4258	319.7	872.2	1191.9	0.5006	1.0799	1.5806	348.0
352.0	138.138	0.01801	3.2423	3.2603	323.9	868.9	1192.7	0.5058	1.0705	1.5763	352.0
356.0	145.424	0.01806	3.0863	3.1044	328.1	865.5	1193.6	0.5110	1.0611	1.5721	356.0
360.0	153.010	0.01811	2.9392	2.9573	332.3	862.1	1194.4	0.5161	1.0517	1.5678	360.0
364.0	160.903	0.01816	2.8002	2.8184	336.5	858.6	1195.2	0.5212	1.0424	1.5637	364.0
368.0	169.113	0.01821	2.6691	2.6873	340.8	855.1	1195.9	0.5263	1.0332	1.5595	368.0
372.0	177.648	0.01826	2.5451	2.5633	345.0	851.6	1196.7	0.5314	1.0240	1.5554	372.0
376.0	186.517	0.01831	2.4279	2.4462	349.3	848.1	1197.4	0.5365	1.0148	1.5513	376.0
380.0	195.729	0.01836	2.3170	2.3353	353.6	844.5	1198.0	0.5416	1.0057	1.5473	380.0
384.0	205.294	0.01842	2.2120	2.2304	357.9	840.8	1198.7	0.5466	0.9966	1.5432	384.0
388.0	215.220	0.01847	2.1126	2.1311	362.2	837.2	1199.3	0.5516	0.9876	1.5392	388.0
392.0	225.516	0.01853	2.0184	2.0369	366.5	833.4	1199.9	0.5567	0.9786	1.5352	392.0
396.0	236.193	0.01858	1.9291	1.9477	370.8	829.7	1200.4	0.5617	0.9696	1.5313	396.0
400.0	247.259	0.01864	1.8444	1.8630	375.1	825.9	1201.0	0.5667	0.9607	1.5274	400.0
404.0	258.725	0.01870	1.7640	1.7827	379.4	822.0	1201.5	0.5717	0.9518	1.5234	404.0
408.0	270.600	0.01875	1.6877	1.7064	383.8	818.2	1201.9	0.5766	0.9429	1.5195	408.0
412.0	282.894	0.01881	1.6152	1.6340	388.1	814.2	1202.4	0.5816	0.9341	1.5157	412.0
416.0	295.617	0.01887	1.5463	1.5651	392.5	810.2	1202.8	0.5866	0.9253	1.5118	416.0
420.0	308.780	0.01894	1.4808	1.4997	396.9	806.2	1203.1	0.5915	0.9165	1.5080	420.0
424.0	322.391	0.01900	1.4184	1.4374	401.3	802.2	1203.5	0.5964	0.9077	1.5042	424.0
428.0	336.463	0.01906	1.3591	1.3782	405.7	798.0	1203.7	0.6014	0.8990	1.5004	428.0
432.0	351.00	0.01913	1.30266	1.32179	410.1	793.9	1204.0	0.6063	0.8903	1.4966	432.0
436.0	366.03	0.01919	1.24887	1.26806	414.6	789.7	1204.2	0.6112	0.8816	1.4928	436.0
440.0	381.54	0.01926	1.19761	1.21687	419.0	785.4	1204.4	0.6161	0.8729	1.4890	440.0
444.0	397.56	0.01933	1.14874	1.16806	423.5	781.1	1204.6	0.6210	0.8643	1.4853	444.0
448.0	414.09	0.01940	1.10212	1.12152	428.0	776.7	1204.7	0.6259	0.8557	1.4815	448.0
452.0	431.14	0.01947	1.05764	1.07711	432.5	772.3	1204.8	0.6308	0.8471	1.4778	452.0
456.0	448.73	0.01954	1.01518	1.03472	437.0	767.8	1204.8	0.6356	0.8385	1.4741	456.0

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

Temp Fahr t	Abs Press Lb per Sq In p	Specific Volume Sat Liquid v_f	Specific Volume Evap v_{fg}	Specific Volume Sat Vapor v_g	Enthalpy Sat Liquid h_f	Enthalpy Evap h_{fg}	Enthalpy Sat Vapor h_g	Entropy Sat Liquid s_f	Entropy Evap s_{fg}	Entropy Sat Vapor s_g	Temp Fahr t
460.0	466.87	0.01961	0.97463	0.99424	441.5	763.2	1204.8	0.6405	0.8299	1.4704	460.0
464.0	485.56	0.01969	0.93588	0.95557	446.1	758.6	1204.7	0.6454	0.8213	1.4667	464.0
468.0	504.83	0.01976	0.89885	0.91862	450.7	754.0	1204.6	0.6502	0.8127	1.4629	468.0
472.0	524.67	0.01984	0.86345	0.88329	455.2	749.3	1204.5	0.6551	0.8042	1.4592	472.0
476.0	545.11	0.01992	0.82958	0.84950	459.9	744.5	1204.3	0.6599	0.7956	1.4555	476.0
480.0	566.15	0.02000	0.79716	0.81717	464.5	739.6	1204.1	0.6648	0.7871	1.4518	480.0
484.0	587.81	0.02009	0.76613	0.78622	469.1	734.7	1203.8	0.6696	0.7785	1.4481	484.0
488.0	610.10	0.02017	0.73641	0.75658	473.8	729.7	1203.5	0.6745	0.7700	1.4444	488.0
492.0	633.03	0.02026	0.70794	0.72820	478.5	724.6	1203.1	0.6793	0.7614	1.4407	492.0
496.0	656.61	0.02034	0.68065	0.70100	483.2	719.5	1202.7	0.6842	0.7528	1.4370	496.0
500.0	680.86	0.02043	0.65448	0.67492	487.9	714.3	1202.2	0.6890	0.7443	1.4333	500.0
504.0	705.78	0.02053	0.62938	0.64991	492.7	709.0	1201.7	0.6939	0.7357	1.4296	504.0
508.0	731.40	0.02062	0.60530	0.62592	497.5	703.7	1201.1	0.6987	0.7271	1.4258	508.0
512.0	757.72	0.02072	0.58218	0.60289	502.3	698.2	1200.5	0.7036	0.7185	1.4221	512.0
516.0	784.76	0.02081	0.55997	0.58079	507.1	692.7	1199.8	0.7085	0.7099	1.4183	516.0
520.0	812.53	0.02091	0.53864	0.55956	512.0	687.0	1199.0	0.7133	0.7013	1.4146	520.0
524.0	841.04	0.02102	0.51814	0.53916	516.9	681.3	1198.2	0.7182	0.6926	1.4108	524.0
528.0	870.31	0.02112	0.49843	0.51955	521.8	675.5	1197.3	0.7231	0.6839	1.4070	528.0
532.0	900.34	0.02123	0.47947	0.50070	526.8	669.6	1196.4	0.7280	0.6752	1.4032	532.0
536.0	931.17	0.02134	0.46123	0.48257	531.7	663.6	1195.4	0.7329	0.6665	1.3993	536.0
540.0	962.79	0.02146	0.44367	0.46513	536.8	657.5	1194.3	0.7378	0.6577	1.3954	540.0
544.0	995.22	0.02157	0.42677	0.44834	541.8	651.3	1193.1	0.7427	0.6489	1.3915	544.0
548.0	1028.49	0.02169	0.41048	0.43217	546.9	645.0	1191.9	0.7476	0.6400	1.3876	548.0
552.0	1062.59	0.02182	0.39479	0.41660	552.0	638.5	1190.6	0.7525	0.6311	1.3837	552.0
556.0	1097.55	0.02194	0.37966	0.40160	557.2	632.0	1189.2	0.7575	0.6222	1.3797	556.0
560.0	1133.38	0.02207	0.36507	0.38714	562.4	625.3	1187.7	0.7625	0.6132	1.3757	560.0
564.0	1170.10	0.02221	0.35099	0.37320	567.6	618.5	1186.1	0.7674	0.6041	1.3716	564.0
568.0	1207.72	0.02235	0.33741	0.35975	572.9	611.5	1184.5	0.7725	0.5950	1.3675	568.0
572.0	1246.26	0.02249	0.32429	0.34678	578.3	604.5	1182.7	0.7775	0.5859	1.3634	572.0
576.0	1285.74	0.02264	0.31162	0.33426	583.7	597.2	1180.9	0.7825	0.5766	1.3592	576.0
580.0	1326.17	0.02279	0.29937	0.32216	589.1	589.9	1179.0	0.7876	0.5673	1.3550	580.0
584.0	1367.7	0.02295	0.28753	0.31048	594.6	582.4	1176.9	0.7927	0.5580	1.3507	584.0
588.0	1410.0	0.02311	0.27608	0.29919	600.1	574.7	1174.8	0.7978	0.5485	1.3464	588.0
592.0	1453.3	0.02328	0.26499	0.28827	605.7	566.8	1172.6	0.8030	0.5390	1.3420	592.0
596.0	1497.8	0.02345	0.25425	0.27770	611.4	558.8	1170.2	0.8082	0.5293	1.3375	596.0
600.0	1543.2	0.02364	0.24384	0.26747	617.1	550.6	1167.7	0.8134	0.5196	1.3330	600.0
604.0	1589.7	0.02382	0.23374	0.25757	622.9	542.2	1165.1	0.8187	0.5097	1.3284	604.0
608.0	1637.3	0.02402	0.22394	0.24796	628.8	533.6	1162.4	0.8240	0.4997	1.3238	608.0
612.0	1686.1	0.02422	0.21442	0.23865	634.8	524.7	1159.5	0.8294	0.4896	1.3190	612.0
616.0	1735.9	0.02444	0.20516	0.22960	640.8	515.6	1156.4	0.8348	0.4794	1.3141	616.0
620.0	1786.9	0.02466	0.19615	0.22081	646.9	506.3	1153.2	0.8403	0.4689	1.3092	620.0
624.0	1839.0	0.02489	0.18737	0.21226	653.1	496.6	1149.8	0.8458	0.4583	1.3041	624.0
628.0	1892.4	0.02514	0.17880	0.20394	659.5	486.7	1146.1	0.8514	0.4474	1.2988	628.0
632.0	1947.0	0.02539	0.17044	0.19583	665.9	476.4	1142.2	0.8571	0.4364	1.2934	632.0
636.0	2002.8	0.02566	0.16226	0.18792	672.4	465.7	1138.1	0.8628	0.4251	1.2879	636.0
640.0	2059.9	0.02595	0.15427	0.18021	679.1	454.6	1133.7	0.8686	0.4134	1.2821	640.0
644.0	2118.3	0.02625	0.14644	0.17269	685.9	443.1	1129.0	0.8746	0.4015	1.2761	644.0
648.0	2178.1	0.02657	0.13876	0.16534	692.9	431.1	1124.0	0.8806	0.3893	1.2699	648.0
652.0	2239.2	0.02691	0.13124	0.15816	700.0	418.7	1118.7	0.8868	0.3767	1.2634	652.0
656.0	2301.7	0.02728	0.12387	0.15115	707.4	405.7	1113.1	0.8931	0.3637	1.2567	656.0
660.0	2365.7	0.02768	0.11663	0.14431	714.9	392.1	1107.0	0.8995	0.3502	1.2498	660.0
664.0	2431.1	0.02811	0.10947	0.13757	722.9	377.7	1100.6	0.9064	0.3361	1.2425	664.0
668.0	2498.1	0.02858	0.10229	0.13087	731.5	362.1	1093.5	0.9137	0.3210	1.2347	668.0
672.0	2566.6	0.02911	0.09514	0.12424	740.2	345.7	1085.9	0.9212	0.3054	1.2266	672.0
676.0	2636.8	0.02970	0.08799	0.11769	749.2	328.5	1077.6	0.9287	0.2892	1.2179	676.0
680.0	2708.6	0.03037	0.08080	0.11117	758.5	310.1	1068.5	0.9365	0.2720	1.2086	680.0
684.0	2782.1	0.03114	0.07349	0.10463	768.2	290.2	1058.4	0.9447	0.2537	1.1984	684.0
688.0	2857.4	0.03204	0.06595	0.09799	778.8	268.2	1047.0	0.9535	0.2337	1.1872	688.0
692.0	2934.5	0.03313	0.05797	0.09110	790.5	243.1	1033.6	0.9634	0.2110	1.1744	692.0
696.0	3013.4	0.03455	0.04916	0.08371	804.4	212.8	1017.2	0.9749	0.1841	1.1591	696.0
700.0	3094.3	0.03662	0.03857	0.07519	822.4	172.7	995.2	0.9901	0.1490	1.1390	700.0
702.0	3135.5	0.03824	0.03173	0.06997	835.0	144.7	979.7	1.0006	0.1246	1.1252	702.0
704.0	3177.2	0.04108	0.02192	0.06300	854.2	102.0	956.2	1.0169	0.0876	1.1046	704.0
705.0	3198.3	0.04427	0.01304	0.05730	873.0	61.4	934.4	1.0329	0.0527	1.0856	705.0
705.47*	3208.2	0.05078	0.00000	0.05078	906.0	0.0	906.0	1.0612	0.0000	1.0612	705.47*

*Critical temperature

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

Table 3. Superheated Steam

Abs Press Lb/Sq In (Sat Temp)		Sat Water	Sat Steam	200	250	300	350	400	450	500	600	700	800	900	1000	1100	1200
1 (101.74)	Sh			98.26	148.26	198.26	248.26	298.26	348.26	398.26	498.26	598.26	698.26	798.26	898.26	998.26	1098.26
	v	0.01614	333.6	392.5	422.4	452.3	482.1	511.9	541.7	571.5	631.1	690.7	750.2	809.8	869.4	929.0	988.6
	h	69.73	1105.8	1150.2	1172.9	1195.7	1218.7	1241.8	1265.1	1288.6	1336.1	1384.5	1433.7	1483.8	1534.9	1586.8	1639.7
	s	0.1326	1.9781	2.0509	2.0841	2.1152	2.1445	2.1722	2.1985	2.2237	2.2708	2.3144	2.3551	2.3934	2.4296	2.4640	2.4969
5 (162.24)	Sh			37.76	87.76	137.76	187.76	237.76	287.76	337.76	437.76	537.76	637.76	737.76	837.76	937.76	1037.76
	v	0.01641	73.53	78.14	84.21	90.24	96.25	102.24	108.23	114.21	126.15	138.08	150.01	161.94	173.86	185.78	197.70
	h	130.20	1131.1	1148.6	1171.7	1194.8	1218.0	1241.3	1264.7	1288.2	1335.9	1384.3	1433.6	1483.7	1534.7	1586.7	1639.6
	s	0.2349	1.8443	1.8716	1.9054	1.9369	1.9664	1.9943	2.0208	2.0460	2.0932	2.1369	2.1776	2.2159	2.2521	2.2866	2.3194
10 (193.21)	Sh			6.79	56.79	106.79	156.79	206.79	256.79	306.79	406.79	506.79	606.79	706.79	806.79	906.79	1006.79
	v	0.01659	38.42	38.84	41.93	44.98	48.02	51.03	54.04	57.04	63.03	69.00	74.98	80.94	86.91	92.87	98.84
	h	161.26	1143.3	1146.6	1170.2	1193.7	1217.1	1240.6	1264.1	1287.8	1335.5	1384.0	1433.4	1483.5	1534.6	1586.6	1639.5
	s	0.2836	1.7875	1.7928	1.8273	1.8593	1.8892	1.9173	1.9439	1.9692	2.0166	2.0603	2.1011	2.1394	2.1757	2.2101	2.2430
14.696 (212.00)	Sh				38.00	88.00	138.00	188.00	238.00	288.00	388.00	488.00	588.00	688.00	788.00	888.00	988.00
	v	0.01672	26.799		28.42	30.52	32.60	34.67	36.72	38.77	42.86	46.93	51.00	55.06	59.13	63.19	67.25
	h	180.17	1150.5		1168.8	1192.6	1216.3	1239.9	1263.6	1287.4	1335.2	1383.8	1433.2	1483.4	1534.5	1586.5	1639.4
	s	0.3121	1.7568		1.7833	1.8158	1.8459	1.8743	1.9010	1.9265	1.9739	2.0177	2.0585	2.0969	2.1332	2.1676	2.2005
15 (213.03)	Sh				36.97	86.97	136.97	186.97	236.97	286.97	386.97	486.97	586.97	686.97	786.97	886.97	986.97
	v	0.01673	26.290		27.837	29.899	31.939	33.963	35.977	37.985	41.986	45.978	49.964	53.946	57.926	61.905	65.882
	h	181.21	1150.9		1168.7	1192.5	1216.2	1239.9	1263.6	1287.3	1335.2	1383.8	1433.2	1483.4	1534.5	1586.5	1639.4
	s	0.3137	1.7552		1.7809	1.8134	1.8437	1.8720	1.8988	1.9242	1.9717	2.0155	2.0563	2.0946	2.1309	2.1653	2.1982
20 (227.96)	Sh				22.04	72.04	122.04	172.04	222.04	272.04	372.04	472.04	572.04	672.04	772.04	872.04	972.04
	v	0.01683	20.087		20.788	22.356	23.900	25.428	26.946	28.457	31.466	34.465	37.458	40.447	43.435	46.420	49.405
	h	196.27	1156.3		1167.1	1191.4	1215.4	1239.2	1263.0	1286.9	1334.9	1383.5	1432.9	1483.2	1534.3	1586.3	1639.3
	s	0.3358	1.7320		1.7475	1.7805	1.8111	1.8397	1.8666	1.8921	1.9397	1.9836	2.0244	2.0628	2.0991	2.1336	2.1665
25 (240.07)	Sh				9.93	59.93	109.93	159.93	209.93	259.93	359.93	459.93	559.93	659.93	759.93	859.93	959.93
	v	0.01692	16.303		16.558	17.829	19.076	20.307	21.527	22.740	25.153	27.557	29.954	32.348	34.740	37.130	39.518
	h	208.52	1160.6		1165.6	1190.2	1214.5	1238.5	1262.5	1286.4	1334.6	1383.3	1432.7	1483.0	1534.2	1586.2	1639.2
	s	0.3535	1.7141		1.7212	1.7547	1.7856	1.8145	1.8415	1.8672	1.9149	1.9588	1.9997	2.0381	2.0744	2.1089	2.1418
30 (250.34)	Sh					49.66	99.66	149.66	199.66	249.66	349.66	449.66	549.66	649.66	749.66	849.66	949.66
	v	0.01701	13.744			14.810	15.859	16.892	17.914	18.929	20.945	22.951	24.952	26.949	28.943	30.936	32.927
	h	218.93	1164.1			1189.0	1213.6	1237.8	1261.9	1286.0	1334.2	1383.0	1432.5	1482.8	1534.0	1586.1	1639.0
	s	0.3682	1.6995			1.7334	1.7647	1.7937	1.8210	1.8467	1.8946	1.9386	1.9795	2.0179	2.0543	2.0888	2.1217
35 (259.29)	Sh					40.71	90.71	140.71	190.71	240.71	340.71	440.71	540.71	640.71	740.71	840.71	940.71
	v	0.01708	11.896			12.654	13.562	14.453	15.334	16.207	17.939	19.662	21.379	23.092	24.803	26.512	28.220
	h	228.03	1167.1			1187.8	1212.7	1237.1	1261.3	1285.5	1333.9	1382.8	1432.3	1482.7	1533.9	1586.0	1638.9
	s	0.3809	1.6872			1.7152	1.7468	1.7761	1.8035	1.8294	1.8774	1.9214	1.9624	2.0009	2.0372	2.0717	2.1046
40 (267.25)	Sh					32.75	82.75	132.75	182.75	232.75	332.75	432.75	532.75	632.75	732.75	832.75	932.75
	v	0.01715	10.497			11.036	11.838	12.624	13.398	14.165	15.685	17.195	18.699	20.199	21.697	23.194	24.689
	h	236.14	1169.8			1186.6	1211.7	1236.4	1260.8	1285.0	1333.6	1382.5	1432.1	1482.5	1533.7	1585.8	1638.8
	s	0.3921	1.6765			1.6992	1.7312	1.7608	1.7883	1.8143	1.8624	1.9065	1.9476	1.9860	2.0224	2.0569	2.0899
45 (274.44)	Sh					25.56	75.56	125.56	175.56	225.56	325.56	425.56	525.56	625.56	725.56	825.56	925.56
	v	0.01721	9.399			9.777	10.497	11.201	11.892	12.577	13.932	15.276	16.614	17.950	19.282	20.613	21.943
	h	243.49	1172.1			1185.4	1210.4	1235.7	1260.2	1284.6	1333.3	1382.3	1431.9	1482.3	1533.6	1585.7	1638.7
	s	0.4021	1.6671			1.6849	1.7173	1.7471	1.7748	1.8010	1.8492	1.8934	1.9345	1.9730	2.0093	2.0439	2.0768
50 (281.01)	Sh					18.99	68.99	118.99	168.99	218.99	318.99	418.99	518.99	618.99	718.99	818.99	918.99
	v	0.01727	8.514			8.769	9.424	10.062	10.688	11.306	12.529	13.741	14.947	16.150	17.350	18.549	19.746
	h	250.21	1174.1			1184.1	1209.9	1234.9	1259.6	1284.1	1332.9	1382.0	1431.7	1482.2	1533.4	1585.6	1638.6
	s	0.4112	1.6586			1.6720	1.7048	1.7349	1.7628	1.7890	1.8374	1.8816	1.9227	1.9613	1.9977	2.0322	2.0652
55 (287.07)	Sh					12.93	62.93	112.93	162.93	212.93	312.93	412.93	512.93	612.93	712.93	812.93	912.93
	v	0.01733	7.787			7.945	8.546	9.130	9.702	10.267	11.381	12.485	13.583	14.677	15.769	16.859	17.948
	h	256.41	1176.0			1182.9	1208.9	1234.2	1259.1	1283.6	1332.6	1381.8	1431.5	1482.0	1533.3	1585.5	1638.5
	s	0.4196	1.6510			1.6601	1.6933	1.7237	1.7518	1.7781	1.8266	1.8710	1.9121	1.9507	1.9871	2.0217	2.0547
60 (292.71)	Sh					7.29	57.29	107.29	157.29	207.29	307.29	407.29	507.29	607.29	707.29	807.29	907.29
	v	0.01738	7.174			7.257	7.815	8.354	8.881	9.400	10.425	11.438	12.446	13.450	14.452	15.452	16.450
	h	262.21	1177.6			1181.6	1208.0	1233.5	1258.5	1283.2	1332.3	1381.5	1431.3	1481.8	1533.2	1585.3	1638.4
	s	0.4273	1.6440			1.6492	1.6829	1.7134	1.7417	1.7681	1.8168	1.8612	1.9024	1.9410	1.9774	2.0120	2.0450
65 (297.98)	Sh					2.02	52.02	102.02	152.02	202.02	302.02	402.02	502.02	602.02	702.02	802.02	902.02
	v	0.01743	6.653			6.675	7.195	7.697	8.186	8.667	9.615	10.552	11.484	12.412	13.337	14.261	15.183
	h	267.63	1179.1			1180.3	1207.0	1232.7	1257.9	1282.7	1331.9	1381.3	1431.1	1481.6	1533.0	1585.2	1638.3
	s	0.4344	1.6375			1.6390	1.6731	1.7040	1.7324	1.7590	1.8077	1.8522	1.8935	1.9321	1.9685	2.0031	2.0361
70 (302.93)	Sh						47.07	97.07	147.07	197.07	297.07	397.07	497.07	597.07	697.07	797.07	897.07
	v	0.01748	6.205				6.664	7.133	7.590	8.039	8.922	9.793	10.659	11.522	12.382	13.240	14.097
	h	272.74	1180.6				1206.0	1232.0	1257.3	1282.2	1331.6	1381.0	1430.9	1481.5	1532.9	1585.1	1638.2
	s	0.4411	1.6316				1.6640	1.6951	1.7237	1.7504	1.7993	1.8439	1.8852	1.9238	1.9603	1.9949	2.0279
75 (307.61)	Sh						42.39	92.39	142.39	192.39	292.39	392.39	492.39	592.39	692.39	792.39	892.39
	v	0.01753	5.814				6.204	6.645	7.074	7.494	8.320	9.135	9.945	10.750	11.553	12.355	13.155
	h	277.56	1181.9				1205.0	1231.2	1256.7	1281.7	1331.3	1380.7	1430.7	1481.3	1532.7	1585.0	1638.1
	s	0.4474	1.6260				1.6554	1.6868	1.7156	1.7424	1.7915	1.8361	1.8774	1.9161	1.9526	1.9872	2.0202

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

Table 3 Superheated Steam – *Continued*

Abs Press Lb/Sq In (Sat Temp)		Sat Water	Sat Steam	350	400	450	500	550	600	700	800	900	1000	1100	1200	1300	1400
80	Sh			37.96	87.96	137.96	187.96	237.96	287.96	387.96	487.96	587.96	687.96	787.96	887.96	987.96	1087.96
(312.04)	v	0.01757	5.471	5.801	6.218	6.622	7.018	7.408	7.794	8.560	9.319	10.075	10.829	11.581	12.331	13.081	13.829
	h	282.15	1183.1	1204.0	1230.5	1256.1	1281.3	1306.2	1330.9	1380.5	1430.5	1481.1	1532.6	1584.9	1638.0	1692.0	1746.8
	s	0.4534	1.6208	1.6473	1.6790	1.7080	1.7349	1.7602	1.7842	1.8289	1.8702	1.9089	1.9454	1.9800	2.0131	2.0446	2.0750
85	Sh			33.74	83.74	133.74	183.74	233.74	283.74	383.74	483.74	583.74	683.74	783.74	883.74	983.74	1083.74
(316.26)	v	0.01762	5.167	5.445	5.840	6.223	6.597	6.966	7.330	8.052	8.768	9.480	10.190	10.898	11.604	12.310	13.014
	h	286.52	1184.2	1203.0	1229.7	1255.5	1280.8	1305.8	1330.6	1380.2	1430.3	1481.0	1532.4	1584.7	1637.9	1691.9	1746.8
	s	0.4590	1.6159	1.6396	1.6716	1.7008	1.7279	1.7532	1.7772	1.8220	1.8634	1.9021	1.9386	1.9733	2.0063	2.0379	2.0682
90	Sh			29.72	79.72	129.72	179.72	229.72	279.72	379.72	479.72	579.72	679.72	779.72	879.72	979.72	1079.72
(320.28)	v	0.01766	4.895	5.128	5.505	5.869	6.223	6.572	6.917	7.600	8.277	8.950	9.621	10.290	10.958	11.625	12.290
	h	290.69	1185.3	1202.0	1228.9	1254.9	1280.3	1305.4	1330.2	1380.0	1430.1	1480.8	1532.3	1584.6	1637.8	1691.8	1746.7
	s	0.4643	1.6113	1.6323	1.6646	1.6940	1.7212	1.7467	1.7707	1.8156	1.8570	1.8957	1.9323	1.9669	2.0000	2.0316	2.0619
95	Sh			25.87	75.87	125.87	175.87	225.87	275.87	375.87	475.87	575.87	675.87	775.87	875.87	975.87	1075.87
(324.13)	v	0.01770	4.651	4.845	5.205	5.551	5.889	6.221	6.548	7.196	7.838	8.477	9.113	9.747	10.380	11.012	11.643
	h	294.70	1186.2	1200.9	1228.1	1254.3	1279.8	1305.0	1329.9	1379.7	1429.9	1480.6	1532.1	1584.5	1637.7	1691.7	1746.6
	s	0.4694	1.6069	1.6253	1.6580	1.6876	1.7149	1.7404	1.7645	1.8094	1.8509	1.8897	1.9262	1.9609	1.9940	2.0256	2.0559
100	Sh			22.18	72.18	122.18	172.18	222.18	272.18	372.18	472.18	572.18	672.18	772.18	872.18	972.18	1072.18
(327.82)	v	0.01774	4.432	4.590	4.935	5.266	5.588	5.904	6.216	6.833	7.443	8.050	8.655	9.258	9.860	10.460	11.060
	h	298.54	1187.2	1199.9	1227.4	1253.7	1279.3	1304.6	1329.6	1379.5	1429.7	1480.4	1532.0	1584.4	1637.6	1691.6	1746.5
	s	0.4743	1.6027	1.6187	1.6516	1.6814	1.7088	1.7344	1.7586	1.8036	1.8451	1.8839	1.9205	1.9552	1.9883	2.0199	2.0502
105	Sh			18.63	68.63	118.63	168.63	218.63	268.63	368.63	468.63	568.63	668.63	768.63	868.63	968.63	1068.63
(331.37)	v	0.01778	4.231	4.359	4.690	5.007	5.315	5.617	5.915	6.504	7.086	7.665	8.241	8.816	9.389	9.961	10.532
	h	302.24	1188.0	1198.8	1226.6	1253.1	1278.8	1304.2	1329.2	1379.2	1429.4	1480.3	1531.8	1584.2	1637.5	1691.5	1746.4
	s	0.4790	1.5988	1.6122	1.6455	1.6755	1.7031	1.7288	1.7530	1.7981	1.8396	1.8785	1.9151	1.9498	1.9828	2.0145	2.0448
110	Sh			15.21	65.21	115.21	165.21	215.21	265.21	365.21	465.21	565.21	665.21	765.21	865.21	965.21	1065.21
(334.79)	v	0.01782	4.048	4.149	4.468	4.772	5.068	5.357	5.642	6.205	6.761	7.314	7.865	8.413	8.961	9.507	10.053
	h	305.80	1188.9	1197.7	1225.8	1252.5	1278.3	1303.8	1328.9	1379.0	1429.2	1480.1	1531.7	1584.1	1637.4	1691.4	1746.4
	s	0.4834	1.5950	1.6061	1.6396	1.6698	1.6975	1.7233	1.7476	1.7928	1.8344	1.8732	1.9099	1.9446	1.9777	2.0093	2.0397
115	Sh			11.92	61.92	111.92	161.92	211.92	261.92	361.92	461.92	561.92	661.92	761.92	861.92	961.92	1061.92
(338.08)	v	0.01785	3.881	3.957	4.265	4.558	4.841	5.119	5.392	5.932	6.465	6.994	7.521	8.046	8.570	9.093	9.615
	h	309.25	1189.6	1196.7	1225.0	1251.8	1277.5	1303.3	1328.6	1378.7	1429.0	1479.9	1531.6	1584.0	1637.2	1691.4	1746.3
	s	0.4877	1.5913	1.6001	1.6340	1.6644	1.6922	1.7181	1.7425	1.7877	1.8294	1.8682	1.9049	1.9396	1.9727	2.0044	2.0347
120	Sh			8.73	58.73	108.73	158.73	208.73	258.73	358.73	458.73	558.73	658.73	758.73	858.73	958.73	1058.73
(341.27)	v	0.01789	3.7275	3.7815	4.0786	4.3610	4.6341	4.9009	5.1637	5.6813	6.1928	6.7006	7.2060	7.7096	8.2119	8.7130	9.2134
	h	312.58	1190.4	1195.6	1224.1	1251.2	1277.4	1302.9	1328.2	1378.4	1428.8	1479.8	1531.4	1583.9	1637.1	1691.3	1746.2
	s	0.4919	1.5879	1.5943	1.6286	1.6592	1.6872	1.7132	1.7376	1.7829	1.8246	1.8635	1.9001	1.9349	1.9680	1.9996	2.0300
130	Sh			2.67	52.67	102.67	152.67	202.67	252.67	352.67	452.67	552.67	652.67	752.67	852.67	952.67	1052.67
(347.33)	v	0.01796	3.4544	3.4699	3.7489	4.0129	4.2672	4.5151	4.7589	5.2384	5.7118	6.1814	6.6486	7.1140	7.5781	8.0411	8.5033
	h	318.95	1191.7	1193.4	1222.5	1249.9	1276.4	1302.1	1327.5	1377.9	1428.4	1479.4	1531.1	1583.6	1636.9	1691.1	1746.1
	s	0.4998	1.5813	1.5833	1.6182	1.6493	1.6775	1.7037	1.7283	1.7737	1.8155	1.8545	1.8911	1.9259	1.9591	1.9907	2.0211
140	Sh				46.96	96.96	146.96	196.96	246.96	346.96	446.96	546.96	646.96	746.96	846.96	946.96	1046.96
(353.04)	v	0.01803	3.2190		3.4661	3.7143	3.9526	4.1844	4.4119	4.8588	5.2995	5.7364	6.1709	6.6036	7.0349	7.4652	7.8946
	h	324.96	1193.0		1220.8	1248.7	1275.3	1301.3	1326.8	1377.4	1428.0	1479.1	1530.8	1583.4	1636.7	1690.9	1745.9
	s	0.5071	1.5752		1.6085	1.6400	1.6686	1.6949	1.7196	1.7652	1.8071	1.8461	1.8828	1.9176	1.9508	1.9825	2.0129
150	Sh				41.57	91.57	141.57	191.57	241.57	341.57	441.57	541.57	641.57	741.57	841.57	941.57	1041.57
(358.43)	v	0.01809	3.0139		3.2208	3.4555	3.6799	3.8978	4.1112	4.5298	4.9421	5.3507	5.7568	6.1612	6.5642	6.9661	7.3671
	h	330.65	1194.1		1219.1	1247.4	1274.3	1300.5	1326.1	1376.9	1427.6	1478.7	1530.5	1583.1	1636.5	1690.7	1745.7
	s	0.5141	1.5695		1.5993	1.6313	1.6602	1.6867	1.7115	1.7573	1.7992	1.8383	1.8751	1.9099	1.9431	1.9748	2.0052
160	Sh				36.45	86.45	136.45	186.45	236.45	336.45	436.45	536.45	636.45	736.45	836.45	936.45	1036.45
(363.55)	v	0.01815	2.8336		3.0060	3.2288	3.4413	3.6469	3.8480	4.2420	4.6295	5.0132	5.3945	5.7741	6.1522	6.5293	6.9055
	h	336.07	1195.1		1217.4	1246.0	1273.3	1299.6	1325.4	1376.4	1427.2	1478.4	1530.3	1582.9	1636.3	1690.5	1745.6
	s	0.5206	1.5641		1.5906	1.6231	1.6522	1.6790	1.7039	1.7499	1.7919	1.8310	1.8678	1.9027	1.9359	1.9676	1.9980
170	Sh				31.58	81.58	131.58	181.58	231.58	331.58	431.58	531.58	631.58	731.58	831.58	931.58	1031.58
(368.42)	v	0.01821	2.6738		2.8162	3.0288	3.2306	3.4255	3.6158	3.9879	4.3536	4.7151	5.0741	5.4315	5.7869	6.1414	6.4950
	h	341.24	1196.0		1215.6	1244.7	1272.2	1298.8	1324.7	1375.8	1426.8	1478.0	1530.0	1582.6	1636.1	1690.4	1745.4
	s	0.5269	1.5591		1.5823	1.6152	1.6447	1.6717	1.6968	1.7428	1.7850	1.8241	1.8610	1.8959	1.9291	1.9608	1.9913
180	Sh				26.92	76.92	126.92	176.92	226.92	326.92	426.92	526.92	626.92	726.92	826.92	926.92	1026.92
(373.08)	v	0.01827	2.5312		2.6474	2.8508	3.0433	3.2286	3.4093	3.7621	4.1084	4.4508	4.7907	5.1289	5.4657	5.8014	6.1363
	h	346.19	1196.9		1213.8	1243.4	1271.2	1297.9	1324.0	1375.3	1426.3	1477.7	1529.7	1582.4	1635.9	1690.2	1745.3
	s	0.5328	1.5543		1.5743	1.6078	1.6376	1.6647	1.6900	1.7362	1.7784	1.8176	1.8545	1.8894	1.9227	1.9545	1.9849
190	Sh				22.47	72.47	122.47	172.47	222.47	322.47	422.47	522.47	622.47	722.47	822.47	922.47	1022.47
(377.53)	v	0.01833	2.4030		2.4961	2.6915	2.8756	3.0525	3.2246	3.5601	3.8889	4.2140	4.5365	4.8572	5.1766	5.4949	5.8124
	h	350.94	1197.6		1212.0	1242.0	1270.1	1297.1	1323.3	1374.8	1425.9	1477.4	1529.4	1582.2	1635.7	1690.0	1745.1
	s	0.5384	1.5498		1.5667	1.6006	1.6307	1.6581	1.6835	1.7299	1.7722	1.8115	1.8484	1.8834	1.9166	1.9484	1.9789
200	Sh				18.20	68.20	118.20	168.20	218.20	318.20	418.20	518.20	618.20	718.20	818.20	918.20	1018.20
(381.80)	v	0.01839	2.2873		2.3598	2.5480	2.7247	2.8939	3.0583	3.3783	3.6915	4.0008	4.3077	4.6128	4.9165	5.2191	5.5209
	h	355.51	1198.3		1210.1	1240.6	1269.0	1296.2	1322.6	1374.3	1425.5	1477.0	1529.1	1581.9	1635.4	1689.8	1745.0
	s	0.5438	1.5454		1.5593	1.5938	1.6242	1.6518	1.6773	1.7239	1.7663	1.8057	1.8426	1.8776	1.9109	1.9427	1.9732

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

Table 3. Superheated Steam – Continued

Abs Press Lb/Sq In (Sat Temp)		Sat Water	Sat Steam	400	450	500	550	600	700	800	900	1000	1100	1200	1300	1400	1500
210 (385.91)	Sh			14.09	64.09	114.09	164.09	214.09	314.09	414.09	514.09	614.09	714.09	814.09	914.09	1014.09	1114.09
	v	0.01844	2.1822	2.2364	2.4181	2.5880	2.7504	2.9078	3.2137	3.5128	3.8080	4.1007	4.3915	4.6811	4.9695	5.2571	5.5440
	h	355.91	1199.0	1209.2	1239.2	1268.0	1295.3	1321.9	1373.7	1425.1	1476.7	1528.8	1581.6	1635.2	1689.6	1744.8	1800.8
	s	0.5490	1.5413	1.5522	1.5872	1.6180	1.6458	1.6715	1.7187	1.7607	1.8001	1.8371	1.8721	1.9054	1.9372	1.9677	1.9970
220 (389.88)	Sh			10.12	60.12	110.12	160.12	210.12	310.12	410.12	510.12	610.12	710.12	810.12	910.12	1010.12	1110.12
	v	0.01850	2.0863	2.1240	2.2999	2.4638	2.6199	2.7710	3.0642	3.3504	3.6327	3.9125	4.1905	4.4671	4.7426	5.0173	5.2913
	h	364.17	1199.6	1206.3	1237.8	1266.9	1294.5	1321.2	1373.2	1424.7	1476.3	1528.5	1581.4	1635.0	1689.4	1744.7	1800.6
	s	0.5540	1.5374	1.5453	1.5808	1.6120	1.6400	1.6658	1.7128	1.7553	1.7948	1.8318	1.8668	1.9002	1.9320	1.9625	1.9919
230 (393.70)	Sh			6.30	56.30	106.30	156.30	206.30	306.30	406.30	506.30	606.30	706.30	806.30	906.30	1006.30	1106.30
	v	0.01855	1.9985	2.0212	2.1919	2.3503	2.5008	2.6461	2.9276	3.2020	3.4726	3.7406	4.0068	4.2717	4.5355	4.7984	5.0606
	h	368.28	1200.1	1204.4	1236.3	1265.7	1293.6	1320.4	1372.7	1424.2	1476.0	1528.2	1581.1	1634.8	1689.3	1744.5	1800.5
	s	0.5588	1.5336	1.5385	1.5747	1.6062	1.6344	1.6604	1.7075	1.7502	1.7897	1.8268	1.8618	1.8952	1.9270	1.9576	1.9869
240 (397.39)	Sh			2.61	52.61	102.61	152.61	202.61	302.61	402.61	502.61	602.61	702.61	802.61	902.61	1002.61	1102.61
	v	0.01860	1.9177	1.9268	2.0928	2.2462	2.3915	2.5316	2.8024	3.0661	3.3259	3.5831	3.8385	4.0926	4.3456	4.5977	4.8492
	h	372.27	1200.6	1202.4	1234.9	1264.6	1292.7	1319.7	1372.1	1423.8	1475.6	1527.9	1580.9	1634.6	1689.1	1744.3	1800.4
	s	0.5634	1.5299	1.5320	1.5687	1.6006	1.6291	1.6552	1.7025	1.7452	1.7848	1.8219	1.8570	1.8904	1.9223	1.9528	1.9822
250 (400.97)	Sh				49.03	99.03	149.03	199.03	299.03	399.03	499.03	599.03	699.03	799.03	899.03	999.03	1099.03
	v	0.01865	1.8432		2.0016	2.1504	2.2909	2.4262	2.6872	2.9410	3.1909	3.4382	3.6837	3.9278	4.1709	4.4131	4.6546
	h	376.14	1201.1		1233.4	1263.5	1291.8	1319.0	1371.6	1423.4	1475.3	1527.6	1580.6	1634.4	1688.9	1744.2	1800.2
	s	0.5679	1.5264		1.5629	1.5951	1.6239	1.6502	1.6976	1.7405	1.7801	1.8173	1.8524	1.8858	1.9177	1.9482	1.9776
260 (404.44)	Sh				45.56	95.56	145.56	195.56	295.56	395.56	495.56	595.56	695.56	795.56	895.56	995.56	1095.56
	v	0.01870	1.7742		1.9173	2.0619	2.1981	2.3289	2.5808	2.8256	3.0663	3.3044	3.5408	3.7758	4.0097	4.2427	4.4750
	h	379.90	1201.5		1231.9	1262.4	1290.9	1318.2	1371.1	1423.0	1474.9	1527.3	1580.4	1634.2	1688.7	1744.0	1800.1
	s	0.5722	1.5230		1.5573	1.5899	1.6189	1.6453	1.6930	1.7359	1.7756	1.8128	1.8480	1.8814	1.9133	1.9439	1.9732
270 (407.80)	Sh				42.20	92.20	142.20	192.20	292.20	392.20	492.20	592.20	692.20	792.20	892.20	992.20	1092.20
	v	0.01875	1.7101		1.8391	1.9799	2.1121	2.2388	2.4824	2.7186	2.9509	3.1806	3.4084	3.6349	3.8603	4.0849	4.3087
	h	383.56	1201.9		1230.4	1261.2	1290.0	1317.5	1370.5	1422.6	1474.6	1527.1	1580.1	1634.0	1688.5	1743.9	1800.0
	s	0.5764	1.5197		1.5518	1.5848	1.6140	1.6406	1.6885	1.7315	1.7713	1.8085	1.8437	1.8771	1.9090	1.9396	1.9690
280 (411.07)	Sh				38.93	88.93	138.93	188.93	288.93	388.93	488.93	588.93	688.93	788.93	888.93	988.93	1088.93
	v	0.01880	1.6505		1.7665	1.9037	2.0322	2.1551	2.3909	2.6194	2.8437	3.0655	3.2855	3.5042	3.7217	3.9384	4.1543
	h	387.12	1202.3		1228.8	1260.0	1289.1	1316.8	1370.0	1422.1	1474.2	1526.8	1579.9	1633.8	1688.4	1743.7	1799.8
	s	0.5805	1.5166		1.5464	1.5798	1.6093	1.6361	1.6841	1.7273	1.7671	1.8043	1.8395	1.8730	1.9050	1.9356	1.9649
290 (414.25)	Sh				35.75	85.75	135.75	185.75	285.75	385.75	485.75	585.75	685.75	785.75	885.75	985.75	1085.75
	v	0.01885	1.5948		1.6988	1.8327	1.9578	2.0772	2.3058	2.5269	2.7440	2.9585	3.1711	3.3824	3.5926	3.8019	4.0106
	h	390.60	1202.6		1227.3	1258.9	1288.1	1316.0	1369.5	1421.7	1473.9	1526.5	1579.6	1633.5	1688.2	1743.6	1799.7
	s	0.5844	1.5135		1.5412	1.5750	1.6048	1.6317	1.6799	1.7232	1.7630	1.8003	1.8356	1.8690	1.9010	1.9316	1.9610
300 (417.35)	Sh				32.65	82.65	132.65	182.65	282.65	382.65	482.65	582.65	682.65	782.65	882.65	982.65	1082.65
	v	0.01889	1.5427		1.6356	1.7665	1.8883	2.0044	2.2263	2.4407	2.6509	2.8585	3.0643	3.2688	3.4721	3.6746	3.8764
	h	393.99	1202.9		1225.7	1257.7	1287.2	1315.2	1368.9	1421.3	1473.6	1526.2	1579.4	1633.3	1688.0	1743.4	1799.6
	s	0.5882	1.5105		1.5361	1.5703	1.6003	1.6274	1.6758	1.7192	1.7591	1.7964	1.8317	1.8652	1.8972	1.9278	1.9572
310 (420.36)	Sh				29.64	79.64	129.64	179.64	279.64	379.64	479.64	579.64	679.64	779.64	879.64	979.64	1079.64
	v	0.01894	1.4939		1.5763	1.7044	1.8233	1.9363	2.1520	2.3600	2.5638	2.7650	2.9644	3.1625	3.3594	3.5555	3.7509
	h	397.30	1203.2		1224.1	1256.5	1286.3	1314.5	1368.4	1420.9	1473.2	1525.9	1579.2	1633.1	1687.8	1743.3	1799.4
	s	0.5920	1.5076		1.5311	1.5657	1.5960	1.6233	1.6719	1.7153	1.7553	1.7927	1.8280	1.8615	1.8935	1.9241	1.9536
320 (423.31)	Sh				26.69	76.69	126.69	176.69	276.69	376.69	476.69	576.69	676.69	776.69	876.69	976.69	1076.69
	v	0.01899	1.4480		1.5207	1.6462	1.7623	1.8725	2.0823	2.2843	2.4821	2.6774	2.8708	3.0628	3.2538	3.4438	3.6332
	h	400.53	1203.4		1222.5	1255.2	1285.3	1313.7	1367.8	1420.5	1472.9	1525.6	1578.9	1632.9	1687.6	1743.1	1799.3
	s	0.5956	1.5048		1.5261	1.5612	1.5918	1.6192	1.6680	1.7116	1.7516	1.7890	1.8243	1.8579	1.8899	1.9206	1.9500
330 (426.18)	Sh				23.82	73.82	123.82	173.82	273.82	373.82	473.82	573.82	673.82	773.82	873.82	973.82	1073.82
	v	0.01903	1.4048		1.4684	1.5915	1.7050	1.8125	2.0168	2.2132	2.4054	2.5950	2.7828	2.9692	3.1545	3.3389	3.5227
	h	403.70	1203.6		1220.9	1254.0	1284.4	1313.0	1367.3	1420.0	1472.5	1525.3	1578.7	1632.7	1687.5	1742.9	1799.2
	s	0.5991	1.5021		1.5213	1.5568	1.5876	1.6153	1.6643	1.7079	1.7480	1.7855	1.8208	1.8544	1.8864	1.9171	1.9466
340 (428.99)	Sh				21.01	71.01	121.01	171.01	271.01	371.01	471.01	571.01	671.01	771.01	871.01	971.01	1071.01
	v	0.01908	1.3640		1.4191	1.5399	1.6511	1.7561	1.9552	2.1463	2.3333	2.5175	2.7000	2.8811	3.0611	3.2402	3.4186
	h	406.80	1203.8		1219.2	1252.8	1283.4	1312.2	1366.7	1419.6	1472.2	1525.0	1578.4	1632.5	1687.3	1742.8	1799.0
	s	0.6026	1.4994		1.5165	1.5525	1.5836	1.6114	1.6606	1.7044	1.7445	1.7820	1.8174	1.8510	1.8831	1.9138	1.9432
350 (431.73)	Sh				18.27	68.27	118.27	168.27	268.27	368.27	468.27	568.27	668.27	768.27	868.27	968.27	1068.27
	v	0.01912	1.3255		1.3725	1.4913	1.6002	1.7028	1.8970	2.0832	2.2652	2.4445	2.6219	2.7980	2.9730	3.1471	3.3205
	h	409.83	1204.0		1217.5	1251.5	1282.4	1311.4	1366.2	1419.2	1471.8	1524.7	1578.2	1632.3	1687.1	1742.6	1798.9
	s	0.6059	1.4968		1.5119	1.5483	1.5797	1.6077	1.6571	1.7009	1.7411	1.7787	1.8141	1.8477	1.8798	1.9105	1.9400
360 (434.41)	Sh				15.59	65.59	115.59	165.59	265.59	365.59	465.59	565.59	665.59	765.59	865.59	965.59	1065.59
	v	0.01917	1.2891		1.3285	1.4454	1.5521	1.6525	1.8421	2.0237	2.2009	2.3755	2.5482	2.7196	2.8898	3.0592	3.2279
	h	412.81	1204.1		1215.8	1250.3	1281.5	1310.6	1365.6	1418.7	1471.5	1524.4	1577.9	1632.1	1686.9	1742.5	1798.8
	s	0.6092	1.4943		1.5073	1.5441	1.5758	1.6040	1.6536	1.6976	1.7379	1.7754	1.8109	1.8445	1.8766	1.9073	1.9368
380 (439.61)	Sh				10.39	60.39	110.39	160.39	260.39	360.39	460.39	560.39	660.39	760.39	860.39	960.39	1060.39
	v	0.01925	1.2218		1.2472	1.3606	1.4635	1.5598	1.7410	1.9139	2.0825	2.2484	2.4124	2.5750	2.7366	2.8973	3.0572
	h	418.59	1204.4		1212.4	1247.7	1279.5	1309.0	1364.5	1417.9	1470.8	1523.8	1577.4	1631.6	1686.5	1742.2	1798.5
	s	0.6156	1.4894		1.4982	1.5360	1.5683	1.5969	1.6470	1.6911	1.7315	1.7692	1.8047	1.8384	1.8705	1.9012	1.9307

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

Table 3. Superheated Steam – *Continued*

Abs Press Lb/Sq In (Sat Temp)		Sat Water	Sat Steam	450	500	550	600	650	700	800	900	1000	1100	1200	1300	1400	1500
400 (444.60)	Sh			5.40*	55.40	105.40	155.40	205.40	255.40	355.40	455.40	555.40	655.40	755.40	855.40	955.40	1055.40
	v	0.01934	1.1610	1.1738	1.2841	1.3836	1.4763	1.5646	1.6499	1.8151	1.9759	2.1339	2.2901	2.4450	2.5987	2.7515	2.9037
	h	424.17	1204.6	1208.8	1245.1	1277.5	1307.4	1335.9	1363.4	1417.0	1470.1	1523.3	1576.9	1631.2	1686.2	1741.9	1798.2
	s	0.6217	1.4847	1.4894	1.5282	1.5611	1.5901	1.6163	1.6406	1.6850	1.7255	1.7632	1.7988	1.8325	1.8647	1.8955	1.9250
420 (449.40)	Sh			.60	50.60	100.60	150.60	200.60	250.60	350.60	450.60	550.60	650.60	750.60	850.60	950.60	1050.60
	v	0.01942	1.1057	1.1071	1.2148	1.3113	1.4007	1.4856	1.5676	1.7258	1.8795	2.0304	2.1795	2.3273	2.4739	2.6196	2.7647
	h	429.56	1204.7	1205.2	1242.4	1275.4	1305.8	1334.5	1362.3	1416.2	1469.4	1522.7	1576.4	1630.8	1685.8	1741.6	1798.0
	s	0.6276	1.4802	1.4808	1.5206	1.5542	1.5835	1.6100	1.6345	1.6791	1.7197	1.7575	1.7932	1.8269	1.8591	1.8899	1.9195
440 (454.03)	Sh				45.97	95.97	145.97	195.97	245.97	345.97	445.97	545.97	645.97	745.97	845.97	945.97	1045.97
	v	0.01950	1.0554		1.1517	1.2454	1.3319	1.4138	1.4926	1.6445	1.7918	1.9363	2.0790	2.2203	2.3605	2.4998	2.6384
	h	434.77	1204.8		1239.7	1273.4	1304.7	1333.7	1361.1	1415.3	1468.7	1522.1	1575.9	1630.4	1685.5	1741.2	1797.7
	s	0.6332	1.4759		1.5132	1.5474	1.5772	1.6040	1.6286	1.6734	1.7142	1.7521	1.7878	1.8216	1.8538	1.8847	1.9143
460 (458.50)	Sh				41.50	91.50	141.50	191.50	241.50	341.50	441.50	541.50	641.50	741.50	841.50	941.50	1041.50
	v	0.01959	1.0092		1.0939	1.1852	1.2691	1.3482	1.4242	1.5703	1.7117	1.8504	1.9872	2.1226	2.2569	2.3903	2.5230
	h	439.83	1204.8		1236.9	1271.3	1302.5	1331.8	1360.0	1414.4	1468.0	1521.5	1575.4	1629.9	1685.1	1740.9	1797.4
	s	0.6387	1.4718		1.5060	1.5409	1.5711	1.5982	1.6230	1.6680	1.7089	1.7469	1.7826	1.8165	1.8488	1.8797	1.9093
480 (462.82)	Sh				37.18	87.18	137.18	187.18	237.18	337.18	437.18	537.18	637.18	737.18	837.18	937.18	1037.18
	v	0.01967	0.9668		1.0409	1.1300	1.2115	1.2881	1.3615	1.5023	1.6384	1.7716	1.9030	2.0330	2.1619	2.2900	2.4173
	h	444.75	1204.8		1234.1	1269.1	1300.8	1330.5	1358.8	1413.6	1467.3	1520.9	1574.9	1629.5	1684.7	1740.6	1797.2
	s	0.6439	1.4677		1.4990	1.5346	1.5652	1.5925	1.6176	1.6628	1.7038	1.7419	1.7777	1.8116	1.8439	1.8748	1.9045
500 (467.01)	Sh				32.99	82.99	132.99	182.99	232.99	332.99	432.99	532.99	632.99	732.99	832.99	932.99	1032.99
	v	0.01975	0.9276		0.9919	1.0791	1.1584	1.2327	1.3037	1.4397	1.5708	1.6992	1.8256	1.9507	2.0746	2.1977	2.3200
	h	449.52	1204.7		1231.2	1267.0	1299.1	1329.1	1357.7	1412.7	1466.6	1520.3	1574.4	1629.1	1684.4	1740.3	1796.9
	s	0.6490	1.4639		1.4921	1.5284	1.5595	1.5871	1.6123	1.6578	1.6990	1.7371	1.7730	1.8069	1.8393	1.8702	1.8998
520 (471.07)	Sh				28.93	78.93	128.93	178.93	228.93	328.93	428.93	528.93	628.93	728.93	828.93	928.93	1028.93
	v	0.01982	0.8914		0.9466	1.0321	1.1094	1.1816	1.2504	1.3819	1.5085	1.6323	1.7542	1.8746	1.9940	2.1125	2.2302
	h	454.18	1204.5		1228.3	1264.8	1297.4	1327.7	1356.5	1411.8	1465.9	1519.7	1573.9	1628.7	1684.0	1740.0	1796.7
	s	0.6540	1.4601		1.4853	1.5223	1.5539	1.5818	1.6072	1.6530	1.6943	1.7325	1.7684	1.8024	1.8348	1.8657	1.8954
540 (475.01)	Sh				24.99	74.99	124.99	174.99	224.99	324.99	424.99	524.99	624.99	724.99	824.99	924.99	1024.99
	v	0.01990	0.8577		0.9045	0.9884	1.0640	1.1342	1.2010	1.3284	1.4508	1.5704	1.6880	1.8042	1.9193	2.0336	2.1471
	h	458.71	1204.4		1225.3	1262.5	1295.7	1326.3	1355.3	1410.9	1465.1	1519.1	1573.4	1628.2	1683.6	1739.7	1796.4
	s	0.6587	1.4565		1.4786	1.5164	1.5485	1.5767	1.6023	1.6483	1.6897	1.7280	1.7640	1.7981	1.8305	1.8615	1.8911
560 (478.84)	Sh				21.16	71.16	121.16	171.16	221.16	321.16	421.16	521.16	621.16	721.16	821.16	921.16	1021.16
	v	0.01998	0.8264		0.8653	0.9479	1.0217	1.0902	1.1552	1.2787	1.3972	1.5129	1.6266	1.7388	1.8500	1.9603	2.0699
	h	463.14	1204.2		1222.2	1260.3	1293.9	1324.9	1354.2	1410.0	1464.4	1518.6	1572.9	1627.8	1683.3	1739.4	1796.1
	s	0.6634	1.4529		1.4720	1.5106	1.5431	1.5717	1.5975	1.6438	1.6853	1.7237	1.7598	1.7939	1.8263	1.8573	1.8870
580 (482.57)	Sh				17.43	67.43	117.43	167.43	217.43	317.43	417.43	517.43	617.43	717.43	817.43	917.43	1017.43
	v	0.02006	0.7971		0.8287	0.9100	0.9824	1.0492	1.1125	1.2324	1.3473	1.4593	1.5693	1.6780	1.7855	1.8921	1.9980
	h	467.47	1203.9		1219.1	1258.0	1292.1	1323.4	1353.0	1409.2	1463.7	1518.0	1572.4	1627.4	1682.9	1739.1	1795.9
	s	0.6679	1.4495		1.4654	1.5049	1.5380	1.5668	1.5929	1.6394	1.6811	1.7196	1.7556	1.7898	1.8223	1.8533	1.8831
600 (486.20)	Sh				13.80	63.80	113.80	163.80	213.80	313.80	413.80	513.80	613.80	713.80	813.80	913.80	1013.80
	v	0.02013	0.7697		0.7944	0.8746	0.9456	1.0109	1.0726	1.1892	1.3008	1.4093	1.5160	1.6211	1.7252	1.8284	1.9309
	h	471.70	1203.7		1215.9	1255.6	1290.3	1322.0	1351.8	1408.3	1463.0	1517.4	1571.9	1627.0	1682.6	1738.8	1795.6
	s	0.6723	1.4461		1.4590	1.4993	1.5329	1.5621	1.5884	1.6351	1.6769	1.7155	1.7517	1.7859	1.8184	1.8494	1.8792
650 (494.89)	Sh				5.11	55.11	105.11	155.11	205.11	305.11	405.11	505.11	605.11	705.11	805.11	905.11	1005.11
	v	0.02032	0.7084		0.7173	0.7954	0.8634	0.9254	0.9835	1.0929	1.1969	1.2979	1.3969	1.4944	1.5909	1.6864	1.7813
	h	481.89	1202.8		1207.6	1249.6	1285.7	1318.3	1348.7	1406.0	1461.2	1515.9	1570.7	1625.9	1681.6	1738.0	1794.9
	s	0.6828	1.4381		1.4430	1.4858	1.5207	1.5507	1.5775	1.6249	1.6671	1.7059	1.7422	1.7765	1.8092	1.8403	1.8701
700 (503.08)	Sh					46.92	96.92	146.92	196.92	296.92	396.92	496.92	596.92	696.92	796.92	896.92	996.92
	v	0.02050	0.6556			0.7271	0.7928	0.8520	0.9072	1.0102	1.1078	1.2023	1.2948	1.3858	1.4757	1.5647	1.6530
	h	491.60	1201.8			1243.4	1281.0	1314.6	1345.6	1403.7	1459.4	1514.4	1569.4	1624.8	1680.7	1737.2	1794.3
	s	0.6928	1.4304			1.4726	1.5090	1.5399	1.5673	1.6154	1.6580	1.6970	1.7335	1.7679	1.8006	1.8318	1.8617
750 (510.84)	Sh					39.16	89.16	139.16	189.16	289.16	389.16	489.16	589.16	689.16	789.16	889.16	989.16
	v	0.02069	0.6095			0.6676	0.7313	0.7882	0.8409	0.9386	1.0306	1.1195	1.2063	1.2916	1.3759	1.4592	1.5419
	h	500.89	1200.7			1236.9	1276.1	1310.7	1342.5	1401.5	1457.6	1512.9	1568.2	1623.8	1679.8	1736.4	1793.6
	s	0.7022	1.4232			1.4598	1.4977	1.5296	1.5577	1.6065	1.6494	1.6886	1.7252	1.7598	1.7926	1.8239	1.8538
800 (518.21)	Sh					31.79	81.79	131.79	181.79	281.79	381.79	481.79	581.79	681.79	781.79	881.79	981.79
	v	0.02087	0.5690			0.6151	0.6774	0.7323	0.7829	0.8759	0.9631	1.0470	1.1289	1.2093	1.2885	1.3669	1.4446
	h	509.81	1199.4			1230.1	1271.1	1306.8	1339.3	1399.1	1455.8	1511.4	1566.9	1622.7	1678.9	1735.7	1792.9
	s	0.7111	1.4163			1.4472	1.4869	1.5198	1.5484	1.5980	1.6413	1.6807	1.7175	1.7522	1.7851	1.8164	1.8464
850 (525.24)	Sh					24.76	74.76	124.76	174.76	274.76	374.76	474.76	574.76	674.76	774.76	874.76	974.76
	v	0.02105	0.5330			0.5683	0.6296	0.6829	0.7315	0.8205	0.9034	0.9830	1.0606	1.1366	1.2115	1.2855	1.3588
	h	518.40	1198.0			1223.0	1265.9	1302.8	1336.0	1396.8	1454.0	1510.0	1565.7	1621.6	1678.0	1734.9	1792.3
	s	0.7197	1.4096			1.4347	1.4763	1.5102	1.5396	1.5899	1.6336	1.6733	1.7102	1.7450	1.7780	1.8094	1.8395
900 (531.95)	Sh					18.05	68.05	118.05	168.05	268.05	368.05	468.05	568.05	668.05	768.05	868.05	968.05
	v	0.02123	0.5009			0.5263	0.5869	0.6388	0.6858	0.7713	0.8504	0.9262	0.9998	1.0720	1.1430	1.2131	1.2825
	h	526.70	1196.4			1215.5	1260.6	1298.6	1332.7	1394.4	1452.2	1508.5	1564.4	1620.6	1677.1	1734.1	1791.6
	s	0.7279	1.4032			1.4223	1.4659	1.5010	1.5311	1.5822	1.6263	1.6662	1.7033	1.7382	1.7713	1.8028	1.8329

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