U.S. NUCLEAR REGULATORY COMMISSION

REGION III

Report No. 50-331/OLS-87-01(DRS)

Docket No. 50-331 Licenses No. DPR-49

Licensee: Iowa Electric Light and Power Company
I.E. Towers
P. O. Box 351
Cedar Rapids, IA 52406

Facility Name: Duane Arnold Energy Center

Examination Administered At: Duane Arnold Energy Center

Examination Conducted: July 15-16, 1987

Examiners: R. D. Lanksbury 8/13/87
Date

E. A. Hare 8/13/87
Date

Approved By: T. M. Burdick, Chief 8/13/87
Operating Licensing Section Date

Examination Summary

Examination administered on July 15-16, 1987 (Report No. 50-331/OLS-87-01(DRS))
Written and oral examinations were administered to two Senior Reactor Operator (SRO) candidates.
Results: Both SRO candidates passed the written and oral examinations.

REPORT DETAILS

1. Examiners

R. D. Lanksbury, Chief Examiner
E. A. Hare

2. Exit Meeting

At the conclusion of the examinations, an exit meeting was conducted. The following personnel attended this exit meeting.

Facility Representatives

C. R. Mick, Operations Supervisor
D. Wilson, Training Superintendent
M. Meyer, Senior Instructor
R. J. Bucker, Acting Training Supervisor, Operations

NRC Representatives

R. D. Lanksbury, Operating Licensing Examiner
E. A. Hare, Operating Licensing Examiner
J. S. Wiebe, Duane Arnold Senior Resident Inspector

The following items were requested from the licensee:

a. A copy of Technical Specifications Interpretations.

b. Ensure complete and up to date material is sent to examiners, especially Technical Specifications. Reference material should not be sent too early (i.e., significantly before the required 60 days, unless so requested).

During the scenario walkthrough, the examiner noted a discrepancy in referenced Operating Instructions (OI) procedure numbers in the Emergency Operating Procedure (EOP) and the currently used OI numbers. The EOPs referenced the old two digit procedure numbering system. A new operating instruction numbering system was implemented which changed the number system to three or four digit codes. The EOP's have not been updated to reference the proper OI number. The examiner requested the facility to review their EOP and correct all reference material. This item was turned over to the Resident Inspectors for followup.

3. Examination Review

Specific facility comments concerning written examination questions, followed by the NRC responses, are enumerated in the attachment.

The examiners noted that significant portions of the facility supplied reference material were out of date at the time of the examination. This material ranged from the Technical Specifications themselves (which were outdated by several amendments) to the Operating Instructions (which in one case was outdated by two revisions). Investigation into the matter revealed that the changes had been issued as must as four months prior to the examination. The facility was requested to ensure that in the future reference materials were up to date.

ATTACHMENT

5.04

Facility Comment: We agree with the answer key, however, we feel the question was misleading since "several hours" was not quantified. Also, this question required the candidate to make an assumption that is beyond the scope of his classroom training. The assumption he had to make was that the burnout of Xenon at that power level is less than the buildup of Xenon due to I-135 decay.

In operating the plant during a startup, he is trained to correlate rod movement at constant powers due to Xenon concentration changes. The Xenon concentration amounts, changes, and when they occur is more a function of the Reactor Engineer.

The training conducted on Xenon Equilibrium is based on conceptual knowledge of:

1. The Xenon production and removal terms.

2. Operational transient effects of Xenon concentration.

3. Relative changes in Xenon Reactivities for reactor startup, shutdown, and power operation.

We feel the question would have been clearer if "several hours" would have been quantified and a phrase explaining that Xenon burnout is insignificant.

Also, Answer "b" is vague so we feel it could be interpreted as the correct answer for the following reasons.

1. The phrase "rapidly insert" is meaningless because there is only one rod speed. The operator has no way to increase rod insertion other than to reduce the time between rod selection.

2. The phrase "high rate of Xenon burnout" is vague and he is not required to quantify Xenon burnout with a power level. He does not know whether it is a high rate of burnout nor is he required to know when the burnout rate is high. Although the different half lives of Iodine and Xenon (6.7 hours for Iodine and 9.2 hours for Xenon) are put into play it becomes very difficult to evaluate this phrase as being incorrect.

We request that credit be given for Letter a or b.

NRC Resolution: Disagree with comment. The facility reference material did not substantiate that b would also be an appropriate answer. In addition, "rapidly insert" rods is a generic industry term not related to rod speed, but rather to how quickly the operator performs the rod insertions. Sufficient information was provided to indicate to a knowledgeable operator that Answer 'b' would not be correct (i.e., Rx just critical means low neutron flux levels which implies low burnout of Xenon). To state in the question that Xenon burnout was minimal would make 'b' an obvious wrong answer and not worth using. It should be also noted that the candidates were briefed prior to the start of the examination that if any question was not clear they should ask the examiner for clarification. The question will be reviewed for any necessary revisions for clarity.

5.06 B

Facility Comment: We agree with the answer key for 5.06 B, but we also feel that there are additional acceptable responses as stated in the reference used.

Several of the major sources of hydrogen are long term sources such as:

Radiolysis of Water
Corrosion of Zinc based paint
Aluminum corrosion

Since the question did not specify the time period, we request the answer key be modified to accept any of the major sources of hydrogen listed below:

Steam: Zirconium
Steam: Steel
Core: Concrete
Radiolysis of Water
Corrosion of Zinc based paint
Corrosion of Aluminum

NRC Resolution: Disagree with comment. The question asked for the principal source of hydrogen in containment following a LOCA. A Steam: Zirconium reaction is the major producer of Hydrogen as shown in MCD Page 6-22, Figure 6-F. The answer key will not be changed.

5.06 C

Facility Comment: Technical Specification Section 3.7 list a limit of 4% for Oxygen in the Primary Containment. The bases for Technical Specification 3.7 lists two values, 4% and 5%. System Description E-12 states that the alarm is set for 4%.

We realize that the Technical Specification bases and the alarm setting are set conservatively low to ensure that the flammability limit stated in Mitigating Core Damage is not exceeded. However, we believe it is more important for the operator to be trained using the Technical Specifications 4% limit since it is a licensed document.

The bases for Technical Specifications also implies there is more than one flammability limit, the 5% limit and the AEC (now NRC) recommendation of 4%.

The question also did not state the document that the operator should reference for the Oxygen limit. Since we believe it is absolutely imperative that the SRO is familiar with Technical Specifications and complies with Technical Specifications at all times, we feel an Oxygen limit of 4% is also a correct answer.

We request that full credit be given for stating that the Oxygen limit is 4%.

NRC Resolution: Disagree with comment. The candidates were specifically asked for the maximum flammable concentrations of hydrogen and oxygen in the containment following an LOCA. The question was for LOCA conditions - not normal operations as stated in your Technical Specification reference. The answer key has not be changed.

5.10

Facility Comment: We believe there is a math error in the answer key.

EOL period calculation is incorrect and should be 45 seconds.

This will also change the final answer to 17 seconds.

62 - 45 = 17

We request the answer key be changed to reflect an EOL period of 45 seconds, and a change of 17 seconds.

NRC Resolution: Agree with comments. The correct answer will be changed to BOL = 62, EOL = 45, Change = 62 - 45 = 17 seconds.

5 11 A

Facility Comment: The question did not ask for the reason or mechanism by which enhanced operation using barrier fuel is obtained. The question asked for the difference between barrier fuel and other fuels.

The answer key includes the difference in the first sentence. The second part of the answer key includes the mechanism by which cracking is inhibited.

We request that the second sentence of the answer for 5.11 A be deleted and full credit be given for stating that a layer of zirconium is bonded to inner surface.

NRC Resolution: Agree with comment. The second sentence will not be required for full credit. The answer key will reflect this change.

5.11 B

Facility Comment: Iowa Electric may or may not eliminate PCIOMR restraints. It is true that Preconditioning can be eliminated by use of barrier fuel. However, from an operational standpoint the main significance of barrier fuel is the ability of the fuel to accommodate large power changes without pellet-clad interaction failures. The operator has been informed that PCIOMR may still be followed in an abbreviated manner to provide additional conservatism.

The use of the term "target exposures" is more of a Reactor Engineer term than an operator term. The operator is more familiar with the term power level and we feel the two terms are synonymous.

We request full credit for answering in terms of allowing large power changes without fuel damage. We also request that no points be taken off if the operator does not state that preconditioning can be eliminated.

NRC Resolution: Partially agree with comment. The answer key specifically states either answer would be acceptable for full credit. Therefore, the candidate does not need to state that preconditioning can be eliminated to receive full credit. However, the examiner does not agree that power level and target exposures are synonymous terms. One aspect of a target exposure is power level. The other aspect is the amount of time at a given power level. Therefore, the two are not synonymous, but are related.

5.13

Facility Comment: This question involves a conversion from psig to psia, determination of the saturation temperature and a subtraction calculation to determine the number of degrees subcooled or superheated.

Any single mistake in this calculation such as improper or no conversion from psig to psia or a reading error on Table 2 could result in an incorrect response for both answers in the answer key.

We request that any single error in the calculation not be carried forward when grading the question.

NRC Resolution: Agree with comment. It is not NRC policy to double jeopardize a candidate when a question of this type is asked. A candidate would not lose full credit for a single error in his calculation.

5.15 B

Facility Comment: We agree with the answer key. We also feel there are alternate answers that are just as correct.

As per the attached reference (System Description C1 Page 47) we feel the below listed responses should also be given full credit:

1. Pump minimum flow valves

2. Pump minimum flow valves which open on low flow (400 gpm)

We request the answer key be modified and full credit be given for the above mentioned items or similar responses.

NRC Resolution: Agree with comment. Will also accept "Pump minimum flow valves" or "Pump minimum flow valves which open on low flow (<400 gpm).

6.01 A

Facility Comment: We agree that Technical Specifications list the five items listed in the answer key, but the list is for the second items and not the actual rod blocks. See attached Technical Specification Bases.

The attached System Description (I-8) and Figure of refueling rod blocks describe the refueling rod blocks in greater detail.

We feel that a better answer to the question would be to list four conditions that result in a rod block.

We request the answer key be modified to accept any four of the below list:

MODE switch in REFUEL and:

1. Trolley mounted hoist loaded with platform over or near core.
2. Frame mounted hoist loaded with platform over or near core.
3. Fuel grapple loaded with platform over or near core.
4. Fuel grapple no full up with platform over or near core.
5. Not all rods in and selection of a second.
6. Service platform hoist loaded.

MODE switch in STARTUP and:

7. Refueling platform over or near core.
8. Service platform hoist loaded.

NRC Resolution: Agree with comment. Will also accept the above mentioned list as answers.

6.02 A

Facility Comment: We agree with the answer key for each condition, however, we do not feel it is absolutely necessary for the operator to answer the question using terms such as "level error, level set, steam flow/feed flow error" in order to demonstrate understanding of the feedwater control system.

We feel the format of this question could be improved by separating the questions from the initial condition statement. It is very difficult for an operator to determine the question he is being asked if the questions are all written as one sentence next to the initial condition. It is also difficult for the operator to check his answers following a lengthy exam if the questions are not readily identifiable.

The answer key for the last 0.5 points states that the "feedwater control valves will open to match new higher level." This statement is confusing and we do not agree with this answer. If the "A" level detector fails low, then the feedwater control system will see a large level error signal no matter how far level increases. Reactor level will increase until the feedwater pumps trip at 211". (See attached System Description D-15, Page 11.)

We request full credit be given if the explanation includes a final resolution of the event, i.e., "level increases until feed pump trip" because we feel this shows understanding of feedwater control.

NRC Resolution: Disagree with comment. The question asked how the reactor level will initially respond (immediately following the failure). Therefore, feedwater pump trip at 211" is the final response due to increasing reactor water level. The answer key will not be changed. The candidate need not use the exact terminology used in the answer key to receive credit. The question will be reviewed for any changes necessary to enhance clarity.

6.02 C

Facility Comment: We request full credit be given if the explanation includes final resolution of the event, i.e., "Feedwater valves close due to Feed flow/Steam flow error until level drops enough for level error to counteract the flow error.

NRC Resolution: Agree in part with comment. The candidate need not have exact wording as the answer key to get full credit. Each candidate's response will be reviewed for its individual content.

6.03 B

Facility Comment: We do not agree with the answer key (prevent lockout) and feel it is more correct to answer that the diesel would fail to start.

OI 324 states that to prevent an inadvertent lockout, a start signal should not be initiated within one minute of resetting an engine trip. This precaution implies that diesel generator lockout may occur. It will not occur if a start signal occurs before the one minute time delay. We feel this precaution is in error and have sent a procedure change request to our Procedure Development Group.

The System Description for the Diesel Generator states that "to ensure there is not a failure to start, a start signal should not be initiated within 60 seconds of resetting a trip."

We feel this is the more correct answer based on review of the DAEC start circuitry and breaker control circuitry.

A short explanation of this circuitry follows:

A diesel generator trip will energize the SDR which seals in and energizes Relay "5" which shuts down the diesel generator fuel racks and prevents a restart.

Once the SDR is reset by clearing the "trip" condition and resetting PB4. The "5" relay is deenergized with a 60 second time delay before it drops out.

Until the "5" relay drops out, the diesel cannot be started because the air start solenoids will remain deenergized. The only way we feel a lockout could occur would be if the operator attempted to close the diesel generator output breaker without having the diesel running and a failure of the Sync check relay. (Sync check - 25, prevents breaker closure if both sources are not in phase.)

Since this entails a procedure violation and equipment failure, we feel this to be unlikely.

We request the answer key be changed to read the following.

The Diesel Generator will not start.

NRC Resolution: Agree with comment. Answer key will be changed to read as follows, "The Diesel Generator will not start."

6.05

Facility Comment: The lower limit to the Standby Liquid Control Boron Injection Rate is no longer applicable, and no longer in our Technical Specifications. The ATWS changes (10 CFR 50.62) required both pumps to start on SBLC initiation via one. Attached is a copy of Technical Specification bases which includes the lower limit. Our System Description (C-4 SBLC) which was the reference for the exam question will be revised.

NRC Resolution: Agree with comment. The answer key will be changed to reflect the deletion of the lower limit. Full credit will be given to a candidate that states the lower limit no longer exists.

6.07 B

Facility Comment: We believe the correct answer for 6.07 B is that the Recirc Drive Motor breaker will trip.

The Drive Motor breaker must be closed in order to start the sequence. If the field breaker has not closed within 15 seconds of the Drive Motor breaker closing, then the incomplete sequence timer will trip the Drive Motor breaker.

We request the answer key be changed to state that "The Recirc Drive motor breaker will trip."

NRC Resolution: Agree with comment. The answer key will be changed to read as follows, "The recirc drive motor breaker will trip."

6.08 A

Facility Comment: The valves listed in Question 6.08 A were not correct in that these valve numbers were for the Head Spray Valves.

The answer key is also confusing for this question because two requirements are included in one statement (2/3 core coverage and LOCA signal). As stated in System Description C-1, Page 37 and Figure 17 (see attached). There are four (4) (not three) conditions that must be satisfied in order to open the containment spray valves after a LOCA.

These conditions are:

1. Drywell pressure greater than 2 psig and

2. Reactor vessel level is above -39 inches (2/3 core coverage) and

3. LPCI initiation signal present and

4. Containment Spray Valve Control Switch to MANUAL

We request the answer key be modified so that full credit is given for any three (3) of the above listed four (4) items.

We also recommend that MO numbers not be used in future questions unless necessary, in order to avoid confusion.

NRC Resolution: Agree with comment. The question will be changed requiring three out of four conditions. The answer key will be changed to include "Containment Spray Valve Control Switch in Manual." The examiners prefer to include valve numbers in case the candidate does not recognize the valve by name.

6.08 B

Facility Comment: As stated in System Description C-1, Page 37 and Figure 17, the Containment Spray Valve Control Keylock switch bypasses the -2/3 core coverage and the LPCI initiation signal.

As stated, this design allows the operator to open the containment spray valves following a LOCA if either:

1. Level is below -39 inches

OR

2. LPCI initiation signal is not present.

We request the answer key be changed to accept either of the conditions listed above.

NRC Resolution: Agree with comment. The answer key will be changed to state as follows, "It allows opening of containment spray valves by bypassing the requirements for 2/3 core coverage (-39 inches) or LPCI Initiation signal present." Either answer will be given full credit.

6.10 D

Facility Comment: This part of Question 6.10 is not defined in enough detail to ensure there is only one correct answer.

APRM B upscale is insufficient because the APRM Upscale alarm is a rod block. The APRM Upscale Trip is an RPS trip.

The operator could interpret the APRM upscale to be either the rod block or the scram.

It should be noted that upon checking the references used for this exam question, inconsistencies in terminology for the APRM upscale Trip and Alarm were found. Change forms have been promulgated to Material Development to correct these deficiencies.

We request the answer key be modified for Question 6.10 D to accept either "rod block" or "1/2 scram" as correct answers.

NRC Resolution: Agree with comment. The answer key has been modified to accept either answer. The question will be reviewed for necessary changes so that only one answer will be acceptable.

6.12

Facility Comment: OI 388 precaution No. 3 states that the battery charger cannot supply emergency power by itself and would trip under this condition.

The question does not state that emergency loads are being supplied by the 250 VDC system when the battery is disconnected.

If emergency loads are not being carried and the battery is disconnected, the charger would probably not trip. System Description G-5 Page 14 also states the charger cannot supply current under all load conditions, meaning that the charger can supply loads under certain conditions.

As per Technical Specifications Section 3.8.B.2.C HPCI must be considered inoperable and requirements of 3.5 must be met. The question did not ask for a procedural response, therefore, we feel the candidates should not be held responsible for mentioning Technical Specifications.

We request the answer key be modified and full credit be given for any of the following response:

1. HPCI inoperable or

2. Charger will carry the system as long as Emergency loads are not started.

NRC Resolution: Agree in part with comment. The candidate was not asked the status of the HPCI system. The candidates were not held responsible for meeting DAEC Technical Specifications since that was not the nature of the question. Therefore, the answer "HPCI inoperable" will not be accepted. The answer key will be changed to add "or the charger will carry the system as long as Emergency loads are not started." Full credit will be given for this answer.

7.01

Facility Comment: We agree with the answer key, but we feel the bases for HCTL curve as stated in NEDC 30796 (see attached) states the same answers as Answer No. 2. We feel it is also correct to state that the pressure or energy contained

in the reactor is low enough so that a LOCA or SRV blowdown will still be adequately condensed by water in the torus.

We request that full credit be given if above answer is used for Answer No. 2.

NRC Resolution: Agree in part with comment. The candidate need not have the exact wording as the answer key to get full credit. Each candidate's response will be reviewed for its individual content.

7.02

Facility Comment: We feel that the question is a good question to ask on an oral or simulator exam, but is inappropriate to ask on a written exam for the following reasons:

- Iowa Electric's accredited SRO training program does not require the operator to memorize the EOP's. The operator must demonstrate the ability to use the EOP's at the simulator.

- The question is a complex problem requiring the operator to enter several EOP procedures. We believe a question of this nature would be appropriate for a written exam only if accompanied by the EOP's.

- ES402 states that the operator must have a complete understanding of immediate actions. We feel the question addresses those actions that are not immediate actions that the operator would take without a procedure.

Recommend Question 7.02 be deleted because it is beyond the scope of the SRO. If Question 7.02 is not deleted, then recommend the following changes.

1. Allow credit in each section based upon the candidate's assumptions and subsequent actions.

2. The answer key for Part A should take into account that the initial conditions stated that Boron Injection is not required, but the answer requires Boron Injection to be explained. This could be confusing to the candidate.

3. The answer key for Part B does not mention that MARFP also takes into account the minimum flow stagnation power level (8%) for no natural circulation. Maintaining pressure constant ensures that the RPV is being properly flooded. (Reference NEDO-30796 Page 8-149.)

4. The answer to Part C should also include operational considerations such as if Boron Injection is being used, or the Rx is shutdown. Again due to the nature of the question (i.e., written vs oral) it is difficult to assume that only some things are changing.

5. The answer to Part D should also include a discussion of the "quality" content of the water, (i.e., Rx water vs river water) and credit given accordingly.

NRC Resolution: Disagree with comment. This question does not require memorization of the EOPs. It simply describes particular plant conditions and corresponding actions taken in the EOPs and then asks why these actions are taken. Since the candidate is actually told what the EOPS require, the EOPs do not need to accompany the question for it to be answered. It is not unreasonable to expect an SRO to understand why he is taking particular actions in an emergency procedure. 10 CFR 55.43(b) prescribes emergency operating procedures as a basis for questions on the written exam. In addition, the question is supported with knowledge and ability ratings that are extremely high. This question is appropriate for a written exam in that its objective is not to see if the candidate has memorized the EOPs, but instead to determine if he really understands them. Requiring an SRO to know the basis of the emergency procedure is consistent with industry practice and guidance provided to NRC examiners. If as this facility comment implies, the SROs at DAEC do not understand the emergency procedures, then this would certainly cast doubt on their ability to understand and control emergency conditions. Since the facility received a satisfactory requalification evaluation in December 1986, it is assumed that SROs at DEAC do understand emergency procedures and that this comment was inappropriate.

1. All assumptions indicated by the candidates will be evaluated on a case-by-case basis. However, all assumptions needed to answer the question correctly were given in the initial conditions.

2. Although in this instance boron injection is not required, the procedure does address this system whether or not it is required at that point. This question specifically provides further clarification that boron injection must be addressed in the answer to receive full credit.

3. The answer given in the facility comment for why RPV pressure is kept above MARFP is the same as that given in the answer key, but stated a little more specifically. The more specific answer given in the facility comment is not required for full credit, but would certainly be considered an appropriate answer.

4. These operational considerations are given in the initial conditions such as to arrive at the correct answers.

5. The quality content of the water is not listed in the references on the answer key. This facility comment was not accompanied by any further references to substantiate this. Therefore, the additional answer given in the facility comment is not acceptable.

In summary, both the question and the answer are considered entirely appropriate and remain in the exam as is.

7.03 A

Facility Comment: The answer key references Page 25 of IPOI-2, but only lists four conditions as stated at the top of the page. In actuality, the page lists other requirements such as Drywell Deinerted, Oxygen concentration greater than 19.5% by volume, and IPOI-7 (Special Instructions). The question implies there are only four (4) conditions, but procedurally there are many more conditions that must be met. We request that full credit be given for any four (4) conditions that are stated per IPOI-7.

NRC Resolution: Agree with comment. Full credit will be given for any four (4) conditions required prior to Drywell entry that are stated in IPOI-7. The answer key is changed to include the following, "5. Drywell is deinerted, 6. Oxygen concentration is greater than 19.5% by volume, 7. Ensure requirements of Plant Radiation Protection Manual are followed for Drywell/Steam Tunnel Inspection. 8. Verify containment air purge in progress. 9. Verify at least one CAD O_2 analyzer recalibrated for high O_2. 10. Verify

that the TIP detectors are in their shields and the drives deenergized. 11. Have Health Physics perform necessary surveys."

7.05 C

Facility Comment: Per EPIP 2.5, the OSS functions as the Emergency Coordinator until relieved.

EPIP 1.1 also directs the OSS to make the plant notifications per EPIP 1.2.

We believe that if the overall responsibilities of the OSS are evaluated using the entire Emergency Plan instead of one procedure it is true that the OSS acts as the Emergency Coordinator until relieved.

Iowa Electric's SRO candidates are trained to function as the Emergency Coordinator until relieved. If an event occurred that was classified as an alert or higher and the Emergency Coordinator has not relieved the OSS, then the OSS should maintain contact with the NRC.

We request full credit be given for a "true" answer in Part C and we also recommend this question be modified so there is only one correct answer.

NRC Resolution: Agree with comment. Since under varied circumstances the answer could be either True or False, this portion of the question has been deleted and the overall point value of the question modified accordingly.

7.06

Facility Comment: The question asks for specific items as addressed in only one part of the EPIP's. We believe that since the candidates are trained on all phases of the EPIP's and log entries into the OSS logbook are done in accordance with ACP 1410.3, Operating Logs, that credit be given for additional items that could be part of any log entry made by an OSS when dealing with emergencies. This would include additional items such as:

1. Time of log entry

2. Changes in plant operating status

3. Other entries. These might include, Deviation Report numbers, 10 CFR 50.72 or 50.73 reports made.

We request the answer key be modified to include other logged items during an emergency per ACP 1410.3.

NRC Resolution: Disagree with comment. The candidates were specifically asked about the log entries required upon declaring an emergency classification of an event. The log entries called out in ACP 1410.3 are entries made during each shift. It is not stated that these entries are required to be logged during an emergency. The answer key will not be changed.

7.08 B

Facility Comment: The answer key lists reasons why the minimum speed setting must be correct, yet the question does not ask why the minimum speed setting is correct. The question is asking for the consequence of improper minimum speed setting, namely that the pump would not start. If more of an answer was desired, than an "explain why" phrase should have been added to the question.

Given the wording of the question we request full credit be given for Part B, by stating that the pump would not start.

NRC Resolution: Agree with comment. The answer key will be changed to state that "the RWCU pump would not start."

7.08 C

Facility Comment: The answer key states that the pump will trip, but no mention is given for the actions that would possibly occur to the rest of the reactor water cleanup system (i.e., DEMIN BEDS going into HOLD). See attached. We request credit be given for answers pertaining to other parts of the system such as DEMIN BEDS going into HOLD.

NRC Resolution: Disagree with comment. The root cause of the reduced flow to the point where the Demin Beds go into hold is the pump having tripped (as stated in the answer key). If the candidate states additional items such as stated in the

comment, they will be accepted, but for full credit the candidate will have to state that the pump trips. The answer key will not be changed.

7.09

Facility Comment: We do not see how candidate No. 3 can be accepted even though he exceeds 5(N-18).

- Even though 10 CFR 20.101 technically allows exceeding 5(N-18), we do not advocate exceeding of this limit nor do we believe any other agency would advocate exceeding 5(N-18).
- Both the National Council for Radiation Protection (NCRP) and the International Council for Radiation Protection (ICRP) recommend that 5(N-18) not be exceeded.
- Duane Arnold's Radiation Protection Training advocates conservatism for personnel exposure.

We request that full credit be given for rejecting candidate No. 3 based on exceeding 5(N-18).

NRC Resolution: Disagree with comment. You are correct in the fact that 10 CFR 20.101 technically allows an individual to exceed 5(N-18). More importantly, the individual is allowed to legally exceed this in the particular question. The document you referenced is not a legal document and can only recommend guidance. The 10 CFR is a binding document. Since no administrative limits are in place preventing an individual from exceeding 5(N-18) and an individual is legally able to receive up to 1.25 Rem/qtr. regardless of 5(N-18) the answer key will not be changed.

7.10

Facility Comment: The question as written leaves off the part of trying to first shutdown the reactor by the normal method. This could be misleading to the candidate as he would be also looking at the operational conditions that would normally be followed prior to shutting down the reactor protection system. We believe credit should be given for answers that utilize those operating conditions.

We also request that full credit be given for stating that RPS should be reset so that the CRD system can provide adequate cooling to the CRD's (see attached).

NRC Resolution: Disagree with comment. The question asked, "What is the reason for this," not "what should be done" as was implied should be correct answer. No evidence was provided indicating that in the shutdown conditions that normally would exist when the RPS system is shutdown that CRD cooling is a concern. The only concern that is documented is that listed in the answer key. The answer key will not be changed.

7.11 A

Facility Comment: We agree with your answer, but we also feel that credit should be given for other operational concerns created by a H/X low level.

- A low level could also result in cavitation of the RCIC pumps due to reduced NPSH.
- RCIC Turbine Trip - Turbine trips at 15" Hg abs. suction pressure.

We also feel credit should be given for stating the precaution is based on draining the H/X dry since the thermal shock is due to RHR-SW flow through the tubes of a hot dry H/X.

We request the answer key be modified to give full credit for any of the following.

1. Minimize thermal shock to H/X
2. Prevent cavitation of RCIC pump
3. Prevent RCIC Turbine trip
4. Prevent draining H/X dry

NRC Resolution: Disagree with comment. The material that was referenced does not substantiate that low level in the heat exchanger would directly cause a RCIC Turbine Trip. DAEC System Description C-1 RHR Page 43 states the following.

"The RCIC pump suction is also supplied from the Condensate Storage Tanks so that if the pressure from the RHR heat exchanger drops below the Condensate

Storage Tank pressure, a check valve opens to supply water from that source so that the RCIC pump is not in danger of losing suction pressure."

The facility answers requested to be added to the answer key are not correct. Prevent Draining the H/X dry was not accompanied by any further references to substantiate this would in fact happen. Therefore, the additional answer given in the facility comment is not acceptable. The answer key will not be changed.

7.11 B

Facility Comment: The caution in OI 149 is not based on a loss of inventory to the Torus. Step (2) of Section 5.3 has the minimum flow valve closed and the breaker tagged open. Also, the caution directs the H/X Bypass Valve be throttled open instead of the LPCI outboard throttle valve. A note in Section 2.0 specifically warns against using the outboard throttle valve.

Failure to open the Bypass Valve within ten seconds will result in the RHR pump operating at shutoff head. This will result in inadequate minimum flow.

We request the answer key be modified and full credit be given for either of the following:

- Provide adequate minimum flow
- Prevent operation at shutoff head

NRC Resolution: Agree with comment. The answer key will be changed to read as follows, "Provide adequate minimum flow for the pump or prevent operation at shutoff head."

The examiner would like to note that the IO referenced in the test was IO 149 Rev. 0 dated July 24, 1986. The licensee supplied reference was IO 149 Rev. 2 dated April 30, 1987, to support this comment. The NRC question was correct from the information supplied by the licensee.

7.13 A

Facility Comment: The question as written could be confusing because of the use of the word "basis." This word could imply the Technical Specifications bases and could cause the

candidate to utilize them in developing his answer. We believe credit should be given as appropriate (i.e., use "reason").

We also request credit be given for other operational concerns that are generic for pumps operating at shutoff head such as:

1. Overheating of Pump
2. Seal Damage
3. Cavitation

NRC Resolution: Disagree with comment. This facility comment was not accompanied by any references to substantiate it. Therefore, the additional answers given in the facility comment are not acceptable for full credit.

7.14

Facility Comment: The answer key references EOP-6, but the question is worded such that other means of shutting down the reactor can be used, other than EOP-6. We request credit be given to reflect other operational means, of scramming the reactor to include the below listed and any other means identified by the candidate.

1. Locally trip the turbine (power above 30%)

2. Deenergize RPS MG Sets by opening breaker at 1B32 and 1B42.

3. Vent the scram air header.

NRC Resolution: Agree with comment. The answer key will be changed to include the following. "c. Locally trip turbine (power above 30%) at Turbine front standard on operating deck; d. Deenergize RPS MG Sets by opening breakers at 1B32 and 1B42 located in the 1A3 and 1A4 switchgear room." Vent the scram header was not included since it was already discussed in 7.14b of the answer key.

8.03

Facility Comment: The question is extremely long and multipart in nature. ES-202-E.12 states that mulitpart questions should be broken down into logical sequential parts. As currently written, we believe that the question is not clear in

stating the requirements expected of the candidate. The question contains both the long initial conditions section and the actual two part requirement of the candidate.

We agree with the answer key in part, however, we believe that credit should be given for actions taken that would check for the actual systems taken out of service and the operability requirements since Technical Specifications 3.13C and 3.13E states that only certain deluge, sprinkler systems, and hose stations are required to be operable. The information provided in the question is not complete, and would require the OSS to check on a P&ID exactly what systems were taken out of service.

NRC Resolution: Disagree with comment. The Region does not consider this to be an example of a multipart question as stated in the comment. An example of a multipart question would be Question 8.04 with two distinct points. This question simply listed a situation and then asked what action was required and how soon. Other similar questions, such as 8.11, were not commented on in this context. The question as stated says that a Technical Specification problem exists. Therefore the candidate does not need to know which specific portion of the deluge and sprinkler system or which hose station is inoperable since the required actions are the same and the LCO for that system is entered as stated in the answer. As far as what was requested of the candidate, it is clearly stated in the final sentence of the paragraph. The answer key will not be changed.

8.06

Facility Comment: The question does not follow the Examiner Standards 202 in the following ways:

1. ES-202 E.12 states that multipart questions should be broken down into logical sequential parts.

2. ES-202 E.16 states that "if a specific number of responses are required, the question should clearly state that expectation . . . ."

3. ES-202 E.20 states that diagrams or sketches should be used as attachments to written examinations. It further states that the use of these attachments

provide an effective and easily interpretable way for the candidate to demonstrate his knowledge of the topic/concept.

As written, the question could be understood by the candidate as one question with three listed conditions together and answered accordingly. The answer key, as written, assumes that credit should be given to the candidate based upon his ability to correctly analyze the situation using all three of the conditions together. Furthermore, since a core map was not provided as an attachment, credit should be given to the candidate for stating the requirements that would be followed if this operational situation were to arise.

Finally, the answer key for condition No. 1 states that this situation would have no effect on plant operations. However, the two rods that are inoperable are in separate RSCS groups. (10-07 in Group A2 and 10-27 in Group B3). Since the original scenario has the candidate making preparations to start up the reactor, having these two control rods inoperable and in separate RSCS groups would place a very large operation restraint upon the plant. Technical Specification 3.3.A.2.f.(2) clearly states that all rods within a notch group containing an inoperable control rod shall be positioned within one notch of the inoperable control rod whenever the rod sequence control system is required to operable. We believe that credit should be given to the candidate for stating the possibility of this constraint, seeing as how a core map was not provided, and we do not require the candidates to memorize RSCS groups.

NRC Resolution: Partially agree with comment. This question, as written, is consistent with other Region III examinations. Each question undergoes an independent QA review by a person other than the author to ensure it meets with the Examiner Standards. The number of responses depends on how the candidate interprets DAEC Technical Specification (also see response to Comment 8.03 and 8.08). The candidate should be familiar enough with a full core display/control rod positions without needing a diagram to assist him. As far as how credit will be given, each candidate will be individually graded for his ability to assess the situation. The question was not intended to require the candidates to have the RSCS groups memorized. The examiner will review all assumptions made at arriving at his answer. The answer for the first condition given will be changed to reflect the operational constraint imposed on the plant as noted in the comment.

8.08

Facility Comment: The question is stated, does not follow the Examiner Standards. ES-202 E.16 states that, "If a specific number of responses are required, the question should clearly state that expectation so the candidate will know when the answer is complete."

The answer key for Question 8.08, list five overtime guidelines that are violated, but there are seven total violations. We believe full credit should be given to the candidate for stating the general guidelines that are violated, rather than being specific and listing them individually.

NRC Resolution: Agree in part with comment. The question is not "open-ended" or "vague." The intent of this question is to see how well the candidate can evaluate a given situation and apply his understanding/knowledge of the overtime guidelines. Therefore, the number of responses are determined by his interpretation of AP 1410.1. Since the question by implication asked for all violations, this in effect is the same as asking "How many criteria have been violated." Credit will be given for the candidate stating the general guidelines violated as well (the specific answers in parenthesis were for the graders use only and are not intended to be required).

8.09 B

Facility Comment: The answer key for Question 8.09 B is directly derived from Section 6.3.2 of ACP 1406.3, revision of Procedures and Instructions. However, there are other places in ACP 1406.3 that describe situations that would utilize temporary procedure revisions. In addition, Figure 2 of ACP 1406.3, shows the temporary document change form, which contains a "temporary change information reviews" block that describes reasons for temporary changes. We believe full credit should be given for answers based upon these situations.

NRC Resolution: Agree with comment. After a review of the reference material, the following list will be added to the answer key. "5. When it's impractical to accomplish permanent revision to approved procedure. 6. Editorial. 7. Improvement. 8. New Procedure. 9. Inactivation or Reactivation. 10. Change of Safety Intent or Function.

8.11

Facility Comment: We agree with the answer key as written, however, we believe that full credit should be given to the candidate for describing the concerns about providing an isolable volume (i.e., 2/3 core coverage), as described in the System Description A-2, Reactor Recirculation System, when dealing with Jet Pump Operability.

NRC Resolution: Agree with comment. Will also accept "provides an isolable volume capable of being flooded after a recirculation line break (2/3 core coverage)" as alternative answer.

8.12 A

Facility Comment: The question is based upon a new Technical Specification change that is currently having a letter of interpretation written to clearly define the facilities stand on the issue. We believe that the question as written does not provide enough information for the candidate to fully answer the question. The candidate must spend time in developing an assumption of the scheduled due date of the surveillance to ensure the correctness of his answer.

We believe that credit should be given for answers that are correct when based upon the candidates assumptions and utilizing Technical Specifications 1.0, Definition No 26, Surveillance Frequency. Also, per ACP 1407.5, Surveillance Program, it is the surveillance performance coordinator's responsibility in setting up the due dates on the surveillance test procedures and not the OSS.

Using Definition No. 26, Surveillance Frequency, as stated in Technical Specifications the following information could be used in developing the candidates answer.

Technical Specifications quarterly (92 days) ± 25% = 23 days prior to the scheduled due date, or 23 days after the scheduled due date.

Combined time interval for any three consecutive surveillance intervals shall not exceed 3.25. 92 days x 3.25 = 299 days.

Assuming January 1, 1987, is the earliest the OSS could run a Schedule Surveillance, places the due date at 24 January 1987. Using that due date the following applies.

RUN "A" 3 October 1986 (90 days prior to 1 January 1987)
RUN "B" 1 January 1987 (Given)
RUN "C" 16 April 1987 (Given)

Combined time interval A, B, C = 197 days

RUN NO. 1 1 January 1987 (23 days prior to 24 January 1987 due date)

RUN NO. 2 16 April 1987 (10 days prior to 26 April 1987 due date)
RUN NO. 3 19 August 1987 (Absolutely last possible date to RUN with 27 July 1986 due date)

Combined time interval 1, 2, 3 = 230 days

NRC Resolution: Disagree with comment. It is obvious from this comment that the facility does not understand the new Tech. Spec. regarding surveillance frequency. The facility proposed answer of August 19, 1987, is in violation of Tech. Specs. in two respects. The maximum allowable extension cannot exceed 25% of a surveillance interval. The time interval between April 16, and August 19, 1987 is greater than 25% (or 115 days maximum). Therefore, the date of August 19, 1987, is not correct. The combined interval between three consecutive surveillances cannot exceed 3.25 of the specified interval, 92 days in this case, or 299 days for a quarterly surveillance. The combined intervals for the surveillances from October 3, 1986 to August 19, 1987 is 321 days or 22 days longer than allowed by Tech. Specs. Therefore, the date of August 19, 1987, is again not correct. The facility is apparently keying in on dates and due dates for surveillances rather than intervals as specified in the Tech. Specs. This is obvious from their calculation of 230 days for the three surveillances conducted on January 1, April 16 and August 19, 1987 to show that they met the 3.25 requirement. This constitutes only two intervals vice the three required by Tech. Specs., but did comprise three dates. The answer key will not be changed.

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

FACILITY: DUANE ARNOLD

REACTOR TYPE: BWR-GE4

DATE ADMINISTERED: 87/07/15

EXAMINER: HABE, E. A.

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
24.50	24.5%	_____	_____	5. THEORY OF NUCLEAR POWER PLANT OPERATION, FLUIDS, AND THERMODYNAMICS
25.00	25.0%	_____	_____	6. PLANT SYSTEMS DESIGN, CONTROL, AND INSTRUMENTATION
25.50	25.5%	_____	_____	7. PROCEDURES - NORMAL, ABNORMAL, EMERGENCY AND RADIOLOGICAL CONTROL
25.00	25.0%	_____	_____	8. ADMINISTRATIVE PROCEDURES, CONDITIONS, AND LIMITATIONS
100.00	100.0%	_____ Final Grade	_____%	Totals

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

_____
Candidate's Signature

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.

8. 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 5.01 (1.00)

Which one of the following statements is true regarding intrinsic neutron sources in a shutdown reactor?

a. Practically all the source neutrons from spontaneous fission come from U-235.

b. The alpha-neutron source comes from the alpha decay of U-238, U-239, and plutonium which interact with O-18 in the moderator to yield neon and a neutron.

c. The major concentration of source neutrons comes from spontaneous fission of U-238.

d. The photo-neutron source is less significant at BOL than EOL.

QUESTION 5.02 (2.00)

TRUE or FALSE.

For a constant reactor period, it takes the SAME AMOUNT OF TIME TO CHANGE reactor power from 1% to 5% as it does to change it from 10% to 50%. EXPLAIN YOUR ANSWER FULLY. SHOW THE CALCULATION YOU WOULD USE TO VERIFY YOUR ANSWER.

QUESTION 5.03 (1.00)

Which one of the following statements is NOT true regarding the LHGR (linear heat generation rate) thermal limit?

a. The LHGR design limit = 13.4 kw/ft for both 8x8 and P8x8R fuel.

b. The limit is based on maintaining peak cladding temperature = < 2200 degrees F.

c. The LHGR specification assures that the LHGR in any rod is less than the design value even if fuel pellet densification is postulated.

d. If the limit is exceeded, it could result in fuel clad cracking due to high stress.

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

QUESTION 5.04 (1.00)

The reactor trips from full power, equilibrium xenon conditions. Four (4) 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 concerning control rod motion during this period?

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 follow its normal decay rate.

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

QUESTION 5.05 (1.00)

The reactor is critical at 106 cps. WHICH of the following best describes the behavior of neutron power following a prompt insertion of negative reactivity. (Assume that not enough negative reactivity is added to shutdown the reactor)

a. Neutron power drops immediately to "beta" (delayed neutron fraction) times the neutron power prior to the prompt insertion of negative reactivity.

b. Neutron power decreases linearly with time after the initial prompt drop.

c. After the initial prompt drop, neutron power decreases on a constant negative period; the magnitude of the period determined by the amount of negative reactivity inserted.

d. Because only delayed neutrons are left immediately after a negative reactivity insertion, neutron power decreases on an 80-second period regardless of the size of the negative reactivity insertion.

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

QUESTION 5.06 (1.50)

The Duane Arnold containment atmospheres are inerted with nitrogen to limit the post LOCA oxygen content.

a. What is the principal source of oxygen in containment following a LOCA?

b. What is the principal source of hydrogen in containment following a LOCA?

c. What are the maximum permissible concentrations (limit of flammable region) of hydrogen and oxygen (in volume percent) in containment following a LOCA?

QUESTION 5.07 (2.50)

Assume that the reactor is being started up from Cold Shutdown and a rod drop accident occurs early in the startup. Of the void, doppler, and temperature coefficients, which will act first, second, and third to limit the rapid power rise? EXPLAIN YOUR ANSWER.

QUESTION 5.08 (2.00)

The reactivity worth of a single control rod will _____. (For each statement below, indicate INCREASE or DECREASE.)

_____ a. If the void content around the rod INCREASES.

_____ b. If the moderator temperature DECREASES.

_____ c. If an adjacent control rod is WITHDRAWN.

_____ d. If Xe-135 concentration around the rod DECREASES.

QUESTION 5.09 (1.50)

HOW does xenon concentration affect peripheral rod worth following a scram from high power and WHY does this occur?

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

QUESTION 5.10 (1.50)

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

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

b. What is the cause for this change in Beff? (0.5)

QUESTION 5.11 (1.50)

a. Explain how barrier fuel differs from the previous types of fuel loaded into the core. (.75)

b. How will this affect or change power operation at your facility with a full core loaded with barrier fuel? (.75)

QUESTION 5.12 (2.50)

Regarding MCPR (Minimum Critical Power Ratio):

a. What PHENOMENON COULD exist in a fuel bundle if it were operated at an MCPR LESS THAN ONE (<1.0) and WHAT is the concern if this phenomenon was to occur? (1.0)

b. Why must the Technical Specification MCPR limit include a K factor when core flow is LESS THAN RATED? (1.0)

c. HOW does CRITIC POWER change (INCREASES, DECREASES, OR REMAINS THE SAME) when let subcooling increases (core inlet water gets cooler)? (0.5

QUESTION 5.13 (1.00)

A fluid is at 400 degrees F and 485 psig. Is it subcooled or superheated and by how many degrees?

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

QUESTION 5.14 (1.50)

The attached Figure 1 shows a T-S diagram for a steam cycle.

a. What phenomenon is taking place between points 1 and 2?

b. How does this process benefit plant operation?

c. What is the disadvantage associated with this process?

QUESTION 5.15 (3.00)

a. What is 'shut-off head' for a pump and why is it undesirable for a pump to run in this condition? (2.0)

b. How does the RHR system protect its pumps from operating at a 'shut-off head' condition? (1.0)

QUESTION 6.01 (2.00)

List FOUR (4) rod blocks associated with refueling equipment. (2.0)

QUESTION 6.02 (4.00)

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.

NOTE: A block diagram of the feedwater level control system is attached. (figure 2)

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 line flow signal fails high.

QUESTION 6.03 (2.00)

The following questions concern the starting of the Emergency Diesel Generators.

a. Explain the concerns on why a diesel generator should not be run unloaded. (1.0)

b. The reactor operator just reset a generator trip. If an attempt was made to restart the diesel before the one minute time lapse, what would be the status of the diesel? (1.0)

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

QUESTION 6.04 (2.50)

a. Briefly explain WHY it is important to closely monitor RWCU system flowrate/temperature when operating in the blowdown mode. (Neglect effect on vessel level.) (1.0)

b. State the purpose of the RWCU Blowdown mode and state when this mode is used. (0.5)

c. State the TWO (2) automatic closure signals for RWCU CV 2729 (the Clean Up Drain Header Control Valve) while operating in the blowdown mode and explain the basis of each. (1.0)

QUESTION 6.05 (2.00)

The Standby Liquid Control System (SBLC) injects sodium pentaborate solution into the reactor coolant. The pump discharge was 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)

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

QUESTION 6.06 (2.00)

The following plant conditions exist:

Jet Pumps 1 - 8 Differential Pressure (Meter) = 3 psid

Jet Pumps 9 - 16 Differential Pressure (Meter)= 15 psid

Recirc System A Only In Service (Annunciator) = ON

a. The TOTAL CORE FLOW Recorder would calculate core flow by which of the following methods? (1.0)

(1) Loop A Jet Pump Flow + Loop B Jet Pump Flow

(2) Loop A Jet Pump Flow - Loop B Jet Pump Flow

(3) Loop B Jet Pump Flow Only

(4) Loop A Jet Pump flow Only

b. After 5 minutes, the operator opens the Discharge Valve of Recirc Pump B to maintain the B Loop temperature. The TOTAL CORE FLOW Recorder would calculate core flow by which one of the following methods? (1.0)

(1) Loop A Jet Pump Flow + Loop B Jet Pump Flow

(2) Loop A Jet Pump Flow - Loop B Jet Pump Flow

(3) Loop B Jet Pump Flow Only

(4) Loop A Jet Pump Flow Only

QUESTION 6.07 (1.50)

a. What will cause a RECIRC SYSTEM A(B) STARTUP SEQUENCE INCOMPLETE annunciator when starting a recirculation pump? (1.0)

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

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

QUESTION 6.08 (1.50)

a. List ~~two~~ THREE (3) conditions that must be met in order to open the Containment Spray Valves (MO ~~1900, 1901~~) after a LOCA. (1.0)

b. What is the purpose of the "Containment Spray Valve Control Keylock Switch"? (0.5)

QUESTION 6.09 (1.00)

The main turbine is at 1800 rpm in preparation for synchronizing the main generator to the grid.

What will happen if the "all valves closed" pushbutton is depressed? (Choose the correct answer from the following.)

a. Nothing will happen since the synchronous speed select signal is sealed in.

b. The turbine control valves and main stop valves will close, but the intercept valves will remain open.

c. All of the control valves (TCVs and IVs) and main stop valves (MSVs) will close.

d. The control valves (TCVs and IVs) will close, but the main stop valves will remain open.

QUESTION 6.10 (2.50)

For EACH of the following conditions, state whether a scram, half-scram, rod block, or no action is generated. For conditions that produce more than one action, state the more severe action (i.e. half-scram is more severe than a rod block). Consider logic only.

a. Loss of one RPS MG set

b. Turbine trip at 20% power

c. Main steam lines B and D isolate, Mode switch in RUN

d. APRM B upscale Mode Switch in RUN

e. Scram discharge volume level is at 60 gallons, Mode switch in STARTUP

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

QUESTION 6.11 (3.00)

An automatic RCIC initiation has occurred. Subsequently, RCIC injection was automatically terminated due to high reactor water level.

a. What component in the RCIC system functioned as a result of the system logic to automatically terminate the injection? (0.5)

b. Assuming no operator action, how will RCIC respond to a subsequent continuously decreasing water level? (1.0)

c. If a RCIC "Turbine Test" had been in progress when the initial automatic initiation signal had been received, how would the system have responded? (1.0)

d. If, following the initiation, the RCIC turbine had tripped on overspeed, (125% of rated), could RCIC injection be restarted from the Control Room? EXPLAIN. (0.5)

QUESTION 6.12 (1.00)

What will happen to the 250 V battery system if the 250 volt battery is disconnected and only the charger is supplying bus voltage?

QUESTION 7.01 (1.00)

Explain why, from the attached Heat Capacity Temperature Limit (HCTL) Curve (figure 3) from EOP-2, Primary Containment Control, the shaded area does not include values less than 135 psig. (TWO reasons required) (1.0)

QUESTION 7.02 (3.50)

A transient has occurred with a resulting reactor scram. However, several rods remain stuck out beyond position 02. (Boron injection is not required.) At the same time, all Reactor Pressure Vessel (RPV) water level indication is lost and thus RC/F "RPV Flooding" (Contingency #6) is entered. RC/P-8, "Emergency Depressurization" (Contingency #2) is being performed concurrently.

a. Explain why, under these circumstances, the flooding procedure first requires that all injection into the RPV be terminated and prevented except that from Boron Injection and CRD. (Full explanation requires reason why injection terminated and why Boron Injection and CRD are exceptions.) (1.0)

b. Explain why, after injection is finally commenced under these circumstances, the flooding procedure requires that RPV pressure be maintained above the Minimum Alternative RPV Flooding Pressure (MARFP) but as low as practical. (must explain both for full credit.) (1.0)

c. Explain what a suddenly decreasing RPV pressure would indicate following commencement of injection and establishment of the MARFP. (0.5)

d. Explain why the preferred systems for injection in this procedure are Condensate/Feedwater, RHR, and CRD. (TWO reasons required.) (1.0)

QUESTION 7.03 (2.50)

a. IPOI-2, Startup, requires that an inspection of the drywell and steam tunnel be performed. List the FOUR (4) conditions that must be met prior to drywell entry. (2.0)

b. If an emergency entry beyond these restrictions is required, who must approve this type of entry? (0.5)

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

QUESTION 7.04 (1.50)

List the THREE (3) reasons why an operator would want cooldown rates above 100 degrees F/hr during Emergency Operating Procedure usage? (1.5)

QUESTION 7.05 (1.50)

In accordance with EPIP 1.2, Notification, the following are the responsibilities of the Operations Shift Supervisor (answer each as either TRUE or FALSE):

a. Advise the Security and Support Supervisor upon completion of all required notifications and appraise him of problems encountered.

b. Verify that the NRC is contacted within 1 hour of initial declaration.

c. For all events classified as an ALERT or higher, verify that continuous communications have been established with the NRC.

QUESTION 7.06 (1.50)

In accordance with EPIP 1.1, Determination of the Emergency Action Level, what THREE (3) items are required to be logged in the Shift Supervisor's Log upon declaring the emergency classification of an event?

QUESTION 7.07 (1.50)

Two cells of the 250 volt DC battery system are found to have a float voltage less than the required 2.13 volts. Does this affect the operability of this system and other plant systems? Explain your answer.

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

QUESTION 7.08 (2.50)

With respect to Operating Instruction No. 261, Reactor Water Cleanup System:

a. State the minimum speed at which the RWCU pump speed controllers should be set during pump startup. (0.5)

b. What would happen if they were set at a lower setting? (1.0)

c. What would happen if the RWCU pump is not secured prior to transferring between local and remote operations? (1.0)

QUESTION 7.09 (1.50)

A condition arises that requires the entry of an operator into a HIGH RADIATION AREA. The operator will receive an estimated whole body dose of 50 mrem. You have the following data available about the three (3) candidates for the job:

Candidate	1	2	3
Age	27	38	24
Exposure:			
Week	15 mrem	35 mrem	5 mrem
Quarter	2954 mrem	957 mrem	16 mrem
Life	18000 mrem	45720 mrem	29995 mrem
Remarks:			
NRC Form 4 on File	YES	YES	NO
Authorized	5000 mrem/yr	1000 mrem/qtr	150 mrem/day

Each candidate is technically competent and physically capable of performing the task. Emergency limits do not apply and time constraints do not permit authorization for an administrative exposure limit increase.

EXPLAIN the reasons for accepting or rejecting each candidate.

QUESTION 7.10 (1.00)

Operating Instruction No. 358, Reactor Protection System, notes that in the event that both RPS Busses must be shut down, all effort should be made to restore at least one RPS Bus to operation and reset the scram as soon as possible. What is the reason for this?

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

QUESTION 7.11 (2.00)

With regard to the RHR System and Operating Instruction No. 149, Residual Heat Removal System:

a. OI 149 cautions the operator to slowly lower HX shell side water level during initiating of the Steam Condensing Mode. WHY?

b. OI 149 cautions the operator that the LPCI Outboard Throttle valve should be throttled open within 10 seconds after starting an RHR pump for the Shutdown Cooling Mode. What is the concern if this is not done?

QUESTION 7.12 (1.50)

The ECCS Operating Instruction Procedures caution you NOT to secure OR override an ECCS System initiation unless certain criteria are met. What are these criteria?

QUESTION 7.13 (2.50)

With regard to Operating Instruction No. 264, Reactor Recirculation System:

a. OI 264 cautions the operator to open the discharge valve as soon as possible after starting a recirc. pump. What is the basis of this precaution? (1.0)

b. OI 264 also cautions the operator that the recirc. pump should not be operated with the pump discharge valve closed, except when starting up or shutting down a pump. Other than your answer to part a., above, what is the basis for this precaution? FULLY explain your answer. Assume that the plant is in RUN Mode and that the other recirc. pump is running normally. (1.5)

QUESTION 7.14 (2.00)

During operations at 100% power, an explosion and subsequent fire in the control room has required immediate evacuation prior to any possible operator action. NAME two (2) alternate methods to achieve a reactor scram and GIVE their locations. (Panel No. not required) (2.0)

QUESTION 8.01 (2.00)

For the following refueling occurrences, choose the correct action.

Occurrences

1. Dropped fuel assembly within the reactor vessel.

2. Damaged fuel assembly with evidence of fission gas release (bubbles).

3. Loss of Water Level Situation.

4. Unexpected Subcritical Multiplication.

Actions

a. Stoppage of core component movement only.

b. Evacuation of refueling floor.

c. Evacuation of refueling floor and drywell.

d. Evacuation of refueling floor, drywell, torus, and torus area.

QUESTION 8.02 (1.50)

TRUE or FALSE?

a. A Jumper and Lifted Lead Clearance Form shall only be completed prior to removing Jumper or Lifted Lead Tags.

b. For Lifted Lead removal, return of the Lifted Lead Tag is sufficient verification that they have been reconnected.

c. During normal surveillance testing, Jumper and Relay Block installation verification is not required; however, final Jumper and Relay Block removal verification by qualified personnel is required.

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

QUESTION 8.03 (2.00)

The reactor is at 100% power and the Fire Protection System Ring Header Flush is in progress when you take the shift as the Shift Engineer. During your review of the work in progress, you note that, per procedure, 2 valves have been closed to allow flushing of the cooling tower loop. At the time this occurred, 2 other post indicating valves on the main header were already closed to allow installation of 2 new fire hydrants. This situation resulted in isolating a section of the deluge, sprinkler, hose, and fire main systems for the last five hours. From a Technical Specification standpoint, this creates a problem. For the above situation, describe what actions should have been taken at the time the 2 valves were closed to isolate the cooling tower loop and in what time frame(s) per your technical specifications.

QUESTION 8.04 (2.00)

Concerning reactor coolant chemistry:

a. DAEC Technical Specifications require that the iodine concentration in the reactor coolant shall not exceed 12 uCi/gm of dose equivalent I-131 for the 48 hours following a power transient. If this limit is exceeded, what TWO (2) actions do the Technical Specifications require the operator to take?

b. When in the shutdown or refueling mode and with steaming rates less than 100,000 lbs/hr, conductivity shall not exceed 5 umho/cm and chlorides not exceed 0.1 ppm per the Technical Specifications. With steaming rates greater than or equal to 100,000 lbs/hr, conductivity shall not exceed 10 umho/cm and chlorides not exceed 0.5 ppm. Why are the limits for conductivity and chlorides allowed to go up when steaming rates are above 100,000 lbs/hr?

QUESTION 8.05 (1.50)

The Technical Specifications state the following "The two diesel generators shall be operable and there shall be a minimum of 35,000 gallons of diesel fuel in the diesel fuel oil tank".

What are the Technical Specification BASES for this amount?

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

QUESTION 8.06 (2.50)

You are making preparations to start up the reactor - the reactor is in the Startup Mode. The following conditions are reported:

1. Control rods 10-07 and 10-27 have inoperable accumulators.

2. The scram time to rod position 46 from full out for control rod 26-23 was 0.370 sec.; for control rod 26-19, the time was 0.372 sec.; for control rod 22-19, the time was 0.371 sec.; and for control rod 22-23, the time was 0.368 sec.

3. Control rod 26-07 cannot be moved with control rod drive pressure.

In accordance with DAEC Technical Specifications, what actions must be taken in this situation and how does this effect plant operations?

NOTE: Use the attached sections of Tech Specs to answer this question. FULLY reference all applicable sections of Tech Specs that you use to develop your answer.

QUESTION 8.07 (1.50)

While playing softball on Sunday afternoon, you severely sprain your ankle. Crutches are needed to report to work on Monday as the Shift Supervisor.

a. Can you legally assume the shift? (0.5) Why or Why not? (0.5)

b. Must a report be sent to the NRC? (0.5)

QUESTION 8.08 (2.00)

Due to vacations and required training, you have been asked to work the following schedule next week. Review the schedule and identify the overtime guidelines of DAEC Administrative Procedure 1410.1, Shift Organization, Operation and Turnover, that you would be violating. (NOTE: All times exclude Shift turnover time.) Assume that the plant is operating at 100% power.

Sunday	0700 - 1900
Monday	0700 - 1800
Tuesday	0700 - 2400
Wednesday	0700 - 1600
Thursday	0700 - 2000
Friday	0700 - 2000
Saturday	0700 - 1800

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

QUESTION 8.09 (2.50)

a. In accordance with DAEC Administrative Procedure 1406.3, Revision of Procedures and Instructions, who shall approve all temporary changes. (1.0)

b. Give THREE (3) REASONS (not examples) why a temporary procedure revision would be issued. (1.5)

QUESTION 8.10 (4.00)

With regard to DAEC Administrative Control Procedure 1410.5, Tagout Procedure:

a. What is a "SAFETY SYSTEM?" (1.0)

b. What are the required actions if a necessary Hold Card is found to be missing? (1.5)

c. In the event that the person whose name is on a Hold Card is not onsite and cannot be reached, WHO can authorize a release of the Hold Card and WHAT requirements must be met before granting the release? (1.5)

QUESTION 8.11 (1.50)

Technical Specifications require that all jet pumps must be operable or be in at least hot shutdown within 12 hours. LIST two (2) checks for operability of the jet pumps and GIVE the reason WHY jet pump operability is a concern. (1.5)

QUESTION 8.12 (2.00)

A Technical Specification Quarterly (92 days) surveillance was performed on the High Pressure Core Injection system on January 1, 1987, and April 16, 1987. The surveillance prior to January 1, 1987, was completed ninety (90) days before January 1, 1987.

a. WHAT is the last MONTH and DAY the next quarterly surveillance can be performed on?

b. What is the consequence of failing to perform a surveillance in the specified time interval?

1987 calendar attached.

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

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

EQUATION SHEET

$f = ma$

$w = mg$

$E = mc^2$

$KE = \frac{1}{2} mv^2$

$PE = mgh$

$V_f = V_0 + at$

$W = -\sqrt{\Delta P}$

$v = s/t$

$s = V_0 t + \frac{1}{2} at^2$

$a = (V_f - V_0)/t$

$w = \theta/t$

$\Delta E = 931\ \Delta m$

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

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

$Pwr = W_f \Delta h$

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

$P = P_0 e^{t/T}$

$SUR = 26.06/T$

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

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

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

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

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

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

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

$\Sigma = \alpha N$

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

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

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

$t_{\frac{1}{2}}eff = \dfrac{[(t_{\frac{1}{2}})\ (t_D)]}{[(t_{\frac{1}{2}}) + (t_D)]}$

$I = I_0 e^{-\Sigma x}$

$I = I_0 e^{-\mu x}$

$I = I_0\ 10^{-x/TVL}$

$TVL = 1.3/\mu$

$HVL = -0.693/\mu$

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

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

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

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

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

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

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

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

$I_1 d_1 = I_2 d_2$

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

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

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

Water Parameters

1 gal. = 8.345 lbm.
1 gal. = 3.78 liters
1 ft^3 = 7.48 gal.
Density = 62.4 lbm/ft
Density = 1 gm/cm^3
Heat of vaporization = 970 Btu/lbm
Heat of fusion = 144 Btu/lbm
1 Atm = 14.7 psi = 29.9 in. Hg.
1 ft H_2O = 0.433 lbf/in^2

Miscellaneous Conversions

1 curie = 3.7×10^{10} dps
1 kg = 2.21 lbm
1 hp = 2.54×10^3 Btu/hr
1 mw = 3.41×10^6 Btu/hr
1 in = 2.54 cm
°F = 9/5°C + 32
°C = 5/9 (°F-32)
1 BTU = 778 ft-lbf

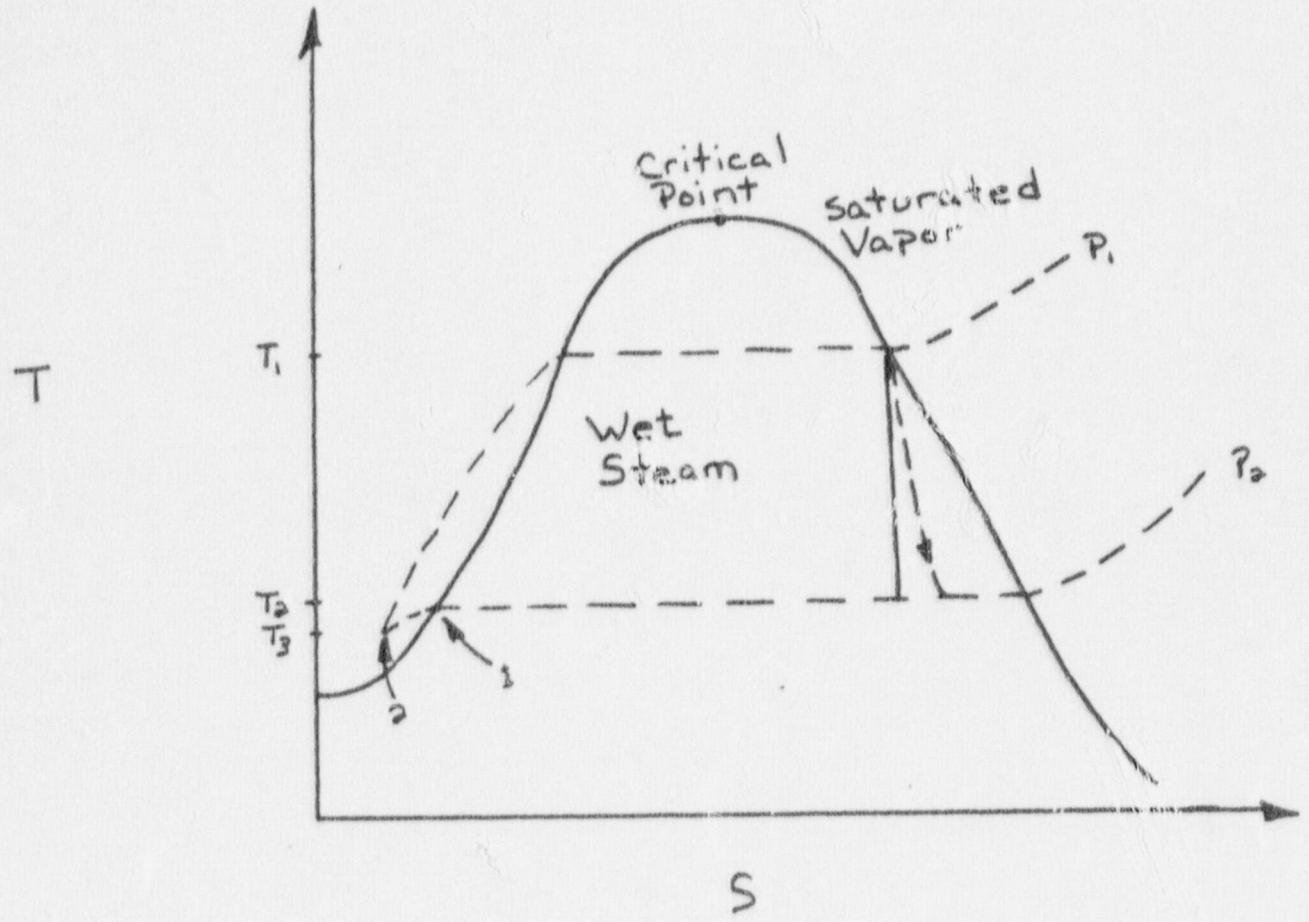

Figure 1 : T-S Diagram

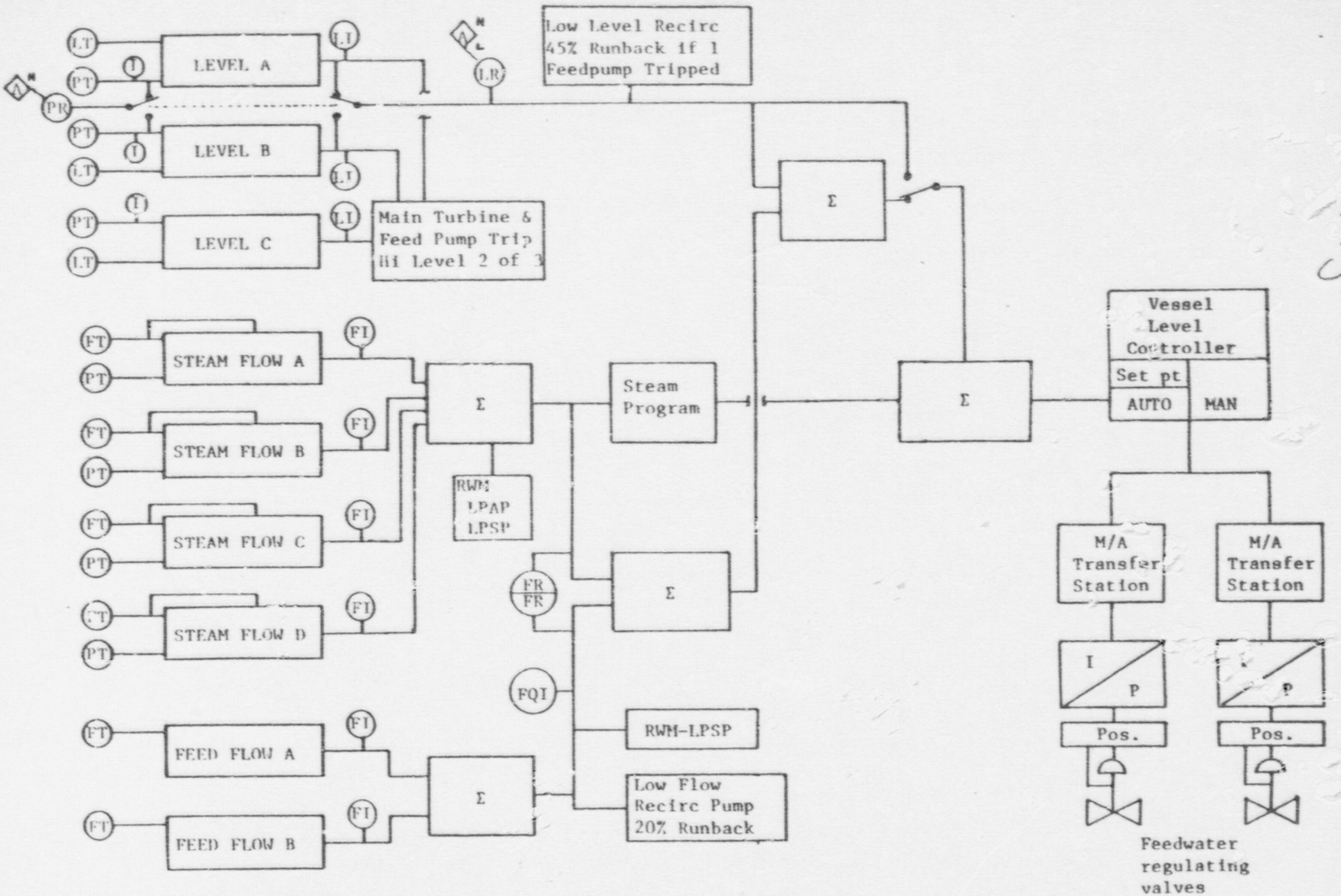

Figure 2

Figure 2 Feedwater Control System

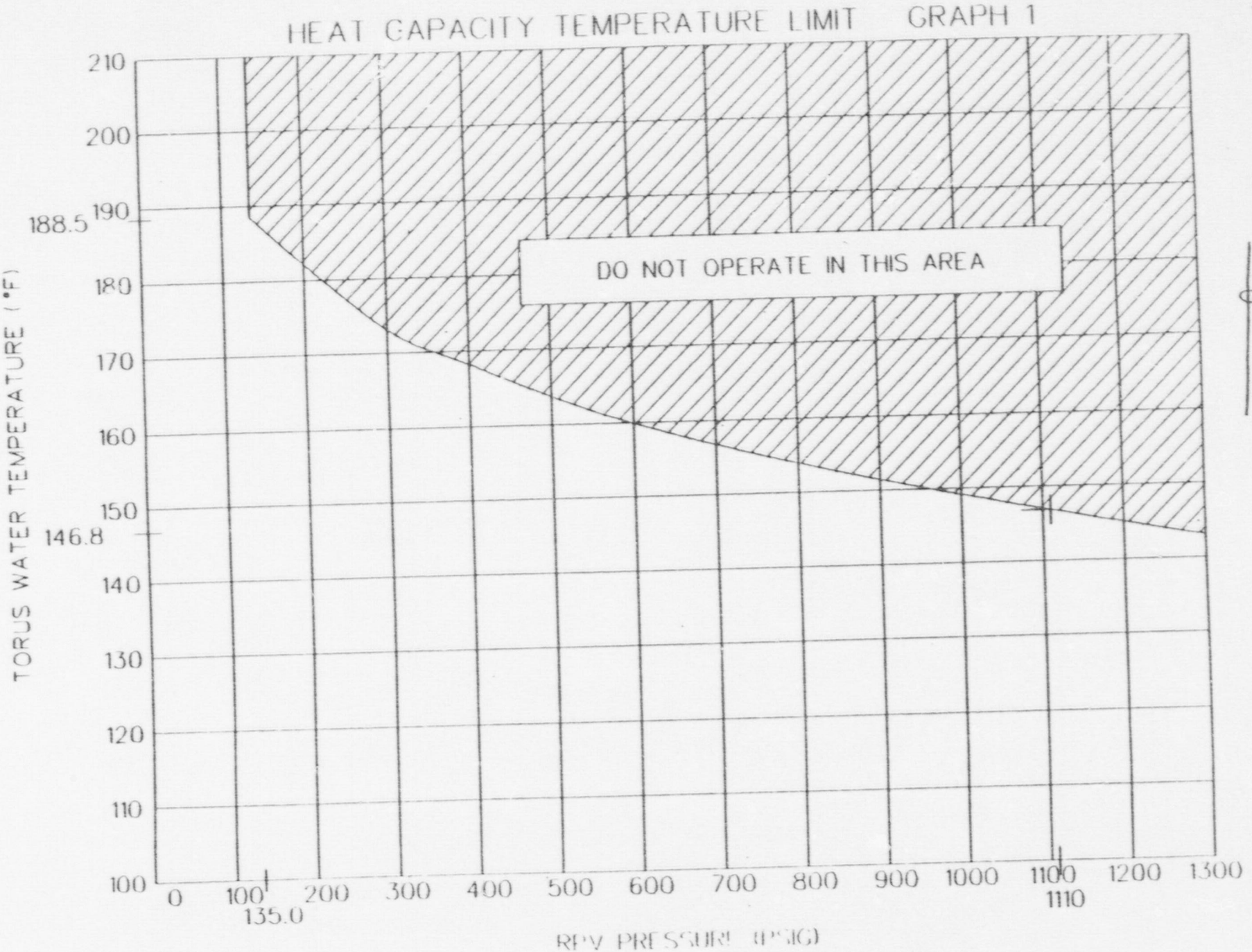
HEAT CAPACITY TEMPERATURE LIMIT GRAPH 1
DO NOT OPERATE IN THIS AREA
TORUS WATER TEMPERATURE (°F)
210
200
188.5
190
180
170
160
150
146.8
140
130
120
110
100
0
100
135.0
200
300
400
500
600
700
800
900
1000
1100
1110
1200
1300
RPV PRESSURE (PSIG)

Figure 3

1986

JANUARY

S	M	T	W	T	F	S
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5	6	7	8	9	10	11
12	13	14	15	16	17	18
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FEBRUARY

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MARCH

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APRIL

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MAY

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JUNE

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JULY

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AUGUST

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SEPTEMBER

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OCTOBER

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NOVEMBER

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DECEMBER

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1987

JANUARY

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FEBRUARY

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MARCH

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APRIL

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JUNE

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JULY

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SEPTEMBER

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OCTOBER

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NOVEMBER

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DECEMBER

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1988

JANUARY

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FEBRUARY

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MARCH

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APRIL

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MAY

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JUNE

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JULY

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AUGUST

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SEPTEMBER

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OCTOBER

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NOVEMBER

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DECEMBER

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CALENDAR YEARS

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	106.56	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	115.96	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	0.2633	1.5480	1.8111	180.0
182.0	7.850	0.016522	48.172	48.189	150.01	989.0	1139.0	0.2667	1.5413	1.8079	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
202.0	12.512	0.016664	31.135	31.151	172.11	975.4	1147.5	0.3001	1.4697	1.7698	202.0
204.0	13.568	0.016691	28.862	28.878	176.14	972.8	1149.0	0.3061	1.4571	1.7632	204.0
208.0	14.696	0.016719	26.782	26.799	180.17	970.3	1150.5	0.3121	1.4447	1.7568	208.0
212.0	15.901	0.016747	24.878	24.894	184.20	967.8	1152.0	0.3181	1.4323	1.7505	212.0
216.0	17.186	0.016775	23.131	23.148	188.23	965.2	1153.4	0.3241	1.4201	1.7442	216.0
220.0	18.556	0.016805	21.529	21.545	192.27	962.6	1154.9	0.3300	1.4081	1.7380	220.0
224.0	20.015	0.016834	20.056	20.073	196.31	960.0	1156.3	0.3359	1.3961	1.7320	224.0
228.0	21.567	0.016864	18.701	18.718	200.35	957.4	1157.8	0.3417	1.3842	1.7260	228.0
232.0	23.216	0.016895	17.454	17.471	204.40	954.8	1159.2	0.3476	1.3725	1.7201	232.0
236.0	24.968	0.016926	16.304	16.321	208.45	952.1	1160.6	0.3533	1.3609	1.7142	236.0
240.0	26.826	0.016958	15.243	15.260	212.50	949.5	1162.0	0.3591	1.3494	1.7085	240.0
244.0	28.796	0.016990	14.264	14.281	216.56	946.8	1163.4	0.3649	1.3379	1.7028	244.0
248.0	30.883	0.017022	13.358	13.375	220.62	944.1	1164.7	0.3706	1.3266	1.6972	248.0
252.0	33.091	0.017055	12.520	12.538	224.69	941.4	1166.1	0.3763	1.3154	1.6917	252.0
256.0	35.427	0.017089	11.745	11.762	228.76	938.6	1167.4	0.3819	1.3043	1.6862	256.0
260.0	37.894	0.017123	11.025	11.042	232.83	935.9	1168.7	0.3876	1.2933	1.6808	260.0
264.0	40.500	0.017157	10.358	10.375	236.91	933.1	1170.0	0.3932	1.2823	1.6755	264.0
268.0	43.249	0.017193	9.738	9.755	240.99	930.3	1171.3	0.3987	1.2715	1.6702	268.0
272.0	46.147	0.017228	9.162	9.180	245.08	927.5	1172.5	0.4043	1.2607	1.6650	272.0
276.0	49.200	0.017264	8.627	8.644	249.17	924.6	1173.8	0.4098	1.2501	1.6599	276.0
280.0	52.414	0.01730	8.1280	8.1453	253.3	921.7	1175.0	0.4154	1.2395	1.6548	280.0
284.0	55.795	0.01734	7.6634	7.6807	257.4	918.8	1176.2	0.4208	1.2290	1.6498	284.0
288.0	59.350	0.01738	7.2301	7.2475	261.5	915.9	1177.4	0.4263	1.2186	1.6449	288.0
292.0	63.084	0.01741	6.8259	6.8433	265.6	913.0	1178.6	0.4317	1.2082	1.6400	292.0
296.0	67.005	0.01745	6.4483	6.4658	269.7	910.0	1179.7	0.4372	1.1979	1.6351	296.0
300.0	71.119	0.01749	6.0955	6.1130	273.8	907.0	1180.9	0.4426	1.1877	1.6303	300.0
304.0	75.433	0.01753	5.7655	5.7830	278.0	904.0	1182.0	0.4479	1.1776	1.6256	304.0
308.0	79.953	0.01757	5.4566	5.4742	282.2	901.0	1183.1	0.4533	1.1676	1.6209	308.0
312.0	84.688	0.01761	5.1673	5.1849	286.3	897.9	1184.1	0.4586	1.1576	1.6162	312.0
316.0	89.643	0.01766	4.8961	4.9138	290.4	894.8	1185.2	0.4640	1.1477	1.6116	316.0
320.0	94.826	0.01770	4.6418	4.6595	294.6	891.6	1186.2	0.4692	1.1378	1.6071	320.0
324.0	100.245	0.01774	4.4030	4.4208	298.7	888.5	1187.2	0.4745	1.1280	1.6025	324.0
328.0	105.907	0.01779	4.1788	4.1966	302.9	885.3	1188.2	0.4798	1.1183	1.5981	328.0
332.0	111.820	0.01783	3.9681	3.9859	307.1	882.1	1189.1	0.4850	1.1086	1.5936	332.0
336.0	117.992	0.01787	3.7699	3.7878	311.3	878.8	1190.1	0.4902	1.0990	1.5892	336.0
340.0	124.430	0.01792	3.5834	3.6013	315.5	875.5	1191.0	0.4954	1.0894	1.5849	340.0
344.0	131.142	0.01797	3.4078	3.4258	319.7	872.2	1191.1	0.5006	1.0799	1.5806	344.0
348.0	138.138	0.01801	3.2423	3.2603	323.9	868.9	1192.7	0.5058	1.0705	1.5763	348.0
352.0	145.424	0.01806	3.0863	3.1044	328.1	865.5	1193.6	0.5110	1.0611	1.5721	352.0
356.0	153.010	0.01811	2.9392	2.9573	332.3	862.1	1194.4	0.5161	1.0517	1.5678	356.0
360.0	160.903	0.01816	2.8002	2.8184	336.5	858.6	1195.2	0.5212	1.0424	1.5637	360.0
364.0	169.113	0.01821	2.6691	2.6873	340.8	855.1	1195.9	0.5263	1.0332	1.5595	364.0
368.0	177.648	0.01826	2.5451	2.5633	345.0	851.6	1196.7	0.5314	1.0240	1.5554	368.0
372.0	186.517	0.01831	2.4279	2.4462	349.3	848.1	1197.4	0.5365	1.0148	1.5513	372.0
376.0	195.729	0.01836	2.3170	2.3353	353.6	844.5	1198.0	0.5416	1.0057	1.5473	376.0
380.0	205.294	0.01842	2.2120	2.2304	357.9	840.8	1198.7	0.5466	0.9966	1.5432	380.0
384.0	215.220	0.01847	2.1126	2.1311	362.2	837.2	1199.3	0.5516	0.9876	1.5392	384.0
388.0	225.516	0.01853	2.0184	2.0369	366.5	833.4	1199.9	0.5567	0.9786	1.5352	388.0
392.0	236.183	0.01858	1.9291	1.9477	370.8	829.7	1200.4	0.5617	0.9696	1.5313	392.0
396.0	247.259	0.01864	1.8444	1.8630	375.1	825.9	1201.0	0.5667	0.9607	1.5274	396.0
400.0	258.725	0.01870	1.7640	1.7827	379.4	822.0	1201.5	0.5717	0.9518	1.5234	400.0
404.0	270.600	0.01875	1.6877	1.7064	383.8	818.2	1201.9	0.5766	0.9429	1.5195	404.0
408.0	282.894	0.01881	1.6152	1.6340	388.1	814.2	1202.4	0.5816	0.9341	1.5157	408.0
412.0	295.617	0.01887	1.5463	1.5651	392.5	810.2	1202.8	0.5866	0.9253	1.5118	412.0
416.0	308.780	0.01894	1.4808	1.4997	396.9	806.2	1203.1	0.5915	0.9165	1.5080	416.0
420.0	322.391	0.01900	1.4184	1.4374	401.3	802.2	1203.5	0.5964	0.9077	1.5041	420.0
424.0	336.463	0.01908	1.3591	1.3782	405.7	798.0	1203.7	0.6014	0.8990	1.5004	424.0
428.0	351.00	0.01913	1.30266	1.32179	410.1	793.9	1204.0	0.6063	0.8903	1.4966	428.0
432.0	366.03	0.01919	1.24887	1.26806	414.6	789.7	1204.2	0.6112	0.8816	1.4928	432.0
436.0	381.54	0.01926	1.19761	1.21687	419.0	785.4	1204.4	0.6161	0.8729	1.4890	436.0
440.0	397.56	0.01933	1.14874	1.16808	423.5	781.1	1204.6	0.6210	0.8643	1.4853	440.0
444.0	414.09	0.01940	1.10212	1.12152	428.0	776.7	1204.7	0.6259	0.8557	1.4815	444.0
448.0	431.14	0.01947	1.05764	1.07711	432.5	772.3	1204.8	0.6308	0.8471	1.4779	448.0
452.0	448.73	0.01954	1.01518	1.03472	437.0	767.8	1204.8	0.6356	0.8385	1.4741	452.0
456.0											456.0

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

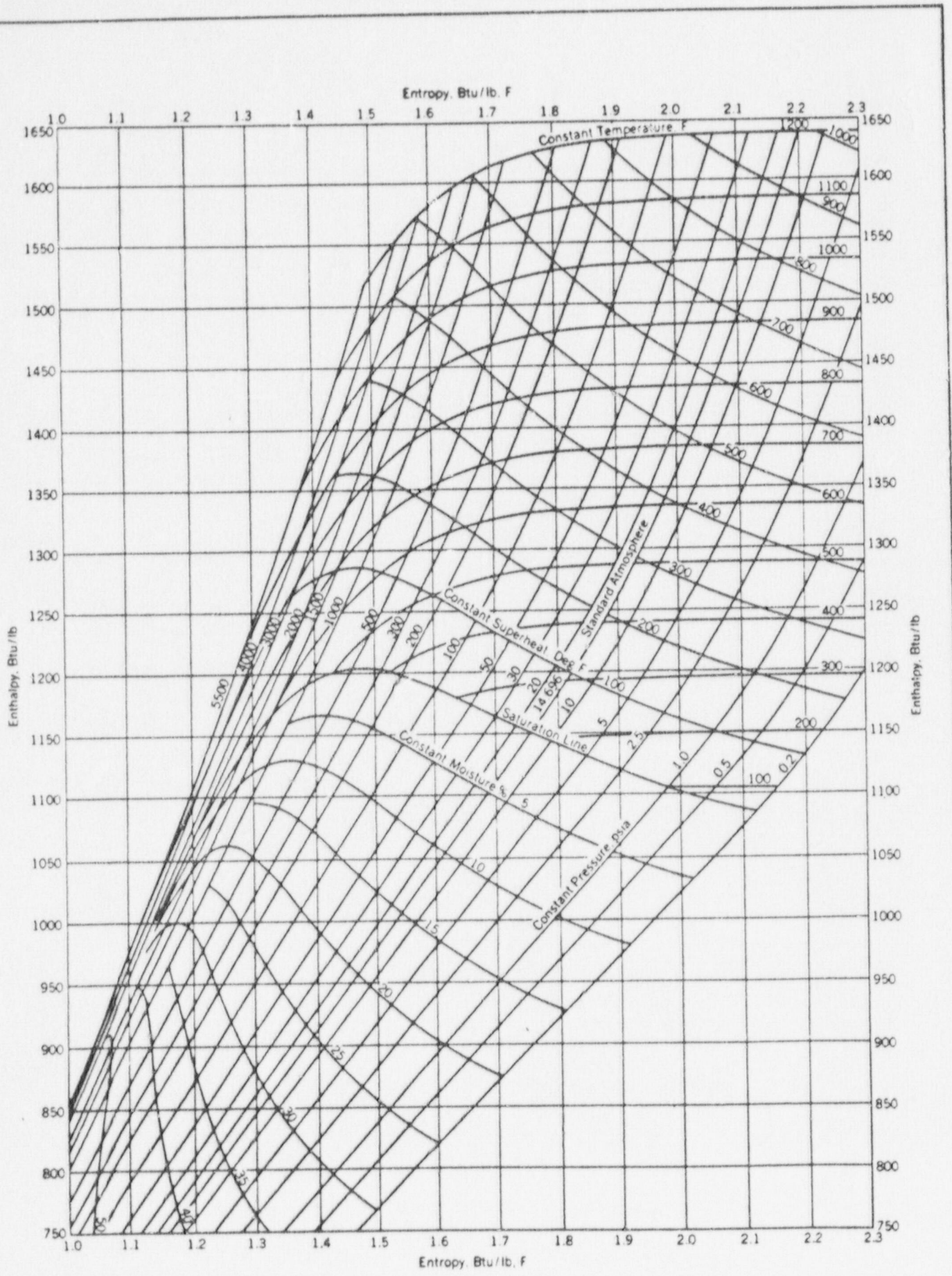
Temp Fahr t	Abs Press Lb per Sq In p	Specific Volume Sat Liquid v_l	Specific Volume Evap v_{lg}	Specific Volume Sat Vapor v_g	Enthalpy Sat Liquid h_l	Enthalpy Evap h_{lg}	Enthalpy Sat Vapor h_g	Entropy Sat Liquid s_l	Entropy Evap s_{lg}	Entropy Sat Vapor s_g	Temp Fahr t
488.8	466.87	0.01961	0.97463	0.99424	441.5	763.2	1204.8	0.6405	0.8299	1.4704	488.8
484.8	485.56	0.01969	0.93588	0.95557	446.1	758.6	1204.7	0.6454	0.8213	1.4667	484.8
480.8	504.83	0.01976	0.89885	0.91862	450.7	754.0	1204.6	0.6502	0.8127	1.4629	480.8
472.8	524.67	0.01984	0.86345	0.88329	455.2	749.3	1204.5	0.6551	0.8042	1.4593	472.8
476.2	545.11	0.01992	0.82958	0.84950	459.9	744.5	1204.3	0.6599	0.7956	1.4555	476.8
488.8	566.15	0.02000	0.79716	0.81717	464.5	739.6	1204.1	0.6648	0.7871	1.4518	488.8
484.8	587.81	0.02009	0.76613	0.78622	469.1	734.7	1203.8	0.6696	0.7785	1.4481	484.8
480.8	610.10	0.02017	0.73641	0.75658	473.8	729.7	1203.5	0.6745	0.7700	1.4444	480.8
488.8	633.03	0.02026	0.70794	0.72820	478.5	724.6	1203.1	0.6793	0.7614	1.4407	482.8
482.8	656.61	0.02034	0.68065	0.70100	483.2	719.5	1202.7	0.6842	0.7528	1.4370	488.8
488.8	680.86	0.02043	0.65448	0.67492	487.9	714.3	1202.2	0.6890	0.7443	1.4333	488.8
484.8	705.78	0.02053	0.62938	0.64991	492.7	709.0	1201.7	0.6939	0.7357	1.4296	484.8
488.8	731.40	0.02062	0.60530	0.62592	497.5	703.7	1201.1	0.6988	0.7271	1.4258	488.8
512.8	757.72	0.02072	0.58218	0.60289	502.3	698.2	1200.5	0.7036	0.7185	1.4221	512.8
516.8	784.76	0.02081	0.55997	0.58079	507.1	692.7	1199.8	0.7085	0.7099	1.4183	516.8
528.8	812.53	0.02091	0.53864	0.55956	512.0	687.0	1199.0	0.7133	0.7013	1.4146	528.8
524.8	841.04	0.02102	0.51814	0.53916	516.9	681.3	1198.2	0.7182	0.6926	1.4108	524.8
528.8	870.31	0.02112	0.49843	0.51955	521.8	675.5	1197.3	0.7231	0.6839	1.4070	528.8
532.8	900.34	0.02123	0.47947	0.50070	526.8	669.6	1196.4	0.7280	0.6752	1.4032	532.8
536.8	931.17	0.02134	0.46123	0.48257	531.7	663.6	1195.4	0.7329	0.6665	1.3993	536.8
548.8	962.79	0.02146	0.44367	0.46513	536.8	657.5	1194.3	0.7378	0.6577	1.3954	548.8
544.8	995.27	0.02157	0.42677	0.44834	541.8	651.3	1193.1	0.7427	0.6489	1.3915	544.8
548.8	1028.49	0.02169	0.41048	0.43217	546.9	645.0	1191.9	0.7476	0.6400	1.3876	548.8
552.8	1062.59	0.02182	0.39479	0.41660	552.0	638.5	1190.6	0.7525	0.6311	1.3837	552.8
556.8	1097.55	0.02194	0.37966	0.40160	557.2	632.0	1189.2	0.7575	0.6222	1.3797	556.8
568.8	1133.38	0.02207	0.36507	0.38714	562.4	625.3	1187.7	0.7625	0.6132	1.3757	568.8
564.8	1170.10	0.02221	0.35099	0.37320	567.6	618.5	1186.1	0.7674	0.6041	1.3716	564.8
568.8	1207.73	0.02235	0.33741	0.35975	572.9	611.5	1184.5	0.7725	0.5950	1.3675	568.8
572.8	1246.26	0.02249	0.32429	0.34678	578.3	604.5	1182.7	0.7775	0.5859	1.3634	572.8
576.8	1285.74	0.02264	0.31162	0.33426	583.7	597.2	1180.9	0.7825	0.5766	1.3592	576.8
588.8	1326.17	0.02279	0.29937	0.32216	589.1	589.9	1179.0	0.7876	0.5673	1.3550	588.8
584.8	1367.7	0.02295	0.28753	0.31048	594.6	582.4	1176.9	0.7927	0.5580	1.3507	584.8
588.8	1410.0	0.02311	0.27608	0.29919	600.1	574.7	1174.8	0.7978	0.5485	1.3464	588.8
592.8	1453.3	0.02328	0.26499	0.28827	605.7	566.8	1172.6	0.8030	0.5390	1.3420	592.8
596.8	1497.8	0.02345	0.25425	0.27770	611.4	558.8	1170.2	0.8082	0.5293	1.3375	596.8
608.8	1543.2	0.02364	0.24384	0.26747	617.1	560.6	1167.7	0.8134	0.5196	1.3330	608.8
604.8	1589.7	0.02382	0.23374	0.25757	622.9	542.2	1165.1	0.8187	0.5097	1.3284	604.8
608.8	1637.3	0.02402	0.22394	0.24796	628.8	533.6	1162.4	0.8240	0.4997	1.3238	608.8
612.8	1686.1	0.02422	0.21442	0.23865	634.8	524.7	1159.5	0.8294	0.4896	1.3190	612.8
616.8	1735.9	0.02444	0.20516	0.22960	640.8	515.6	1156.4	0.8348	0.4794	1.3141	616.8
628.8	1786.9	0.02466	0.19615	0.22081	646.9	506.3	1153.2	0.8403	0.4689	1.3092	628.8
624.8	1839.0	0.02489	0.18737	0.21226	653.1	496.6	1149.8	0.8458	0.4583	1.3041	624.8
628.8	1892.4	0.02514	0.17880	0.20394	659.5	486.7	1146.1	0.8514	0.4474	1.2988	628.8
632.8	1947.0	0.02539	0.17044	0.19583	665.9	476.4	1142.2	0.8571	0.4364	1.2934	632.8
636.8	2002.8	0.02566	0.16226	0.18792	672.4	465.7	1138.1	0.8628	0.4251	1.2879	636.8
648.8	2059.9	0.02595	0.15427	0.18021	679.1	454.6	1133.7	0.8686	0.4134	1.2821	648.8
644.8	2118.3	0.02625	0.14644	0.17269	685.9	443.1	1129.0	0.8746	0.4015	1.2761	644.8
648.8	2178.1	0.02657	0.13876	0.16534	692.9	431.1	1124.0	0.8806	0.3893	1.2699	648.8
652.8	2239.2	0.02691	0.13124	0.15816	700.0	418.7	1118.7	0.8868	0.3767	1.2634	652.8
656.8	2301.7	0.02728	0.12387	0.15115	707.4	405.7	1113.1	0.8931	0.3637	1.2567	656.8
668.8	2365.7	0.02768	0.11663	0.14431	714.9	392.1	1107.0	0.8995	0.3502	1.2498	668.8
664.8	2431.1	0.02811	0.10947	0.13757	722.9	377.7	1100.6	0.9064	0.3361	1.2425	664.8
668.8	2498.1	0.02858	0.10239	0.13087	731.5	362.1	1093.5	0.9137	0.3210	1.2347	668.8
672.8	2566.6	0.02911	0.09514	0.12424	740.2	345.7	1085.9	0.9212	0.3054	1.2266	672.8
676.8	2636.8	0.02970	0.08799	0.11769	749.2	328.5	1077.6	0.9287	0.2892	1.2179	676.8
688.8	2708.6	0.03037	0.08080	0.11117	758.5	310.1	1068.5	0.9365	0.2720	1.2086	688.8
684.8	2782.1	0.03114	0.07349	0.10463	768.2	290.2	1058.4	0.9447	0.2537	1.1984	684.8
688.8	2857.4	0.03204	0.06596	0.09799	778.8	268.2	1047.0	0.9535	0.2337	1.1872	688.8
692.8	2934.5	0.03313	0.05797	0.09110	790.5	243.1	1033.6	0.9634	0.2110	1.1744	692.8
696.8	3013.4	0.03455	0.04916	0.08371	804.4	212.8	1017.2	0.9749	0.1841	1.1591	696.8
708.8	3094.3	0.03662	0.03857	0.07519	822.4	172.7	995.2	0.9901	0.1490	1.1390	708.8
702.8	3135.5	0.03824	0.03173	0.06997	835.0	144.7	979.7	1.0006	0.1246	1.1252	702.8
704.8	3177.2	0.04108	0.02182	0.06300	854.2	102.0	956.2	1.0169	0.0876	1.1046	704.8
705.8	3198.3	0.04427	0.01304	0.05730	873.0	61.4	934.4	1.0329	0.0527	1.0856	705.8
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	0.02106	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



Mollier diagram (h-s) for steam.

LIMITING CONDITION FOR OPERATION	SURVEILLANCE REQUIREMENT
3.3 REACTIVITY CONTROL	4.3 REACTIVITY CONTROL
Applicability:	Applicability:
Applies to the operational status of the control rod system.	Applies to the surveillance requirements of the control rod system.
Objective:	Objective:
To assure the ability of the control rod system to control reactivity.	To verify the ability of the control rod system to control reactivity.
Specification:	Specification:
A. Reactivity Limitations	A. Reactivity Limitations
1. Reactivity margin - core loading	1. Reactivity margin - core loading
A sufficient number of control rods shall be operable so that the core could be made subcritical in the most reactive condition during the operating cycle with the strongest control rod fully withdrawn and all other operable control rods fully inserted.	Sufficient control rods shall be withdrawn following a refueling outage when core alterations were performed to demonstrate with a margin of 0.38 $\Delta k/k$ that the core can be made subcritical at any time in the subsequent fuel cycle with the analytically determined strongest operable control rod fully withdrawn and all other operable rods fully inserted.
2. Control Rod Exercise	2. Control Rod Exercise
a. Control rods which cannot be moved with control rod drive pressure shall be considered inoperable. If a partially or fully withdrawn control rod drive cannot be moved with drive or scram pressure, the reactor shall be brought to a shutdown condition within 48 hours unless investigation demonstrates that the cause of the failure is not due to a failed control rod drive mechanism collet housing.	a. Each partially or fully withdrawn operable control rod shall be exercised one notch at least once each week when operating above 30% power. This test shall be performed at least once per 24 hours in the event power operation is continuing above 30% power with two or more inoperable control rods or in the event power operation is continuing above 30% power with one fully or partially withdrawn rod which cannot be moved and for which control rod drive mechanism damage has not been ruled out. The surveillance need not be completed within 24 hours if the number of inoperable rods has been reduced to less than two and if it has been demonstrated that control rod drive mechanism collet housing failure is not the cause of an immovable control rod.

LIMITING CONDITION FOR OPERATION	SURVEILLANCE REQUIREMENT
b. The control rod directional control valves for inoperable control rods shall be disarmed electrically and the control rods shall be in such position that Specification 3.3.A.1 is met.	b. A second licensed operator shall verify the conformance to Specification 3.3.A.2d before a rod may be bypassed in the Rod Sequence Control System.
c. Control rods with inoperable accumulators or those whose position cannot be positively determined shall be considered inoperable.	c. Once per week when the plant is in operation, check status of pressure and level alarms for each CRD accumulator.
d. Control rods with a failed "Full-in" or "Full-out" position switch may be bypassed in the Rod Sequence Control System and considered operable if the actual rod position is known. These rods must be moved in sequence to their correct positions (full-in on insertion or full-out on withdrawal).	d. Once per quarter verify that: (1) the Scram Discharge Volume (SDV) vent and drain valves close within 30 seconds after receipt of a close signal, and (2) after removal of the close signal, that the SDV vent and drain valves are open. Once per month verify that the SDV vent and drain valve position indicating lights located in the control room indicate that the valves are open.
e. Control rods with scram times greater than those permitted by Specification 3.3.C.3 are inoperable, but if they can be inserted with control rod drive pressure they need not be disarmed electrically.	e. Once per operating cycle verify that: (1) the SDV vent and drain valves close within 30 seconds after receipt of a signal for the control rods to scram, and (2) open when the scram signal is reset.
f. Inoperable control rods shall be positioned such that Specification 3.3.A.1 is met.	

LIMITING CONDITION FOR OPERATION	SURVEILLANCE REQUIREMENT
1) In addition, whenever the reactor is in the startup or run mode no more than one control rod in any 5 x 5 array may be inoperable (at least 4 operable control rods must separate any 2 inoperable ones). If this Specification cannot be met, the reactor shall not be started, or if at power, the reactor shall be brought to a cold shutdown condition within 24 hours.	
2) All rods within a notch group containing an inoperable rod will be positioned within 1 (one) notch of the inoperable rod whenever the Rod Sequence Control System is required.	
g. During reactor power operation the number of inoperable control rods shall not exceed 8. Specification 3.3.A.1 must be met at all times.	
B. Control Rods	B. Control Rods
1. Each control rod shall be coupled to its drive and have rod position indication available for the "full in" and "full out" position or completely inserted and the control rod directional control valves disarmed electrically. This requirement does not apply in the refuel condition when the reactor is vented. Two control rod drives may be removed as long as Specification 3.3.A.1 is met.	1. The coupling integrity shall be verified for each withdrawn control rod as follows:
	a. When a rod is withdrawn the first time after each refueling outage or after maintenance, observe discernible response of the nuclear instrumentation and rod position indication for the "full in" and "full out" position. However, for initial rods when response is not discernible, subsequent exercising of these rods after the reactor is above 30% power shall be performed to verify instrumentation response.
	b. When the rod is fully withdrawn the first time after each refueling outage or after CRD maintenance, observe that the drive does not go to the overtravel position.

LIMITING CONDITION FOR OPERATION	SURVEILLANCE REQUIREMENT
	c. During each REFUELING OUTAGE observe that any drive which has been uncoupled from and subsequently recoupled to its control rod does not go to the overtravel position.
2. The control rod drive housing support system shall be in place during REACTOR POWER OPERATION or when the reactor coolant system is pressurized above atmospheric pressure with fuel in the reactor vessel, unless all control rods are fully inserted and Specification 3.3.A.1 is met.	2. The control rod drive housing support system shall be inspected after reassembly and the results of the inspection recorded.
3.a Whenever the reactor is in the STARTUP or RUN mode below 30% RATED POWER, and the control rod movement is within the group notch mode after 50% of the control rods have been withdrawn, the Rod Sequence Control System (RSCS) shall be OPERABLE. If the system is determined to be inoperable in accordance with checks in Specification 4.3.3.3, power may be increased above 30% RATED POWER by increasing core flow.	3.a. Prior to the start of control rod withdrawal towards criticality and prior to attaining 30% RATED POWER during rod insertion at shutdown, the capability of the Rod Sequence Control System to properly fulfill its function shall be verified by the following check: Group Notch - Test the six comparator circuits. Go through each comparator inhibit, initiate test, verify error, and reset. After completing checks initiate test and observe completion of cycle indicated by illumination of test complete light.
b. Whenever the reactor is in the STARTUP or RUN modes below 30% RATED POWER the Rod Worth Minimizer (RWM) shall be OPERABLE or a second Reactor Operator shall verify that the Reactor Operator at the reactor console is following the control rod program.	b. Prior to the start of control rod withdrawal towards criticality and prior to attaining 30% RATED POWER during rod insertion at shutdown, the capability of the Rod Worth Minimizer (RWM) shall be verified by the following checks:
c. If either Specifications 3.3.B.3.a or .b cannot be met, the reactor shall not be started, or if the reactor is in the RUN or STARTUP modes at less than 30% RATED POWER, control rod movement shall not be permitted, except by a scram. Limited control rod movement is permitted for the purpose of determining RSCS or RWM OPERABILITY and shall be verified by a second Reactor Operator.	1) The correctness of the Reduced Notch Worth Procedure sequence input to the RWM computer shall be verified.

LIMITING CONDITION FOR OPERATION	SURVEILLANCE REQUIREMENT
	2) The RWM computer on line diagnostic test shall be successfully performed.
	3) Proper annunciation of the selection error of at least one out-of-sequence control rod in each fully inserted group shall be verified.
	4) The rod block function of the RWM shall be verified by withdrawing the first rod as an out-of-sequence control rod no more than to the block point.
4. Control rods shall not be withdrawn in STARTUP or REFUEL modes unless at least two Source Range Monitor Channels have an observed count rate equal to or greater than three counts per second.	4. Prior to control rod withdrawal in STARTUP or REFUEL modes, verify that at least two Source Range Monitor Channels have an observed count rate of at least three counts per second.
5. During operation with Limiting Control Rod Patterns, either: a. Both RBM channels shall be OPERABLE, or b. With one RBM channel inoperable, control rod withdrawal shall be blocked within 24 hours, unless OPERABILITY is restored within this time period, or c. With both RBM channels inoperable, control rod withdrawal shall be blocked until OPERABILITY of at least one channel is restored.	5. When a Limiting Control Rod Pattern exists, an Instrument Functional Test of the RBM shall be performed prior to withdrawal of the designated rod(s).

LIMITING CONDITION FOR OPERATION

C. Scram Insertion Times

1. The average scram insertion time, based on the de-energization of the scram pilot valve at time zero, of all OPERABLE control rods in the reactor power operation condition shall be no greater than:

Rod Position	Average Scram Insertion Times (Sec)
46	0.35
38	0.937
26	1.86
06	3.41

2. The average scram insertion times for the three fastest control rods of all groups of four control rods in a 2 x 2 array shall be no greater than:

Rod Position	Average Scram Insertion Times (Sec)
46	0.37
38	1.01
26	1.97
06	3.62

3. Maximum scram insertion time to rod position 04 of any OPERABLE control rod should not exceed 7.00 seconds.

SURVEILLANCE REQUIREMENT

C. Scram Insertion Times

1. After each refueling outage all OPERABLE rods shall be scram time tested from the fully withdrawn position to the drop-out of the reed switch at the rod position required by Specification 3.3.C. The nuclear system pressure shall be above 950 psig (with saturation temperature) and the requirements of Specification 3.3.B.3.a met. This testing shall be completed prior to exceeding 40% power. Below 30% power, only rods in those sequences (A_{12} and A_{34} or B_{12} and B_{34}) which are fully withdrawn in the region from 100% rod density to 50% rod density shall be scram time tested. During all scram time testing below 30% power, the Rod Worth Minimizer shall be OPERABLE or a second licensed operator shall verify that the operator at the reactor console is following the control rod program.

ANSWERS -- DUANE ARNOLD -87/07/15-HARE, E. A.

ANSWER 5.01 (1.00)

d.

REFERENCE
DAEC RXTH-SH-16, pg. 2-2
292003K110 ...(KA'S)

ANSWER 5.02 (2.00)

True.

Using the equation $P = P_o e^{(t/T)}$
solving for time results in the equation:
$t = T \times \ln(P/P_o)$
From this it can be seen that since 5/1 yields the same value as 50/10, and since all other factors in the equation are equal, the time is equal. (2.0)

REFERENCE
DAEC Reactor Theory, Period Equation, Pg. 2
292003K108 ...(KA'S)

ANSWER 5.03 (1.00)

b.

REFERENCE
DAEC Heat Transfer 14, Mitigating Reactor Core Damage 3-44
293009K107 ...(KA'S)

ANSWER 5.04 (1.00)

a.

REFERENCE
DAEC RXTH-SH24-4
292006K107 9 292006K108 ...(KA'S)

ANSWERS -- DUANE ARNOLD -87/07/15-HARE, E. A.

ANSWER 5.05 (1.00)

c.

REFERENCE
DAEC RXTH-SH-19a, pg. 2
292003K107 ...(KA'S)

ANSWER 5.06 (1.50)

a. Radiolytic decomposition of water. (0.5)

b. Metal (fuel cladding) to water reaction or Zr - Water reaction. (0.5)

c. Oxygen - 2%

Hydrogen - 4% (0.5)

REFERENCE
Duane Arnold Mitigating Reactor Core Damage, pg. 6-5, 6-13, 6-46
223001A204 223001A205 223001K404 ...(KA'S)

ANSWER 5.07 (2.50)

a. Doppler [0.33] is the first to add negative reactivity. The increase in power level causes a rise in fuel temperature and a corresponding addition of negative reactivity due to doppler effect [0.5].

b. Moderator Temperature Coefficient [0.33] is next as there is a time delay (fuel time constant) for the heat generated in the fuel pellet to reach the coolant in the channel and cause the temperature to increase [0.5].

c. Void Coefficient [0.33] is last as the moderator temperature has to increase to the point of saturation before voids are formed in appreciable quantity. (Also accept if there are no voids early in startup) [0.5].

REFERENCE
DAEC RXTH-SH-22, pgs. 4 and 5
292004K114 ...(KA'S)

ANSWERS -- DUANE ARNOLD -87/07/15-HARE, E. A.

ANSWER 5.08 (2.00)

a. DECREASE
b. DECREASE
c. INCREASE
d. INCREASE
(4 @ 0.5 pts each)

REFERENCE
DAEC RXTH-SH-29, pg. 4, SH-27, pgs. 4 and 5
292005K104 ...(KA'S)

ANSWER 5.09 (1.50)

Peripheral rod worth will increase. (0.5) High Xe concentration in the center of the core (highest power before scram) will depress the thermal neutron flux in that region causing the relative neutron flux in the peripheral bundles to be higher, thus increase the relative rod worth in peripheral rods. (1.0)

REFERENCE
DAEC, RXTH-SH-29, pg. 2
292006K107 ...(KA'S)

ANSWER 5.10 (1.50)

a. BOL: $t = \frac{\rho - P}{\alpha P} = \frac{(.0072 - .001)}{(0.1)(0.001)} = 62$ seconds (0.33)

EOL: $t = \frac{(0.0055 - .001)}{(0.1)(0.001)} = \frac{\cancel{xx}}{45}$ seconds (0.33)

CHANGE $62 - \frac{\cancel{xx}}{45} = \frac{\cancel{xx}}{17}$ seconds (0.33)

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
DAEC Reactor Theory, SH-20, pg. 8
292003K106 ...(KA'S)

ANSWERS -- DUANE ARNOLD -87/07/15-HARE, E. A.

ANSWER 5.11 (1.50)

a. This design utilizes a layer of zirconium metal bonded to the inner surface of the cladding. ~~This liner inhibits cracking by easing the stress and chemical reaction between the pellets and cladding~~. (0.75)

b. With a full core load of barrier fuel, it is expected that operation to targeted exposures without pellet-clad interaction failures or operational constraints on load swings (preconditioning) can be achieved. (0.75)

REFERENCE
DAEC System Description A-4, pg. 8-9
293009K131 293009K137 ...(KA'S)

ANSWER 5.12 (2.50)

a. Transition boiling may occur [0.5]. This could lead to fuel damage [0.5].

b. To make the MCPR limit more conservative to account for the possibility of a sudden flow increase and the resultant power increase. (1.0)

c. Increases. (0.5)

REFERENCE
DAEC - Thermodynamics, Heat Transfer, and Fluid Flow, pg. 13-1
293009K120 293009K127 ...(KA'S)

ANSWER 5.13 (1.00)

485 psig + 14.7 psig = 499.7 psia

499.7 psia = 467 degrees F

467 degrees F - 409 degrees F = 67 degrees F (.50)

Fluid is SUBCOOLED (.50)

REFERENCE
DAEC Thermodynamics 10-1
293003K123 ...(KA'S)

ANSWERS -- DUANE ARNOLD -87/07/15-HARE, E. A.

ANSWER 5.14 (1.50)

a. Condensate depression or subcooling

b. Helps provide NPSH to condensate pumps to prevent cavitation

c. Reduces plant efficiency - (this is additional heat energy that must be provided by the reactor).

(3 @ 0.5 each = 1.5)

REFERENCE
DAEC Heat Transfer, pg. 16-15
293003K116 293006K110 ...(KA'S)

ANSWER 5.15 (3.00)

a. Pump shut-off head is the pump head at which the maintainable flow rate is reduced to zero [1.0]. It is undesirable because the pump overheats and may result in mechanical damage to the pump [1.0].

b. Provided with a minimum flow recirculation valve and return line. (1.0)

REFERENCE
DAEC, Thermodynamics, Heat Transfer, and Fluid Flow, pg. 4-5
DAEC, System Description C-1, pg. 47
293006K111 293006K117 ...(KA'S)

ANSWERS -- DUANE ARNOLD -87/07/15-HARE, E. A.

ANSWER 6.01 (2.00)

1. Refueling platform positioned near or over the core.

2. Refueling platform hoists are fuel-loaded (fuel grapple, frame mounted hoist, monorail mounted hoist).

3. Fuel grapple not full up.

4. Service platform hoist fuel-loaded.

5. One rod withdrawn.

(4 of 5 required @ 0.5 pts each = 2.0)

REFER TO PAGE 25A .

REFERENCE
DAEC Technical Specifications 3.9.1, pg. 3.9-6
234000A302 234000K502 ...(KA'S)

ANSWER 6.02 (4.00)

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 to open 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
DAEC System Description pg. 6, 20-22, Figure 5, 6
259001K108 259001K109 259001K301 259001K302 ...(KA'S)

MODE switch in REFUEL and:

1. Trolley mounted hoist loaded with platform over or near core.
2. Frame mounted hoist loaded with platform over or near core.
3. Fuel grapple loaded with platform over or near core.
4. Fuel grapple not full up with platform over or near core.
5. Not all rods in and selection of a second.
6. Service platform hoist loaded

MODE switch in STARTUP and:

7. Refueling platform over or near core.
8. Service platform hoist loaded.

ANSWERS -- DUANE ARNOLD -87/07/15-HARE, E. A.

ANSWER 6.03 (2.00)

a. Operating an unloaded diesel increases the air blower temperatures to the maximum operating value due to decreased air flow, and may result in blower damage. (1.0)

or

Carbon-rich combustion products could collect in the E D/G exhaust ports and present a combustion hazard.

b. ~~A diesel generator lockout would occur.~~ (1.0)

REFERENCE
OI 324, pgs. 6 and 7
DAEC System Description G-2, pg. 33
264000A203 264000K401 ...(KA'S)

ANSWER 6.04 (2.50)

a. Because the regenerative HX has no flow through the secondary side, blowdown flow must be limited to the capacity of the NRHX in order to prevent overheating of the demineralizer bed. (1.0)

b. Blowdown is used during startup, heatup, or hot standby operations [0.25] to reduce reactor water inventory [0.25].

c. In order to prevent draining of the system, CV 2729 closes on low pressure sensed upstream (5 psig). This prevents draining the RWCU system to main condenser in the event CV 2729 is not fully closed. (0.5)

Also closes on 140 psig sensed downstream to protect the low pressure piping, prevents possible over pressurization. (0.5)

REFERENCE
DAEC System Description B-4, pgs. 3, 13, 19
204000K109 204000K402 204000K407 ...(KA'S)

ANSWERS -- DUANE ARNOLD -87/07/15-HARE, E. A.

ANSWER 6.05 (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 override the rate of reactivity insertion caused by cooldown of the reactor following the xenon poison peak [1.0]. ~~yet slow enough to ensure that there is sufficient mixing so boron does not recirculate through the core in uneven concentrations that could possibly cause nuclear power to rise and fall cyclically~~ [1.0].

REFERENCE
DAEC System Description C-4, pg. 9
211000A107 211000K405 ...(KA'S)

ANSWER 6.06 (2.00)

a. (2) (1.0)
b. (2) (1.0)

REFERENCE
DAEC System Description A-2, pg. 64
202002A106 202002A107 202002K603 ...(KA'S)

ANSWER 6.07 (1.50)

a. If the field breaker is not shut within 15 seconds after the pump sequence is started. (1.0)

b. The recirc MG drive motor breaker ~~does not close~~ will trip (0.5)

REFERENCE
DAEC System Description A-2, pg. 39, Table 1, Figure 16
202001K112 202001K407 202001K606 ...(KA'S)

ANSWERS -- DUANE ARNOLD -87/07/15-HARE, E. A.

ANSWER 6.08 (1.50)

a. DW pressure greater than 2 psig.

(2/3 core coverage X LOCA signal present) — reactor vessel level is above X-39 inches.

Containment Spray Valve switch in manual.

(0.33 pts each = 1.0) LPCI initiation signal is present

b. It allows opening of containment spray valves by bypassing the requirement for 2/3 core coverage x. (0.5)

(-39") a.c/CC LPCI initiation

REFERENCE
DAEC System Description C-1, pg. 37
226001K108 226001K113 ...(KA'S)

ANSWER 6.09 (1.00)

c.

REFERENCE
DAEC System Description D-11
245000A103 ...(KA'S)

ANSWER 6.10 (2.50)

a. half-scram

b. no action

c. half-scram

d. rod block

e. scram

(0.5 pts each)

REFERENCES
DAEC System Description I-7, pg. 4, 22, Figure 5
DAEC System Description I-3, 4, pg. 33
201001K107 212000K305 215005K101 239001K127 245000A201
...(KA'S)

ANSWERS -- DUANE ARNOLD -87/07/15-HARE, E. A.

ANSWER 6.11 (3.00)

a. The Turbine Steam Supply Valve (MO-2404) closed. (0.5)

b. When level decreases to the initiation level (119.5"), the 2404 valve will reopen. (1.0)

c. The turbine test circuitry would be automatically bypassed and the RCIC system would revert to flow control mode. (1.0)

d. No [0.25]. The mechanical overspeed must be reset locally [0.25].

REFERENCE
DAEC System Description B-2, pgs. 17, 24, 25, 36, 38
217000A101 217000A103 217000A301 217000A402 ...(KA'S)

ANSWER 6.12 (1.00)

The charger will trip [0.5] (on high emergency load starting currents) and power would then be lost to all associated loads [0.5] (both normal and emergency). Or the charger will carry its capacity load as long as emergency loads are not started (0.5)

REFERENCE
DAEC OI 388, pg. 5
263000K102 263000K201 263000K302 ...(KA'S)

ANSWERS -- DUANE ARNOLD -87/07/15-HARE, E. A.

ANSWER 7.01 (1.00)

1. Below this range, torus heat capacity is less of a concern since the shutdown cooling system may be used for heat removal. (0.5)

2. Steam flow rates during SRV discharge will be sufficiently low to preclude unstable condensation. (0.5)

REFERENCE
DAEC EOP-2
NEDO 30796, Bases for Emergency Operating Procedures at DAEC, page 7-2
295013K104 295026A203 295026K102 295030K103 ...(KA'S)

ANSWER 7.02 (3.50)

a. To avoid rapid injecti[illegible] cold unborated water during depressurization and t[illegible] the resulting reactivity excursion. (0.5) Boron injection and CRD flow are continued to achieve reactor shutdown. (0.5)

b. Kept above MAREP to provide sufficient steam flow through the open SRVs to ensure adequate STEAM COOLING to an uncovered core. (0.5) Kept as low as [illegible]ractical to ~~the~~ control flooding rate and thus possible power excursions. (0.5)

c. Would indicate that water is suddenly entering the RPV at a rate that is less than the rate of steam production and therefore, RPV water level is decreasing. (0.5)

d. Motor-driven pumps are necessary because the RPV will be depressurized prior to flooding. (0.5) Systems injecting outside the shroud are preferred to minimize cold water reactivity addition. (0.5)

REFERENCE
DAEC EOP-1, pages 51 thru 55.
NEDO 30796, Bases for Emergency Operating Procedures at DAEC, pages 8-145 thru 8-154
GE Emergency Operating Procedure Fundamentals, pages C6-1 thru C6-3
216000K324 295031G012 295031K304 295037G012 ...(KA'S)

ANSWERS -- DUANE ARNOLD -87/07/15-HARE, E. A.

ANSWER 7.03 (2.50)

a. Drywell inspections shall only be performed under the following conditions:

1. Shift Supervisors and Operators are notified of entry and exit times and appropriate log entries are made.

2. The reactor is subcritical and < 5% reactor power.

3. RPV pressure is below 400 psig.

4. No evolutions are performed by operators that would significantly increase system pressure.

(4 @ 0.5 pts each = 2.0)

b. Emergency entries beyond these restrictions must be approved by the Plant Superintendent. (0.5)

REFERENCE
DAEC IPOI-2, pg. 25
223000G001 223001A106 223001K116 ...(KA'S)

ANSWER 7.04 (1.50)

1. To conserve water inventory

2. To protect containment inventory

3. To limit radioactive release to be environment

(3 @ 0.5 pts each = 1.5)

REFERENCE
DAEC EOP-C, Operating Cautions, pg. 9, Caution 15
2900024204 2900026001 ...(KA'S)

ANSWERS -- DUANE ARNOLD -87/07/15-HARE, E. A.

ANSWER 7.05 (1.50)

a. False
b. True
~~c. False~~

(2 @ 0.5 pts each)

REFERENCE
DAEC EPIP 1.2
294001K116 ...(KA'S)

ANSWER 7.06 (1.50)

1. The event

2. The time declared

3. Action(s) taken

REFERENCE
DAEC EPIP 1.1
294001K106 ...(KA'S)

ANSWER 7.07 (1.50)

Yes. [0.5] The 250 volt DC battery is considered inoperable [0.5] (if more than one cell is out of service).

The HPCI System shall also be considered inoperable. [0.5]

REFERENCE
DAEC OI 38B, pg. 6, 14
Technical Specification 3.8.E.2.c.
263000A402 2630000005 263000K201 ...(KA'S)

ANSWERS -- DUANE ARNOLD -87/07/15-HARE, E. A.

ANSWER 7.08 (2.50)

a. 20%. (0.5)

b. The pump starting current will not overcome the thrust force on the pump bearing assembly resulting in a locked rotor. (1.0)
or the pump will not start.

c. The pump will trip off when the Mode Switch is shifted between positions. (1.0)

REFERENCE
GI 261 RWCU, pgs. 41 and 46
204000A401 204000K401 ...(KA'S)

ANSWER 7.09 (1.50)

Candidate #1 - Rejected, would exceed the 10 CFR 20 quarterly limit

Candidate #2 - Rejected, would exceed the administrative quarterly limit

Candidate #3 - Accepted, even though 5 (N-16) exceeded the limit only applies if going to 3000 mrem/qtr. Candidate will not exceed any administrative or 10 CFR 20 limits

REFERENCE
10 CFR 20, DAEC Health Physics Procedure 3102.1, pg. 2
294001K103 ...(KA'S)

ANSWER 7.10 (1.00)

To minimize wear on the CRD piston seals. (1.0)

REFERENCE
DAEC OI 056
201001K107 ...(KA'S)

ANSWERS -- DUANE ARNOLD -87/07/15-HARE, E. A.

ANSWER 7.11 (2.00)

a. To minimize thermal shock to the HX.

b. The ~~minimum flow bypass valve will open causing a loss of reactor coolant inventory to the suppression pool.~~ ensure adequate minimum flow for the pump operation is always met.

REFERENCE
DAEC OI No. 149
205000A110 205000K102 205000K502 217000G001 217000K105
...(KA'S)

ANSWER 7.12 (1.50)

By at least two independent indications [0.5] misoperation in automatic mode is confirmed [0.5], OR adequate core cooling is assured [0.5].

REFERENCE
DAEC OI Nos. 149, 150, 151, and 152
203000K401 206000K407 209001K408 ...(KA'S)

ANSWER 7.13 (2.50)

a. To prevent damage to the pumps hydrostatic thrust bearing. (1.0)

b. LPCI loop selection logic will mistakenly assume normal 2 pump operation exists even though 1 of the pump discharge valves is closed since it uses pump delta-p to sense that a pump is running. (1.5)

REFERENCE
DAEC OI 264
202001K224 202001K116 ...(KA'S)

ANSWERS -- DUANE ARNOLD -87/07/15-HARE, E. A.

ANSWER 7.14 (2.00)

a. Turn off circuit breakers (BUS A CKT 02 and BUS B CKT 02) to Power Range Neutron Monitoring System (0.5) in the 1A3 switchgear room (0.5)

b. Close air supply to Scram Valve Pilot Air Header located in Rx. Bldg. 757 level (Col. C6) (0.5) and Vent scram air header at PI-1841/PS-1842 (0.5)

REFERENCE
DAEC EOP-6 pg. 17
295016A301 295016G006 ...(KA'S)

ANSWERS -- DUANE ARNOLD -87/07/15-HARE, E. A.

ANSWER 8.01 (2.00)

1. c.
2. b.
3. d.
4. a.

(4 @ 0.5 pts each = 2.0)

REFERENCE
DAEC Fuel and Reactor Component Handling Procedure #5, pgs. 9 and 10
DAEC Enabling Objective, FRCHP #5-3
234000A102 234000A401 234000G014 ...(KA'S)

ANSWER 8.02 (1.50)

a. False.
b. False.
c. True.

(3 @ 0.5 pts each = 1.5)

REFERENCE
DAEC Administrative Procedure 1410.6, pgs. 3, 6, 7
294001K107 ...(KA'S)

ANSWER 8.03 (2.00)

Per Technical Specifications, if a deluge and sprinkler system is not operable, an hourly fire watch patrol with portable fire extinguishing equipment in all affected areas is required to be established within one hour [1.0] and with a hose station inoperable, a fire watch patrol with portable fire extinguishing equipment shall be established within one hour until an additional hose can be routed from an operable hose station to the unprotected area [1.0].

REFERENCE
DAEC Technical Specification 3.13 C and E and LER 86-015-00.
286000A105 286000G005 286000K401 ...(KA'S)

ANSWERS -- DUANE ARNOLD -87/07/15-HARE, E. A.

ANSWER 8.04 (2.00)

a. 1. Shut down the reactor

2. Close the MSIV's

(2 @ 0.5 each)

b. Boiling occurs at higher steaming rates causing deaeration of the reactor water, thus maintaining oxygen concentration at low levels and assuring that the chorlide-oxygen content is not such as would tend to induce stress corrosion cracking. (1.0)

REFERENCE
DAEC Technical Specifications 3.6.B.1, 3.6.B.2, 3.6.B Bases
294001A114 ...(KA'S)

ANSWER 8.05 (1.50)

The minimum diesel fuel supply of 35,000 gallons will supply one diesel generator [0.5] for a minimum of seven days of operation [0.5].

REFERENCE
DAEC Technical Specification 3.8.A.2 and Technical Specification BASES 3.8.1.
264000G005 264000G006 264000K105 ...(KA'S)

ANSWERS -- DUANE ARNOLD -87/07/15-HARE, E. A.

ANSWER 8.06 (2.50)

1. Technical Specification 3.3.A.2.c. states that control rods with inoperable accumulators shall be considered inoperable. ~~However, 10-07 and 10-27 do not effect plant operation.~~ (0.75)

2. Technical Specification 3.3.C.2 states average scram insertion times for the three fastest control rods in a 2 x 2 array shall be no greater than 0.370 secs. from rod position 46. The three fastest rods have an average time of 0.369 secs and therefore, do not affect plant operation. (0.75)

3. Technical Specification 3.3.A.2.a. states a rod which cannot be moved by control rod drive pressure is inoperable and since 26-07 is within the 5 x 5 array of 10-07, Technical Specification 3.3.A.2.f.1 states the reactor shall be brought to cold S/D within 24 hours. (1.0)

REFERENCE
DAEC Technical Specification 3.3
2010010005 ...(KA'S)

ANSWER 8.07 (1.50)

a. No. (0.5) The basic medical qualifications of 10 CFR 55 are no longer met. (0.5) (Will accept alternate wording such as "Unfit for Duty".

b. Yes. (0.5)

REFERENCE
10 CFR 55.11, 55.41
2940014103 ...(KA'S)

ANSWERS -- DUANE ARNOLD -87/07/15-HARE, E. A.

ANSWER 8.08 (2.00)

1. No more than 16 hours in a 24 hour period (Tuesday 17 hours).

2. No more than 24 hours in a 48 hour period (Monday - Tuesday).

3. At least 8 hours rest between work periods (Tuesday - Wednesday).

4. No more than 72 hours in any 7 day period (86 hrs. Sunday-Saturday).

5. No more than 16 hours straight (Tuesday).

(5 @ 0.4 pts each)

REFERENCE
DAEC Administrative Procedure 1410.1
2940010103 ...(KA'S)

ANSWER 8.09 (2.50)

a. A member of the Plant Management Staff and an Operations Shift Supervisor. (1.0)

b. 1. To provide guidance in unusual situations not within the scope of procedures.

2. To ensure orderly and uniform operations for short periods when to the plant, a system, or a component of a system is performing in a manner not covered by existing detailed procedures, or has been modified or extended in such a manner that portions of existing procedures do not apply.

3. To direct operations during testing and maintenance.

4. To correct procedural errors discovered during performance of the procedure.

(Any 3 of the 4 required at 0.5 pts each)

REFERENCE
DAEC Administrative Procedure 1406.3, pg. 2, 5, and 6
2940010101 ...(KA'S)

ANSWERS -- DUANE ARNOLD -87/07/15-HARE, E. A.

ANSWER 8.10 (4.00)

a. Mechanical and electrical systems which have direct design features involving accident prevention and/or mitigation. (1.0)

b. Stop affected work if a personnel or safety hazard exists [0.5]. Make a duplicate Hold Card and mark it as a duplicate [0.5]. Note "duplicate" issued next to the pertinent entry on the Maintenance Tagging Form [0.5]. (Work may be resumed when proper isolation has been verified.) (1.5)

c. The OSS [0.5], if deemed necessary for safe operation or shutdown of the plant [0.5] but only after investigating and assuring him/herself that there is no danger to personnel and that other personnel involved have been informed [0.5]. (1.5)

REFERENCE
DAEC Administrative Control Procedure 1410.5
294001K102 ...(KA'S)

ANSWER 8.11 (1.50)

Operability:

a. Either recirculation loop flow differs (by > 15%) from given speed/flow characteristic.

b. Indicated total core flow differs (by > 10%) from the value measured from loop flow measurements.

c. Diffuser-to-lower plenum delta P of any individual jet pump differs from norm (by > 10%).

(Any 2 of the above @ 0.5 pts each)

Bases:

Increases cross sectional flow area for blowdown during LOCA. (0.5)

REFERENCE
DAEC Technical Specifications, Sections 3.6.E.1, 4.6.E.1, 3.6.E.8, and 4.6.E
202001A201 202001K101 202001K106 202001K113 202001K601
...(KA'S)

ANSWERS -- DUANE ARNOLD -87/07/15-HARE, E. A.

ANSWER 8.12 (2.00)

a. July 27, 1987 (1.0)

b. Failure to meet the time interval for a surveillance constitutes a failure to meet the operability requirement of the LCO. (1.0)

REFERENCE
DAEC Technical Specification 1.0, Definition 26
Z06000C005 ...(KA'S)

QUESTION	VALUE	REFERENCE
05.01	1.00	EAH0001221
05.02	2.00	EAH0001222
05.03	1.00	EAH0001223
05.04	1.00	EAH0001224
05.05	1.00	EAH0001225
05.06	1.50	EAH0001226
05.07	2.50	EAH0001227
05.08	2.00	EAH0001228
05.09	1.50	EAH0001229
05.10	1.50	EAH0001230
05.11	1.50	EAH0001231
05.12	2.50	EAH0001232
05.13	1.00	EAH0001233
05.14	1.50	EAH0001234
05.15	3.00	EAH0001235
	24.50	
06.01	2.00	EAH0001236
06.02	4.00	EAH0001237
06.03	2.00	EAH0001238
06.04	2.50	EAH0001239
06.05	2.00	EAH0001240
06.06	2.00	EAH0001241
06.07	1.50	EAH0001242
06.08	1.50	EAH0001243
06.09	1.00	EAH0001244
06.10	2.50	EAH0001245
06.11	3.00	EAH0001246
06.12	1.00	EAH0001247
	25.00	
07.01	1.00	EAH0001248
07.02	3.50	EAH0001249
07.03	2.50	EAH0001250
07.04	1.50	EAH0001251
07.05	1.50	EAH0001252
07.06	1.50	EAH0001253
07.07	1.50	EAH0001254
07.08	2.50	EAH0001255
07.09	1.50	EAH0001256
07.10	1.00	EAH0001257
07.11	2.00	EAH0001258
07.12	1.50	EAH0001259
07.13	2.50	EAH0001260
07.14	2.00	EAH0001261
	26.00	
08.01	2.00	EAH0001262

QUESTION	VALUE	REFERENCE
08.02	1.50	EAH0001263
08.03	2.00	EAH0001264
08.04	2.00	EAH0001265
08.05	1.50	EAH0001266
08.06	2.50	EAH0001267
08.07	1.50	EAH0001268
08.08	2.00	EAH0001269
08.09	2.50	EAH0001270
08.10	4.00	EAH0001271
08.11	1.50	EAH0001272
08.12	2.00	EAH0001273
	25.00	
	100.50	