UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

November 14, 2018

Dr. Wei Ji, Director
Reactor Critical Facility
Rensselaer Polytechnic Institute
110 8th Street
NES Building 1-10
Troy, NY 12180 3590

SUBJECT: EXAMINATION REPORT NO. 50-225/OL-19-01, RENSSELAER POLYTECHNIC INSTITUTE

Dear Dr. Ji:

During the week of October 29, 2018, the U.S. Nuclear Regulatory Commission (NRC) administered an operator licensing examination at your Rensselaer Polytechnic Institute research reactor. The examinations were conducted according to NUREG-1478, "Operator Licensing Examiner Standards for Research and Test Reactors," Revision 2. Examination questions and preliminary findings were discussed with those members of your staff identified in the enclosed report at the conclusion of the examination.

In accordance with Title 10 of the *Code of Federal Regulations*, Section 2.390, a copy of this letter and the enclosures will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records (PARS) component of NRC's Agencywide Documents Access and Management System (ADAMS). ADAMS is accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html. The NRC is forwarding the individual grades to you in a separate letter which will not be released publicly. Should you have any questions concerning this examination, please contact Mr. John T. Nguyen at (301) 415-4007 or via internet e-mail John.Nguyen@nrc.gov.

Sincerely,

/RA/

Anthony J. Mendiola, Chief
Research and Test Reactors Oversight Branch
Division of Licensing Projects
Office of Nuclear Reactor Regulation

Docket No. 50-225

Enclosures:
1. Examination Report No. 50-225/OL 19-01
2. Written examination

cc: Glenn Winters, RPI

cc: w/o enclosures: See next page

SUBJECT: EXAMINATION REPORT NO. 50-225/OL-19-01, RENSSELAER POLYTECHNIC INSTITUTE DATED NOVEMBER 14, 2018

DISTRIBUTION:
PUBLIC
RidsNrrDlpPrlb Resource
RidsNrrDlpProb Resource
Facility File (CJRandiki)

ADAMS Accession No. ML18319A017 **NRR-079**

OFFICE	NRR/DLP/PROB/CE	NRR/DLP/IOLB/OLA	NRR/DLP/PROB/BC
NAME	JNguyen	CJRandiki	AMendiola
DATE	11/7/2018	11/13/2018	11/14/2018

OFFICIAL RECORD COPY

cc:

Mayor of the City of Schenectady
Schenectady City Hall
105 Jay St.
Schenectady, NY 12305

Dr. Shekhar Garde
Dean, School of Engineering
Rensselaer Polytechnic Institute
110 8th Street
Troy, NY 12181-3590

Reactor Operations Supervisor
JEC Room 2049
Department of Mechanical Aerospace
and Nuclear Engineering
Rensselaer Polytechnic Institute
110 8th Street
Troy, NY 12180-3590

Chief, Radiation Section
Division of Environmental Remediation
NY State Dept. of Environmental
Conservation
625 Broadway
Albany, NY 12233-7255

Radiation Safety Officer
NES Building, Room 1-10,
MANE Department
Rensselaer Polytechnic Institute
110 8th St.
Troy, NY 12180-3590

RCF Supervisor
NES Building, Room 1-10,
MANE Department
Rensselaer Polytechnic Institute
110 8th St.
Troy, NY 12180

Annette Chism, Director EH&S
Rensselaer Polytechnic Institute
21 Union Street
Gurley Building 2nd Floor
Troy, NY 12180

State Liaison Officer Designee
Senior Project Manager
Radioactive Waste Policy and Nuclear
Coordination
New York State Energy Research &
Development Authority
17 Columbia Circle
Albany, NY 12203-6399

Test, Research and Training
Reactor Newsletter
P.O. Box 118300
University of Florida
Gainesville, FL 32611

U.S. NUCLEAR REGULATORY COMMISSION
OPERATOR LICENSING INITIAL EXAMINATION REPORT

REPORT NO.: 50-225/OL-19-01

FACILITY DOCKET NO.: 50-225

FACILITY LICENSE NO.: CX-22

FACILITY: Critical

EXAMINATION DATES: October 30, 2018

SUBMITTED BY: ***/RA/*** 11/07/2018
John T. Nguyen, Chief Examiner Date

SUMMARY:
During the week of October 29, 2018, the NRC administered an operator licensing examination to one Senior Reactor Operator candidate. The candidate passed all applicable portions of the examination.

REPORT DETAILS

1. Examiner: John T. Nguyen, Chief Examiner, NRC

2. Results:

	RO PASS/FAIL	SRO PASS/FAIL	TOTAL PASS/FAIL
Written	N/A	1/0	1/0
Operating Tests	N/A	1/0	1/0
Overall	N/A	1/0	1/0

3. Exit Meeting:
John T. Nguyen, Chief Examiner, NRC
Glenn Winters, Operations Supervisor, RPI

Upon completion of the examination, the NRC Examiner met with facility staff representatives to discuss the results. At the conclusion of the meeting, the NRC examiner thanked the facility for their support in the administration of the examination.

ENCLOSURE 1

U.S. NUCLEAR REGULATORY COMMISSION
NON-POWER REACTOR LICENSE EXAMINATION

FACILITY:	Rensselaer Polytechnic Institute
REACTOR TYPE:	Critical Facility
DATE ADMINISTERED:	10/30/2018
CANDIDATE:	______________________

INSTRUCTIONS TO CANDIDATE:
Answers are to be written on the Answer sheet provided. Attach all Answer sheets to the examination. Point values are indicated in parentheses for each question. A 70% in each category is required to pass the examination. Examinations will be picked up three (3) hours after the examination starts.

CATEGORY VALUE	% OF TOTAL	CANDIDATE'S SCORE	% OF CATEGORY VALUE	CATEGORY
18.00	33.3	________	_____	A. REACTOR THEORY, THERMODYNAMICS AND FACILITY OPERATING CHARACTERISTICS
18.00	33.3	________	_____	B. NORMAL AND EMERGENCY OPERATING PROCEDURES AND RADIOLOGICAL CONTROLS
18.00	33.3	________	_____	C. FACILITY AND RADIATION MONITORING SYSTEMS
54.00		________ FINAL GRADE	_____ %	TOTALS

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

____
Candidate's Signature

ENCLOSURE 2

Category A – Reactor Theory, Thermodynamics, & Facility Operating Characteristics

A N S W E R   S H E E T

Multiple Choice (Circle or X your choice)
If you change your Answer, write your selection in the blank.

A01 a b c d ___

A02 a b c d ___

A03 a b c d ___

A04 a b c d ___

A05 a b c d ___

A06 a b c d ___

A07 a b c d ___

A08 a b c d ___

A09 a b c d ___

A10 a b c d ___

A11 a b c d ___

A12 a ___ b ___ c ___ d ___ (0.25 each)

A13 a b c d ___

A14 a b c d ___

A15 a b c d ___

A16 a b c d ___

A17 a ___ b ___ c ___ d ___ (0.25 each)

A18 a b c d ___

(***** END OF CATEGORY A *****)

Category B – Normal/Emergency Operating Procedures and Radiological Controls

A N S W E R   S H E E T

Multiple Choice   (Circle or X your choice)
If you change your Answer, write your selection in the blank.

B01 a b c d ___

B02 a b c d ___

B03 a b c d ___

B04 a b c d ___

B05 a b c d ___

B06 a b c d ___

B07 a b c d ___

B08 a b c d ___

B09 a b c d ___

B10 a b c d ___

B11 a b c d ___

B12 a b c d ___

B13 a b c d ___

B14 a b c d ___

B15 a b c d ___

B16 a b c d ___

B17 a b c d ___

B18 a b c d ___

(***** END OF CATEGORY B *****)

C. PLANT AND RAD MONITORING SYSTEMS

A N S W E R   S H E E T

Multiple Choice (Circle or X your choice)
If you change your Answer, write your selection in the blank.

C01 a b c d ___

C02 a b c d ___

C03 a b c d ___

C04 a b c d ___

C05 a b c d ___

C06 a ___ b ___ c ___ d ___ (0.50 each)

C07 a b c d ___

C08 a ___ b ___ c ___ d ___ (0.25 each)

C09 a ___ b ___ c ___ d ___ (0.50 each)

C10 a b c d ___

C11 a b c d ___

C12 a b c d ___

C13 a b c d ___

C14 a b c d ___

C15 a b c d ___

C16 a ___ b ___ c ___ d ___ (0.25 each)

(***** END OF CATEGORY C *****)
(********** END OF EXAMINATION **********)

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. After the examination has been completed, you must sign the statement on the cover sheet indicating that the work is your own and you have neither received nor given assistance in completing the examination. This must be done after you complete the examination.

3. 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.

4. Use black ink or dark pencil <u>only</u> to facilitate legible reproductions.

5. Print your name in the blank provided in the upper right-hand corner of the examination cover sheet and each Answer sheet.

6. Mark your Answers on the Answer sheet provided. USE ONLY THE PAPER PROVIDED AND DO NOT WRITE ON THE BACK SIDE OF THE PAGE.

7. The point value for each question is indicated in [brackets] after the question.

8. If the intent of a question is unclear, ask questions of the examiner only.

9. When turning in your examination, assemble the completed examination with examination questions, examination aids and Answer sheets. In addition turn in all scrap paper.

10. Ensure all information you wish to have evaluated as part of your Answer is on your Answer sheet. Scrap paper will be disposed of immediately following the examination.

11. To pass the examination you must achieve a grade of 70 percent or greater in each category.

12. There is a time limit of three (3) hours for completion of the examination.

EQUATION SHEET

$$\dot{Q} = \dot{m} c_P \Delta T = \dot{m}\Delta H = UA\Delta T$$

$$P_{\max} = \frac{(\beta - \rho)^2}{(2\alpha\lambda)}$$

$$\lambda_{eff} = 0.1 \sec^{-1}$$

$$P = P_0 \, e^{t/\mathrm{T}}$$

$$SCR = \frac{S}{-\rho} \cong \frac{S}{1 - K_{eff}}$$

$$\lambda^* = 1 \times 10^{-4} \sec$$

$$SUR = 26.06 \left[\frac{\lambda_{eff}\rho + \dot{\rho}}{\overline{\beta} - \rho} \right]$$

$$CR_1(1 - K_{eff_1}) = CR_2(1 - K_{eff_2})$$

$$CR_1(-\rho_1) = CR_2(-\rho_2)$$

$$P = \frac{\beta(1-\rho)}{\beta - \rho} P_0$$

$$M = \frac{1}{1 - K_{eff}} = \frac{CR_2}{CR_1}$$

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

$$M = \frac{1 - K_{eff_1}}{1 - K_{eff_2}}$$

$$SDM = \frac{1 - K_{eff}}{K_{eff}}$$

$$\mathrm{T} = \frac{\lambda^*}{\rho - \overline{\beta}}$$

$$\mathrm{T} = \frac{\lambda^*}{\rho} + \left[\frac{\overline{\beta} - \rho}{\lambda_{eff}\rho + \dot{\rho}} \right]$$

$$T_{\frac{1}{2}} = \frac{0.693}{\lambda}$$

$$\Delta\rho = \frac{K_{eff_2} - K_{eff_1}}{K_{eff_1} K_{eff_2}}$$

$$\rho = \frac{K_{eff} - 1}{K_{eff}}$$

$$DR = DR_0 \, e^{-\lambda t}$$

$$DR_1 d_1^{\,2} = DR_2 d_2^{\,2}$$

$$DR = \frac{6\,Ci\,E(n)}{R^2}$$

$$\frac{(\rho_2 - \beta)^2}{Peak_2} = \frac{(\rho_1 - \beta)^2}{Peak_1}$$

DR – Rem, Ci – curies, E – Mev, R – feet

---

1 Curie = 3.7 x 10^{10} dis/sec

1 Horsepower = 2.54 x 10^3 BTU/hr

1 BTU = 778 ft-lb

1 gal (H_2O) ≈ 8 lb

c_P = 1.0 BTU/hr/lb/°F

1 kg = 2.21 lb

1 Mw = 3.41 x 10^6 BTU/hr

°F = 9/5 °C + 32

°C = 5/9 (°F - 32)

c_p = 1 cal/sec/gm/°C

Category A: Reactor Theory, Thermodynamics, and Facility Operating Characteristics

QUESTION A.01 [1.0 point]
Several processes occur that may increase or decrease the available number of neutrons. SELECT ONE of the following six-factor formula term that describes an INCREASE in the number of neutrons during the cycle.

a. Reproduction Factor.

b. Thermal Utilization Factor.

c. Resonance Escape Probability.

d. Thermal Non-leakage Probability.

QUESTION A.02 [1.0 point]
Which ONE of the following conditions will require the control rod withdrawal to maintain constant power level after the following change?

a. Adding of a fuel experiment such as U-235 into the core.

b. Removal of an experiment containing borated graphite.

c. Increase of pool water temperature.

d. Burnout of Xenon in the core.

QUESTION A.03 [1.0 point]
The reactor is critical at 1.0 watts. A control rod is withdrawn to insert a positive reactivity of 0.10% $\Delta k/k$. Which ONE of the following will be the stable reactor period as a result of this reactivity insertion? Given beta effective = 0.0078

a. 22 seconds

b. 46 seconds

c. 68 seconds

d. 80 seconds

QUESTION A.04 [1.0 point]
Five minutes after shutting down the reactor, reactor power is 3×10^6 counts per minute. Which ONE of the following is the count rate you would expect to three minutes later?

a. 1×10^6 cpm

b. 8×10^5 cpm

c. 5×10^5 cpm

d. 3×10^5 cpm

QUESTION A.05 [1.0 point]
Which ONE of the following best describes the likelihood of fission occurring in U-235 and U-238?

a. Neutron cross sections of U-235 and U-238 are independent from the neutron velocity.

b. Neutron cross section of U-235 increases with increasing neutron energy, whereas neutron cross section of U-238 decreases with increasing neutron energy.

c. Neutrons at low energy levels (eV) are more likely to cause fission with U-238 than neutrons at higher energy levels (MeV).

d. Neutrons at low energy levels (eV) are more likely to cause fission with U-235 than neutrons at higher energy levels (MeV).

QUESTION A.06 [1.0 point]
The delayed neutron precursor (β) for U^{235} is 0.0065. However, when calculating reactor parameters you use β_{eff} with a value of ~0.0076. Which ONE of the following is a main reason why β_{eff} is larger than β?

a. Since the fuel also contains U-238 which has a relatively large β for fast fission.

b. U-238 in the core becomes Pu-239 (by neutron absorption), which has a higher β for fission.

c. Delayed neutrons are born at higher energies than prompt neutrons resulting in a greater a number of delayed neutrons.

d. Delayed neutrons are born at lower energies than prompt neutrons resulting in less leakage during slowdown to thermal energies.

QUESTION A.07 [1.0 point]
Reactor power is critical at 1 mW. Reactor operator makes a mistake by inserting a sample worth of +0.008 $\Delta k/k$ into the reactor core. Which ONE of the following best describes the reactor kinetic?   The reactor is:

a. subcritical

b. critical

c. supercritical

d. prompt critical

QUESTION A.08 [1.0 point]
Reactor power is rising on a 10 second period. Approximately how long will it take for power to quadruple?

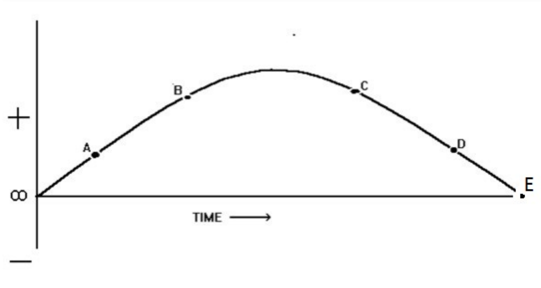
a. 14 seconds

b. 29 seconds

c. 55 seconds

d. 72 seconds

QUESTION A.09 [1.0 point]
Shown below is a trace of reactor period as a function of time. Between points D and E reactor power is:



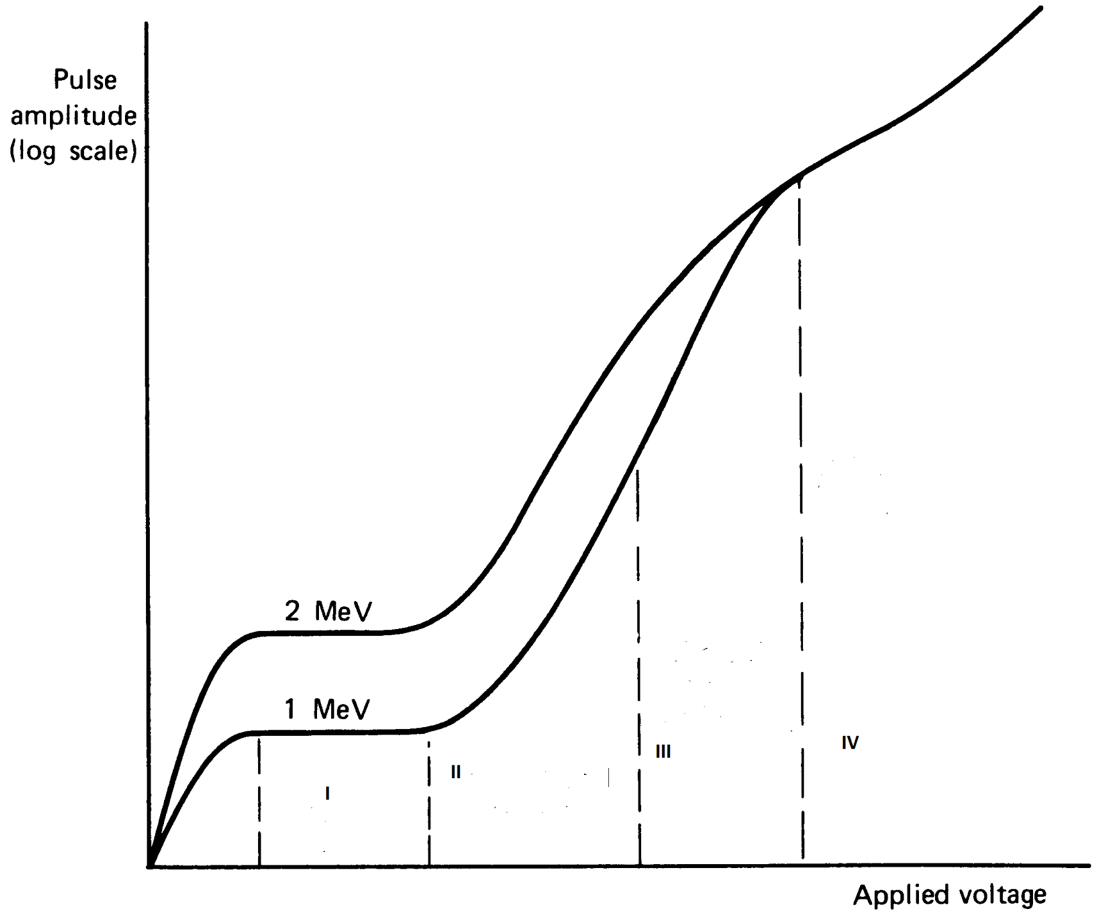
a. constant.

b. continually decreasing.

c. continually increasing.

d. increasing, then constant.

QUESTION A.10 [1.0 point]
Graph below depicts the different regions of operation for gas-filled detectors. Which ONE of the following labels is the Geiger-Mueller region?



QUESTION A.11 [1.0 point]
If the multiplication factor, k, is increased from 0.800 to 0.950, the amount of reactivity added is:

a. 0.150 $\Delta k/k$

b. 0.197 $\Delta k/k$

c. 0.250 $\Delta k/k$

d. 0.297 $\Delta k/k$

QUESTION A.12 [1.0 point, 0.25 each]
A fissile material is one that causes fission upon absorption of a thermal neutron. A fertile material is one that will become a fissile material upon absorption of a thermal neutron. Identify each of the listed isotopes as either fissile or fertile.

a. Th-232

b. U-235

c. U-238

d. Pu-239

QUESTION A.13 [1.0 point]
The K_{eff} for the reactor is 0.955. The reactivity needed to bring the reactor to the criticality is:

a. +0.0471

b. +0.0450

c. -0.0471

d. -0.0450

QUESTION A.14 [1.0 point]
A thermal neutron is a neutron which:

a. is produced as a result of thermal fission.

b. possesses thermal rather than kinetic energy.

c. has been produced several seconds after its initiating fission occurred.

d. experiences no net change in its energy after several collisions with atoms of the diffusing medium.

QUESTION A.15 [1.0 point]
The reactor is critical and increasing in power. Power has increased from 20 mW to 80 mW in 60 seconds. How long will it take at this rate for power to increase from 0.080 W to 160 W?

a. 0.5 minute

b. 2.5 minutes

c. 5.5 minutes

d. 10.5 minutes

QUESTION A.16 [1.0 point]
Control Rod withdrawal mainly changes Keff by changing the …

a. fast fission factor (ε).

b. thermal utilization factor (f).

c. neutron reproduction factor (η).

d. resonance escape probability (p).

QUESTION A.17 [1.0 point, 0.25 each]
Replace "X" with the type of decay necessary (Alpha, Positron, Gamma or Neutron emission) to produce the following reactions. Choices may be used once, more than once, or not at all.

a. $_{92}U^{238} \rightarrow {}_{90}Th^{234} + X$

b. $_{83}Bi^{203} \rightarrow {}_{82}Pb^{203} + X$

c. $_{2}He^{4} + {}_{4}Be^{9} \rightarrow {}_{6}C^{12} + X$

d. $_{84}Po^{210} \rightarrow {}_{82}Pb^{206} + X$

QUESTION A.18 [1.0 point]
Reactor is at 100 % power. The following graph shows the reactor time behavior following a reactor scram. Which ONE of the following best describes the transition of power between point C and D after the initial rod insertion? .

a. An immediate decrease in the prompt neutron fraction due to leakage, absorption, and a reduction in the fission rate.

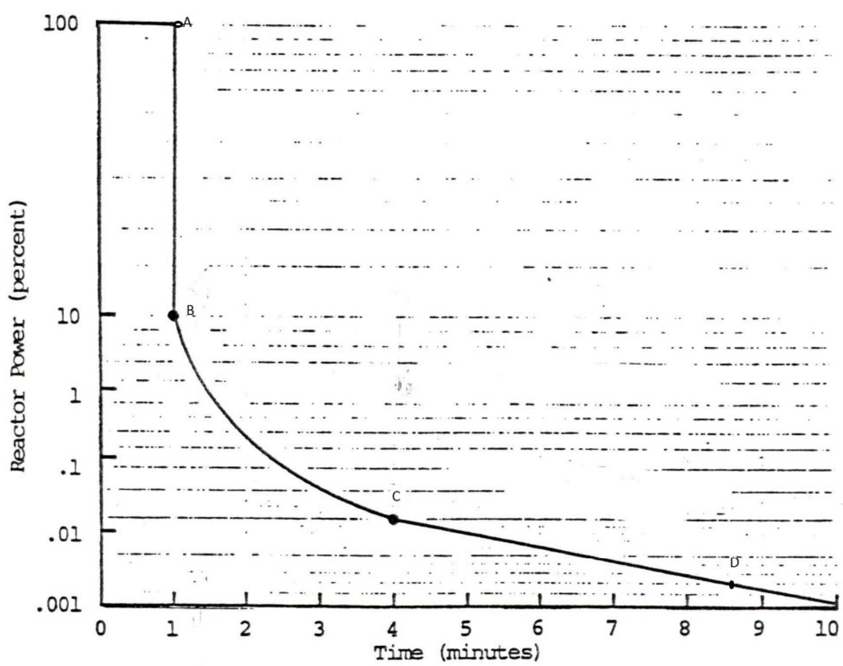
b. Fission product gases such as xenon begin to buildup causing the expansion of fuel density.

c. The **longest** lived delayed neutron precursor begins to effect such as Bromine-87.

d. The **short** lived delayed neutron precursors begin to effect such as Iodine-137, Cesium-144, and Krypton-95.

INTRODUCTION TO NUCLEAR REACTOR OPERATIONS
Reactor Kinetics
Reed Robert Burn
December 1988

Figure 4.3 Reactor Time Behavior Following a Reactor Scram



(***** END OF CATEGORY A *****)

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.01 [1.0 point]
The MAIN purpose to encapsulate a corrosive material irradiated in the reactor core is to prevent:

a. damage on the fuel cladding.

b. pressure build up in the sample holder.

c. possibility of fires in the vicinity of the reactor.

d. maximum reactivity change during removal or insertion of experiment.

QUESTION B.02 [1.0 point]
How long will it take a 1 Curie source, with a half-life of 2 year, to decay to 0.1 Curie?

a. 4.6 Years

b. 6.6 Years

c. 10.6 Years

d. 16.6 Years

QUESTION B.03 [1.0 point]
Which ONE of the following statements is NOT true for the Limiting Conditions for Operation?

a. The maximum reactivity worth of any clean fuel pin shall be $0.20.

b. The thermal power level shall be controlled so as not to exceed 1 kW, and the integrated thermal power for any consecutive 365 days shall not exceed 2 kW-hr.

c. The auxiliary reactor scram (moderator-reflector water dump) shall add negative reactivity within one minute of its activation.

d. The scram time for each control rod from its fully withdrawn position to its fully inserted position shall be less than or equal to 900 milliseconds. This includes a maximum 50 millisecond magnetic clutch release time.

QUESTION B.04 [1.0 point]
Per RCF Technical Specifications, what is a minimum level of authority to approve minor changes to previous approved experiments that do not change the effectiveness or the original intent of the experiments?

a. Nuclear Safety and Review Board (NSRB)

b. Radiation Safety Officer

c. Operations Supervisor

d. Senior Reactor Operators

QUESTION B.05 [1.0 point]
Per RCF Technical Specifications, when the Area Gamma Monitor (AGM) over the reactor room (high level monitor) is inoperable, the reactor operations may continue only if:

a. Control room AGM is still operable.

b. Critical detector system is still operable.

c. Constant Air Monitor and the control room AGM are still operable.

d. Portable gamma sensitive instrument having their own alarm is substituted.

QUESTION B.06 [1.0 point]
Which ONE of the following statements correctly describes the relationship between the Safety Limit (SL) and the Limiting Safety System Setting (LSSS)?

a. The SL is a maximum operationally limiting value that prevents exceeding the LSSS during normal operations.

b. The SL is a parameter that assures the integrity of the fuel pellet cladding. The LSSS initiates protective actions to preclude reaching the SL.

c. The SL is a maximum setpoint for instrumentation response. The LSSS is the minimum number of channels required to be operable.

d. The LSSS is a parameter that assures the integrity of the fuel pellet. The SL initiates protective action to preclude reaching the LSSS.

QUESTION B.07 [1.0 point]
You are currently the licensed operator at RCF. Which ONE of the following will violate 10 CFR Part 55.53 “Conditions of licenses”?

a. Last requalification operating test was 14 months ago.

b. Last requalification written examination was 20 months ago.

c. Last quarter you were the licensed operator for 8 hours.

d. Last licensed renewal was 48 months ago.

QUESTION B.08 [1.0 point]
A radiation survey of an area reveals a general radiation reading of 1 mrem/hr. There is, however, a small pipe which reads 20 mrem/hr at one (1) meter. Which ONE of the following defines the posting requirements for the area in accordance with 10CFR20?

a. Control Access Area.

b. Caution, Radiation Area.

c. Caution, High Radiation Area.

d. Grave Danger, Very High Radiation Area.

QUESTION B.09 [1.0 point]
The dose rate from a mixed beta-gamma point source is 100 mrem/hour at a distance of one (1) foot, and is 0.1 mrem/hour at a distance of twenty (20) feet. What is a ratio of gamma and beta radiation (gamma/beta) at 1 foot?

a. 0.10

b. 0.53

c. 0.67

d. 1.54

QUESTION B.10 [1.0 point]
Per RCF Technical Specifications, which ONE of the following will NOT violate the TS?

a. The minimum operating temperature = 50 °F

b. The excess reactivity = 0.60 $

c. Steady State reactor power = 1200 mW

d. Reactor Period = 5 seconds

QUESTION B.11 [1.0 point]
An irradiated sample provides a dose rate of 0.5 rem/hr at 2 ft. Approximately how far from the sample reads 5 mrem/hr?

a. 6 ft.

b. 9 ft.

c. 14 ft.

d. 20 ft.

QUESTION B.12 [1.0 point]
In accordance with 10CFR20.1301, individual members of the public are limited to a TEDE in one year of:

a. 50 mrem.

b. 100 mrem.

c. 500 mrem.

d. 1250 mrem.

QUESTION B.13 [1.0 point]
According to emergency classification guide, the event associated with the contaminated moderator is defined as:

a. Operational Event

b. Unusual Event

c. Alert

d. Site Area Emergency

QUESTION B.14 [1.0 point]
Which ONE of following types of radiation is the **LOWEST** Quality Factor specified in 10 CFR 20?

a. Alpha

b. Beta

c. Proton (high energy)

d. Neutron (unknown energy)

QUESTION B.15 [1.0 point]
Which ONE of the following experiments is NOT allowed to be installed in the reactor or experiment facilities under ANY condition? The experiment:

a. contains corrosive materials.

b. contains 15 milligrams of TNT material.

c. contains a movable worth of $0.50.

d. causes the reactivity insertion rate to exceed $0.10 per second.

QUESTION B.16 [1.0 point]
"The reactor power shall NOT exceed the minimum reactor period of 5 seconds". This is an example of:

a. Safety Limit (SL)

b. Limiting Safety System Setting (LSSS)

c. Limiting Conditions for Operation (LCO)

d. Surveillance Requirement (SR)

QUESTION B.17 [1.0 point]
All applicants for an RO or SRO license must submit NRC Form 396 and 398 to the U.S. NRC before taking the examinations. This requirement is specified in 10 CFR:

a. Part 19

b. Part 20

c. Part 50

d. Part 55

QUESTION B.18 [1.0 point]
"Specific instrument readings, or observations; radiological dose or dose rates; or specific contamination levels of airborne or surface-deposited radioactive materials that may be used as thresholds for establishing emergency classes and initiating appropriate emergency measures." The above statement is defined as:

a. Emergency Procedures.

b. Emergency Action Levels.

c. Emergency Planning Zones.

d. Protective Action Guides.

(***** END OF CATEGORY B *****)

Category C: Facility and Radiation Monitoring Systems

QUESTION C.01 [1.0 point]
According to the Pre-Startup Procedures, which ONE of the following is the material used as a source check for the area gamma monitors?

a. U-235

b. Pu-240

c. Cs-137

d. Na-24

QUESTION C.02 [1.0 point]
The reactor operation is completed for the day. Which ONE of the following items is NOT required to be checked on the Reactor Secured Checklist?

a. All control rods are fully inserted.

b. The vault is closed and locked.

c. Turn off the ventilation system.

d. Turn off all instrumentation.

QUESTION C.03 [1.0 point]
All of the following are interlocks that prevent control rod withdrawal during reactor operations EXCEPT:

a. Moderator-Reflector Water Fill "ON"

b. Line Voltage to Recorders = 120 V

c. Reactor period = 10 seconds.

d. Neutron Flux = 1 cps

QUESTION C.04 [1.0 point]
If control rod sensitivity is known, withdrawal of the rods as a bank is permitted as long as:

a. the source is inserted to the reactor core.

b. the reactivity addition does not exceed $0.50

c. the reactor period does not exceed 12 seconds.

d. the reactivity addition does not exceed $0.12 per second up to 10 times the source.

Category C: Facility and Radiation Monitoring Systems

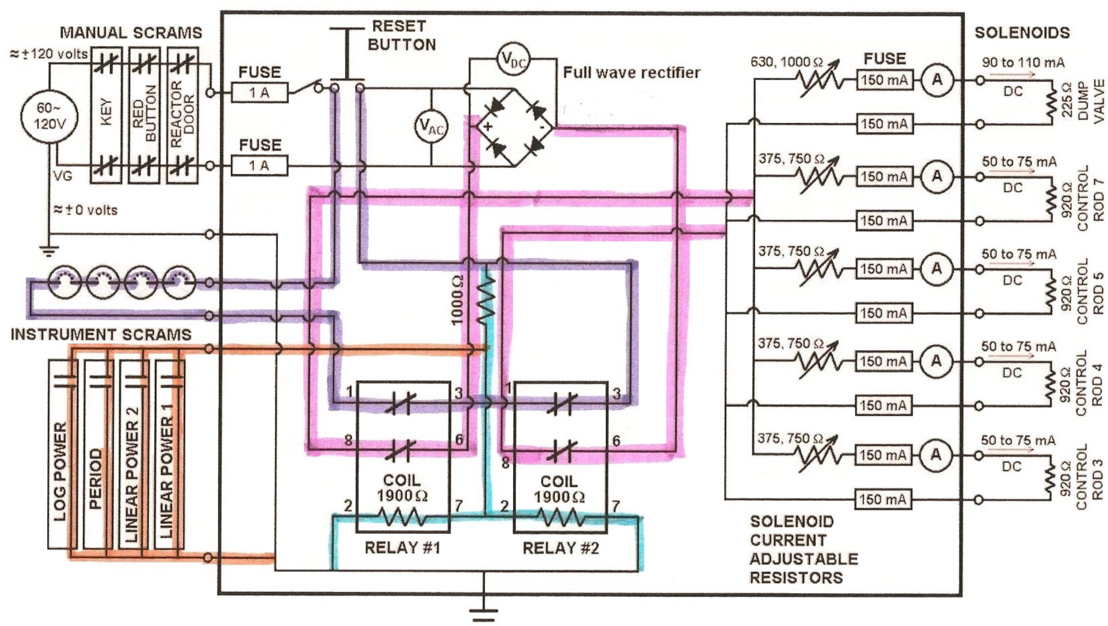
QUESTION C.05 [1.0 point]
Use the drawing of the Scram Block Diagram provided. The function of the Full Wave rectifier is to:

a. Convert the AC voltage to the DC voltage for the Instrument Scram circuit.

b. Convert the DC voltage to the AC voltage for Key, Red Button, and Reactor Door Scrams.

c. Provide the AC voltage to Key, Red Button, and Reactor Door Scrams; and provide the DC voltage to Instrument Scram circuit.

d. Provide the DC voltage to Key, Red Button, and Reactor Door Scrams; and provide the AC voltage to Instrument Scram circuit.



QUESTION C.06 [2.0 points, 0.5 each]
For the area radiation monitoring system, match the alarm settings in Column B with the appropriate channel in Column A. Items in Column B may be used once, more than once, or not at all.

	Column A		Column B
a.	Control room	1.	10 mR/hr
b.	Equipment hallway	2.	20 mR/hr
c.	Vault criticality monitor	3.	40 mR/hr
d.	Reactor deck	4.	100 mr/hr
		5.	200 mR/hr

QUESTION C.07 [1.0 point]
Use the drawing of the Interlock Block Diagram provided. Which ONE of the following conditions is allowed to move the control rods?

a. Fill Pump: OFF + Recorder: ON + Reactor Period >15 sec + Startup Channel < 2 cps

b. Fill Pump: OFF + Recorder: OFF + Reactor Period <15 sec + Startup Channel > 2 cps

c. Fill Pump: ON + Recorder: ON + Reactor Period >15 sec + Startup Channel > 2 cps

d. Fill Pump: OFF + Recorder: ON + Reactor Period >15 sec + Startup Channel > 2 cps

Category C: Facility and Radiation Monitoring Systems

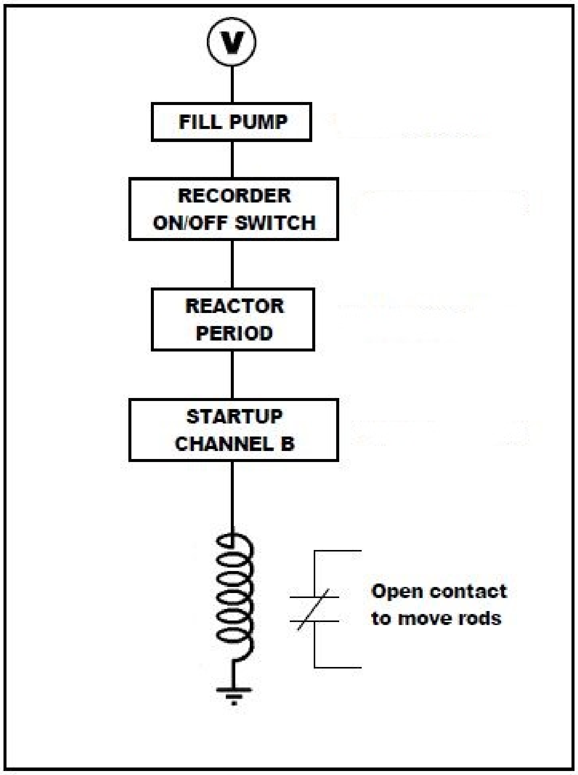


Figure 7.2: Interlock Block Diagram

QUESTION C.08 [1.0 point, 0.25 each]
Select YES/NO to the following systems that have a bypass provision.

a. Linear Power High Neutron Level Scram (Y/N)

b. Moderator Dump Valve Scram (Y/N)

c. Reactor Door Scram (Y/N)

d. Log N Period Scram (Y/N)

QUESTION C.09 [2.0 points, 0.5 each]
Match the item provided in column A, with the correct Nuclear Instrumentation from column B. (Items in column B can be used only once.)

	Column A		Column B
a.	< 2 cps rod withdrawal inhibit	1.	Log N
b.	Reactor period scram	2.	Start-up Channel
c.	High Flux Scram	3.	Linear Power Channel
d.	Reactor Key Switch	4.	AC Power Supply

QUESTION C.10 [1.0 point]
Control rods are partially withdrawn from the core. At this point, the Fill Pump is turned ON by the operator. As a result:

a. the control rods cannot be withdrawn any further.

b. the control rods cannot be inserted any further.

c. the control rods stuck and cannot be moved in any direction.

d. the control rods can only be inserted by placing the key switch in the “OFF” position.

QUESTION C.11 [1.0 point]
Which of the following would you most likely find in the control rod “baskets”?

a. An aluminum oxide (Al_2O_3) insulator.

b. A reflector section made of graphite.

c. An absorber section made of boron.

d. An absorber section made of cadmium.

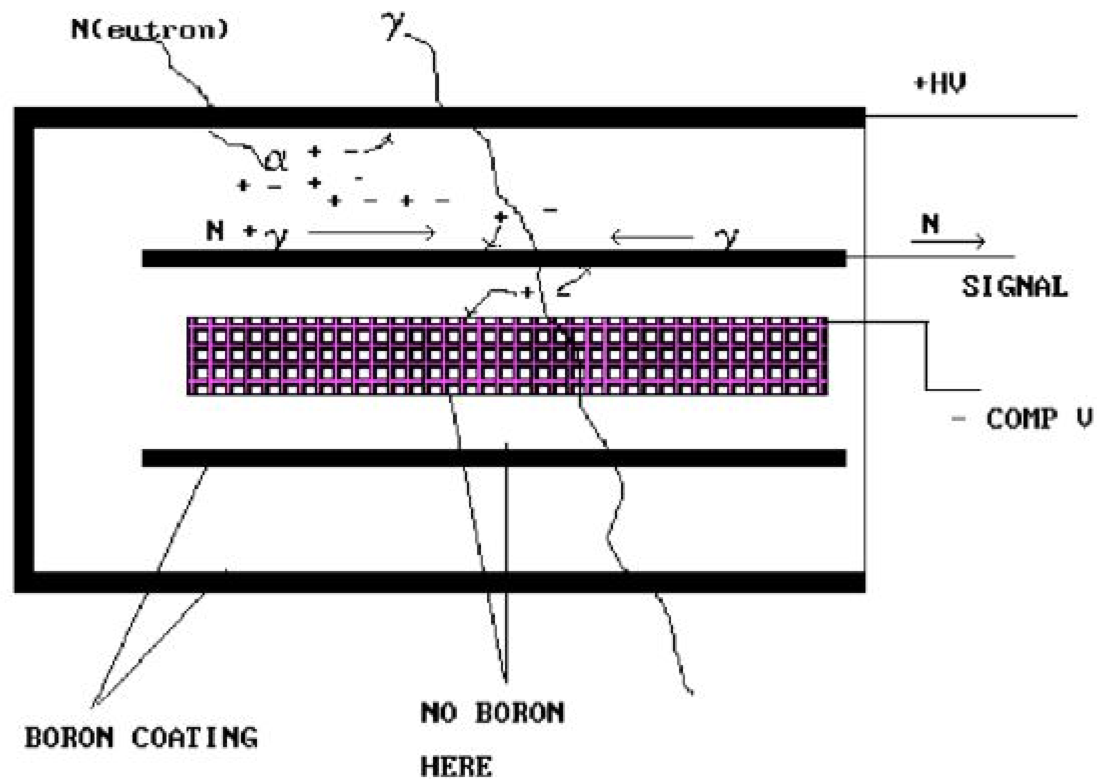
QUESTION C.12 [1.0 point]
The Figure below depicts:

a. The Compensated Ion Chamber.

b. The Uncompensated Ion Chamber.

c. The Gamma Ion Chamber.

d. The Fission Chamber.



QUESTION C.13 [1.0 point]
The RCF neutron startup source is:

a. Americicium-Beryllium (Am-Be)

b. Uranium-Beryllium (U-Be)

c. Radon-Beryllium (Ra-Be)

d. Plutonium-Beryllium (Pu-Be)

QUESTION C.14 [1.0 point]
The RCF fuel element shall consist of:

a. uranium fuel in the form of 4.8 weight percent or less enriched UO_2 pellets in stainless steel cladding.

b. uranium fuel in the form of 8.4 weight percent or less enriched UO_2 pellets in stainless steel cladding.

c. uranium fuel in the form of 4.8 weight percent or less enriched UO_2 pellets in aluminum cladding.

d. uranium fuel in the form of 8.4 weight percent or less enriched UO_2 pellets in aluminum cladding.

QUESTION C.15 [1.0 point]
Per RCF Technical Specifications, the main reason to have the minimum number of 4 control rods is to:

a. Control the thermal power from exceeding 100 W.

b. Reduce the effect of flux tilting due to uneven power distribution.

c. Prevent conditions which would cause fuel element failure in SPERT fuel.

d. Ensure there is adequate shutdown margin, even for a stuck rod condition.

QUESTION C.16 [1.0 point, 0.25 each)]
The storage tank needs to be refilled with fresh water from the city water supply. Therefore, you need to turn or check these valves in OPEN or CLOSE. Select the following valves' status during the refill of the water.

a. Valves #15 (city water supply) Open/Close

b. Valves #16 (city water supply Open/Close

c. Valves #18 (vent) Open/Close

d. Valves #7 (to storage tank) Open/Close

(***** END OF CATEGORY C *****)
((***** END OF EXAM *****))

Category A: Reactor Theory, Thermodynamics, and Facility Operating Characteristics

A.01
Answer: a
Reference: Burn, R., Introduction to Nuclear Reactor Operations, ©3.3, 1988

A.02
Answer: b
Reference: Burn, R., Introduction of Nuclear Reactor Operations, © 1988, Sec 3.3.1

A.03
Answer: c
Reference: Reactivity added = 0.1 % ∆k/k = 0.001 ∆ k/k

$\tau = (\beta-\rho)/\lambda_{eff}\rho = \frac{0.0078 - 0.001}{(0.1)(0.001)} = 68$ seconds

A.04
Answer: d
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Sec 4.6
For S/D reactor, τ = -80 seconds. Time = 180 seconds.
$P = P_0\, e^{t/\tau} = 3 \times 10^6\, e^{-180/80} = 3.162 \times 10^5$

A.05
Answer: d
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, Section 3.2

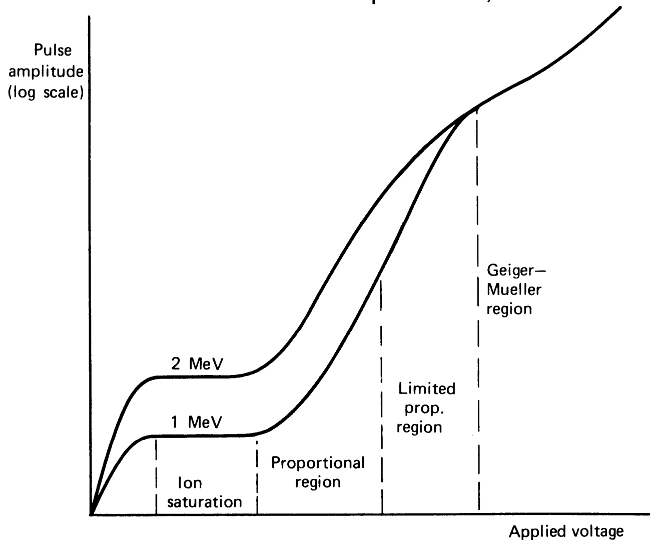
A.06
Answer: d
Reference: Burn, R., Introduction of Nuclear Reactor Operations, © 1988, Figure 3.3

A.07
Answer: d
Reference: Burn, R., Introduction of Nuclear Reactor Operations, © 1988, Sec 4.2
When the insertion of 0.008 ∆k/k > Keff, reactor is prompt critical.

A.08
Answer: a
Reference: P = P0 et/T —> ln(4) = time ÷ 10 seconds –> time = ln (4) x 10 sec. 1.386 x 10 ≈ 13.8 sec.

A.09
Answer: d
Reference: Reactor is increasing, then constant when reactor period reaches to infinitive.

A.10
Answer: d
Reference: A Manual of Experiment, MANE-4440, Section 1.2



A.11
Answer: b
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1982, Sec 3.3.3, page 3-21.
$\Delta\rho$ = keff1-keff2/(keff1 x keff2) = 0.95-0.8 /(0.8*0.95)=0.197 $\Delta k/k$

A.12
Answer: a. = fertile; b. = fissile; c. = fertile; d. = fissile
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Sec 3.2

A.13
Answer: a
Reference: $\Delta\rho = (K_{eff1} - K_{eff2}) \div (K_{eff1} * K_{eff2})$
$\Delta\rho = (1.0000-0.9550) \div (0.9550 * 1.0000)$
$\Delta\rho = 0.0450 \div 0.9550 = 0.0471$

A.14
Answer d
Reference: Introduction to Nuclear Operation, Reed Burn, 1988, Sec 2.45

A.15
Answer: c
Reference:
$P = Poe^{t/T}$ $80 = 20e^{60\ sec/T}$ T = 43.28 sec 160 watts = $0.080e^{t/43.28}$
t = 329 sec = 5.5 minutes

A.16
Answer: b
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, § 3.13

Category A: Reactor Theory, Thermodynamics, and Facility Operating Characteristics

A.17
Answer: a = alpha b = +1 β0 c = neutron d = alpha (0.25 each)

A.18
Answer: c
Reference: Burn, R., Introduction to Nuclear Reactor Operations, ©4.5, 1988

Category B: Normal/Emergency Operating Procedures and Radiological Controls

B.01
Answer: a
Reference: TS 3.8, Bases

B.02
Answer: b
Reference: $A = A_{\circ} * e^{-\lambda t}$
$0.1Ci = 1\ Ci * e^{-\lambda(t)}$
$\lambda = \ln(2) / (\text{half-life})$
$\lambda = 0.693 / 2$ years $= 0.3466$
$\ln(0.1/1) = -0.3466*(t)$ --> $-2.30/-0.3466$
solve for t: 6.6 years

B.03
Answer: b
Reference: TS 3.2

B.04
Answer: c
Reference: TS 6.5

B.05
Answer: d
Reference: TS 3.7.1

B.06
Answer: b
Reference: TS 2.1 and 2.2, Objective

B.07
Answer: a
Reference: 10 CFR Part 55.53
• 55.53(i) – the licensee shall have a biennial medical examination.
• 55.53(h), 55.59(c) – annual operating tests
• 55.53(e) – the licensee shall actively perform the functions of a licensed operator
for a minimum of 4 hours per calendar quarter.
• 55.53(h), 55.59(c)(1) – "The requalification program must be conducted for a continuous period not to exceed 2 years"
License renewal : 6 years

B.08
Answer: c
Reference: $DR_1D_1^2 = DR_2D_2^2$;
20 mrem/hr at one meter (100 cm.)
results in 222.2 mrem/hr at 30 cm.

B.09
Answer: c
Reference: 10CFR20 - At 20 feet, there is no beta radiation. Gamma at 20 feet = 0.1 mrem/hour, gamma at 1 foot = 40 mrem/hour. Therefore a ratio = 40 mrem/hr/60 mrem/hr = 0.67

B.10
Answer: c
Reference: TS 2.2 and 3.1

B.11
Answer: d
Reference: $DR_1*(D_1)^2 = DR_2*(D_2)^2$;
500 mrem $(2)^2$ = 5 mrem $(d)^2$
D = 20 ft

B.12
Answer: b
Reference: 10CFR20

B.13
Answer: b
Reference: Emergency Plan, Section 5

B.14
Answer: b
Reference: 10CFR20

B.15
Answer: b
Reference: TS 3.8

B.16
Answer: b
Reference: TS 2.2

B.17
Answer: d
Reference: 10CFR55

B.18
Answer: b
Reference: EP, Definitions

Category C: Facility and Radiation Monitoring Systems

C.01
Answer: c
Reference: Pre-Startup Procedures, Section I

C.02
Answer: c
Reference: SOP, Section D, Securing the Reactor

C.03
Answer: b
Reference: TS 3.2, Table 2

C.04
Answer: d
Reference: SOP, Section A, Reactor Startup

C.05
Answer: a
Reference: SAR 7.3

C.06
Answer: c
Reference: a. = 1 b. = 3 c. = 2 d. = 4 (0.5 each)
SAR, 7.7 Radiation Monitoring System

C.07
Answer: d
Reference: SAR, Figure 7.2

C.08
Answer: a = N b = Y c = Y d = N (0.25 each)
Reference: TS 3.2

C.09
Answer: a = 2 b = 1 c = 3 d = 4 (0.5 each)
Reference: TS 3.2

C.10
Answer: a
Reference: SAR 7.3

C.11
Answer: c
Reference: SAR 4.2.2

Category C: Facility and Radiation Monitoring Systems

C.12
Answer: a
Reference: NRC Standard Questions

C.13
Answer: d
Reference: SAR 4.1

C.14
Answer: a
Reference: TS 5.3 and SAR 4.2.1

C.15
Answer: d
Reference: TS 3.2.2

C.16
Answer: a = Open b = Open c = Close d = Open (0.25 each)
Reference: SOP, Section J, Water Refill