U.S. NUCLFAR REGULATORY COMMISSION

REGION III

Report No. 50-315/OL-86-01

Docket Nos. 50-315; 50-316 License No. DPR-58

Licensee: Indiana and Michigan Electric Company
P.O. Box 458
Bridgeman, MI 49106

Facility Name: Donald C. Cook Nuclear Plants 1 and 2

Examination Administered At: Donald C. Cook Nuclear Plants 1 and 2

Examination Conducted: March 11, 1986

TM Burdick for

Examiner: Leo J. Defferding

TM Burdick

Approved By: T. M. Burdick, Chief
Operating Licensing Section

4-15-86
Date

Examination Summary

Examination administered on March 11, 1986 (Report No. 50-315/OL-86-01)
A written examination was administered to two SRO candidates. They had previously passed the plant walkthrough examination.
Results: Both candidates passed the written examination.

REPORT DETAILS

1. Examiners

L. J. Defferding

2. Examination Review Meeting

No longer conducted. The specific facility comment, followed by the NRC response, appears below:

QUESTION 5.02 a: a. To what level would the tank drop to as the pump continues to remove water from the tank?

FACILITY COMMENT: The keyed answer indicated full credit for 3.4 feet (four feet water - 0.256 psia) and 80% credit for four feet.

The equation used for NPSH found on Page 24 of the Thermodynamics Study Guide is:

$$NPSH = P_{TANK} + Z - h_L - P_{SAT}$$

if h_L is neglected (small) then

$$NPSH = P_{TANK} + Z - P_{SAT}$$

Since the pressure in the tank will be saturation pressure for 60°F (.256 psia)

$$NPSH = Z \text{ (height of water)}$$

Therefore, if it is assumed that the tank level stops decreasing when minimum NPSH is reached, the full credit value should be four feet. The tank level would continue to decrease, however, because the pump will still move water after it begins to cavitate. Eventually, the tank could empty. Since the time from minimum NPSH to pump failure (and how much water will be removed from the tank) is not known, the final level in the tank cannot be realistically determined.

We request that full credit be granted for four feet or an indication that the tank would empty and partial credit be assigned for identifying the elements (equation) for NPSH.

NRC RESPONSE: Accepted answer changed to read "four feet" (+0.5).

QUESTION 5.04 c.: During a loss of offsite power cooldown, the Natural Circulation Procedure instructs the operator to lower RCS pressure from 2235 psig to 200 psig in a time period in excess of 17 hours.

c. According to the procedure, RCS and S/G pressures are initially held at 2235 and 635 psig, respectively. Assuming natural circulation has been established, what is the approximate amount of RCS subcooling?

ANSWER 5.04 c.: c. 110-130°F (+1.0)
(will except 131-160°F for +0.5).

FACILITY COMMENT: The answer to this question makes a specific assumption that is critical to its correct calculation. The assumption is that a very large ΔT (approximately 38°F) exists between the hot and cold legs. To obtain a ΔT of this magnitude, two conditions must exist: Nearly a maximum power history and a very short time period (minutes) following the reactor trip. If these two assumptions are not made, the magnitude of the subcooling will be much greater than that allowed for full credit by the answer key. Since the question does not state the amount of time elapsed, the amount of decay heat present, or suggest that the candidate assume a ΔT for the calculation, we request that a calculation similar to below also be allowed for a full credit answer.

2235# (2250 psia) = 653°F
635# (650 psia) = 495°F

$$\begin{array}{r} 653^\circ \\ -\ 495^\circ \\ \hline 158^\circ F \end{array}$$

(Assume $T_{avg} = T_{stm}$)

This calculation assumes a low power history and three hours elapsed time following the trip to obtain a negligible ΔT. (See attached procedure OHP-4023.001.008, Step 5.3.2)

NRC RESPONSE: Accepted. Answer changed to read "110-160°F (+1.0) (exact amount depends on power history which was not given)."

QUESTION 5.12: State why each of the Rod Control System limits are provided.

a. Withdrawal limit

b. Maneuvering band upper limit

c. Maneuvering band lower limit

d. Insertion limit

ANSWER 5.12:

a. To help avoid dumping steam if a decrease in power is initiated. (+0.75) (will accept "to provide sufficient bite" for (+0.5)).

b. To allow an "immediate" return to full power operation (without boron dilution). (+0.75)

c. To maintain even axial flux depletion. (+0.75)

d. To maintain adequate shutdown margin. (0.75)

FACILITY COMMENT. a.: Since there are many factors that determine whether steam will be dumped on a power decrease, it is more appropriate to state the primary reason for the withdrawal limit as being control rod bite. We request that full credit be granted for "to provide sufficient bite."

b. and c.: The term "Maneuvering Band" is not used at D. C. Cook. We request that these parts be deleted from the exam for the following reasons:

1. A maximum power escalation rate of six percent per hour precludes an immediate return to full power. See Technical Data Book Figure 11.9.

2. Rod position is dictated by maintaining Axial Flux Difference in the Target Band specified on Figure 13.1 of the Technical Data Book.

d.: The Technical Specification Basis for the insertion limit (TS 3.1.3.5) identifies three reasons for each Unit. Unit One specifies:

1. Maintaining acceptable power distribution.

2. Maintaining minimum shutdown margin.

3. Minimize the effects of an ejected rod.

We request that any of these reasons also be accepted without point loss.

NRC RESPONSE: (a) Accepted. Full credit (+0.75) given for "to provide sufficient bite."; (b) and (c) Comments noted and taken into consideration in grading; (d) Accepted. Full credit given for (1) maintaining acceptable power distribution, (2) maintaining minimum shutdown margin, or (3) minimize the effects of an ejected rod.

QUESTION 5.13 b.: Burnable poison rods are used in the first fuel cycle.

b. Why aren't they needed in subsequent fuel cycles?

ANSWER 5.13 b.: b. The partially depleted fuel and the building of fission product poisons in the subsequent fuel cycles limit excess reactivity to a value controllable by soluble boron alone. (+0.75)

FACILITY COMMENT: At D. C. Cook, burnable poison rods are used in subsequent fuel cycles for the same reason as in the first fuel cycle. See Reactor Core Lesson Plan, LP-RTOP-NS1. Since the candidate may attempt to answer the question as stated, we request the keyed answer or an explanation as to why we still use burnable poisons be accepted for full credit.

NRC RESPONSE: Accepted. Full credit (+0.75) given if candidate explains why burnable poison rods are used in subsequent fuel cycles.

QUESTION 6.01: a. What automatic actions take place in the Component Cooling Water (CCW) system upon a Safety Injection signal? Assume standby pump is locked out.

b. What automatic actions take place in the Component Cooling Water (CCW) system upon a Containment Spray signal?

ANSWER 6.01: a. Hx outlet open (+0.5).

RHR Hx outlet goes to INTERMEDIATE position giving approximately 3000 gpm flow (+0.5).

Isolation occurs on BA evaporator, spent fuel pit cooling, letdown Hx excess letdown Hx and Rx support coolers (+0.1 each).

b. CCW to and from the RCPs, thermal barrier heat exchangers upper and lower bearing oil coolers, is isolated. CCW to and from the CEQ fan motors is unisolated. (+1.5)

FACILITY COMMENT: a. We request that isolation of CCW to either the BA evaporator or the South Rad. Waste evaporator (SRWE) should be accepted as correct.

The evaporators are unit specific. The BA evaporator is supplied with CCW from Unit 1's system; the SRWE is supplied with CCW from Unit 2's system. Listing either evaporator indicates knowledge of this automatic action.

b. The isolation of CCW from the RCP thermal barriers and motor bearing oil coolers is summarized by the statement "CCW to RCP's isolates." Reference lesson plan RO-C-AS01 D.1.b. (Page 11 of 13).

The question does not specifically elicit a response which lists discrete reactor coolant pump support systems supplied with CCW cooling. As both RCP support systems supplied with CCW cooling isolate on a Phase B isolation/containment spray signal, the above referenced summarized response should be accepted as a complete answer.

NRC RESPONSE: (a) Accepted. Credit (+0.1 each) given for isolation of CCW to either the BA evaporator or the South Rad. Waste evaporator (SRWE); (b) Accepted. Full credit given for "CCW to RCP's isolates."

QUESTION 6.02: List the associated components/pumps from the Emergency Core Cooling System needed for the Injection Phase and the RCS pressure at which they will begin to inject.

ANSWER 6.02:

Pump	Shutoff Head
Centrifugal Charging Pumps	2540 psig (+0.5)
Safety Injection Pumps	1560 psig (+0.5)
Accumulators	620 psig (+0.5)
Residual Heat Removal	200 psig (+0.5)

FACILITY COMMENT: The shutoff head pressures listed are design numbers; pump operating characteristics and actual values will depend on specific operating conditions. We request that the answers within the following ranges of pressures be accepted for full credit.

Centrifugal Charging Pumps	2500-2550 psig
Safety Injection Pumps	1550-1600 psig
Residual Heat Removal	200-220 psig

Accumulator nitrogen cover pressure is dictated by LCO 3.5.1. We request that answers within the following pressure ranges be accepted for full credit.

Unit 1 Accumulators	585-658 psig
Unit 2 Accumulators	599-622 psig

NRC RESPONSE: Accepted. Answer changed to read:

Pump	Shutoff Head
Centrifugal Charging Pumps	2500-2550 psig (+0.5)
Safety Injection Pumps	1550-1600 psig (+0.5)
Accumulators or	580-660 psig (+0.5)
Units 1 Accumulators	585-658 psig (+0.25)
Units 2 Accumulators	599-622 psig (+0.25)
Residual Heat Removal	200-220 psig (+0.5)

(+2.0 maximum)

QUESTION 6.05: List the components of the ECCS which receive an actuating signal on a safety injection and what action that component must take.

ANSWER 6.05: Centrifugal Charging Pumps - Start

CCP Suction from RWST (IMO-910/911) - Open

BIT Inlet and Outlet Valves - Open

SI Pumps - Start

RHR Pumps - Start

CCP Mini Flow Valves - Open

Accumulator Isolation Valves - Open

BIT Recirculation Valves - Close

(+0.15 for each component, +0.1 for each action)

FACILITY COMMENT: The accumulator isolation valves are maintained open with their breakers racked out when pressurizer pressure is greater than 2000 psig (TS 3.5.1). With no valve control power available, the safety injection valve opening signal performs no action. We request that the Accumulator Isolation Valve action not be required for full credit.

NRC RESPONSE: Accepted. "Accumulator Isolation Valves-Open" deleted from answer. Point value changed (+0.2 for each component, +0.1 for each action) +2 0 maximum

QUESTION 6.06: List the four (4) ice condenser monitoring systems that are available to control room operators.

ANSWER 6.06:

1. Ice bed temperature (+0.5)

2. Ice condenser door position (+0.5)

3. Ice condenser floor cooling temperature (+0.5)

4. Equipment and personnel doors (+0.5)

FACILITY COMMENT: This question is based on a poorly worded objective (No. 8) of the lesson plan RO-C-NS14. The only "system" located in the control room is the Ice Bed Temperature Recorder. The only indication in the control room for the other "systems" are annunciators which indicate that an abnormal condition exists (see Paragraph VI.E. on Page 19 of RO-C-NS14). The lesson plan clearly states in Section VI.B.2., VI.C.2, and VI.D.2. that these "systems" are operated from the Containment Auxiliary Subpanel (CAS). The lesson does not indicate that this panel is not in the control room because its location in the Auxiliary Building is common knowledge for Operations personnel.

When the question was clarified to the candidates, they were told to consider "indications even if they were on other panels." This would lead the candidates to identify indications (status lights, valve positions, alarms, etc.) located in the control room, on the CAS Panel or Refrigeration Panel (also in the Auxiliary Building).

Because of the confusion associated with this question, we request that it either be deleted or credit be awarded for indications associated with the "monitoring systems." These indications would include:

- Ice Bed Temperature Recorders (SG-7, SG-17)
- Control Room Annunciators (See lesson plan Paragraph VI.E.)
- Indications located on the CAS Panel (See attached Drawing 1-5585-16)

- Indications located on the Refrigeration Panel (See attached Drawings 12-5584 and 12-98297-0)

NRC RESPONSE: Accepted. Other appropriate recorders, annunciators, and indicators accepted for credit.

QUESTION 6.07: The reactor trip breaker shunt coils will:

(a.) energize on a manual trip signal.

(b.) energize on an automatic trip signal.

(c.) deenergize on a manual trip signal.

(d.) deenergize on an automatic trip signal.

ANSWER 6.07: (a.) (+1.0)

FACILITY COMMENT: RFC 12-2663 (completion notice attached) modified the Reactor Trip Breakers to activate both the shunt and undervoltage devices to trip the breaker on an automatic trip signal. Unit 1 was completed October 30, 1985, and Unit 2 completed November 7, 1985. We request that the answer key be amended to allow full credit for "a and b."

NRC RESPONSE: Accepted with slight modification. Credit given for (a.) and (b.).

QUESTION 6.09: This question asks the candidate to list the setpoints for VCT level control.

FACILITY COMMENT: The keyed answer for Part b "Stops auto makeup" is incorrect. The correct answer is 24% (see CVCS lesson plan RO-C-NS06, Page 5).

NRC RESPONSE: Accepted. Answer changed from 27 to 24.

QUESTION 6.13 c.: Fill-in the blanks to make the following statements about reactor coolant pump operation correct.

c. A pressure differential of at least ____ psid should be maintained across the No. 1 seal.

ANSWER 6.13 c.: c. 275 (+0.25)

FACILITY COMMENT: Unit 1 RCP seal parameters changed prior to Cycle 9 restart. Reference 1-OHP-4021.002.003, Precaution 4.5. (See attached Page 3 of 1-OHP-4021.002.003 with Procedure Change Sheet 2 incorporated.)

Unit 2 minimum RCP No. 1 seal differential pressure remains at 275 psid. Reference 2-OHP-4021.002.003, Precaution 4.5.

We request that either 200 psid or 275 psid be accepted for full credit.

NRC RESPONSE: Accepted. Credit given for 200 or 275.

QUESTION 6.14: What activities does the failed fuel detector system monitor when in service? (Note any differences between units.)

ANSWER 6.14: Gross Gamma, I-135, Cs-137 Unit 1 (+0.5)

Gross Gamma, I-131 Unit 2 (+0.5)

FACILITY COMMENT: The keyed answer is not solicited by the question. The question requests "activities" while the key required specific isotopes. We request that full credit be awarded for Gross Gamma or fission product activity (see Page 2 of Primary Sample System lesson plan, RO-C-NS17).

NRC RESPONSE: Accepted. Full credit given for Gross Gamma (+0.5) or fission product activity (+0.5).

QUESTION 7.02: Assume during reactor coolant or shutdown the RHR capability is lost. List three (3) alternate cooling methods. (State any assumptions.)

ANSWER 7.02: Head on

1. Condenser steam dump. (+0.5)

2. Atmospheric steam dump. (+0.5)

Head off

3. Spent fuel pit cooling. (+0.5)

FACILITY COMMENT: There are additional answers on the page referenced in the answer key that are not included in the exam answer key. (OHP-4023.017.001, Page 3). We request that any of these be considered as correct answers in addition to those listed on the key.

Step 5.7.4: "Additional cooling can be achieved by establishing maximum charging and letdown of the reactor coolant system." (Utilizes NRHX as heat sink.)

Step 5.8.1: "If not already done, flood the refueling cavity to the normal refueling level." (Provides a large volume of RWST water to the cavity as an immediate heat sink.)

Step 5.8.5: "Establish maximum refueling cavity filtering and purification." (This system does not provide cooling, but is included in the procedure because it does provide forced circulation of the refueling cavity water.)

Step 5.8.4: "Operate sufficient containment ventilation units to maintain containment air temperature at or below about 80°F." (Increases driving force for heat dissipation to ambient.)

We would also request that the apparent assumptions (Head on and Head off) not be required for full credit. The question did not specifically state Head on/Head off configuration. Also, the configuration would be implicit to the cooling method listed by the examinee. For example, an operator would probably not think it necessary to state that the Rx vessel head would be on while dumping steam from the S/G's.

NRC RESPONSE: Accepted. "Head on" and "Head off" deleted from answer. Credit given for following additional answers:

4. Establish maximum letdown and charging (+0.5)

5. Flood the refueling cavity (+0.5)

6. Establish maximum refueling cavity filtering and purification (+0.5)

7. Operate containment ventilation units (+0.5)

(+1.5 maximum)

QUESTION 7.05: Answer the following questions about the emergency diesel engines.

a. What condition will cause the incomplete start sequence to occur?

b. How can the operator in the control room tell this has occurred?

c. List the two (2) conditions either of which will permit a restart.

ANSWER 7.05:

a. During a EDG start < 95% rated speed > 10 second. (+0.5)

b. A red failure light is energized in the control room. (+0.5)

c. Two minutes elapse or push the EDG reset button. (+0.5)

FACILITY COMMENT: Though the lesson plan may be interpreted to imply that the "two minute closure of SV5" must be completed prior to restart of a diesel generator after an incomplete start sequence, this action is not required to be completed before restart. If an automatic start signal is present, the diesel has the ability to start as soon as the reset pushbutton is depressed. (A simplified control circuit diagram is included.) When the reset pushbutton is depressed, SV5 will receive an open signal. The diesel will not restart unless the reset pushbutton is depressed.

We would request that the answer "two minutes elapse" be deleted from the answer key and that any additional "reasonable" answers not be marked incorrect as the question did ask for two answers.

NRC RESPONSE: Accepted. Full credit given for SI and blackout start and "two minutes elapse or" was deleted from the answer key.

QUESTION 7.10: If system frequency drops to 58.8 Hz due to loss of generating capacity, what five (5) actions are required after 30 minutes if the system frequency does not recover?

ANSWER 7.10:

1. Open breakers K and K-1. (+0.5)

2. Verify steam dump controls have functioned to limit T-avg and Pressurizer pressure transients. If not, trip the reactor. (+0.5)

3. Monitor reactor power to ensure the rods are moving inward to reduce power level. If not, take manual control and reduce reactor power. (Automatic Rod Withdrawal is blocked below 15% C-5). (+0.5)

4. Adjust turbine speed to maintain frequency at 60 Hz. (+0.5)

5. Monitor T-avg to ensure the Steam Dump System is performing properly; take manual control if required. (+0.5)

FACILITY COMMENT: In order to correctly answer the question, all the right assumptions must be made. If answers 1 and 2 are stated and a Rx trip is assumed, answers 3 and 4 would be quite impossible to carry out. We would request

that latitude in grading of this question be considered based on a possible lack of answers 3, 4 and/or 5 based on those given as 1 and 2.

NRC RESPONSE: Accepted. Comments noted and taken into consideration during grading.

QUESTION 8.01 c.: Answer the following TRUE or FALSE.

c. Areas outlined in magenta on the Radiation Information Board are EHR areas.

ANSWER 8.01 c.: c. FALSE (+0.5) (outlined and crosshatched in red)

FACILITY COMMENT: This true or false question is technically correct. We would, however, like to point out that all individuals entering the controlled area are required to check out the Radiation Information Board (RIB) prior to entry. The RIB contains a color code/grahic legend to enable all individuals to ascertain conditions of a given area. Additionally, EHR areas are specifically stated in PMP-6010.RAD.001 and are under RP key and lock control. Individuals entering these areas require RP coverage. It is not realistic for an individual to remember the color coding, which is not procedurally addressed except for EHR, where six (6) colors plus "crosshatching" are used.

NRC RESPONSE: Comments noted. No change.

QUESTION 8.10: If one (1) emergency diesel generator is taken out of service for maintenance and the reactor is in Mode 1, what action must be taken?

ANSWER 8.10: Demonstrate operability of remaining AC source (+0.5) (by performing Surveillance Requirements 4.8.1.1.1.a and 4.8.1.1.2.a.4) within one hour (+0.5) (and at least once every eight hours thereafter).

FACILITY COMMENT: We request that the following be accepted as an additional correct answer.

"Restore to operable within one hour or conduct the Emergency Diesel Generator Operability Test (STP.027)".

STP.027 is performed to show compliance with TS 3.8.1.1 including breaker alignment (STP. 031). STP.027 has been included for your information.

NRC RESPONSE: Accepted. Credit given for "restore to operable within one hour or conduct the Emergency Diesel Generator Operability Test" (STP.027).

QUESTION 8.12
c. and d.: For each of the following ECC Systems, specify whether the Technical Specification LCO is the SAME or DIFFERENT for Units 1 and 2 for Mode 1 operation.

c. RWST boron concentration, Technical Specification 3.5.5.

d. RWST minimum water temperature, Technical Specification 3.5.5.

ANSWER 8.12
c. and d.: c. DIFFERENT (U_1: $\leq$ 1950 ppm; U_2: 2000-2200 ppm) (+0.5)

d. DIFFERENT (U_1: 70°F; U_2 80°F) (+0.5)

FACILITY COMMENT: c. The answer key is correct except for the Unit 1 value for RWST boron concentration. The value should be $\geq$ 1950 ppm.

d. The answer key is technically correct in accordance with technical specifications. Attached is a copy of PMSO.074. We feel that this question can be answered as either SAME or DIFFERENT. Our plant procedure requires us to treat RWST minimum temperature as 80°F and should a violation occur, the Action Statement must be followed.

NRC RESPONSE: c. Accepted. Answer changed to read DIFFERENT (U_1: $\geq$ 1950 ppm; U_2: 2000-2200 ppm).

d. Disagree. Administrative limits are the same but technical specification limits are different. SROs should know technical specifications.

QUESTION 8.13 d.: State whether each of the following, as specified in 10 CFR 72, requires NRC notification within one HOUR or four HOURS.

d. Transfer of a contaminated individual to a local hospital.

ANSWER 8.13 d.: d. four hours (+0.5)

FACILITY COMMENT: d. The keyed answer is technically correct in accordance with 10 CFR 72 classifications. However, PMP-2080.EPP.001 ECC-20 also classifies transfer of a contaminated individual to an offsite facility as on Unusual Event. Unusual Events must be reported within one hour. We request that either one hour or four hours report be accepted as correct.

NRC RESPONSE: Because the answer one hour or four hours is potentially correct, Question 8.13(d) was deleted from the exam.

QUESTION 8.14 b.: A plant emergency occurs which requires activation of the D. C. Cook Emergency Plan.

b. At what minimum emergency condition classification is activation of each of the following required?

a. Technical Support Center.

b. Operations Staging Area.

c. Emergency Operations Facility.

ANSWER 8.14.b.:

a. Alert (+0.5)

b. Alert (+0.5)

c. Site Area Emergency (+0.5)

FACILITY COMMENT: This keyed answer is technically correct by the current procedures. At this time, all Emergency Plan procedures are undergoing a complete revision. Annual Emergency Plan training, conducted during November and December of 1985, revealed several changes that were going to be implemented prior to June 10, 1986, NRC EVALUATED EXERCISE. One of these changes is the activation of the Emergency Operations Facility (EOF) (Part c) at the Alert level. We request that Alert and Site Area Emergency be accepted for full credit based on the fact the activation of EOF is an administrative decision of plant management and does not violate current procedures.

NRC RESPONSE: Accepted. Full credit given for "Alert" or "Site Area Emergency." (+0.5)

3. Exit Meeting

Not conducted because no plant walkthrough examinations were administered.

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

Facility: Cook 1 and 2

Reactor Type: Westinghouse - PWR

Date Administered: March 11, 1986

Examiner: L. J. Defferding

Candidate: ANSWER KEY

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 Cat. Value	Category
25	25.13			5. Theory of Nuclear Power Plant Operation, Fluids and Thermodynamics
25	25.13			6. Plant System Design, Control and Instrumentation
25	25.13			7. Procedures - Normal, Abnormal, Emergency, and Radiological Control
~~25~~ 24.5	~~25~~ 24.61			8. Administrative Procedures, Conditions, and Limitations
~~100~~ 99.5				TOTALS

Final Grade _____ %

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

_____
Candidate's Signature

Points
Available

5.0 THEORY OF NUCLEAR POWER PLANT OPERATION, FLUIDS AND THERMODYNAMICS (25.0)

QUESTION 5.01

The plant is operating at 30% power, rod control in manual, turbine control in automatic, when loop 1 RCP trips. Assuming no reactor trip or operator actions, indicate whether the following parameters will be HIGHER or LOWER at the end of the transient as compared to their initial values.

a. T_h in loop 2 (0.5)

b. T_c in loop 1 (0.5)

c. #3 RCS loop flow (0.5)

d. #2 S/G pressure (0.5)

ANSWER 5.01

a. HIGHER **[+0.5]** (higher delta T for each operating loop)

b. LOWER **[+0.5]** (reverse flow from other cold legs with lower T-cold)

c. HIGHER **[+0.5]** (lower pressure drop across core)

d. LOWER **[+0.5]** (higher heat transfer for each operating loop)

Reference(s) 5.01

1. DCC Thermodynamics Study Guide (Integrated Knowledge).

-Section 5.0 Continued on Next Page-

Points
Available

QUESTION 5.02

A large vented water tank 60-ft high has a small capacity centrifugal pump taking a suction from its base. The pump is located at a vertical elevation corresponding to 1 ft below the bottom of the tank and it requires 5 ft of net positive suction head (NPSH) to prevent cavitation. The tank is initially entirely full of water and is maintained at 60°F by heaters. Assume that the vent becomes totally clogged (fully closed) while the pump is in operation. Answer the following questions.

a. To what level would the tank drop to as the pump continues to remove water from the tank? (0.5)

b. What two (2) types of equipment failures could result from continued pump operation with a clogged vent? (1.0)

c. To what level could the pump continue to pump water to if the vent was then opened? (0.5)

ANSWER 5.02

a. ~~3.4~~ 4 feet ~~(4 ft water - 0.256 psia)~~ [+0.5] ~~(will accept 4 ft for [+0.4]).~~

b. (1) Pump damage due to cavitation [+0.5].

(2) Tank implosion due to low internal pressure [+0.5].

c. 0 ft (all the water) [+0.5]. (The added pressure of 14.7 psia (34 ft of water) would allow all of the water to be removed.)

Reference(s) 5.02

1. DCC Thermodynamics Study Guide, Pump Theory, Section 4.4, pp. 24-25.

-Section 5.0 Continued on Next Page-

Points
Available

QUESTION 5.03

Letdown water (75 gpm) at 538°F enters the regenerative heat exchanger and exits at 290°F. Assuming normal, steady-state, at power operation (total charging flow of 87 gpm at 115°F), what is the temperature of the charging water entering the RCS from the regenerative heat exchanger? Show all work and state all assumptions. (1.5)

ANSWER 5.03

$\dot{Q}_{letdown} = \dot{Q}_{charging}$ [+0.5]

$\dot{m} \Delta T = m_c \Delta T_c$

$\Delta T_c = \Delta T (\dot{m}/\dot{m}_c)$

$\dot{m} = 75$ gpm

$\dot{m}_c = 55$ gpm (charging less 32 gpm for RCP seals) [+0.5]

$\Delta T_c = 248°F$ (75/55)

$= 338°F$

Outlet temperature is therefore 115 + 338 = 453°F [+0.5]

Reference(s) 5.03

1. DCC Thermodynamics Study Guide, Heat Exchangers, Section 6.1, pp. 40-41.

-Section 5.0 Continued on Next Page-

Points
Available

QUESTION 5.04

During a loss of off-site power cooldown, the Natural Circulation Procedure instructs the operator to lower RCS pressure from 2235 psig to 200 psig in a time period in excess of 17 hours.

a. Why is the depressurization accomplished in such a gradual manner? (0.75)

b. What would indicate an insufficient depressurization period? (0.75)

c. According to the procedure, RCS and S/G pressures are initially held at 2235 and 635 psig, respectively. Assuring natural circulation has established, what is the approximat amount of RCS subcooling? (1.0)

ANSWER 5.04

a. To allow adequate cooling of the upper head region. [+0.75]

b. A rapid increase in Pressurizer level. [+0.75]

c. 110-~~130~~ 160°F [+1.0] ~~(will except 131-160°F for [+0.5]).~~ (exact answer depends on power history which was not given)

Reference(s) 5.04

1. DCC 2-OHP 4023.001.008, Natural Circulation, pp. 1-5.

2. DCC Thermodynamics Study Guide, Core Damage Mitigation, Section 8.3, p. 49.

-Section 5.0 Continued on Next Page-

Points
Available

QUESTION 5.05

The plant is operating at 100% power when a 10% turbine load runback occurs. All control systems are in auto.

A. Initial rod movement is caused by a change in: (1.0)

(a.) NI power

(b.) T-avg

(c.) Feedwater flow

(d.) Turbine first stage pressure

B. The transient response of T-avg is best described as an initial _____ followed by an equilibrium temperature _____ the initial temperature. (1.0)

(a.) Increase; slightly less than

(b.) Increase; the same as

(c.) Decrease; the same as

(d.) Decrease; slightly less than

C. The transient response of steam generator level is best described as an initial _____ followed by an equilibrium level _____ the initial level. (1.0)

(a.) Increase; slightly less than

(b.) Increase; the same as

(c.) Decrease; the same as

(d.) Decrease; slightly less than

-Section 5.0 Continued on Next Page-

Points
Available

ANSWER 5.05

A. (d.) [+1.0]

B. (a.) [+1.0]

C. (c.) [+1.0]

Reference(s) 5.05

1. DCC Rod Control Lesson Plan, RO-C-NS04, Figure NS-4-1.

2. DCC Thermodynamics Study Guide, "Steam Generator", Section 7, pp. 42-44.

-Section 5.0 Continued on Next Page-

Points
Available

QUESTION 5.06

Due to a loss of one (1) feedwater pump, power is limited to about 60%. In order to extract the maximum megawatts from the turbine generator, steam to the high-pressure heaters is secured. Assume rod control is in manual. State whether the resultant steady-state value of each of the following parameters has INCREASED or DECREASED.

a. T-avg (0.5)

b. ΔT (0.5)

c. Plant efficiency (0.5)

ANSWER 5.06

a. DECREASED [+0.5]

b. INCREASED [+0.5]

c. DECREASED [+0.5]

Reference(s) 5.06

1. DCC Thermodynamics Study Guide, Rankine and Regenerative Circles, Section 2.6, pp. 10-12.

-Section 5.0 Continued on Next Page-

Points
Available

QUESTION 5.07

Explain why departure from nucleate boiling is allowed in a S/G but not in the core. (1.0)

ANSWER 5.07

In the S/G, the heat transfer surface temperature cannot exceed the hottest RCS coolant temperature; while in the reactor, the cladding temperature can increase until the fuel rods destroy themselves due to the accumulation of decay heat. [+1.0]

Reference(s) 5.07

1. DCC Thermodynamics Study Guide, Core Cooling Mechanics, Sections 5.9-5.12, pp. 33-37.

-Section 5.0 Continued on Next Page-

Points
Available

QUESTION 5.08

The reactor is initially on a 1 DPM power increasing ramp below the POAH. Boron concentration, temperature, and Xe concentration are constant. Rods are then inserted until power stops increasing and starts to decrease. Describe how reactor SUR changes as rods are inserted. (1.0)

ANSWER 5.08

SUR decreases immediately (step change) upon rod insertion due to the change in the reactivity insertion rate [+0.5]. SUR becomes smaller until it is zero [+0.25], then it becomes negative [+0.25].

Reference(s) 5.08

1. DCC Reactor Theory, Neutron Kinetics (I-3), pp. 15-19.

-Section 5.0 Continued on Next Page-

Points
Available

QUESTION 5.09

The Unit 1 reactor is at the following condition:

- IR power: 10^{-8} amps
- T-avg: $515^{o}F$
- Rods: 204 steps on C-Bank

A. If rods are withdrawn to produce a 1 DPM startup rate, how long does it take to reach 5×10^{-7} amps? (1.0)

(a.) 30 seconds

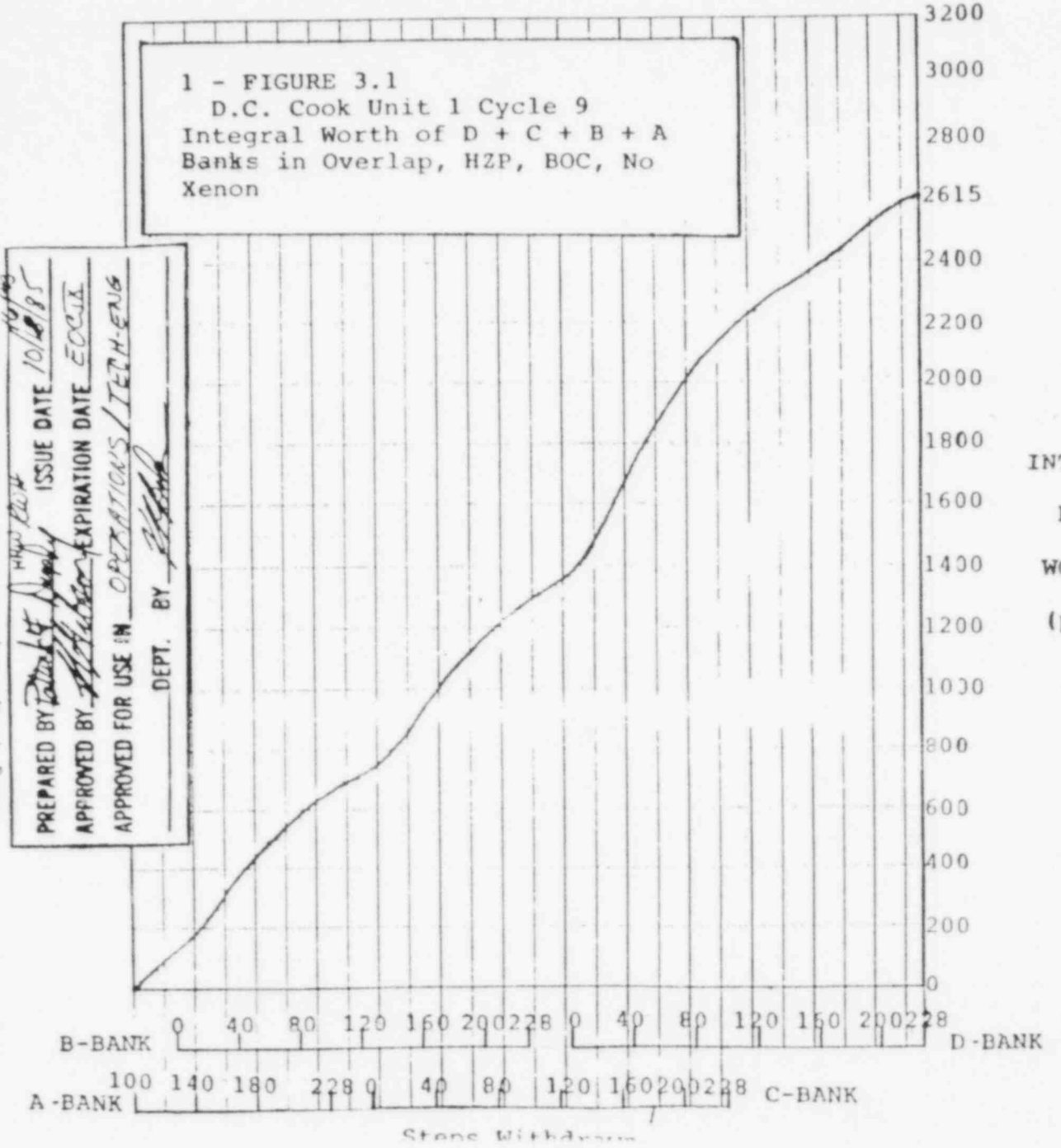
(b.) 42 seconds

(c.) 90 seconds

(d.) 102 seconds

B. Referring to the attached Integral Worth Curve (Figure 3.1), to what final position must rods be withdrawn to raise T-avg to $547^{o}F$? Assume an Isothermal Temperature Coefficient of 12.5 pcm/^{o}F. (1.5)

-Section 5.0 Continued on Next Page-



STEP	Δρ To STEP 228	STEP	Δρ To STEP 228
228	0	193	104.0
227	1.8	192	107.0
226	3.5	191	113.5
225	5.3	190	120.0
224	7.0	188	122.5
223	9.0	186	134.0
222	11.0	184	143.0
221	13.0	182	150.5
220	15.0	180	158.0
219	16.3	178	167.5
218	17.5	176	177.0
217	18.8	174	185.0
216	20.0	172	193.0
215	24.3	170	195.0
214	28.5	168	205.0
213	32.8	166	212.5
212	37.0	164	220.0
211	37.5	162	225.0
210	38.0	160	230.0
209	41.5	158	237.5
208	45.0	156	245.0
207	48.8	154	251.0
206	52.5	152	257.0
205	56.3	150	270.0
204	60.0	148	271.0
203	63.8	146	279.0
202	67.5	144	287.0
201	71.3	142	293.5
200	75.0	140	300.0
199	80.0	138	305.0
198	85.0	136	310.0
197	90.0	134	316.5
196	95.0	132	323.0
195	98.0	130	330.0
194	101.0	128	335.0

-Section 5.0 Continued on Next Page-

Points
Available

ANSWER 5.09

A. (d.) [+1.0]

B. Δ T-avg = $32^{o}F$

$\Delta \rho = \Delta$ T-avg x ITC

$= 32^{o}F \times 12.5\ pcm/^{o}F$

= 400 pcm [+0.5]

$\rho_{final} = \rho_i + \Delta\rho$

= 2000 + 400

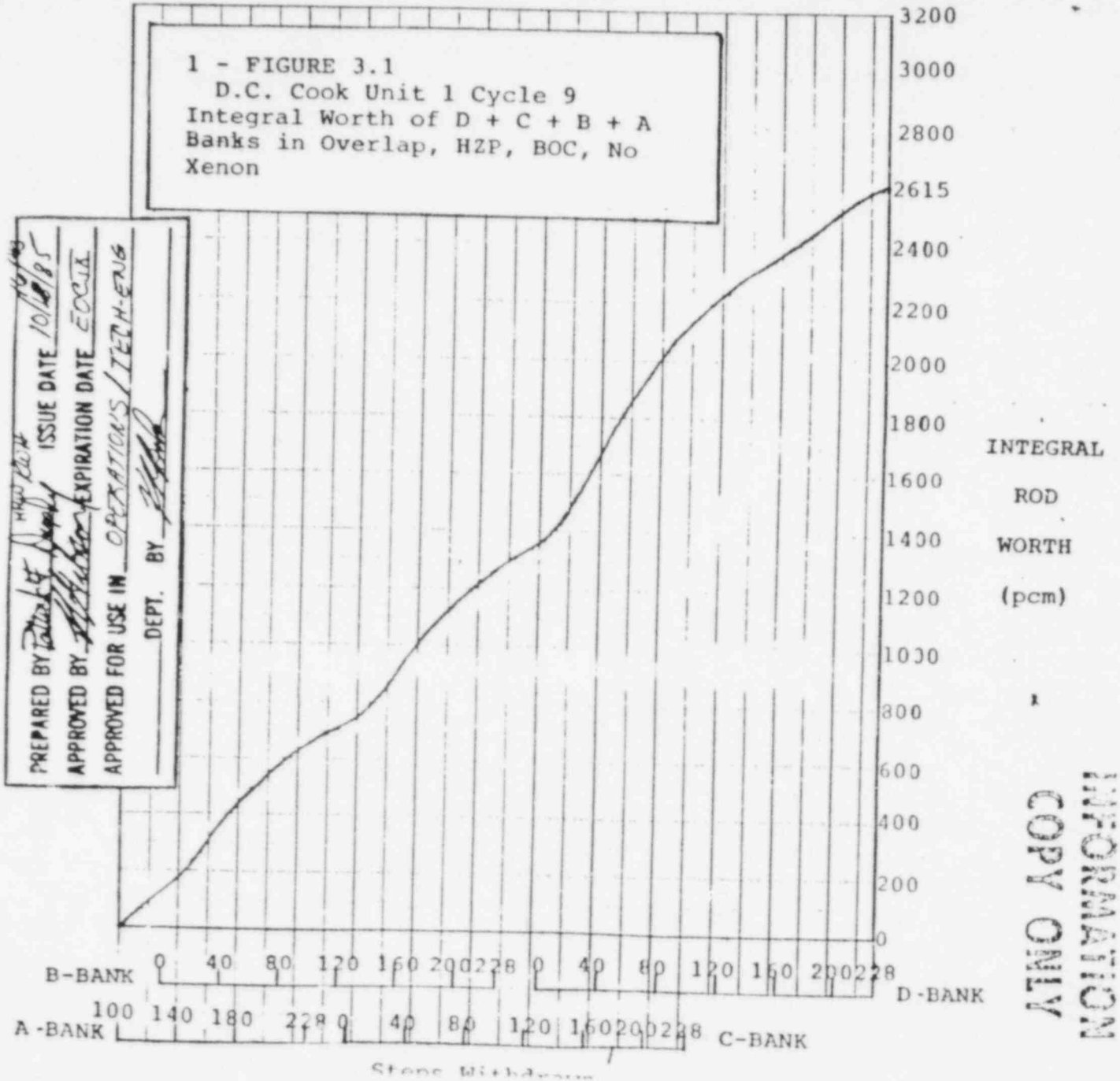
= 2400

Rod height is therefore 168 steps on D-Bank. [+1.0]

Reference(s) 5.09

1. DCC Reactor Theory, Neutron Kinetics (I-3), p. 15.
2. DCC Reactor Theory, PWR Core Physics (I-5), pp. 10-22, 36-40.

-Section 5.0 Continued on Next Page-



STEP	Δρ To STEP 228	STEP	Δρ To STEP 228
228	0	193	104.0
227	1.8	192	107.0
226	3.5	191	113.5
225	5.3	190	120.0
224	7.0	188	122.5
223	9.0	186	134.0
222	11.0	184	143.0
221	13.0	182	150.5
220	15.0	180	158.0
219	16.3	178	167.5
218	17.5	176	177.0
217	18.8	174	185.0
216	20.0	172	193.0
215	24.3	170	195.0
214	28.5	168	205.0
213	32.8	166	212.5
212	37.0	164	220.0
211	37.5	162	225.0
210	38.0	160	230.0
209	41.5	158	237.5
208	45.0	156	245.0
207	48.8	154	251.0
206	52.5	152	257.0
205	56.3	150	270.0
204	60.0	148	271.0
203	63.8	146	279.0
202	67.5	144	287.0
201	71.3	142	293.5
200	75.0	140	300.0
199	80.0	138	305.0
198	85.0	136	310.0
197	90.0	134	316.5
196	95.0	132	323.0
195	98.0	130	330.0
194	101.0	128	335.0

Points Available

-Section 5.0 Continued on Next Page-

Points
Available

QUESTION 5.10

With no fuel in the reactor, the count rate is 125 cps. After loading six (6) fuel assemblies, the count rate is 500 cps. A new detector, farther from the core, is now used and it has a count rate of 300 cps. Four (4) more fuel assemblies are loaded, increasing the count rate to 750 cps on the new detector. What is the value of k_{eff} after the ten (10) fuel assemblies have been loaded? (1.0)

ANSWER 5.10

Moving the detector changes the base count rate:

$$C_o \text{ (new)} = C_o \frac{C_i \text{ (new)}}{C_i} = (125 \text{ cps}) \frac{300 \text{ cps}}{500 \text{ cps}} = 75 \text{ cps} \quad [+0.5]$$

After loading four more fuel assemblies:

$$k_{eff} = 1 - \frac{C_o \text{ (new)}}{C_i} = 1 - \frac{75 \text{ cps}}{750 \text{ cps}} = 0.90 \quad [+0.5]$$

Alternately:

The value of k_{eff} with six fuel elements is:

$$k_{eff} = 1 - \frac{C_o}{C_i} = 1 - \frac{125 \text{ cps}}{500 \text{ cps}} = 0.75 \quad [+0.5]$$

After loading four more fuel assemblies:

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

$$= 1 - \frac{300}{750} (1 - 0.75)$$

$$= 0.90 \qquad [+0.5]$$

Reference(s) 5.10

1. DCC Reactor Theory, Neutron Sources and Subcritical Multiplication (I-4), pp. 13-24.

-Section 5.0 Continued on Next Page-

Points
Available

QUESTION 5.11

Differential boron worth changes over core life (see Figure I-5.27 below).

a. Why does it initially decrease (become less negative)? (0.75)

b. Why does it subsequently increase (become more negative)? (0.75)

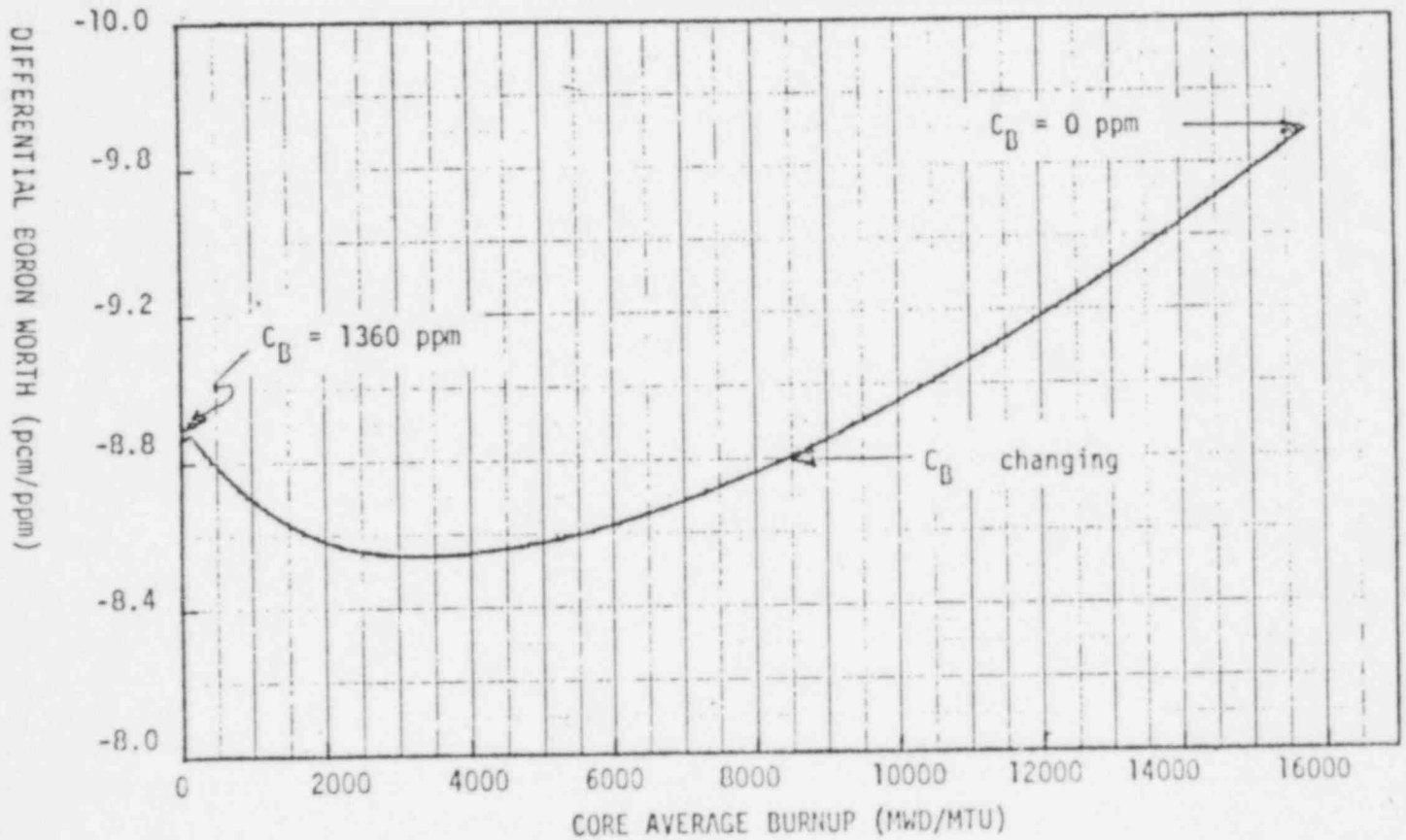


FIGURE I-5.27 Composite Graph of Changing Differential Boron Worth as a Function of Core Burnup

-Section 5.0 Continued on Next Page-

Points
Available

ANSWER 5.11

a. Fission product buildup (causes dbw to become less negative. This initially outweights the decreasing boron concentration effect.) **[+0.75]**

b. Decreasing boron concentration (causes dbw to become more negative. This subsequently outweights the fission product buildup.) **[+0.75]**

Reference(s) 5.11

1. DCC Reactor Theory, PWR Core Physics (I-5), pp. 31-35.

-Section 5.0 Continued on Next Page-

Points
Available

QUESTION 5.12

State why each of the Rod Control System limits are provided.

a. Withdrawal limit (0.75)

b. Maneuvering band upper limit (0.75)

c. Maneuvering band lower limit (0.75)

d. Insertion limit (0.75)

ANSWER 5.12

a. To help avoid dumping steam if a decrease in power is initiated. [+0.75] (will accept "to provide sufficient bite" for ~~[+0.5])~~ [+0.75]).

b. To allow an "immediate" return to full power operation (without boron dilution). [+0.75]

c. To maintain even axial flux depletion. [+.75]

d. To maintain adequate shutdown margin. [+0.75] Also accepted for full credit: maintaining acceptable power distribution, maintaining minimum shutdown margin, and minimize the effects of an ejected rod.

Reference(s) 5.12

1. DCC Reactor Theory, Power Core Physics (I-5), pp. 50-51.

-Section 5.0 Continued on Next Page-

Points
Available

QUESTION 5.13

Burnable poison rods are used in the first fuel cycle.

a. Why are they necessary? (0.75)

b. Why aren't they needed in subsequent fuel cycles? (0.75)

ANSWER 5.13

a. To maintain a negative moderator temperature coefficient (by providing partial control of the excess reactivity associated with the first fuel cycle). [+0.75]

b. The partially depleted fuel and the building of fission product poisons in the subsequent fuel cycles limit excess reactivity to a value controllable by soluble boron alone. [+0.75] Full credit will be given if candidate explains why burnable poison rods are used in subsequent fuel cycles.

Reference(s) 5.13

1. DCC Reactor Theory, PWR Core Physics (I-5), p. 57.

-Section 5.0 Continued on Next Page-

Points
Available

QUESTION 5.14

Select the correct statement regarding Xe behavior in the core? (1.0)

(a.) Buildup and decay of Xe is similar to Sm.

(b.) The value of peak Xe, after a reactor trip, is independent of the pre-trip power level.

(c.) Xe peaking, after a reactor trip, occurs at a fixed time independent of the pre-trip power level.

(d.) Equilibrium Xe concentration, after a reactor trip, is independent of the pre-trip power level.

ANSWER 5.14

(d.) **[+1.0]**

Reference(s) 5.14

1. DCC Reactor Theory, PWR Core Physics (I-5.1), pp. 63-79.

-End of Section 5.0-

Points
Available

6.0 PLANT SYSTEM DESIGN, CONTROL AND INSTRUMENTATION (25.0)

QUESTION 6.01

a. What automatic actions take place in the Component Cooling Water (CCW) system upon a Safety Injection signal? Assume standby pump is locked out. (1.5)

b. What automatic actions take place in the Component Cooling Water system (CCW) upon a Containment Spray signal? (1.5)

ANSWER 6.01

a. Hx outlet open [+0.5].

RHR hx outlet goes to INTERMEDIATE position giving approximately 3000 gpm flow [+0.5].

Isolation occurs on BA evaporator, spent fuel pit cooling, letdown Hx, excess letdown Hx and Rx support coolers [+0.1 each] Also accepted isolation of CCW to either the BA evaporator or the South Aux. Waste evaporator (ERWE). [+0.1 each]

b. CCW to and from the RCPs (thermal barrier heat exchangers upper and lower bearing oil coolers,) is isolated. [+0.75] CCW to and from the CEQ fan motors is unisolated. [+~~0.75~~ +0.75] Also accepted CCW to RCP's isolates [+~~0.75~~ +0.75]

Reference(s) 6.01

1. DCC Lesson Plan, RO-C-AS01, p. 6.

-Section 6.0 Continued on Next Page-

Points
Available

QUESTION 6.02

List the associated components/pumps from the Emergency Core Cooling System needed for the Injection Phase and the RCS pressure at which they will begin to inject. (2.0)

ANSWER 6.02

Pump	Shut-Off Head	
Centrifugal Charging Pumps	~~2540~~ 2100-2570 psig	[+0.5]
Safety Injection Pumps	~~1560~~ 1550-1600 psig	[+0.5]
Accumulators	~~620~~ 580-660 psig	[+0.5]
Residual Heat Removal	~~200~~ 200-220 psig	[+0.5]
or (Unit 1 Accumulators	585-658 psig	[+~~0.5~~ 0.25]
Unit 2 Accumulators)	549-622 psig	[+~~0.5~~ 0.25]

[+2.0 max.]

Reference(s) 6.02

1. DCC Lesson Plan, RO-C-NS12.

-Section 6.0 Continued on Next Page-

Points
Available

QUESTION 6.03

In order to satisfy the interlock and open the recirculation sump suction valves, which of the following conditions are not required? (1.0)

(a.) The RHR pump suctions from the RWST (IMO-310/320) must be closed.

(b.) The charging pump suctions from the RWST (IMO-910/911) must be closed.

(c.) The SI pump suctions from the RWST (IMO-215/225) must be closed.

(d.) Control power to the recirc sump suction valve must be on.

ANSWER 6.03

(b.) [+1.0]

Reference(s) 6.03

1. DCC Lesson Plan, RO-C-NS12.

-Section 6.0 Continued on Next Page-

Points
Available

QUESTION 6.04

List the parameters that will initiate a Safety Injection signal along with the actual setpoint for each unit. Do not include manual. (2.5)

ANSWER 6.04

PZR low pressure: 1837 psig on Unit 1, 1908 psig on Unit 2 **[0.5]**

Steam line delta-P: 100 psig **[+0.5]**

Containment high pressure: 1.1 psig **[+0.5]**

High steam line flow (1.42 to 3.88 x 10^6 pph, this value not required for full credit) on Unit 1 with lo-lo T-avg of 541^{0}F or low steam line pressure of 600 psig **[+0.5]**

Low steam line pressure: 600 psig on Unit 2 **[+0.5]**

Reference(s) 6.04

1. DCC Lesson Plan, RO-C-NS12.

-Section 6.0 Continued on Next Page-

Points
Available

QUESTION 6.05

List the components of the ECCS which receive an actuating signal on a safety injection and what action that component must take. (2.0)

ANSWER 6.05

Centrifugal Charging Pumps - Start ✓

CCP Suction from RWST (IMO-910/911) - Open ✓

BIT Inlet and Outlet Valves - Open ✓

SI Pumps - Start ✓

RHR Pumps - Start ✓

CCP Mini Flow Valves - Close ✓

~~Accumulator Isolation Valves - Open~~ ✓

BIT Recirc Valves - Close.

[+0.~~15~~ 2 for each component, +0.1 for each action] 2.0 pts max

Reference(s) 6.05

1. DCC Lesson Plan, RO-C-NS12.

-Section 6.0 Continued on Next Page-

Points
Available

QUESTION 6.06

List the four (4) ice condenser monitoring systems that are available to control room operators. (2.0)

ANSWER 6.06

1. Ice bed temperature [+0.5]
2. Ice condenser door position [+0.5]
3. Ice condenser floor cooling temperature [+0.5]
4. Equipment and personnel doors [+0.5]

Other appropriate recorders, annunciators, and indicators accepted for credit.

Reference(s) 6.06

1. DCC Lesson Plan, RO-C-NS14, p. 17.

QUESTION 6.07

The reactor trip breaker shunt coils will: (1.0)

(a.) energize on a manual trip signal.

(b.) energize on an automatic trip signal.

(c.) deenergize on a manual trip signal.

(d.) deenergize on an automatic trip signal.

ANSWER 6.07

(a.) [+1.0]

or b.

Reference(s) 6.07

1. DCC Lesson Plan, RO-C-NS11.

-Section 6.0 Continued on Next Page-

Points
Available

QUESTION 6.08

a. What automatic functions are performed when an Urgent Failure alarm is received? (1.5)

b. What will cause a Non-Urgent Failure alarm? (1.0)

ANSWER 6.08

a. 1) Lift coil is deenergized. [+0.5]

2) Stationary and movable gripper coils are both energized at reduced current. [+0.5]

3) Stops manual and automatic rod motion. [+0.5]

b. Loss of any one of the two 120V AC power supplies. [+1.0]

Reference(s) 6.08

1. DCC Lesson Plan, RO-C-NS04.

-Section 6.0 Continued on Next Page-

Points
Available

QUESTION 6.09

Fill in the set points in the level control program for the Volume Control tank. (1.0)

a. ____ % Hi Level alarm - full divert

b. ____ % Stops auto makeup

c. ____ % VCT low level alarm

d. ____ % Shifts charging pump suction to RWST.

ANSWER 6.09

a. 87 [+0.25]

b. ~~27~~ 24 [+0.25]

c. 7 [+0.25]

d. 1 [+0.25]

Reference(s) 6.09

1. DCC Lesson Plan, RO-C-NS06.

-Section 6.0 Continued on Next Page-

Points
Available

QUESTION 6.10

State the four (4) signals which will cause an automatic closure of the letdown orifice isolation valves (QRV 160, 161, 162). Include setpoints if applicable. (2.0)

ANSWER 6.10

1. Containment Isolation [+0.5]
2. Loss of all charging pumps (breakers) [+0.5]
3. Closing of letdown isolation valves QRV-111, 112 [+0.5]
4. Low pressurizer water level of 17% [+0.5]

Reference(s) 6.10

1. DCC Lesson Plan, RO-C-NS06.

-Section 6.0 Continued on Next Page-

Points
Available

QUESTION 6.11

During a programmed power increase from 0% power, the Auctioneer T-avg increases to 560°F. The PZR levels should increase from (2.0)

U_1 ____ % to ____ %

U_2 ____ % to ____ %

Show calculations.

ANSWER 6.11

U_1 22% **[+0.25]** to 37% **[+0.75]**

$$U_1 \text{ Lvl} = 22 + (46 - 22)\frac{560 - 547}{567.8 - 547} = 37$$

U_2 22% **[+0.25]** to 38% **[+0.75]**

$$U_2 \text{ Lvl} = 22 + (55 - 22)\frac{560 - 547}{573.8 - 547} = 38$$

Reference(s) 6.11

1. DCC Lesson Plan, RO-C-NS03, p. 27.
2. DCC Lesson Plan, RO-C-NS04, Figure 2.1.1 and Figure 2.1 or RO-C-NS-06, page 26.

-Section 6.0 Continued on Next Page-

Points
Available

QUESTION 6.12

The Pressurizer Pressure Relief System is designed to prevent a reactor trip under four (4) transient conditions. List them. (2.0)

ANSWER 6.12

1. Load at 5%/min with auto rod control. [+0.5]
2. Unload at 5%/min with auto rod control. [+0.5]
3. 10% step change with auto rod control. [+0.5]
4. Step change from 100% to auxiliary load power with auto rod control and steam dumps. [+0.5]

Reference(s) 6.12

1. DCC Lesson Plan, RO-C-NS03.

-Section 6.0 Continued on Next Page-

Points
Available

QUESTION 6.13

Fill-in the blanks to make the following statements about reactor coolant pump operation correct.

a. Minimum VCT pressure necessary for proper seal operation is _____ psig. (0.25)

b. Seal water injection temperature should not exceed _____ ^{o}F as read at the VCT. (0.25)

c. A pressure differential of at least _____ psig should be maintained across the No. 1 seal. (0.25)

d. Operation above _____ ^{o}F requires 4 RCPs to be in service. (0.25)

ANSWER 6.13

a. 15 [+0.25]

b. 130 [+0.25]

c. 275 [+0.25]

d. 541 [+0.25]

Reference(s) 6.13

1. DCC Lesson Plan, OHP-4021.002.003.

-Section 6.0 Continued on Next Page-

Points
Available

QUESTION 6.14

What activities does the failed fuel detector system monitor when in service? (Note any differences between units.) (1.0)

ANSWER 6.14

Gross Gamma, I-135, Cs-137 Unit 1 **[+0.5]**

Gross Gamma, I-131 Unit 2 **[+0.5]**

Credit given for Gross Gamma, or fission product activity. [+0.5] [+0.5]

Reference(s) 6.14

1. DCC Lesson Plan, RO-C-NS17.

-End of Section 6.0-

Points
Available

7.0 PROCEDURES: NORMAL, ABNORMAL, EMERGENCY, AND RADIOLOGICAL CONTROL (25.0)

QUESTION 7.01

Operating Procedure OHP-4021.012.003 "Rod Control and Position Indication Operation", lists three (3) conditions that require insertion of the control banks during unit startup. List two (2) of these conditions. (1.0)

ANSWER 7.01

1. Critical with control bank height less than insertion limits for 0 power, Technical Specification 3.13.5.

2. Critical at 1000 pcm below ECP.

3. Rod withdrawal to 500 pcm past ECP and startup not guided by a 1/M plot.

Any two (2) [+0.5] each.

Reference(s) 7.01

1. DCC Lesson Plan, RO-C-NS04.

2. DCC Operating Procedure OHP-4021.012.003.

-Section 7.0 Continued on Next Page-

Points
Available

QUESTION 7.02

Assume during reactor cooldown or shutdown the RHR capability is lost. List three (3) alternate cooling methods. (State any assumptions.) (1.5)

ANSWER 7.02

~~Head on~~

1. Condenser steam dump. [+0.5]
2. Atmospheric steam dump. [+0.5]

~~Head off~~

3. Spent fuel pit cooling. [+0.5]

Reference(s) 7.02

1. DCC Emergency Operating Procedure OHP-4023.017.001, 3.

Additional acceptable answers

4. Establish maximum letdown and charging [+0.5]
5. Flood the refueling cavity [+0.5]
6. Establish maximum refueling cavity filtering and purification [+0.5]
7. Operate Containment ventilation units [+0.5]

([1.5] max)

-Section 7.0 Continued on Next Page-

Points
Available

QUESTION 7.03

Answer the following statements about Reactor Coolant Pump (RCP) operation TRUE or FALSE.

a. The Shift Supervisor's approval is required before starting an RCP with less than 0.3 gpm leakoff flow from No. 1 seal. (0.5)

b. The maximum vibration allowed is greater on a ramp increase than during steady operation. (0.5)

c. If the RCS temperature is higher than 150°F, an emergency diesel must be operable when any RCP is running. (0.5)

d. An RCP can be started while the plant is solid, as long as the RCS temperature is higher than 175°F. (0.5)

ANSWER 7.03

a. TRUE [+0.5]

b. FALSE [+0.5]

c. TRUE [+0.5]

d. FALSE [+0.5]

Reference(s) 7.03

1. DCC Operating Procedure 2-OHP-4021.002.003, pp. 4-5.

-Section 7.0 Continued on Next Page-

Points
Available

QUESTION 7.04

List the four (4) conditions that must be satisfied before a spurious Safety Injection can be reset. (2.0)

ANSWER 7.04

1. RCS pressure > 2000 psig and increasing. [+0.5]
2. PZR level above no-load value. [+0.5]
3. Subcool margin > $45^{o}F$ for T_{hot} RTD or $33^{o}F$ for incore T/Cs. [+0.5]
4. S/G wide range H_2O levels rising. [+0.5]

Reference(s) 7.04

1. DCC Emergency Operating Procedure 1-OHP-4023.001.002, p.5.

-Section 7.0 Continued on Next Page-

Points
Available

QUESTION 7.05

Answer the following questions about the emergency diesel engines.

a. What condition will cause the incomplete start sequence to occur? (0.5)

b. How can the operator in the control room tell this has occurred? (0.5)

c. List the two (2) conditions either of which will permit a restart. (0.5)

ANSWER 7.05

a. During a EDG start < 95% rated speed > 10 sec. [+0.5]

b. A red failure light is energized in the control room. [+0.5]

c. ~~3 minutes elapse or~~ push the EDG reset button. [+0.5]
With accept SI and Blackout start for full credit

Reference(s) 7.05

1. DCC Lesson Plan, Vol. III, RO-C-AS10, p. 25.

-Section 7.0 Continued on Next Page-

Points
Available

QUESTION 7.06

According to Technical Specifications, which of the following does NOT have to be monitored and logged when the plant computer is inoperable. (1.0)

(a.) rod position

(b.) axial flux difference

(c.) subcooled margin

(d.) quadrant power tilt ratio.

ANSWER 7.06

(c.) **[+1.0]**

Reference(s) 7.06

1. DCC Lesson Plan, Volume III, RO-C-AS20, p. 28.

QUESTION 7.07

During cooldown using the natural circulation emergency procedure, what is the reason for the caution: "When steaming single steam generator, (for cooldown) care must be taken not to get 100 psid between steam generators"? (1.0)

ANSWER 7.07

If greater than 100 psid develops between S/Gs, SI will occur.
[+1.0]

Reference(s) 7.07

1. DCC Emergency Operating Procedure 1-OHP-4023.001.008, p. 3.

-Section 7.0 Continued on Next Page-

Points
Available

QUESTION 7.08

a. The Technical Specification operating temperature limits for the Pressurizer are

Maximum heat up in any 1 hour is _____ ^{o}F. (0.5)

Maximum cooldown in any 1 hour is _____ ^{o}F. (0.5)

Maximum spray water temperature differential is _____ ^{o}F. (0.5)

b. Answer TRUE or FALSE. The temperature limits in part a. are based on the pressurizer fatigue limit. (0.5)

ANSWER 7.08

a. 1. 100^{o}F [+0.5]

2. 200^{o}F [+0.5]

3. 320^{o}F [+0.5]

b. TRUE [+0.5]

Reference(s) 7.08

1. DCC Technical Specifications, Units 1 and 2, 3.4.9.2.

2. DCC Technical Specifications, Units 1 and 2, 3.4.9.2, (Bases).

-Section 7.0 Continued on Next Page-

Points
Available

QUESTION 7.09

Match the Technical Specification leakage categories in Column A with the item in Column B (some categories in A may have more than one (1) item B). (3.0)

A	B
a. Identified leakage	1. Leakage past reactor head o-ring
b. Unidentified leakage	2. Leakage through atmospheric steam dumps
c. Controlled leakage	3. S/G tube leakage
d. Boundary leakage	4. Weld on loop 2 RTD manifold T_{cold}
	5. Leakage past No. 2 seal of the RCP
	6. Weld crack-wide range T_{hot} thermowell
	7. PORV leakage

ANSWER 7.09

a. 1. [+0.5]
3. [+0.5]
7. [+0.5]
4. [+0.5]
(for item 4. in a. and/or b).

b. 4.

c. 5. [+0.5]

d. 6. [+0.5]

Reference(s) 7.09

1. DCC Technical Specification 3.4.6.2.

2. DCC Lesson Plan RO-C-NS2A, pp. 14-16.

-Section 7.0 Continued on Next Page-

Points
Available

QUESTION 7.10

If system frequency drops to 58.8 Hz due to loss of generating capacity, what five (5) actions are required after 30 minutes if the system frequency does not recover? (2.5)

ANSWER 7.10

1. Open breakers K and K-1. [+0.5]

2. Verify steam dump controls have functioned to limit T-avg and Pressurizer pressure transients. If not, trip the reactor. [+0.5]

3. Monitor reactor power to ensure the rods are moving inward to reduce power level. If not, take manual control and reduce reactor power. (Automatic Rod Withdrawal is blocked below 15% C-5). [+0.5]

4. Adjust turbine speed to maintain frequency at 60 Hz. [+0.5]

5. Monitor T-avg to ensure the Steam Dump System is performing properly; take manual control if required. [+0.5]

Reference(s) 7.10

1. DCC Abnormal Operating Procedure 1-OHP-4022.001.002, p. 2.

-Section 7.0 Continued on Next Page-

Points
Available

QUESTION 7.11

It is acceptable to continue operation with a leaking PZR Safety Valve if what three (3) conditions are met? (1.5)

ANSWER 7.11

1. Charging pump can maintain PZR level. [+0.5]

2. Temperature, pressure, level in PRT can be maintained within limits. [+0.5]

3. Leakage must stay below Technical Specification leakage limit for identified leakage (< 10 gpm). [+0.5]

Reference(s) 7.11

1. DCC Abnormal Operating Procedure 1-OHP-4022.002.010, p. 1.

2. DCC Technical Specification 3.4.6.2.

-Section 7.0 Continued on Next Page-

Points
Available

QUESTION 7.12

If PZR level and VCT level indicate a loss of letdown flow, what four (4) Immediate Manual Actions are required? (2.0)

ANSWER 7.12

1. If PZR reaches high level limit, be sure Rx has tripped. [+0.5]

2. Reduce charging flow to maintain seal injection. [+0.5]

3. Stop charging through Regen. HX. [+0.5]

4. Use excess letdown path. [+0.5]

5. Makeup to VCT at proper Boron concentration

6. Reestablish normal letdown.

Reference(s) 7.12

1. DCC Abnormal Operating Procedure 1-OHP-4022.003.001, p. 4.

-Section 7.0 Continued on Next Page-

Points
Available

QUESTION 7.13

While manually withdrawing the control rod banks the rod movement stops. List the five (5) possible causes, including values where appropriate. (2.5)

ANSWER 7.13

1. Power range NI overpower (103%) (C-2). [+0.5]
2. Intermediate range nuclear overpower - current equivalent to 20% (C-1). [+0.5]
3. Overpower ΔT - 3% below trip setpoint (C-4). [+0.5]
4. Overtemperature ΔT - 3% below trip setpoint (C-4). [+0.5]
5. Urgent failure alarm. [+0.5]

Reference(s) 7.13

1. DCC Lesson Plan RO-C-NS04, p. 7.

-Section 7.0 Continued on Next Page-

Points
Available

QUESTION 7.14

The reactor is operating 100% power when a Reactor Trip/ Safety Injection occurs. Reactor pressure has decreased to 1600 psig and containment pressure is 2.5 psig and is increasing.

a. At what containment pressure should Phase B isolation occur? (0.5)

b. When should reactor coolant pumps be tripped? State any assumptions. (1.0)

ANSWER 7.14

a. 2.9 psig. [+0.5]

b. 1450 psi [+0.5] or they should be tripped within 5 minutes after Phase B isolation occurs. [+0.5]

Reference(s) 7.14

1. DCC Emergency Operating Procedure 1-OHP-4023.001.002, p. 4.

2. DCC Abnormal Operating Procedure 1-OHP-4022.034.002, p. 1.

-End of Section 7.0-

Points
Available

8.0 ADMINISTRATIVE PROCEDURES, CONDITIONS, AND LIMITATIONS ~~(25.0)~~ 24.5

QUESTION 8.01

Answer the following TRUE or FALSE.

a. The official version of a Radiation Work Permit is stored in the computer. (0.5)

b. Separate keys are required to access both the locked Extremely High Radiation (EHR) and locked High Radiation (HR) areas. (0.5)

c. Areas outlined in magenta on the Radiation Information Board are EHR areas. (0.5)

d. Areas where the major portion of the body could receive 0.1 R/hr are designated as HR areas. (0.5)

e. The administrative limit for whole body radiation dose from external sources is 1.25 rem/quarter. (0.5)

ANSWER 8.01

a. TRUE [+0.5] (all others are copies)

b. TRUE [+0.5]

c. FALSE [+0.5] (outlined and crosshatched in red)

d. TRUE [+0.5] (100 mR/hr)

e. FALSE [+0.5] (1.0 rem/quarter)

Reference(s) 8.01

1. DCC PMP 6010.RAD.001, Radiation Protection Manual, Revision 6, p. 36, 122.

2. DCC PMP 6010.RAD.002, Entry Into High Radiation Areas, Revision 2, pp. 2-4.

-Section 8.0 Continued on Next Page-

Points
Available

QUESTION 8.02

Answer the following TRUE or FALSE.

a. A striped tag clearance issued to one shift supervisor is valid for all shift supervisors. (0.5)

b. A clearance permit may include some equipment with red tags and some with striped tags. (0.5)

c. A master clearance can be used to isolate a system where numerous unlisted activities are being performed. (0.5)

d. A supervisor from the same department can sign off a clearance permit if the responsible individual is not available on site. (0.5)

ANSWER 8.02

a. TRUE **[+0.5]**

b. TRUE **[+0.5]**

c. FALSE (all activities must be listed) **[+0.5]**

d. TRUE **[+0.5]**

Reference(s) 8.02

1. DCC PMI 2110, p. 3, 5, 9.

-Section 8.0 Continued on Next Page-

Points
Available

QUESTION 8.03

A licensed operator shall not work more than _____ hours in any 48-hour period. (0.5)

ANSWER 8.03

24 [+0.5]

Reference(s) 8.03

1. Previously in PMI-1050, now cancelled. CAF.

-Section 8.0 Continued on Next Page-

Points
Available

QUESTION 8.04

a. Complete the table for minimum staffing, Modes 1, 2, 3, and 4, Technical Specification Table 6.2-1.

License Category	Minimum Shift Crew, One (1) Unit	
SOL	_____	(0.25)
OL	_____	(0.25)
Aux. operator (non-licensed)	_____	(0.25)
STA	_____	(0.25)

b. List by licensing category, the personnel that may be shared between Units 1 and 2. (0.5)

c. For how long a period may the crew be at less than minimum strength, provided steps are taken immediately to restore crew personnel? (0.5)

ANSWER 8.04

a. 1 [+0.25]
2 [+0.25]
2 [+0.25]
1 [+0.25]

b. SOL [+0.25]
STA [+0.25]

c. 2 hours [+0.5]

Reference(s) 8.04

1. DCC Technical Specification Table 6.2-1 and footnotes.

-Section 8.0 Continued on Next Page-

Points
Available

QUESTION 8.05

a. During an emergency, it may be overly time consuming to process a clearance request. How does the Shift Supervisor ensure that control of isolation points, such as valves or circuit breakers, are protected from inadvertent operation? (1.0)

b. Answer TRUE or FALSE. A Reg Tag clearance permit denotes that equipment is not to be operated except by request of the permit holder. (0.5)

ANSWER 8.05

a. The Shift Supervisor dispatches people to guard the points. [+1.0]

b. FALSE (No manipulation of any kind allowed.) [+0.5]

Reference(s) 8.05

1. DCC PMI-2110, Clearance Permit System, Revision 9, pp. 1-3.

-Section 8.0 Continued on Next Page-

Points
Available

QUESTION 8.06

For each of the following, list the limiting condition for operation in Mode 6:

a. Shutdown k_{eff} (0.5)

b. Shutdown time prior to fuel movement (0.5)

c. Water level above vessel flange (0.5)

d. Required nuclear instrumentation (1.0)

ANSWER 8.06

a. $k_{eff} \leq 0.95$ [+0.5]

b. subcritical ≥ 100 hours [+0.5]

c. ≥ 23 ft over flange [+0.5]

d. Two (2) SR monitors operable and operating with continuous visual indication in control room [+0.5] and audible in control room and containment. [+0.5]

Reference(s) 8.06

1. DCC Technical Specifications 3.9.1, 3.9.3, 3.9.10, 3.9.2, respectively.

-Section 8.0 Continued on Next Page-

Points
Available

QUESTION 8.07

Identify how the RHR system is used to satisfy Technical Specification 3.4.9.3, "Overpressure Protection System", when the RCS is cold and pressurized. (1.0)

ANSWER 8.07

The RHR pump suction relief valve [+1.0] (in conjunction with two (2) operable PORVs) satisfies (paragraph b. of) the Technical Specification.

Reference(s) 8.07

1. DCC Technical Specification 3.4.9.3.b.

2. DCC RHR Lesson Plan, RO-C-NS08, Figure NS-8-5.

QUESTION 8.08

Describe the two (2) boron injection flow paths required to be operable by Technical Specification 3.1.2.2 while in Modes 1, 2, 3, and 4. (2.0)

ANSWER 8.08

1. Boric acid tanks via a boric acid transfer pump and charging pump to RCS. [+1.0]

2. RWST via charging pump to RCS. [+1.0]

Reference(s) 8.08

1. DCC Technical Specification 3.1.2.2, paragraphs a. and b.

2. DCC CVCS Lesson Plan, RO-C-NS06, Figure NS-6-9.

-Section 8.0 Continued on Next Page-

Points
Available

QUESTION 8.09

Answer the following with regard to Technical Specification 3.2.1 on Axial Flux Difference limits.

a. When operating above 90% power, how much time is the operator allowed to get AFD within the target band before he must reduce power? (0.5)

b. When operating between 50% and 60% power level, what is the time limitation on the operator for operating outside the AFD target band? (0.5)

ANSWER 8.09

a. 15 minutes [+0.5]

b. 1 hour in 24 [+0.5]

Reference(s) 8.09

1. DCC Technical Specification 3.2.1.

-Section 8.0 Continued on Next Page-

Points
Available

QUESTION 8.10

If one (1) emergency diesel generator is taken out of service for maintenance and the reactor is in Mode 1, what action must be taken? (1.0)

ANSWER 8.10

Demonstrate operability of remaining AC sources [+0.5] (by performing Surveillance Requirements 4.8.1.1.1.a and 4.8.1.1.2.a.4) within 1 hour [+0.5] (and at least once every 8 hours thereafter), or restore to operable within one hour, or conduct the Emergency Diesel Generator Operability Test (STP.027). [+0.5] [+0.5]

Reference(s) 8.10

1. DCC Technical Specification 3.8.1.1, Action a.

-Section 8.0 Continued on Next Page-

Points
Available

QUESTION 8.11

According to Technical Specification 3.4.11 "Relief Valves", three (3) PORVs and their associated block valves shall be OPERABLE.

a. If a single PORV is inoperable, what action(s) must be accomplished to allow plant operation at 100% power to continue? (1.5)

b. What is the minimum number of OPERABLE PORVs required to allow at power operation to continue indefinitely according to this Technical Specification? (0.5)

ANSWER 8.11

a. 1. Restore PORV to OPERABLE status [+0.5] or

2. Close the associated block valve [+0.5] and

3. Remove power from the block valve [+0.5].

b. 0 (if "one or more" are inoperable, close block valves) [+0.5]

Reference(s) 8.11

1. DCC Technical Specification 3.4.11.

-Section 8.0 Continued on Next Page-

Points
Available

QUESTION 8.12

For each of the following ECC Systems, specify whether the Technical Specification LCO is the SAME or DIFFERENT for Units 1 and 2 for Mode 1 operation.

a. Accumulator water volume, Technical Specification 3.5.1 (0.5)

b. Accumulator nitrogen cover-pressure, Technical Specification 3.5.1 (0.5)

c. RWST boron concentration, Technical Specification 3.5.5 (0.5)

d. RWST minimum water temperature, Technical Specification 3.5.5 (0.5)

ANSWER 8.12

a. SAME [+0.5]

b. DIFFERENT (U_1: 585-658 psig; U_2: 599-644 psig) [+0.5]

c. DIFFERENT (U_1: ~~1900~~ 1950 ppm; U_2: 2000-2200 ppm) [+0.5]

d. DIFFERENT (U_1: 70°F; U_2: 80°F) [+0.5] Will accept SAME for full credit if candidate explains why they are the same.

Reference(s) 8.12

1. DCC Technical Specification 3.5.1.

2. DCC Technical Specification 3.5.5.

-Section 8.0 Continued on Next Page-

Points
Available

QUESTION 8.13

State whether each of the following, as specified in 10 CFR 72, requires NRC notification within 1 HOUR or 4 HOURS.

a. Shutdown required by Technical Specifications. (0.5)

b. Reactor trip. (0.5)

c. Declaration of an unusual event. (0.5)

~~d. Transfer of a contaminated individual to a local hospital. (0.5)~~

ANSWER 8.13

a. 1 hour [+0.5]

b. 4 hours [+0.5]

c. 1 hour [+0.5]

~~d. 4 hours [+0.5]~~

Q+A deleted as either answer is potentially correct. Answer is technically correct, although stated event does result in an Unusual Event which requires 1 hour notification

Reference(s) 8.13

1. 10 CFR 50.72.

-Section 8.0 Continued on Next Page-

Points
Available

QUESTION 8.14

A plant emergency occurs which requires activation of the D.C. Cook Emergency Plan.

A. Who is responsible for initiating PMP 2080 EPP.001, Emergency Plan Activation and Condition Classification? (0.5)

B. At what minimum emergency condition classification is activation of each of the following required?

a. Technical Support Center. (0.5)

b. Operations Staging Area. (0.5)

c. Emergency Operations Facility. (0.5)

C. List four (4) individuals who can relieve the initial On-Site Emergency Coordinator. (1.0)

ANSWER 8.14

A. Shift Supervisor [+0.5]

B. a. Alert [+0.5]
b. Alert [+0.5]
c. ~~Site Area Emergency [+0.5]~~
Alert ~~and~~ Site Area Emergency [+0.5]

C. 1. Production Supervisor of Affected Unit
2. Operations Superintendent
3. Assistant Plant Manager - Operations
4. Assistant Plant Manager - Maintenance
5. D. C. Cook Plant Manager
6. Vice President, Nuclear Operations

Any four (4) [+0.25] each.

-Section 8.0 Continued on Next Page-

Points
Available

Reference(s) 8.14

1. DCC PMP 2080 EPP.001, Emergency Plan Activation Classification, pp. 1-2.

2. DCC PMP 2080 EPP.015, Responsibilities of the On-Site Emergency Coordinator, p. 2.

-End of Section 8.0-

-End of Exam-

EQUATION SHEET

Where $\dot{m}_1 = \dot{m}_2$

$(\text{density})_1(\text{velocity})_1(\text{area})_1 = (\text{density})_2(\text{velocity})_2(\text{area})_2$

$KE = \frac{mv^2}{2}$ $\quad PE = mgh$ $\quad PE_1+KE_1+P_1V_1 = PE_2+KE_2+P_2V_2$ $\quad$ where V = specific volume, P = Pressure

$Q = \dot{m}c_p(T_{out}-T_{in})$ $\quad Q = UA\,(T_{ave}-T_{stm})$ $\quad Q = \dot{m}(h_1-h_2)$

$P = P_0 10^{(SUR)(t)}$ $\quad P = P_0 e^{t/T}$ $\quad SUR = \frac{26.06}{T}$ $\quad T = \frac{(B-p)t}{p}$

$\text{delta } K = (K_{eff}-1)$ $\quad CR_1(1-K_{eff1}) = CR_2(1-K_{eff2})$ $\quad CR = S/(1-K_{eff})$

$M = \frac{(1-K_{eff1})}{(1-K_{eff2})}$ $\quad SDM = \frac{(1-K_{eff}) \times 100\%}{K_{eff}}$

$\text{decay constant} = \frac{\ln(2)}{t_{1/2}} = \frac{0.693}{t_{1/2}}$ $\quad A_1 = A_0 e^{-(\text{decay constant})x(t)}$

Water Parameters

1 gallon = 8.345 lbs
1 gallon = 3.78 liters

1 ft^3 = 7.48 gallons

Density = 62.4 lbm/ft^3
Density = 1 gm/cm^3

Heat of Vaporization = 970 Btu/lbm
Heat of Fusion = 144 Btu/lbm
1 Atm = 14.7 psia = 29.9 in Hg

Miscellaneous Conversions

1 Curie = 3.7×10^{10} dps
1 kg = 2.21 lbs

1 hp = 2.54×10^3 Btu/hr

1 MW = 3.41×10^6 Btu/hr
1 Btu = 778 ft-lbf

Degrees F = (1.8 x Degrees C) + 32
1 inch = 2.54 centimeters
g = 32.174 $ft\text{-}lbm/lbf\text{-}sec^2$

EQUATION SHEET

Where $\dot{m}_1 = \dot{m}_2$

$(\text{density})_1(\text{velocity})_1(\text{area})_1 = (\text{density})_2(\text{velocity})_2(\text{area})_2$

$KE = \frac{mv^2}{2}$ $\quad PE = mgh$ $\quad PE_1+KE_1+P_1V_1 = PE_2+KE_2+P_2V_2$ $\quad$ where V = specific volume, P = Pressure

$Q = \dot{m}c_p(T_{out}-T_{in})$ $\quad Q = UA\,(T_{ave}-T_{stm})$ $\quad Q = \dot{m}(h_1-h_2)$

$P = P_0 10^{(SUR)(t)}$ $\quad P = P_0 e^{t/T}$ $\quad SUR = \frac{26.06}{T}$ $\quad T = \frac{(B-p)t}{p}$

$\text{delta K} = (K_{eff}-1)$ $\quad CR_1(1-K_{eff1}) = CR_2(1-K_{eff2})$ $\quad CR = S/(1-K_{eff})$

$M = \frac{(1-K_{eff1})}{(1-K_{eff2})}$ $\quad SDM = \frac{(1-K_{eff}) \times 100\%}{K_{eff}}$

$\text{decay constant} = \frac{\ln(2)}{t_{1/2}} = \frac{0.693}{t_{1/2}}$ $\quad A_1 = A_0 e^{-(\text{decay constant})x(t)}$

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