U. S. NUCLEAR REGULATORY COMMISSION REGION I
OPERATOR LICENSING EXAMINATION REPORT

EXAMINATION REPORT NO. 50-219/84-16

FACILITY DOCKET NO. 50-219

FACILITY LICENSE NO. DPR-16

LICENSEE: General Public Utilities
P. O. Box 388
Forked River, New Jersey 08731

FACILITY: Oyster Creek Nuclear Generating Station

DATES: April 10-13, 1984

CHIEF EXAMINER: Original Signed By, JUN 5 1984
John A. Berry
Reactor Engineer
Date

APPROVED BY: Original Signed By, JUN 19 1984
A. F. Johnson for
Chief, Project Section 1D
Date

SUMMARY: Written and oral examinations were administered to four Senior Reactor Operator candidates and one Instructor Certification candidate the week of April 10, 1984. All candidates passed the oral examinations. Two candidates failed the written examination.

REPORT DETAILS

TYPE OF EXAMS: Initial ___ Replacement X Requalification ___

EXAM RESULTS:

	RO Pass/Fail	SRO Pass/Fail	Inst. Cert Pass/Fail	Fuel Handler Pass/Fail
Written Exam	/	2/2	1/0	/
Oral Exam	/	4/0	1/0	/
Simulator Exam	/	/	0/0	/
Overall	/	2/2	1/0	/

1. CHIEF EXAMINER AT SITE: I. S. Levy - Pacific Northwest Laboratory

2. PERSONS EXAMINED

SRO

A. N. Garcia
R. J. Kautter
J. D. Kowalski
K. J. Mulligan

Instructor Certification

P. A. Hays

1. Summary of generic strengths or deficiencies noted on oral exams:

   The examiner noted a deficiency in the use of hand-held radiation detectors.

2. Summary of generic strengths or deficiencies noted from grading of written exams:

   None

3. Comments on availability and candidate familiarization with plant reference material:

   Availability and familiarity were satisfactory.

4. Comments on availability and candidate familiarization with plant design, procedure, T. S. changes and LERs:

   Availability and familiarity were satisfactory.

5. Comments on interface effectiveness with plant training staff and plant operations staff during exam period.

   Plant staff personnel were cooperative and helpful in all respects during the examination period.

6. Improvements noted in training programs as a result of prior operator licensing examinations/suggestions, etc:

   Not Applicable

7. Personnel Present at Exit Meeting:

NRC Personnel

C. Cowgill, SRI, Oyster Creek NGS

NRC Contractor Personnel

I. S. Levy - Pacific Northwest Laboratories

Facility Personnel

P. Fiedler
D. Gaines
M. Laggart

8. Summary of NRC Comments made at exit interview:

At the conclusion of the site visit, on April 13, 1984, I. S. Levy met with representatives of plant staff to discuss the results of the examinations. I. S. Levy noted that all candidates clearly passed the oral examination. I. S. Levy made the observation, relative to the training program, that no obvious, consistent deficiencies were observed during oral examinations except for use of hand-held radiation detectors.

I. S. Levy also noted that during review of the written examination, instances occurred where the referenced lesson plans were shown not to reflect actual plant conditions; and, as well, that one of the new AOP's didn't include all of the relevant plant parameters that an operator would be expected to observe and that this AOP (and perhaps others also) therefore, did not reflect actual plant conditions.

9. CHANGES MADE TO WRITTEN EXAM

Facility comments on the written examination, and the resolution of those comments, are attached.

WRITTEN EXAM REVIEW

The written exam was reviewed, after completion of the exam by all candidates, at the O.C. training center commencing at 3:25 p.m. The review ended at 5:25 p.m. Facility reviewers were, Rod Davidson, Dave Fawcett and John Young.

The complete comments are attached. No questions were deleted, though two questions were possible candidates for deletion and were resolved as follows:

6.9 As a result of inaccurate reference material from the Lesson Plans, valve V-31-2 was incorrectly identified in both the question and answer as to its locations and purpose.

I gave credit to both possible answers (i.e., to those who recognized the Lesson Plan material and to those who dealt with the real plant situation) since deletion of the question would have lowered all candidate scores (greater weight being given to the remaining questions).

8.3 Dave Fawcett said that operators are not required to know more than 1-hr notification occurrences and, therefore, the 4-hr part of the question should be deleted. I called John Berry, who said 10CFR requires both 1-hr and 4-hr., so the question remained as written.

All other comments on questions were either resolved as "accepted", or answers were to be evaluated during the grading process so as to ensure that the candidates grades would not be affected by the phrasing of questions.

UTILITY COMMENTS

5.3.a	Comment 1:	also acceptable should be "It decays away without burn-out; therefore, it comes and goes. Therefore, it is more important since it has to be dealt with inter-mittently, as opposed to being constant."
	Response:	I accept
5.4	Comment:	If answer is a curve of ΔK or N_{mod}/N_{fuel} OK!
	Response:	I said if the candidate explains what is happening on the curve, its OK.
5.6.a	Comment:	None of the regions of the core are reactive, i.e., we're in shutdown. The question should have said on an immediate restart following a scram.
	Response:	I said I'll look at the answers to see if there was any confusion.
5.7.c	Comment 1:	Why 600 gal/hr in math of answer
	Response 1:	I'll check - probably a typo
	Resolution 1:	Was a typo; should have been "800 gpm".
	Comment 2:	Minimum requirement would go up so 120°F value would go up; may go to 140 and cause isolation.
	Response 2:	I said candidates need to assume it stays at 120°F as stated.
5.8	Comment:	Void content will not change much at all. Power will turn down as T increases and then go up and T will do the same (pressure not important since <600 psig, since MSIVs closed otherwise you'd scram)
	Response:	I'll accept.
5.10.b	Comment:	Change in viscosity should not be required. Density difference is sufficient.
	Response:	I'll accept.

6.1.a Comment: Fuel transfer won't cause interruption (confirmed from ref. material).

Response: I'll accept.

6.2.b Comment: Other possible answers (Ref. LP64, p. 7, ¶4):
Initiates core spray
Initiates contaminant spray
Containment isolation
Reactor isolation
Recirc. pump trip
SGTS initiates
Initiates isolation condenser

Response: I'll accept either original answer (lo lo level trip) only or "any one or more of" the answers given in the comment.

6.2.c Comment: set points have been changed:
2 EMRV's at 1060 not 1050; at 1050 is reactor scram
[Ref: Standing Order #1, p. 1 (6/20/83)]

Response: I'll accept only R_x scram at 1050 since Standing Order (an ops. doc.) supercedes lesson plans.

6.3.a Comment: Additional is automatic time delay of 2 minutes.

Response: I'll accept.

6.3.b Comment 1: Should accept TC as another part of answer for sensing and for indications.

Response 1: TCs don't separate high flow from low flow; not accepted

Comment 2: Accelerometers are acoustic indicators; therefore, acoustic reactors should also be acceptable.

Response 2: I'll accept (either is OK).

6.4.b Comment 1: Answer 4 no longer correct; disabled this outage.

Response 1: I'll accept either answer.

Comment 2: Additional bypasses also should be acceptable; IRM upscale IRM inop. both via moving mode switch from Start to Run.
(Ref: LP46, p. 15, ¶2)

Response 2: I'll accept if candidate states in startup mode or if states changing mode from startup to run.

6.5 Comment: Systems versus components not clear in question.

Response: I'll look at answers to see if ambiguity caused problems.

6.7.a Comment: Answer is 3700 gpm (3400 + 300 min flow to torus).

Response: I'll accept.

6.7.d Comment: No "interlocks" prevent manual operation. Therefore, "none" is a correct answer.

Response: I'll accept if that answer is given; and will review other answers to ensure no confusion or caused problems.

6.8.a Comment 1: Another start for pump is autostart of second or third pump on low pressure.
(Ref: LP5 VC if)

Response 1: I'll accept

Comment 2: Isolation valves do not autoinitiate (only manual). (Reference check showed my reference was for the air compressor.) Therefore, should delete isolation valve part of question.

Response 2: I accept that isolation valves are only manually initiated. I'll delete only if answers show confusion.

6.9.b Comment 1: memorization of V-31-2 not required

Response 1: The question <u>also</u> identified it as the motor op. valve in the CRD pump room. Therefore, should be not problem with value identification - comment not accepted.

Comment 2: V-31-2 is <u>not</u> motor operated; the lesson plan is incorrect.
(Ref: P_ID GE 706E249)

Response 2: I'll accept.

Comment 3: V-31-2 is not located in CRD pump room but in Rx Building elev. 95 and is also not the valve separating CRD from hand cooling but rather the final entry valve for head cooling.
(Ref: GE print 886-D403)

Response 3: I'll accept and delete questions if conservative for candidates to do so.

Resolution: Gave credit for both "isolation" and "CRD entry valve to head cooling system" (more beneficial to candidate than to delete).

6.10.a Comment 1: Valves are located at pump pad, condensate transfer pump room and west of turbine building (all next to chlorination building) but sensors/signals located in mechanical vacuum room and low flow control in a mech. vac. pump room and hotwell level control is in feed pump room.

Response 1: I'll accept these answers.

Comment 2: a) it controls valves: i.e., the dumper valve, dumper bypass valve sucker (makeup) valve and sucker bypass valves
b) it controls level in hotwell not hotwell itself, etc.

Response 2: I'll accept the valves listed in comment (2a).

7.1.b Comment: Additional sentence in plant ops. explaining limitations, approvals, etc.

Response: OK; but original answer is all that is required.

7.5.c Comment: Answer 2 is not an "immediate op. action" and therefore should be deleted.

Response: I'll accept, even though it is stated in the reference as an "immediate op. action"

7.7.a Comment: 4.8 ft not now lowest; TAF monitoring system modification has been made and will become operational at end of outage.

Response: If candidates discuss new TAF monitoring, they must state that 4.8 is currently the lowest until TAF becomes operational.

7.8 Comment: Additional plant parameters (not given in procedures) also change:
Condensor vacuum - decrease
ADG system flow - decrease
Generator/electric output - decrease
SJAE room Hi Hydrogen -increase
(Ref: ¶3.6, p. 8 of ref. shows the last item only)

Response: I'll accept the above responses.

8.3 Comment: Operators only need to know action items of <1 hr; Therefore, 4 hr not relevant question (both 1 hr and 4 hr are in Admin. Prp. 125 effective 2/1/84; deleted all of 6.9 in T.S.)

Response: I'll check with NRC (Berry) re. 4 hr to delete or not.

Resolution: ~~Berry said its a 10 CFR requirement to know both; therefore, not accepted.~~ – Question Deleted at Region I

8.4 Comment: Also addition acceptable answers: the G.S.S. must not be assigned to the fire brigade.
(Ref: Admin. Procedures, 106 p. 14/42, ¶4.1.5)

Response: I'll accept.

MASTER

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

Facility: OYSTER CREEK

Reactor Type: BWR-3

Date Administered: 4/10/84

Examiner: I.S. LEVY

Candidate: _____

INSTRUCTIONS TO CANDIDATE:

Use separate paper for the answers. Write answers on one side only. Staple question sheet on top of the answer sheet. Points for each question are indicated in parenthesis 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 Cat. Value	Category
25	25			5. Theory of Nuclear Power Plant Operation, Fluids and Thermodynamics
25	25			6. Plant System Design, Control and Instrumentation
25	25			7. Procedures - Normal, Abnormal, Emergency, and Radiological Control
25	25			8. Administrative Procedures, Conditions, and Limitations
100				TOTALS

Final Grade _____ %

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

_____
Candidate's Signature

Oyster Creek SRO Exam - 4/10/84

5.0 Theory of Nuclear Power Plant Operations, Fluids and Thermodynamics (25.0)

5.1 Give three (3) reasons why fuel densification is a problem. (2.25)

5.2 Regarding a Reactor Startup:

a. Does the magnitude of the initial level of source range counts affect the Estimated Critical Position? Why? (1.25)

b. How long will it take to reach 0.08% power, if the reactor is just critical at 0.002% power and on a steady period with a "doubling time" of 40 seconds? (Show all work.) (1.0)

5.3 With regard to some aspects of Fission Product Poisons:

a. Of the two fission product poisons, Xe, Sm, why is xenon more important? (1.0)

b. What is the mechanism(s) for removal of Samarium-149 once it is produced in the core? (1.0)

5.4 Explain how a positive temperature coefficient is possible late in core life. What problems are associated with this in terms of reactor control? (2.0)

5.5 Explain the reason why the effective decay constant [redacted] is typically 0.1 for up power transients and 0.05 for down power transients. (1.5)

5.6 Following a scram from high power, answer the following:

a. What are the most reactive regions of the core? (1.0)

b. Why are these regions more reactive? (1.25)

c. What problem does this cause for the operator during a subsequent start up. Why? (1.25)

- Category 5 continued on next page -

5.7 In reference to the reactor water cleanup regenerative heat exchanger, assume the following conditions and, then, perform the calculations.

Conditions:

T inlet from reactor (tube side) = 550°F
T outlet from H_x (tube side) = 250°F
T inlet shell side = 120°F
Tubeside flow rate from reactor = 1300 gal/min
Shell ~~Tube~~side flow rate to reactor = 1300 gal/min

Calculate (and show all work):

a. The amount of heat transfer (Btu/hr) on the tube side. (1.0)

b. The temperature of the water going back to the reactor. (1.0)

c. The maximum temperature of water going back to the reactor if the flow back to the reactor were decreased from 1,300 gpm to 800 gpm. (1.0)

5.8 Following initial criticality (MSIVs closed, moderator T > 212°F), a constant positive period is established. Briefly explain what happens over the next several hours to pressure, temperature and power if no rod movement occurs. (1.5)

5.9 a. What is pump runout and why is it an undesirable condition? (1.5)

b. What are two (2) reasons a centrifugal pump should be started with the discharge piping filled and the discharge valve shut? (1.0)

5.10 a. Assume the reactor is at 100% power and flow. Explain what happens to core flow, and why, for a reduction in power by driving rods in. (Recirculation pump speed remains constant.) (1.25)

b. At low power conditions prior to void generation, an increase in reactor power by control rod withdrawal will (increase, decrease, not change) flow through the core. Choose the correct answer and briefly explain your choice. (1.25)

5.11 When boiling transition occurs in a fuel channel, is the critical power ratio (CPR) larger or smaller than when nucleate boiling occurs? (0.5)

5.12 Besides neutron flux, list three (3) other factors which help determine actual differential worth of a control rod. (1.5)

- End Category 5 -

6.0 Plant System Design, Control and Instrumentation (25.0)

6.1 With regard to the Standby Diesel Generator (SDG):

a. List four (4) of five (5) annunciator relays which will interrupt the circuit to the normal lockout relay. (2.0)

b. Which of these are bypassed in the fast start mode? (1.0)

6.2 What safety action(s) are initiated at each of the following indications:

a. 90" Yarway? (0.5)

b. 0" Yarway? (0.5)

c. 1050 psig? (0.5)

d. 600 psig? (0.5)

6.3 With respect to the Automatic Depressurization System (ADS):

a. List (including setpoints) the automatic activation sequence for ADS. (1.5)

b. How is high flow through a relief valve sensed and indicated? (1.5)

6.4 With regard to the Reactor Protection System Auto Subchannels 1A, 1B, IIA and IIB trip functions:

a. Which trip has as its basis the prevention of a condition that would cause a reduction in the CPR due to an increase in core inlet enthalpy? (0.5)

b. Which trip(s) can only be bypassed manually? (2.0)

6.5 With regard to the AC Electrical Distribution System:

a. When the Isolation Valve Motor Control Center 1AB2 is de-energized, it affects eleven (11) loads distributed among six (6) components. Give these six (6) components and one (1) load for each. (3.0)

b. Will the ED closing circuit allow the ED breaker to be closed if D/G-#2 breaker is open? (0.5)

- Category 6 continued on next page -

6.6 Concerning the Standby Liquid Control System:

a. The SBLC pumps are heat traced (TRUE or FALSE)? (0.5)

b. What is the purpose behind the SBLC storage tank heater? (1.0)

c. There is a trip on low flow (TRUE or FALSE)? (0.5)

6.7 Answer the following questions concerning the Core Spray System (CSS):

a. What is the design flow of the main pumps? (0.75)

b. The single initiation signal sensor for each channel will trip both systems (TRUE or FALSE)? (0.5)

c. When a CSS trip signal is received, auto start of CRD pump is inhibited (TRUE or FALSE)? (0.5)

d. What are the interlocks associated with the manual opening of the V-20-12 pump discharge valve? (0.75)

6.8 With regard to the Turbine Building Closed Cooling Water System (TBCCW):

a. What is the purpose of the Chemical Feed System? (1.0)

b. What causes starting of the TBCCW pumps and opening of isolation valves? (1.0)

c. During shutdown, what is the status of the third TBCCW pump? (0.5)

6.9 Concerning the CRD Hydraulic System:

a. Give the appropriate values for the following:

1. Accumulator pressure required to meet the 90% total scram times at 1000 psig reactor pressure with discharge volume at atmospheric pressure. (0.5)

2. Drive water pressure at 400 psig reactor pressure. (0.5)

3. Cooling water pressure at 400 psig reactor pressure. (0.5)

b. What is the purpose of the motor operated valve V-31-2 in in the CRD Pump Room (NW Corner Room)? (0.75)

- Category 6 continued on next page -

6.10 Concerning the Feed and Condensate System:

a. Where is the Condensate Flow Control System located and what four (4) component(s) does it control? (1.25)

b. Both feedwater HP and LP heaters have external drain coolers (TRUE or FALSE)? (0.5)

- End Category 6 -

7.0 Procedures - Normal, Abnormal, Emergency, and Radiological Control (25.0)

7.1 With regard to Operating Procedure 201.2, Plant Heatup to Hot Standby:

a. What is the preferred action the operator should take to maintain water level between 70 and 80 inches yarway during heatup? (1.0)

b. What condition(s) in the containment must be achieved before placing the mode switch in the run position? (1.0)

c. The ΔT(s) between which components are to be monitored to ensure heatup rate is within limits? (1.0)

7.2 With regard to the Operating Procedures for the Control Rod Drive Manual Control System (302.2):

a. After selecting a rod, the operator is instructed to momentarily move the Rod Control switch to "Rod Out Notch". What two (2) indications should he then see? (1.5)

b. If the Rod Control switch is not then immediately released, what will happen? (1.0)

c. Which of the Withdrawal Permissive Criteria need only be satisfied in the Run mode? (0.5)

7.3 Relative to the Emergency Operating Procedure for Containment Control (EMG-3200.02):

a. List the five (5) entry conditions. (2.0)

b. State the "caution" with regard to removing the control power fuses in the 480 V switchgear room. (1.5)

- Category 7 continued on next page -

7.4 According to procedures for Emergency RPV Depressurization (EMG-3300.04):

a. What is the minimum number of EMRV's required for Emergency Depressurization? (0.5)

b. What is the minimum EMRV re-opening pressure? (0.5)

c. Should either of the above two minimums be exceeded, the operator is to use one or more of which systems (and in which preferred order) to rapidly depressurize the RPV? (1.5)

7.5 Assuming a loss of feedwater heaters while operating at 100% power, according to Abnormal Operating Procedure 3200.16:

a. What 4 events could have caused this? (2.0)

b. What change would you expect to see in the Main Generator MW (increase, decrease)? (0.5)

c. What are the two immediate operator actions you should take? (1.75)

7.6 With regard to the operating procedure for Placing Vital Motor Control Center 1A2 in Service (OP.339, Section 2.0):

a. The "precautions and limitations" state that the reactor shall not be made critical until certain buses or panels are energized. Which one(s) of these are on the 23'6" elevation in the reactor building? (1.0)

b. Before racking out any breaker, what should be done? (0.75)

c. When placing VMCC 1A2 in service should you close the breaker for Auto-Transfer Switch ST-C? (0.5)

7.7 With regard to the Fuel Cladding Integrity safety limit:

a. Why does Specification D state, in part, that the water level shall not be less than 4'8" above the top of the normal active fuel zone with fuel in the reactor? (1.0)

b. According to Specification C, for how long can the neutron flux exceed its scram setting? Why? (1.5)

- Category 7 continued on next page -

7.8 The Reactor Operator reports that the SJAE inlet valve has isolated and the off gas system Hi pressure annunciator has come on.

a. What would you conclude has happened? (0.5)

b. What four (4) plant parameters would be affected and in what way (increase, decrease)? (1.5)

7.9 According to the Oyster Creek Technical Specifications, are the following statements TRUE or FALSE?

a. If the APLHGR is not returned to within the prescribed limits within eight (8) hours, action shall be initiated to bring the reactor to the cold shutdown within 36 hours. (0.5)

b. The two isolation condenser loops shall be operable during power operation and whenever the reactor coolant temperature is greater than 212°F or the reactor shall be placed in a cold shutdown condition. (0.5)

7.10 According to the Abnormal Operation Event Procedures for Fires (3200.29), among the "Indications" will be six (6) actuations. List any five (5) of these. (1.0)

- End Category 7 -

8.0 Administrative Procedures, Conditions, and Limitations (25.0)

8.1 a. Reactor coolant leakage into the primary containment from unidentified sources shall not exceed (1) gpm and the total coolant leakage shall not exceed (2) gpm. (1.0)

b. What is the basis behind the unidentified leakage rate? (0.75)

8.2 What conditions (LCO) are required in order for secondary containment to be in effect? (3.5)

8.3 There are occurrences that require 1 hour or 4 hour reports to the NRC. State two (2) occurrences for each reporting frequency. (2.0)

8.4 With regard to the Fire Brigade:

a. What is the minimum number of personnel required? (0.5)

b. Who are specifically excluded from the Fire Brigade? (0.75)

c. Where and when is the Fire Brigade to be maintained? (0.75)

8.5 With regard to Standing Order 34 (Diesel Generator Critical Loads):

a. What is the purpose of this standing order? (1.0)

b. How is it to be used? (1.0)

c. Give two (2) safety systems that have pumps but have no priority pumps. (1.0)

8.6 According to Standing Order 1 (Instrument Setpoints):

a. What is the Technical Specification limit for the refueling Grapple Load Switch? (0.5)

b. Is there a Technical Specification Limit for "LPRM High"? (0.5)

- Category 8 continued on next page -

8.7 With regard to Administrative Procedure 106 (Conduct of Operations):

a. There must be two (2) licensed operators in the Control Room at all times (TRUE or FALSE)? (0.5)

b. All core alterations shall be supervised by a Group Operating Supervisor (TRUE or FALSE)? (0.5)

c. When shall the Shift Technical Advisor be at the station? (0.5)

d. Under what conditions can the Shift Control Room Operator shut the reactor down without being instructed by the Group Shift Supervisor or required by the Station Emergency Procedures? (1.0)

e. If, while at power, the GSS leaves the control room, what action needs to take place? (0.75)

8.8 According to Administrative Procedure 108 (Equipment Control):

a. If a tag is placed on a component's power supply, a tag shall also be placed on each remote control and the component's manual operator (TRUE or FALSE)? (0.5)

b. A disconnecting device bearing a Red or Blue tag may not be closed (TRUE or FALSE)? (0.5)

c. Which tag is a mechanical tag that signifies operation would create an unsafe condition? (0.5)

d. Under what conditions may systems or components which affect Technical Specifications be tagged out? (0.75)

e. After the operator hanging the tags fills them out and initials the log sheet, he notifies the GSS or GOS who then releases the equipment to the person requesting the outage (TRUE or FALSE)? (0.5)

- Category 8 continued on next page -

8.9 According to the Radiation Safety Manual:

a. What are the administrative whole body dose limits? (1.0)

b. Based upon 10CFR20, what is the maximum allowable whole body exposure for a 30 year old person? (0.5)

c. What is the definition of a Radiation Area? (1.0)

d. Any object that exceeds (FILL IN) above background cannot be released from a contaminated area without special controls. (0.5)

8.10 With regard to the Emergency Plan Implementation Procedures:

a. In which of the four emergency classes would you place the following: (1.0)
   1. An ATWS
   2. Shutdown occurs but decay heat removal capability is lost; core degradation in 8 hours is anticipated.

b. If there is a major injury:
   1. Who is responsible for initiating action? (0.5)
   2. Who should he notify? (1.25)

- End Category 8 -

EQUATIONS/DATA SHEET

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

$1Ci = 3.7 \times 10^{10} Bq$

$\alpha_D = -1 \times 10^{-5} \frac{\Delta K/K}{^\circ F}$

$\alpha_v = -1 \times 10^{-3} \frac{\Delta K/K}{\%\ voids}$

$\alpha_M = -4.5 \times 10^{-4} \frac{\Delta K/K}{^\circ F}$

$\alpha_p = -4.5 \times 10^{-4} \frac{\Delta K/K}{\%\ power}$

$I(t) = Io\ e^{-\lambda t}$

$T1/2 = \ln(2)/\lambda$

$Cp = (CP_{base})\ (Ks)\ (K_A)$

$Q = MCp\ \Delta t$

$\Delta\rho = f \frac{L}{D} \frac{\rho V^2}{2g_c}$

$f = 64/Re$

$\rho = \frac{k(eff) - 1}{K(eff)}$

$\frac{1}{M} = \frac{CR1}{CR2} = \frac{1-K(eff)2}{1-K(eff)1}$

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

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

$M = 1/(1-k)$

$N(t) = No\ e^{-\lambda T}$

$\alpha_r = (L_f + L_s) \frac{(\phi rod)^2}{(\phi avg)}$

$n = \nu/(1 + d)$

$P = \Sigma\ \phi\ \nu/(3.7 \times 10^{10})$

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

$\dot{\tau} = \bar{\ell}/\rho + (\beta - \rho)/\lambda\dot{\rho}$

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

$v = v_f + x v_{fg}$

$H = xh_g + (1-x)\ h_f$

$S = xS_g + (1-x)\ S_f$

1 in. = 2.54 cm

1 gal. = 3.785 liters

1 kg = 2.205 lb

$N = \rho A_o/A$

17.58 watts = 1 BTU/min
1psi = 6.895 Pa
1psi = 2.036 " H_g (@ 0C)
1psi = 27.68 " H^2O (@ 4C)

$\bar{\beta} = .0071$

$\bar{\ell} = 2 \times 10^{-5}$ sec

Table 1. Saturated Steam: Temperature Table

Temp Fahr t	Abs Press Lb per Sq in p	Specific Volume Sat Liquid v_f	Evap v_{fg}	Sat Vapor v_g	Enthalpy Sat Liquid h_f	Evap h_{fg}	Sat Vapor h_g	Entropy Sat Liquid s_f	Evap s_{fg}	Sat Vapor s_g	Temp Fahr t
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	1.995	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	0.016025	1482.4	1482.4	22.058	1063.1	1085.1	0.0439	2.0695	2.1134	54.0
56.0	0.22183	0.016029	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	1.9428	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	64.005	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	1117.9	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	1122.9	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	127.98	1002.2	1130.2	0.2313	1.6174	1.8487	160.0
162.0	4.9722	0.016405	73.90	73.92	129.98	1001.0	1131.0	0.2345	1.6103	1.8448	162.0
164.0	5.2124	0.016417	70.70	70.72	131.98	999.8	1131.8	0.2377	1.6032	1.8409	164.0
166.0	5.4623	0.016428	67.67	67.68	133.97	998.6	1132.6	0.2409	1.5961	1.8371	166.0
168.0	5.7223	0.016440	64.78	64.80	135.97	997.4	1133.4	0.2441	1.5892	1.8333	168.0
170.0	5.9926	0.016451	62.04	62.06	137.97	996.2	1134.2	0.2473	1.5822	1.8295	170.0
172.0	6.2736	0.016463	59.43	59.45	139.98	995.0	1135.0	0.2505	1.5753	1.8258	172.0
174.0	6.5656	0.016474	56.95	56.97	141.98	993.8	1135.8	0.2537	1.5684	1.8221	174.0
176.0	6.8690	0.016486	54.59	54.61	143.99	992.6	1136.6	0.2568	1.5616	1.8184	176.0
178.0	7.1840	0.016498	52.35	52.36	145.99	991.4	1137.4	0.2600	1.5548	1.8147	178.0

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

Temp °F t	Abs Press Lb per Sq in a	Specific Volume Sat Liquid v_f	Evap v_{fg}	Sat Vapor v_g	Enthalpy Sat Liquid h_f	Evap h_{fg}	Sat Vapor h_g	Entropy Sat Liquid s_f	Evap s_{fg}	Sat Vapor s_g	Temp °F 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	1.5412	1.8075	182.0
184.0	8.203	0.016534	46.222	46.239	152.01	987.8	1139.8	0.2694	1.5344	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	1.5212	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	982.9	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	1.4953	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	972.9	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	1.6549	284.0
288.0	55.795	0.01734	7.6634	7.6807	257.4	918.8	1176.2	0.4208	1.2290	1.6498	288.0
292.0	59.350	0.01738	7.2301	7.2475	261.5	915.9	1177.4	0.4263	1.2186	1.6449	292.0
296.0	63.084	0.01741	6.8259	6.8433	265.6	913.0	1178.6	0.4317	1.2082	1.6400	296.0
300.0	67.005	0.01745	6.4483	6.4658	269.7	910.0	1179.7	0.4372	1.1979	1.6351	300.0
304.0	71.119	0.01749	6.0955	6.1130	273.8	907.0	1180.9	0.4426	1.1877	1.6303	304.0
308.0	75.433	0.01753	5.7655	5.7830	278.0	904.0	1182.0	0.4479	1.1776	1.6256	308.0
312.0	79.953	0.01757	5.4566	5.4742	282.1	901.0	1183.1	0.4533	1.1676	1.6209	312.0
316.0	84.688	0.01761	5.1673	5.1849	286.3	897.9	1184.1	0.4586	1.1576	1.6162	316.0
320.0	89.643	0.01766	4.8961	4.9138	290.4	894.8	1185.2	0.4640	1.1477	1.6116	320.0
324.0	94.826	0.01770	4.6418	4.6595	294.6	891.6	1186.2	0.4692	1.1378	1.6071	324.0
328.0	100.245	0.01774	4.4030	4.4208	298.7	888.5	1187.2	0.4745	1.1280	1.6025	328.0
332.0	105.907	0.01779	4.1788	4.1966	302.9	885.3	1188.2	0.4798	1.1183	1.5981	332.0
336.0	111.820	0.01783	3.9681	3.9859	307.1	882.1	1189.1	0.4850	1.1086	1.5936	336.0
340.0	117.992	0.01787	3.7699	3.7878	311.3	878.8	1190.1	0.4902	1.0990	1.5892	340.0
344.0	124.430	0.01792	3.5834	3.6013	315.5	875.5	1191.0	0.4954	1.0894	1.5849	344.0
348.0	131.142	0.01797	3.4078	3.4258	319.7	872.2	1191.1	0.5006	1.0799	1.5806	348.0
352.0	138.138	0.01801	3.2423	3.2603	323.9	868.9	1192.7	0.5058	1.0705	1.5763	352.0
356.0	145.424	0.01806	3.0863	3.1044	328.1	865.5	1193.6	0.5110	1.0611	1.5721	356.0
360.0	153.010	0.01811	2.9392	2.9573	332.3	862.1	1194.4	0.5161	1.0517	1.5678	360.0
364.0	160.903	0.01816	2.8002	2.8184	336.5	858.6	1195.2	0.5212	1.0424	1.5637	364.0
368.0	169.113	0.01821	2.6691	2.6873	340.8	855.1	1195.9	0.5263	1.0332	1.5595	368.0
372.0	177.648	0.01826	2.5451	2.5633	345.0	851.6	1196.7	0.5314	1.0240	1.5554	372.0
376.0	186.517	0.01831	2.4279	2.4462	349.3	848.1	1197.4	0.5365	1.0148	1.5513	376.0
380.0	195.729	0.01836	2.3170	2.3353	353.6	844.5	1198.0	0.5416	1.0057	1.5473	380.0
384.0	205.294	0.01842	2.2120	2.2304	357.9	840.8	1198.7	0.5466	0.9966	1.5432	384.0
388.0	215.220	0.01847	2.1126	2.1311	362.2	837.2	1199.3	0.5515	0.9876	1.5392	388.0
392.0	225.516	0.01853	2.0184	2.0369	366.5	833.4	1199.9	0.5564	0.9786	1.5352	392.0
396.0	236.193	0.01858	1.9291	1.9477	370.8	829.7	1200.4	0.5613	0.9696	1.5312	396.0
400.0	247.259	0.01864	1.8444	1.9630	375.1	825.9	1201.0	0.5662	0.9607	1.5274	400.0
404.0	258.725	0.01870	1.7640	1.7827	379.4	822.0	1201.5	0.5711	0.9518	1.5234	404.0
408.0	270.600	0.01875	1.6877	1.7064	383.8	818.2	1201.9	0.5760	0.9429	1.5195	408.0
412.0	282.894	0.01881	1.6152	1.6340	388.1	814.2	1202.4	0.5808	0.9341	1.5157	412.0
416.0	295.617	0.01887	1.5463	1.5651	392.5	810.2	1202.8	0.5856	0.9253	1.5118	416.0
420.0	308.780	0.01894	1.4808	1.4997	396.9	806.2	1203.1	0.5905	0.9165	1.5080	420.0
424.0	322.391	0.01900	1.4184	1.4374	401.3	802.2	1203.5	0.5954	0.9077	1.5042	424.0
428.0	336.463	0.01906	1.3591	1.3782	405.7	798.0	1203.7	0.6004	0.8990	1.5004	428.0
432.0	351.00	0.01913	1.30266	1.32179	410.1	793.9	1204.0	0.6053	0.8902	1.4966	432.0
436.0	366.03	0.01919	1.24887	1.26806	414.6	789.7	1204.2	0.6102	0.8816	1.4928	436.0
440.0	381.54	0.01926	1.19781	1.21687	419.0	785.4	1204.4	0.6151	0.8729	1.4890	440.0
444.0	397.56	0.01933	1.14876	1.16809	423.5	781.1	1204.6	0.6200	0.8643	1.4853	444.0
448.0	414.09	0.01940	1.10212	1.12152	428.0	776.7	1204.7	0.6249	0.8557	1.4815	448.0
452.0	431.14	0.01947	1.05764	1.07711	432.5	772.3	1204.8	0.6298	0.8471	1.4778	452.0
456.0	448.73	0.01954	1.01518	1.03472	437.0	767.8	1204.8	0.6346	0.8385	1.4731	456.0

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

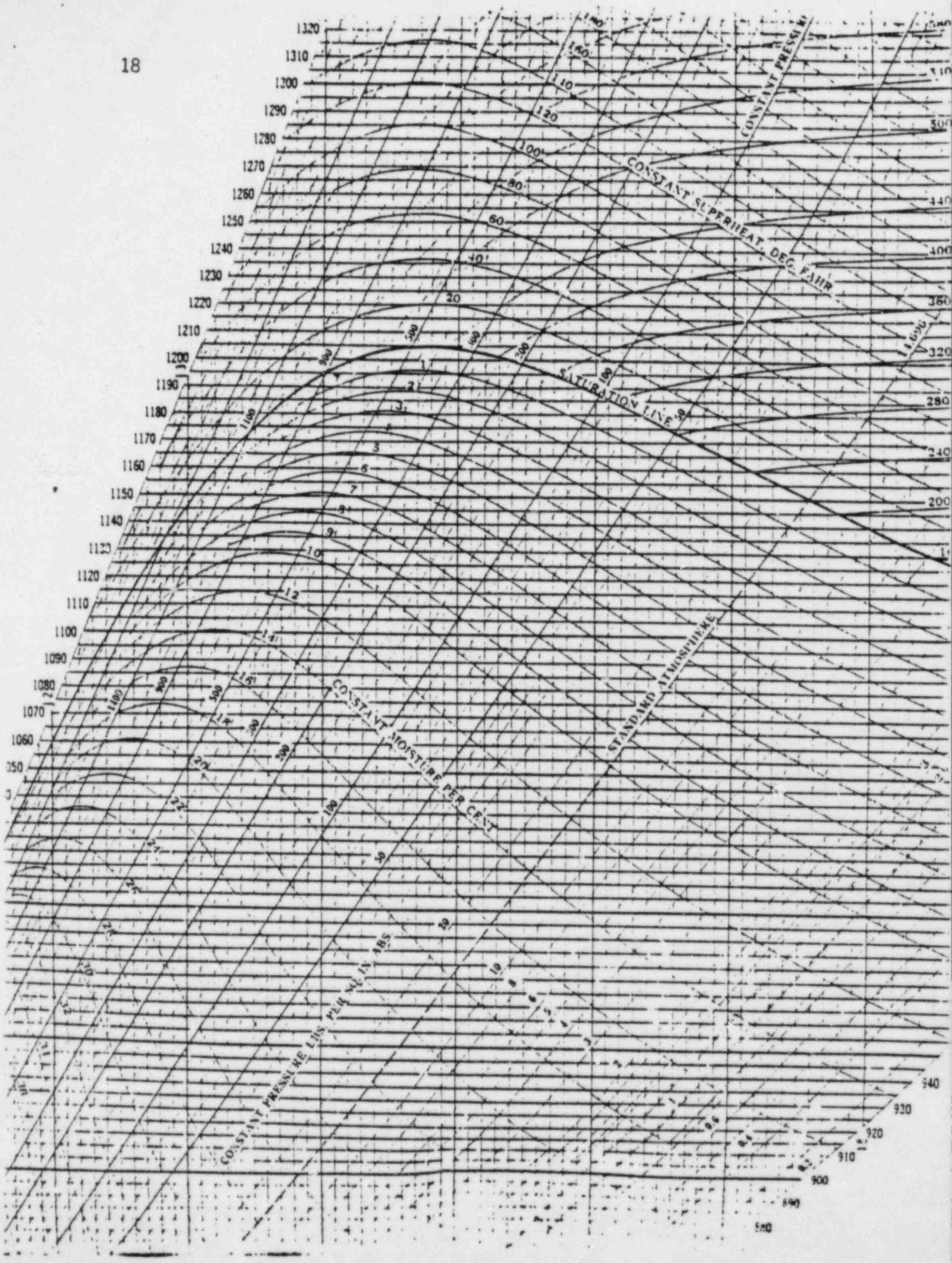
Temp °F t	Abs Press lb per Sq in p	Specific Volume Sat Liquid v_f	Evap v_{fg}	Sat Vapor v_g	Enthalpy Sat Liquid h_f	Evap h_{fg}	Sat Vapor h_g	Entropy Sat Liquid s_f	Evap s_{fg}	Sat Vapor s_g	Temp °F t
468.0	466.87	0.01981	0.97463	0.99424	441.5	783.2	1204.8	0.6405	0.5599	1.4704	468.0
464.0	485.56	0.01969	0.93588	0.95557	446.1	758.6	1204.7	0.6454	0.5413	1.4867	464.0
460.0	504.83	0.01956	0.89885	0.91862	450.7	754.0	1204.6	0.6502	0.5227	1.4629	460.0
472.0	524.67	0.01984	0.86345	0.88329	455.2	749.3	1204.5	0.6551	0.5042	1.4192	472.0
476.0	545.11	0.01992	0.82958	0.84950	459.9	744.5	1204.3	0.6599	0.4956	1.4555	476.0
480.0	566.15	0.02000	0.79716	0.81717	464.5	739.6	1204.1	0.6648	0.4871	1.4518	480.0
484.0	587.81	0.02009	0.76613	0.78672	469.1	734.7	1203.8	0.6696	0.4785	1.4481	484.0
488.0	610.10	0.02017	0.73641	0.75658	473.8	729.7	1203.5	0.6745	0.4700	1.4444	488.0
492.0	633.03	0.02026	0.70794	0.72820	479.5	724.6	1203.1	0.6793	0.4614	1.4407	492.0
496.0	656.61	0.02034	0.68065	0.70100	483.2	719.5	1202.7	0.6842	0.4528	1.4370	496.0
500.0	680.86	0.02043	0.65448	0.67492	487.9	714.3	1202.2	0.6890	0.4443	1.4333	500.0
504.0	705.78	0.02053	0.62938	0.64991	492.7	709.0	1201.7	0.6939	0.4357	1.4296	504.0
508.0	731.40	0.02062	0.60530	0.62592	497.5	703.7	1201.1	0.6987	0.4271	1.4258	508.0
512.0	757.72	0.02072	0.58218	0.60289	502.3	698.2	1200.5	0.7036	0.4185	1.4221	512.0
516.0	784.76	0.02081	0.55997	0.58079	507.1	692.7	1198.8	0.7085	0.4099	1.4183	516.0
520.0	812.53	0.02091	0.53864	0.55956	512.0	687.0	1199.0	0.7133	0.4013	1.4146	520.0
524.0	841.04	0.02102	0.51814	0.53916	516.9	681.3	1198.2	0.7182	0.3926	1.4108	524.0
528.0	870.31	0.02112	0.49843	0.51955	521.8	675.5	1197.3	0.7231	0.3839	1.4070	528.0
532.0	900.34	0.02123	0.47947	0.50070	526.8	669.6	1196.4	0.7280	0.3752	1.4032	532.0
536.0	931.17	0.02134	0.46123	0.48257	531.7	663.6	1195.4	0.7329	0.3665	1.3993	536.0
540.0	962.79	0.02146	0.44367	0.46513	536.8	657.5	1194.3	0.7378	0.3577	1.3954	540.0
544.0	995.22	0.02157	0.42677	0.44834	541.8	651.3	1193.1	0.7427	0.3489	1.3915	544.0
548.0	1028.49	0.02169	0.41048	0.43217	546.9	645.0	1191.9	0.7476	0.3400	1.3876	548.0
552.0	1062.59	0.02182	0.39479	0.41660	552.0	638.5	1190.6	0.7525	0.3311	1.3837	552.0
556.0	1097.55	0.02194	0.37966	0.40160	557.2	632.0	1189.2	0.7575	0.3222	1.3797	556.0
560.0	1133.38	0.02207	0.36507	0.38714	562.4	625.3	1187.7	0.7625	0.3132	1.3757	560.0
564.0	1170.10	0.02221	0.35099	0.37320	567.6	618.5	1186.1	0.7674	0.3041	1.3716	564.0
568.0	1207.72	0.02235	0.33741	0.35975	572.9	611.5	1184.5	0.7725	0.2950	1.3675	568.0
572.0	1246.26	0.02249	0.32429	0.34678	578.3	604.5	1182.7	0.7775	0.2859	1.3634	572.0
576.0	1285.74	0.02264	0.31162	0.33426	583.7	597.2	1180.9	0.7825	0.2766	1.3592	576.0
580.0	1326.17	0.02279	0.29937	0.32216	589.1	589.9	1179.0	0.7878	0.2673	1.3550	580.0
584.0	1367.7	0.02295	0.28753	0.31048	594.6	582.4	1176.9	0.7927	0.2580	1.3507	584.0
588.0	1410.0	0.02311	0.27608	0.29919	600.1	574.7	1174.8	0.7978	0.2485	1.3464	588.0
592.0	1453.3	0.02329	0.26499	0.28827	605.7	566.8	1172.6	0.8030	0.2390	1.3420	592.0
596.0	1497.8	0.02345	0.25425	0.27770	611.4	558.8	1170.2	0.8082	0.2293	1.3375	596.0
600.0	1543.2	0.02364	0.24386	0.26747	617.1	550.6	1167.7	0.8134	0.2196	1.3330	600.0
604.0	1589.7	0.02382	0.23374	0.25757	622.9	542.2	1165.1	0.8187	0.2097	1.3284	604.0
608.0	1637.3	0.02402	0.22394	0.24796	628.8	533.6	1162.4	0.8240	0.1997	1.3238	608.0
612.0	1686.1	0.02422	0.21442	0.23865	634.8	524.7	1159.5	0.8294	0.1896	1.3190	612.0
616.0	1736.9	0.02444	0.20516	0.22960	640.8	515.6	1156.4	0.8348	0.1794	1.3141	616.0
620.0	1788.9	0.02466	0.19615	0.22081	646.9	506.3	1153.2	0.8403	0.1689	1.3092	620.0
624.0	1839.0	0.02489	0.18737	0.21225	653.1	496.6	1149.8	0.8458	0.1583	1.3041	624.0
628.0	1892.4	0.02514	0.17880	0.20394	659.5	486.7	1146.1	0.8514	0.1474	1.2988	628.0
632.0	1947.0	0.02539	0.17044	0.19583	665.9	476.4	1142.2	0.8571	0.1364	1.2934	632.0
636.0	2002.8	0.02566	0.16226	0.18792	672.4	465.7	1138.1	0.8628	0.1251	1.2879	636.0
640.0	2059.9	0.02595	0.15427	0.18021	679.1	454.6	1133.7	0.8686	0.1134	1.2821	640.0
644.0	2118.3	0.02625	0.14644	0.17269	685.9	443.1	1129.0	0.8746	0.1015	1.2761	644.0
648.0	2178.1	0.02657	0.13876	0.16534	692.9	431.1	1124.0	0.8806	0.0893	1.2699	648.0
652.0	2239.2	0.02691	0.13123	0.15816	700.0	418.7	1118.7	0.8868	0.0767	1.2634	652.0
656.0	2301.7	0.02728	0.12381	0.15115	707.4	405.7	1113.1	0.8931	0.0637	1.2567	656.0
660.0	2365.7	0.02768	0.11663	0.14431	714.9	392.1	1107.0	0.8995	0.0502	1.2498	660.0
664.0	2431.1	0.02811	0.10947	0.13757	722.9	377.7	1100.6	0.9064	0.0361	1.2425	664.0
668.0	2498.1	0.02858	0.10229	0.13087	731.5	362.1	1093.5	0.9137	0.0210	1.2347	668.0
672.0	2566.6	0.02911	0.09514	0.12424	740.2	345.7	1085.9	0.9212	0.0054	1.2266	672.0
676.0	2636.8	0.02970	0.08799	0.11769	749.2	328.5	1077.6	0.9287	0.0092	1.2179	676.0
680.0	2708.6	0.03037	0.08080	0.11117	758.5	310.1	1068.5	0.9365	0.0270	1.2086	680.0
684.0	2782.1	0.03114	0.07349	0.10463	768.2	290.2	1058.4	0.9447	0.0537	1.1984	684.0
688.0	2857.4	0.03204	0.06595	0.09799	778.8	268.2	1047.0	0.9535	0.0837	1.1872	688.0
692.0	2934.5	0.03313	0.05797	0.09110	790.5	243.1	1033.6	0.9634	0.1210	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	3094.1	0.03662	0.03857	0.07519	827.4	172.7	999.2	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	0.1236	1.1242	702.0
704.0	3177.7	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	877.0	61.4	938.4	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 F hr 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	2.0429	2.0971	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	1.7878	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	1.7553	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	238.1	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	907.5	1180.6	0.4414	1.1905	1.6319	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	894.8	1185.5	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	3.4356	3.4536	319.0	872.5	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	2.9955	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	0.9222	1.5105	300.0
350.0	431.73	0.01912	1.30442	1.32354	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	1204.1	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	494.99	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	0.58890	0.60949	500.9	699.8	1200.7	0.7022	0.7212	1.4233	750.0
800.0	518.21	0.02087	0.54809	0.56896	509.8	689.6	1199.4	0.7111	0.7054	1.4165	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	0.45084	0.47225	534.7	660.0	1194.7	0.7358	0.6612	1.3970	950.0
1000.0	544.58	0.02159	0.42486	0.44646	542.5	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	579.8	603.8	1182.5	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	1.3526	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	0.29911	605.3	567.4	1172.8	0.8025	0.5397	1.3422	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	0.25601	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	0.5074	1.3273	1600.0
1650.0	609.05	0.02407	0.22144	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	0.02471	0.19390	0.21861	648.5	503.9	1152.3	0.8417	0.4665	1.3082	1800.0
1850.0	624.83	0.02495	0.18559	0.21052	654.5	494.6	1149.0	0.8470	0.4566	1.3036	1850.0
1900.0	628.56	0.02517	0.17761	0.20278	660.4	485.2	1145.6	0.8522	0.4469	1.2991	1900.0
1950.0	632.22	0.02541	0.16999	0.19540	666.3	475.9	1142.0	0.8574	0.4374	1.2947	1950.0
2000.0	635.80	0.02565	0.16266	0.18831	672.1	466.2	1138.3	0.8625	0.4280	1.2904	2000.0
2100.0	642.76	0.02615	0.14885	0.17501	683.8	446.7	1130.5	0.8727	0.4095	1.2822	2100.0
2200.0	649.45	0.02669	0.13602	0.16272	695.5	426.7	1122.2	0.8828	0.3914	1.2742	2200.0
2300.0	655.89	0.02727	0.12406	0.15133	707.2	406.0	1113.2	0.8929	0.3736	1.2665	2300.0
2400.0	662.11	0.02799	0.11287	0.14086	719.0	384.8	1103.7	0.9031	0.3560	1.2590	2400.0
2500.0	668.11	0.02859	0.10239	0.13098	731.7	361.6	1093.3	0.9139	0.3376	1.2515	2500.0
2600.0	673.91	0.02938	0.09272	0.12210	744.5	337.6	1082.0	0.9247	0.3197	1.2445	2600.0
2700.0	679.53	0.03029	0.08365	0.11394	757.3	312.3	1069.7	0.9356	0.3021	1.2377	2700.0
2800.0	684.96	0.03134	0.07511	0.10645	770.7	285.1	1055.8	0.9468	0.2849	1.2317	2800.0
2900.0	690.22	0.03262	0.06658	0.09920	785.1	254.7	1039.8	0.9588	0.2675	1.2263	2900.0
3000.0	695.33	0.03419	0.05803	0.09222	801.8	218.4	1020.3	0.9728	0.2491	1.2219	3000.0
3100.0	700.28	0.03681	0.04771	0.08452	824.0	169.3	993.3	0.9914	0.2260	1.2174	3100.0
3200.0	705.08	0.04472	0.03191	0.07663	875.5	56.1	931.6	1.0351	0.1742	1.2093	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


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

MASTER

Answers to Oyster Creek SRO Exam - '10/84

5.0 Theory of Nuclear Power Plant Operation, Fluids and Thermodynamics (25.0)

5.1 (any 3; 0.75 each) (2.25)

1. Local power spikes resulting from axial fuel column gaps.
2. Increased linear heat generation rate due to pellet axial shrinkage.
3. Cladding collapsed at the location of axial fuel column gaps.
4. Increased stored energy due to decreased pellet-cladding thermal conductance resulting from increased radial gap size.

Ref: O.C. Thermo/HT/Fluid Flow (3/83), pg. 9-107

5.2 a. No (0.5). Initial count rate does not affect the amount of reactivity required to go critical, which determines ECP (0.75). [The higher the count rate, the higher the count rate when criticality is reached.] (1.25)

b. $P = P_o e^{(t/T)}$
$T = 40 / (\ln 2) = 57.71$ sec -1
$t = 57.71 (\ln(P/P_0)) = \underline{212.88}$ sec (1.0)

Ref: O.C. Lesson Plans: 300.09, pg. 20; and 300.11, pg. 14, respectively.

5.3 a. Because of its exceptionally large thermal neutron absorption cross-section ; also $\alpha\pi$: it decays away without burnout. ∴ it comes and goes + is not to be dealt with intentionally by a control rod being withdrawn. (1.0)

b. Sm-149 is removed only by burnout (1.0)

Ref: O.C. Lesson Plan 300.10, pg. 5 and 21, respectively.

5.4 This occurs when the moderator to fuel ratio has increased to the point where neutron absorption in water is significant (1.0). Problems associated are that you can have a positive reactivity insertion as the moderator (water) temperature increases (1.0) (2.0)

Ref: O.C. Lesson Plan 300.08, pg. 38. also $\alpha\pi$: $\Delta\pi$ vs. $\frac{N \text{ mod}}{N \text{ fuel}}$ curve if fully explained.

- Category 5 continued on next page-

5.5 For up power transients the short lived precursors are dominant due to the addition of power (0.75), while for down power transients the long lived precursors dominate the decay constant (0.75) (1.5)

Ref: O.C. Lesson Plan 300.11, pg. 9.

5.6 a. Near the edges and at the top (1.0)

b. Xe concentrates, during power operation, where power is highest, i.e., in the center and near the bottom of the core (0.75), where it acts as a poison, adding negative reactivity (0.50) alternately: power flux shape tilts in opposite direction (1.25)

c. Operator must be extremely cautious while pulling edge and top rods (0.5) since normally low worth rods have now excessively high incremental worths (0.75) (1.25)

Ref: O.C. Lesson Plan 300.08, pg. 61-62.

5.7 a. $Q = M \times C_p \times \Delta T$

$= 1300 \text{ gal/min} \times 60 \text{ min/hr} \times 8.33 \text{ lbm/gal}$

$\times 1 \text{ Btu/lbm°F} \times (550-250)$

$= 1.949 \times 10^8 \text{ Btu/hr.}$ (1.0)

b. ~~300~~ 420° (conservation of mass) & energy (1.0)

c. 550°F as follows:

$Q = M \times C_p \times \Delta T$

$T_{max} = Q/M + 120$

$= \frac{1.949 \times 10^8 \text{ Btu/hr}}{\sout{600 \text{ gal/hr}}\ 800 \text{ gpm}} \times \frac{1}{60}\frac{\text{hr}}{\text{min}} \times \frac{1}{8.33}\frac{\text{gal}}{\text{lbm}} \times \frac{1}{1 \text{ Btu}}\frac{\text{F}}{\text{lbm}} + 120$

$= 607.5 \text{ F}$ (1.0)

but cannot be greater than 550°F (max. T from reactor to inlet)

Ref: O.C. Thermo/HT/Fluid Flow (3/83), pgs. 8-40,41.

- Category 5 continued on next page -

5.8 alt. ok answer: Pressure not important since [illegible] (since MSIV's closed otherwise we'd scram. (P and T will oscillate, on small scale, [illegible]); [illegible] T↑ and then P and T↓.

5.8 Power initially increases but levels off due to negative reactivity insertion resulting from increasing void concentration and moderator temperature (0.75). Pressure and temperature initially increase but level off when power levels off, and then reduce due to ambient losses (0.75). (1.5)

Ref: O.C. Lesson Plan 300.08, pg. 9-50.

5.9 a. An increase in pump flow due to loss of backpressure (0.75). The increased flow causes the motor to draw more current and possibly damage the motor winding (0.75) (1.5)

b. Water hammer and excessive starting current. (1.0)

Ref: O.C. Thermo/HT/Fluid Flow (3/83), pg. 7-124 and 7-123, respectively.

5.10 a. Core flow would increase (0.5) due to a reduction in two phase flow condition (and, therefore, in the core less resistance to flow) (0.75). (1.25)

not required - ok.

b. Increase (0.5). Flow resistance in the channels drops due to [decreased liquid viscosity with temperature (0.375); and] greater density differences between warm channels and cool downcomer will increase flow, causing greater natural circulation (0.375) 0.75 (due to increased thermal driving head (is ok).) (1.25)

Ref: O.C. Thermo/HT/Fluid Flow (3/83), pg. 9-51.

5.11 Smaller (0.5)

Ref: O.C. Heat Transfer and Fluid Flow (1/79), pg. 2-167.

5.12 (any 3; 0.5 each) (1.5)

1. Location in core
2. Positioning of adjacent control rods
3. Effects of Xenon poisoning
4. Size of the rod
5. Moderator temperature
6. Core age
7. Void content

Ref: O.C. Lesson Plan 300.08, pg. 5 and 21, respectively.

- End Category 5 -

6.0 Plant System Design, Control and Instrumentation (25.0)

6.1 a. (~~any~~ all 4, 0.5 each) (2.0)

~~1. Fuel Transfer~~ delete

2. Sequence
3. Engine Temperature
4. Generator Breaker
5. Engine

b. 1. Engine Temperature (#3) (0.5)
2. Engine (#5) (0.5)

Ref: O.C. Lesson Plan 65, pg. 34-35

6.2 a. Turbine trip (0.5)

b. Lo Lo level trip (0.5)

c. ~~Two EMRV actuate~~ Rx scram (0.5)

d. Bypass MSIV closure and ~~low vacuum~~ scram. (0.5)

Ref: O.C. Lesson Plan 38, Section VD3.

6.3 a. 1. Hi drywell pressure (>2 psig) ~~(0.5)~~ .395
2. Triple low water level (4'8" above TAF) ~~(0.5)~~ .395
3. Discharge pressure at core spray booster pumps discharge (230 psig) ~~(0.5)~~ .395
4. automatic time delay of 2 min. (acoustic monitors, OK) .395

b. Sensed by accelerometers connected to discharge pipes (0.75) and indicated by Hi Alarm red lamp on the valve position monitoring system (0.75) (1.5)

Ref: O.C. Lesson Plan 5, Section V2A and V3E, respectively.

6.4 a. Reactor Low Level Trip (0.5)

b. (0.5 each) → 0.67 each (2.0)

1. APRM upscale
2. APRM inop.
3. Discharge volume Hi level trip
4. Low air header pressure trip (disabled during surveillance OK if not given ∴ 3 answers .67 each)

Ref: O.C. Lesson Plan 46, pg. 14-20 and 18, respectively.

- Category 6 continued on next page -

6.5 a. [0.25 each component; 0.25 each load (1 per component)] (3.0)

1) Core spray - isolation valve. "parallel ok"
2) Main steam line - drain V-1-106 or drain V-1-107.
3) Isolation Condensor A - inlet or return isolation valve.
4) Isolation Condensor B - inlet or return isolation valve.
5) Shutdown cooling - inlet or outlet isolation valve.
6) Cleanup system - inlet or return isolation valve.

b. Yes (0.5)

Ref: O.C. Lesson Plan 39, pp. 16-17 and 18, respectively.

6.6 a. FALSE (0.5)

b. Maintains solution temperature high enough to prevent precipitation of the sodium pentaborate. (1.0)

c. FALSE (0.5)

Ref: O.C. Lesson Plan 53, Section VBc2 and VBd2, respectively.

6.7 a. ~~3400~~ 3700 gpm [with <110 psid reactor to torus.] (0.75)

b. TRUE (0.5)

c. TRUE (0.5)

d. <285 psig or V-20-15 and V-2-40 shut (or "None" since no "interlocks" for man. op. or breaker open is reached and "if need to check up the before man op.") (0.75)

Ref: O.C. Lesson Plan 10, Section VB3, VD1b, VD1c, VD2c, respectively.

6.8 a. To inject hydrazine to inhibit corrosion (1.0)

b. 1st Pump~~s~~ start~~s~~ manually [Panel 13R] (0.5); second or 3rd pumps auto start on low pressure; isolation valves ~~open when pump starts~~ & manually initiated (0.5) (1.0)

c. Interlocked off ("in PTL") (0.5)

Ref: O.C. Lesson Plan 55, Section VC4.

- Category 6 continued on next page -

6.9 a. 1. 0 psig (i.e., not needed) (0.5)

2. Rx + 250 = 650 psig (0.5)

3. Rx + 15 = 415 psig (0.5)

b. To isolate the Standby CRD supply pump discharge from the reactor vessel Head Cooling System; (0.75)

Ref: O.C. Lesson Plan 9, pg. 10, 7, 5 and 24, respectively.

6.10 a. Next to chlorination bldg. (0.25); hot well, feed pumps, condensate pumping SJAE condensers, and steam packing exhausters (1.0) (1.25)

b. FALSE (0.5)

Ref: O.C. Lesson Plan 15, Section VC10c(4).

- End of Category 6 -

7.0 Procedures - Normal, Abnormal, Emergency and Radiological Control (25.0)

7.1 a. Reject water to the main condenser hotwell. (1.0)

b. It must be inerted to <5% oxygen. (1.0)

c. Head metal and head flange (0.5); vessel flange and vessel wall (0.5) (1.0)

7.2 a. The green INSERT indicating light (0.75); momentary display, on the rod position readout, of the next lower odd-numbered digit (0.75). (1.5)

b. The timer will complete its cycle but will not reset until released. or the rod will settle into next notch position OK (1.0)

c. "APRM Downscale" block not actuated. (0.5)
Ref spec 302.2 pg. 4; 4; table 302.2 & 2.2.1.3, respectively

7.3 a. All of the following at 0.4 each. (2.0)

1. Torus water temperature above 90°F.
2. Drywell temperature above 135°F.
3. Drywell pressure above 2.0 psig.
4. Torus level above +10.9 in.
5. Torus level below -1.9 in.

b. Removing the control power fuses from both NR108A and NR108B defeats ADS for all valves. (1.5)

Ref: O.C. EMG-3200.02, pg. 2.

7.4 a. 3 (0.5)

b. 50 psig (0.5)

c. (~~0.03~~ 0.2 for order, ~~0.04~~ 0.3 each for systems) (1.5)
1. Main condenser
2. Main steam line drains
3. Isolation condensers tube side vents

Ref: O.C. EMC-3203.04, pg. 2 ¶C2-3.

- Category 7 continued on next page -

7.5 a. (0.5 each answer) (2.0)

1. Heater isolation on high water level.
2. Turbine trip.
3. (System malfunction resulting in the) isolation of one or more feedwater heaters.
4. (System malfunction resulting in the) closure of extraction steam line valves for one or more feedwater heaters.

b. Increase (0.5)

c. 1. IF a reactor scram has not occurred, THEN reduce reactor power as follows:

(1.1) Reduce recirculation flow as necessary to maintain power 20 percent below its pre-trip value.

(1.2) IF recirculation flow is at minimum, THEN insert control rods (in accordance with Procedure 1001.22, "Power Distribution Control During Power Operation,") to maintain power below the rod block setpoint. (1.0)

2. Do not return the feedwater heaters to service until permission to do so is granted by both the Manager Plant Operations and the Manager Core Engineering or their designees. (0.75)

Ref: O.C. AOEP 3200.16, pg. 2-3.

7.6 a. (0.2 each) (1.0)
1A21A, 1B21A, 1A21B, 1B21B; isolation valve MCC 1AB2.

b. Check the target to ensure the breaker is open. (0.75)

c. No. (0.5)

Ref: O.C. O.P. 339: pg. 3, Section 2.2.2; pg. 4, Section 2.2.5; pg. 5, Section 2.3.4.1, respectively.

7.7 a. Because this is the lowest point at which the water level can presently be monitored. (1.0)

b. Up to 1.75 secs (0.5); because the safety limit will not be exceeded for the normal turbine or generator trips which are the most severe normal transients (1.0). (1.5)

Ref: O.C. Tech. Spec., pg. 2.1-4, and 2.1-1 and -4, respectively.

- Category 7 continued on next page -

7.8 a. Off Gas Explosion (0.5)

b. (0.25 each parameter; 0.125 each change) (1.5)
Air Ejector Off-Gas flow - decrease
1-12 Sump Hydrogen concentration - increase
Stack Gas activity - increase
SJAE Radiation level - increase

Ref: O.C. AOP 3200.25, pg. 2.

7.9 a. FALSE (0.5)

b. FALSE (0.5)

Ref: O.C. Tech. Spec., pg. 3.10-1.

7.10 (any 5, 0.2 each) (1.0)

a. Wet pipe sprinklers.

b. Deluge and water sprays.

c. Halon systems.

d. CO_2 systems

e. Local gongs.

f. Local fire panel alarms.

Ref: O.C. AOEP 3200.29, p. 2, ¶2.3.3.

- End Category 7 -

8.0 Administrative Procedures, Conditions, and Limitations (25.0)

8.1 a. 1. 5 gpm (0.5)
2. 25 gpm (0.5)

b. Leakage would not result from a crack approaching the critical size for rapid propagation. (0.75)

Ref: O.C. Tech. Spec., pg. 3.3-2, -4, respectively.

8.2 Secondary containment integrity shall be maintained at all times unless all of the following conditions are met: (0.75)

a. The reactor is subcritical and Specification 3.2.A is met. (0.55)

b. The reactor is in the cold shutdown condition. (0.55)

c. The reactor vessel head or the drywell head are in place. (0.55)

d. No work is being performed on the reactor or its connected systems in the reactor building. (0.55)

e. No operations are being performed in, above, or around the spent fuel storage pool that could cause release of radioactive materials. (0.55)

(NOTE: 3.2.A not required for full credit.):

3.2 A Core Reactivity
The core reactivity shall be limited such that the core could be made subcritical at any time during the operating cycle, with the strongest operable control rod fully withdrawn and all other operable rods fully inserted.

Ref: O.C. Tech. Spec., pg. 3.5-3a, 3.2-1.

- Category 8 Continued on next page -

8.3 (any 2 occurrences for each repository frequency; 0.375 each occurrence; 0.125 each report time) (2.0)

a. CAF

b. CAF

c. ~~CAF~~

d. CAF

see addenda to answer key

4 hr Notifications deleted by RI 5/14/84

Ref: O.C. Tech. Spec., CAF.

8.4 a. 5 (0.5)

b. The minimum shift crew necessary for safe shutdown of the unit (a.w.) or any personnel required for other essential functions during a fire emergency (C.R.S. + C.S.S. must not be assigned to the fire brigade) (0.75)

c. Onsite (0.375) at all times (0.375) (0.75)

Ref: O.C. Tech. Spec., pg. 6-1. and Admin. Proc. 106, p 14 of 42; 91 4.1.6 for added clarification

8.5 a. To supply plant operators with a quick reference to the engineered safety features powered by each D/G to verify T.S. (3.4.A.5, 3.4.C.5, 3.7.C.2) are met (i.e. ECCS operable when D/G's) (1.0)

b. As a cross check for removing safety-related equipment or systems from service with one D/G already out of service. (1.0)

c. (any two; 0.5 pts. each) (1.0)

SLC, CRD, Service Water System, RBCCW.

Ref: O.C. Standing Order 34, Tables 1 and 2.

8.6 a. ≤485 lb (0.5)

b. No (0.5)

Ref: O.C. Standing Order 1, pg. 5.

- Category 8 Continued on next page -

8.7 a. False (0.5)

b. False (0.5)

c. When mode switch is in "startup" or "run" or reactor coolant is greater than 212°F. (0.5)

d. When verified operating parameters should have indicated a scram and no scram occurred. (1.0)

e. His leaving shall be logged in the Control Room Operator log book. (0.75)

Ref: O.C. Admin. Proc. 106, pgs. 10, 10, 11, 15, 16, respectively.

8.8 a. False (0.5)

b. True (0.5)

c. Red/White (0.5)

d. If the redundant equipment is operable. (0.75)

e. False (0.5)

Ref: O.C. Admin. Proc. 108, pgs. 16, 16, 17, 21, 23, respectively.

8.9 a. (0.25 each) (1.0)

100 mrem/day, 300 mrem/weekly, 1000 mrem/quarter, 3000 mrem/year

b. 5 (N-18) = 5 (30-18) = 5 x 12 = 60 rem (0.5)

c. An area of greater than 2.5 mrem/hr and less than 100 mrem/hr (1.0)

d. 100 cpm (0.5)

- Category 8 Continued on next page -

8.10 a. (0.5 for each) (1.0)

(1) Site Emergency
(2) General Emergency

b. (1) Emergency Director (0.5)

(2) (0.312 each) (1.25)
(a) Lacey First-Aid Squad
(b) Onsite Medical Department
(c) Site Protection Sergeant
(d) Shift Radiological Controls Technician

Ref: O.C. EPIP: EPIP-1, Attachment 1, pg. 3-4; EPIP-7, pg. 8-9.

- End Category 8 -

Q.F.3 addenda

ENCLOSURE 1

CATEGORY I REPORTABLE EVENTS (ONE-HOUR)

EVENT NO.	DESCRIPTION	ENCLOSURE 2 REPORTING SCHEME
1.	Declaration of any emergency class specified in the plant's emergency plan.	Category I
2.	Initiation of any shutdown required by the plant's technical specifications.	Category I
3.	Any deviation from the plant's technical specifications authorized by 10 CFR 50.54(x).	Category I
4.	Any event that results in the condition of the nuclear power plant, including its principal safety barriers being seriously degraded; or results in the plant being: a. In an unanalyzed condition that significantly compromises plant safety; b. In a condition that is outside the design basis of the plant; or c. In a condition not covered by the plant's operating and emergency procedures.	Category I
5.	Any natural phenomenon or other external condition that poses an actual threat to the safety of the plant or significantly hampers site personnel in the performance of duties necessary for the safe operation of the plant.	Category I
6.	Any event that results or should have resulted in emergency core cooling system (ECCS) discharge into the reactor coolant system as a result of a valid signal.	Category I
7.	Any event that results in a major loss of emergency assessment capability, offsite response capability, or communications capability.	Category I
8.	Any event that poses an actual threat to the safety of the plant or significantly hampers site personnel in the performance of duties necessary for the safe operation of the plant, including fires, toxic gas releases, or radioactive releases.	Category I

ENCLOSURE 1 (CONT'D)

CATEGORY II REPORTABLE EVENTS (FOUR-HOUR)

EVENT NO.	DESCRIPTION	ENCLOSURE 2 REPORTING SCHEME
9.	Inoperability of the NRC Emergency Phone Network; notify NRC at (215) 337-5000.	Category I
	NOTE: The following shall be reported within one (1) hour to the:	Category I

a) Ocean County Utilities Authority
(201) 269-4503

b) Lacey Municipal Utilities Authority
(609) 693-8685

c) Ocean County Radiological Offices
(201) 341-3451 (Mon. through Fri. - 8:30 to 4:30)
Ms. Jackie Charltos (609) 597-2540 (off-hours)

- The occurrence of any legitimate alarm condition at the sewage collection pit radiation monitoring system when contamination levels are sufficient to result in automatic shutoff of the sewage collection pit pumps;

- Failure of the sewage collection pit radiation monitoring system which will result in the system being in operation for 24 hours or more.

ENCLOSURE 1 (CONT'D)

CATEGORY II REPORTABLE EVENTS (FOUR-HOUR)

In addition to the above events, licensees are required to report to the NRC, as soon as practical and in all cases within four (4) hours, the following events:

EVENT NO.	DESCRIPTION	ENCLOSURE 2 REPORTING SCHEME
1.	Any event, found while the reactor is shut down, that, had it been found while the reactor was in operation, would have resulted in the plant, including its principal safety barriers, being seriously degraded or being in an unanalyzed condition that significantly compromises plant safety.	Category II
2.	Any event or condition that results in manual or automatic actuation of an engineered safety feature except that a preplanned sequence during testing or reactor operation need not be reported.	Category II
3.	Any event or condition that alone could have prevented the fulfillment of the safety function of structures or systems that are needed to:	Category II
	a. Shut down the reactor and maintain it in a safe shutdown condition; b. Remove residual heat; c. Control the release of radioactive material; or d. Mitigate the consequences of an accident.	Category II
4.	a. Any airborne radioactive release that exceeds two (2) times the applicable concentrations of the limits specified in Appendix B, Table II, of Part 20 into the unrestricted areas when averaged over a time period of one (1) hour.	Category II
	b. Any liquid effluent release that exceeds two (2) times the limiting combined maximum permissible concentration at the point of entry into the receiving water (i.e., unrestricted area) for all radionuclides except tritium and dissolved noble gases, when averaged over a time period of one (1) hour.	Category II
5.	Any event requiring the transport of a radioactively-contaminated person to an offsite medical facility for treatment.	Category II

ENCLOSURE 1 (CONT'D)

EVENT NO.	DESCRIPTION	ENCLOSURE 2 REPORTING SCHEME
6.	Any event or situation, related to the health and safety of the public or onsite personnel, or protection of the environment, for which a news release is planned or notification to other government agencies has been or will be made.	Category II

In addition to making the required initial telephone notification, the NRC is to be notified of any of the following:

1. Any further degradation in the level of safety to the plant or other worsening plant conditions, including those that require the declaration of any of the emergency classes, if such a declaration has not been previously made;

2. Any change from one emergency class to another; or

3. The results of ensuing evaluations or assessments of plant conditions;

4. The effectiveness of response or protective measures taken; and

5. Information related to plant behavior that is not understood.

ENCLOSURE 1 (CONT'D)

EVENT NO.	DESCRIPTION	ENCLOSURE 2 REPORTING SCHEME
6.	Any event or situation, related to the health and safety of the public or onsite personnel, or protection of the environment, for which a news release is planned or notification to other government agencies has been or will be made.	Category II

In addition to making the required initial telephone notification, the NRC is to be notified of any of the following:

1. Any further degradation in the level of safety to the plant or other worsening plant conditions, including those that require the declaration of any of the emergency classes, if such a declaration has not been previously made;

2. Any change from one emergency class to another; or

3. The results of ensuing evaluations or assessments of plant conditions;

4. The effectiveness of response or protective measures taken; and

5. Information related to plant behavior that is not understood.