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

April 21, 2022

Mr. Andrew Cook
Interim Reactor Facility Director
Radiation Sciences Department
Armed Forces Radiobiology Research Institute
4301 Jones Bridge Road, Building 42
Bethesda, MD 20889-5648

SUBJECT: EXAMINATION REPORT NO. 50-170/OL-22-01, ARMED FORCES RADIOBIOLOGY RESEARCH INSTITUTE

Dear Andrew Cook:

During the week of February 28, 2022, the U.S. Nuclear Regulatory Commission (NRC) administered operator licensing examinations at the Armed Forces Radiobiology Research Institute (AFRRI) and Idaho National Laboratory Neutron Radiography (INL/NRAD). The examinations were conducted according to NUREG-1478, "Operator Licensing Examiner Standards for Research and Test Reactors," Revision 2, Federal Register Notice 2021-23467, and AFRRI exemption Docket ID NRC 2021-0198. Examination questions and preliminary findings were discussed with you and 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. If you have any questions regarding the examination, please contact Michele DeSouza at (301) 415-0747 or Michele.DeSouza@nrc.gov.

Sincerely,

Travis L. Tate Digitally signed by Travis L. Tate

Travis L. Tate, Chief
Non-Power Production and Utilization Facility
Oversight Branch
Division of Advanced Reactors and Non-Power
Production and Utilization Facilities
Office of Nuclear Reactor Regulation

Docket No. 50-170

Enclosures:
1. Examination Report No. 50-170
/OL-22-01
2. Written Examination

cc (w/o enclosures): See next page

SUBJECT: EXAMINATION REPORT NO. 50-170/OL-22-01, ARMED FORCES RADIOBIOLOGY RESEARCH INSTITUTE DATED: APRIL 21, 2022

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ADAMS ACCESSION No.: ML22111A277 ***via email** **NRR-079**

Office	NRR/DANU/UNPO/CE	NRR/DANU/UNPO/OLA*	NRR/DANU/UNPO/BC*
Name	MDeSouza	ZTaru	TTate
Date	03/07/2022	04/19/2022	04/21/2022

OFFICIAL RECORD COPY

cc:

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Montgomery County Executive
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Environmental Program Manager III
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Test, Research and Training
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Attention: Ms. Amber Johnson
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Manager
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Colonel Mohammad Naeem, Director
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U. S. NUCLEAR REGULATORY COMMISSION
OPERATOR LICENSING INITIAL EXAMINATION REPORT

REPORT NO.: 50-170/OL-22-01

FACILITY DOCKET NO.: 50-170

FACILITY LICENSE NO.: R-84

FACILITY: Armed Forces Radiobiology Research Institute

EXAMINATION DATES: February 28 – March 4, 2022

SUBMITTED BY: *Michele C DeSouza* 03/07/2022
Michele C DeSouza, Chief Examiner Date

SUMMARY:
During the week of February 28, 2022, the NRC administered operator licensing examinations to three Senior Reactor Operator-Institute (SRO-I) and one Reactor Operator (RO) candidates. Three SRO-I and one RO candidates passed all applicable portions of the examinations.

REPORT DETAILS

1. Examiner: Michele C DeSouza, Chief Examiner, NRC

2. Results:

	RO PASS/FAIL	SRO PASS/FAIL	TOTAL PASS/FAIL
Written	1/0	3/0	4/0
Operating Tests	1/0	3/0	4/0
Overall	1/0	3/0	4/0

3. Exit Meeting:
Michele C DeSouza, Chief Examiner, NRC
LTC Jeffrey Brown, AFRRI, Chief of Staff
LTC Omololu Makinde, AFRRI Head, Radiation Sciences Department
2LT Lionel Gumireddy, AFRRI Executive Officer, Radiation Sciences Department
Andrew Cook, AFRRI Interim Reactor Facility Director

Prior to administration of the written examination, based on facility comments, adjustments were accepted. Comments provided corrections and additional clarity to questions/answers and identified where changes were appropriate based on current facility conditions. During emergency response simulations the NRC Examiner noted fire extinguishers were not present throughout the reactor, reactor related and support areas. This information was provided at the exit meeting and passed to the NRC Inspector. Upon completion of all operator licensing examinations, 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.

U.S.NRC

UNITED STATES NUCLEAR REGULATORY COMMISSION

Protecting People and the Environment

Armed Forces Radiobiology Research Institute

Operator Licensing Examinations

Week of February 28, 2022

ENCLOSURE 2

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

FACILITY: AFRRI

REACTOR TYPE: TRIGA

DATE ADMINISTERED: 03/04/2022

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
20.00	33.3	_____	_____	A. REACTOR THEORY, THERMODYNAMICS AND FACILITY OPERATING CHARACTERISTICS
20.00	33.3	_____	_____	B. NORMAL AND EMERGENCY OPERATING PROCEDURES AND RADIOLOGICAL CONTROLS
20.00	33.3	_____	_____	C. FACILITY AND RADIATION MONITORING SYSTEMS
60.00		_____ FINAL GRADE	_____ %	TOTALS

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

_____
Candidate's Signature

Category A: Reactor Theory, Thermodynamics, and 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 ___

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 ___

A18 a b c d ___

A19 a _____ b _____ c _____ d _____ (0.25 each)

A20 a b c d ___

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

Category B: Normal/Emergency 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 _____ (0.25 each)

B13 a b c d ___

B14 a b c d ___

B15 a _____ b _____ c _____ d _____ (0.25 each)

B16 a b c d ___

B17 a b c d ___

B18 a b c d ___

B19 a b c d ___

B20 a b c d ___

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

Category C: Facility and Radiation 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~~ DELETED d _____ ~~(0.5 each)~~ (0.66 each)

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 ___

C07 a b c d ___

C08 a b c d ___

C09 a b c d ___

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 ___

C17 a b c d ___

C18 a b c d ___

C19 a b c d ___

(***** 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 only 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

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

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

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

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

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

$$\ell^* = 1\times10^{-4}\ \text{sec}$$

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

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

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

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

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

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

$$M = \frac{1-K_{eff_1}}{1-K_{eff\,2}}$$

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

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

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

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

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

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

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

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

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

$$DR = DR_0 e^{-\mu x}$$

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

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-lbf
1 gal (H_2O) ≈ 8 lbm
c_P = 1.0 BTU/hr/lbm/°F
1ft = 30.48 cm

1 kg = 2.21 lbm
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]
During a reactor startup, criticality occurred at a LOWER rod height than the last startup. Which ONE of the following reasons could be the cause?

a. Moderator temperature increased

b. Adding an experiment with positive reactivity

c. Adding an experiment with negative reactivity

d. Maintenance on the control rods resulted in a slightly faster rod speed

QUESTION A.02 [1.0 point]
The reactor is critical and increasing in power. Power has increased from 10 W to 800 W in 90 seconds. How long at this rate will it take power to increase from 4 kW to 10 kW?
Note: neglect the negative temperature coefficient.

a. 8 seconds

b. 19 seconds

c. 35 seconds

d. 67 seconds

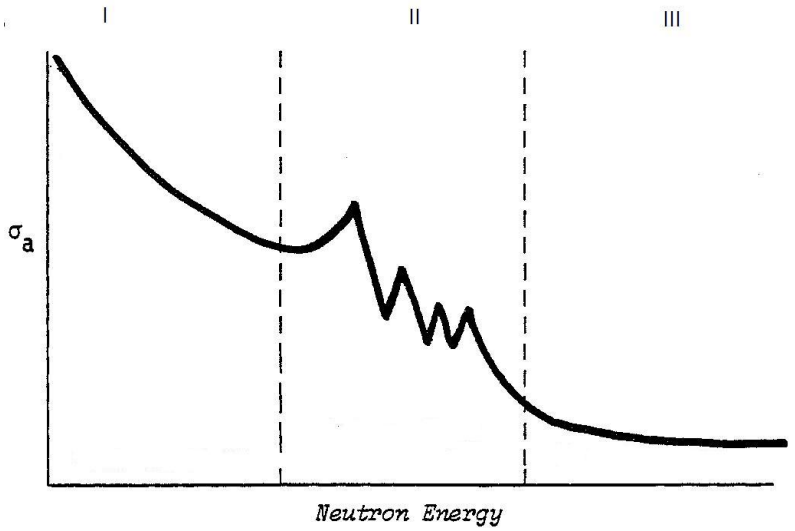
QUESTION A.03 [1.0 point]
In the following graph, how is the neutron behavior within Region II best described?

a. The neutron cross-section is inversely proportional to the neutron velocity (1/V)

b. Neutrons of specific energy levels have a greater potential for leakage from the reactor core

c. The neutron cross-section decreases steadily with increasing neutron energy (1/E)

d. Neutrons of specific energy levels are more likely to be readily absorbed than neutrons at other energy levels



QUESTION A.04 [1.0 point]
A reactor is subcritical with the following values for each of the factors in the six-factor formula:

Fast Fission Factor = 1.03	Fast non-leakage probability = 0.84
Resonance Escape Probability = 0.96	Thermal non-leakage probability = 0.88
Thermal Utilization Factor = 0.68	Reproduction Factor = 1.96

A control rod is withdrawn to bring the reactor back to critical. Assuming all other factors remain unchanged, the new value for the Thermal Utilization Factor is approximately:

a. 0.695

b. 0.698

c. 0.702

d. 0.704

QUESTION A.05 [1.0 point]
Following a reactor scram, what is the reason for the 80 second negative period?

a. Decay constant for the longest-lived precursor

b. Fuel temperature coefficient adds positive reactivity as a result of the decrease in fuel temperature following a scram

c. The ability of U-235 to fission with source neutrons

d. The amount of negative reactivity added during a scram is greater than the shutdown margin

QUESTION A.06 [1.0 point]
What ONE of the following is the primary heat transfer mechanism through the cladding of a fuel rod?

a. Radiation

b. Convection

c. Conduction

d. Mass transfer

QUESTION A.07 [1.0 point]
Which ONE of the following has a long-term effect on K_{eff} but is of no consequence during short term and transient operation?

a. Fuel burnup

b. Increase in fuel temperature

c. Increase in moderator temperature

d. Xenon and Samarium fission products

QUESTION A.08 [1.0 point]
An experimenter inserts an experiment into the core, and the count rate decreases to 60 cps from an original count rate of 100 cps. Given the initial K_{eff} of the reactor was 0.92, what is the worth of the experiment?

a. $\Delta\rho = + 0.02$

b. $\Delta\rho = - 0.04$

c. $\Delta\rho = - 0.07$

d. $\Delta\rho = + 0.07$

QUESTION A.09 [1.0 point]
Which ONE of the following best describes the values of K_{eff} and ρ during the power increment when the reactor is increasing power from 10 kW to 100 kW in a prompt criticality?

a. $K_{eff} > 1$ and $0 < \rho < \beta_{eff}$

b. $K_{eff} > 1$ and $\beta_{eff} < \rho < 1$

c. $K_{eff} > 1$ and $\rho > 1$

d. $K_{eff} > 1$ and $\rho > 1$

QUESTION A.10 [1.0 point]
Which ONE of the following is defined as the balance between the rate of production of fast neutrons from thermal fission and rate of absorption of thermal neutrons by the fuel?

a. Utilization Factor

b. Infinite Multiplication Factor

c. Reproduction Factor

d. Effective Multiplication Factor

QUESTION A.11 [1.0 point]
Inelastic scattering can be described as a process whereby a neutron collides with a nucleus in an excited state. What does the nucleus later emit?

a. Only an alpha particle

b. A beta particle and a neutron with lower energy

c. A gamma ray and a neutron with lower energy

d. A gamma ray and a neutron with higher energy

QUESTION A.12 [1.0 point]
Delayed neutrons contribute more to reactor stability than prompt neutrons because they _____ the average neutron generation time and are born at a _____ kinetic energy.

a. Increase, higher

b. Increase, lower

c. Decrease, higher

d. Decrease, lower

QUESTION A.13 [1.0 point]
Which ONE of the following is the meaning of '*any point on a differential rod worth curve*'?

a. The amount of reactivity that one unit (e.g. one inch, one percent) of rod motion would insert at that position in the core

b. The zero reactivity when the rod is on the bottom and the positive reactivity being added as the rod is withdrawn

c. The cumulative area under the differential curve starting from the bottom of the core

d. The negative reactivity added as the rod is inserted

QUESTION A.14 [1.0 point]
Excess reactivity is the amount of reactivity _____.

a. associated with burnable poisons.

b. needed to achieve prompt criticality.

c. available below that which is required to make the reactor subcritical.

d. available above that which is required to keep the reactor subcritical.

QUESTION A.15 [1.0 point]
How long will it take power to triple, given a reactor period of 32 seconds?

a. 62 seconds

b. 54 seconds

c. 41 seconds

d. 35 seconds

QUESTION A.16 [1.0 point]
Which is the effective multiplication factor, given the source strength is 10,000 neutrons per second (N/sec) and it produces the stable neutron count rate of 50,000 N/sec?

a. 0.65

b. 0.70

c. 0.75

d. 0.80

QUESTION A.17 [1.0 point]
Which ONE of the following answers provides the number of protons, the number of neutrons, and the number of electrons in the Uranium-235 nucleus ($_{92}U^{235}$)?

a. 92, 92, 143

b. 143, 92,143

c. 92, 143, 92

d. 143, 143, 92

QUESTION A.18 [1.0 point]
What is the reason the activity of the neutron poison Xe-135 peak hours after shutdown?

a. The fission fragments of Xe-135 decays with a 9.2 hour half-life to Cs-135

b. The fission fragments of I-135 decays with a 6.7 hour half-life to Xe-135

c. Delayed neutrons continue to produce Xe-135 after shutdown

d. The fission fragments of Te-135 decays with an 11 second half-life to I-135

QUESTION A.19 [1.0 point, 0.25 each]
Match the items in Column A with the isotopes in Column B.
The most important fission product poison is ^{135}Xe. The process that shows how this isotope is formed and its decay is:

Column A

$$\underbrace{\mathbf{a}}_{fission} \xrightarrow[19s]{} {}_{-1}^{0}\beta + \underbrace{\mathbf{b}}_{fission} \xrightarrow[6.57h]{} {}_{-1}^{0}\beta + \underbrace{{}_{54}^{135}Xe}_{fission} \xrightarrow[9.1h]{} {}_{-1}^{0}\beta + \mathbf{c} \xrightarrow[2.3E6y]{} \mathbf{d}\ (stable)$$

Column B

1. $_{56}\mathrm{Ba}^{135}$
2. $_{52}\mathrm{Te}^{135}$
3. $_{53}\mathrm{I}^{135}$
4. $_{55}\mathrm{Cs}^{135}$

QUESTION A.20 [1.0 point]
What is the major source of energy released during fission?

a. Kinetic energy of prompt and delayed neutrons

b. Kinetic energy of fission fragments

c. Alpha and beta radiation

d. Gamma radiation decay

(***** End of Category A *****)

Category B: Normal and Emergency Operating Procedures and Radiological Controls

QUESTION B.01 [1.0 point]
The pool is ruptured and causes a significant loss of water to occur. Which ONE of the following is most likely the greatest concern as a result of this event?

a. Increased personnel exposure to higher amounts of radiation

b. Ground contamination to the surrounding water table

c. Fission products release due to cladding rupture

d. Zirconium-Hydride interact with oxygen in air, releasing explosive hydrogen gas due to TRIGA fuel overheat

QUESTION B.02 [1.0 point]
In an emergency, 10 CFR 50.54 allows reasonable action that departs from a license condition or a technical specification when this action is immediately needed to protect the public health and safety. In this case, what is the MINIMUM level of authorization or approval needed to depart from a license condition or technical specification?

a. Senior Reactor Operator

b. Reactor Operator

c. Director, AFRRI

d. President, USUHS

QUESTION B.03 [1.0 point]
What federal regulation will you find the radiation dose limits for an individual member of the public, received as a result of facility operations?

a. 10 CFR 20

b. 10 CFR 50

c. 10 CFR 55

d. 10 CFR 70

Category B: Normal and Emergency Operating Procedures and Radiological Controls

QUESTION B.04 [1.0 point]
Which ONE of the following conditions below is NOT permissible when the reactor is operating? (According to the AFRRI Technical Specifications).

a. Fuel temperature = 500 ºC

b. Shutdown margin = $0.60

c. Primary pool temperature = 70 ºC

d. Maximum excess reactivity = $5.00

QUESTION B.05 [1.0 point]
What is the dose rate at 1 foot given 80% of the decay of a 2 Curie source results in emission of 100 keV gamma?

a. 0.09 R/hr

b. 0.96 R/hr

c. 9.60 R/hr

d. 960 R/hr

QUESTION B.06 [1.0 point]
According to the AFRRI Emergency Response Guidebook, which ONE of following events is NOT an event that would be considered a Class 0 event?

a. Civil disturbance at the Walter Reed National Military Medical Center

b. Fire alarm in the linear particle accelerator (LINAC)

c. Unanticipated actuation of the stack gas monitor

d. Medical injury incident occurs in the calibration facility standards laboratory

Category B: Normal and Emergency Operating Procedures and Radiological Controls

QUESTION B.07 [1.0 point]
What is the MINIMUM number of hours you must complete before resumption of functions authorized by your license if you were unable to perform the functions of an operator for the minimum number of hours during the previous calendar quarter?

a. 4

b. 6

c. 8

d. 10

QUESTION B.08 [1.0 point]
During reactor operations, you use a Geiger-Mueller detector to measure about 1 foot from the demineralizer tank. You measure the radiation reading between closed window and open window of the detector. In comparing the closed window reading to the open window reading the latter would:
(Assume no piping leaks or contamination)

a. increase because it measures additional beta radiation of Argon-41 decay from the tank.

b. remain the same because the quality factor for gamma and beta radiation are the same.

c. increase because it measures additional radiation of Nitrogen-16 and Tritium betas from the tank.

d. remain the same because it only measures gamma radiation from the demineralizer tank.

QUESTION B.09 [1.0 point]
According to the AFRRI Technical Specifications, which ONE of the following surveillance activities is NOT performed annually?

a. Control Rod Drop Times

b. Area Radiation Monitor Calibrations

c. Fuel Temperature Measuring Channels

d. Stack Gas Monitor Calibration

QUESTION B.10 [1.0 point]
A 40-mm thick sheet of lead placed at a certain location in a beam of gamma rays reduced the gamma radiation level from 600 mR/hr to 150 mR/hr. How much ADDITIONAL lead would be needed to reduce the gamma radiation level to 75 mR/hr?

a. 10 mm

b. 20 mm

c. 35 mm

d. 75 mm

QUESTION B.11 [1.0 point]
Which ONE of the following personnel '*directs the activities of the emergency and has overall responsibility of all personnel on site for the emergency or recovery operation"*?

a. AFRRI Director

b. Health Physics Coordinator

c. Security Coordinator

d. Operations Coordinator

QUESTION B.12 [1.0 point, 0.25 each]
Match the surveillances activities in Column A with the appropriate actions (Channel Check, Channel Test, or Channel Calibration) in Column B. (Answers may be used once, more than once, or not at all)

Column A	Column B
a. Adjustment of the Linear Power Channel Channel in accordance with data collected during a recent reactor power calibration	1. Channel CHECK 2. Channel TEST 3. Channel CALIBRATION
b. During performance of the Daily Startup Checklist, readings of Radiation Area Monitor 1 and Radiation Area Monitor 2 are compared	
c. During performance of the Daily Startup Checklist, a SCRAM button is pressed to verify a scram on the safety system channel	
d. The Continuous Air Monitor (CAM) detector is exposed to a 2 mCi check source to verify its output is operable	

QUESTION B.13 [1.0 point]
The AFRRI Requalification Program must be conducted for a continuous period not to exceed 24 months in duration, in accordance with _____.

a. 10 CFR 19

b. 10 CFR 20

c. 10 CFR 50

d. 10 CFR 55

QUESTION B.14 [1.0 point]
The reactor is shutdown with the pulse rod stuck all the way out. Calculate the amount of reactivity by which the reactor is shutdown with a stuck pulse rod. Assume the following values: Shim Rod Worth = $2.95; Regulating Rod Worth = $2.75; Safety Rod Worth = $2.00; Pulse Rod Worth = $2.25; Excess reactivity = $2.00.

a. $0.25

b. $2.00

c. $3.70

d. $5.70

QUESTION B.15 [1.0 point, 0.25 each]
Match the requirements of 10 CFR 55 in Column A with the appropriate time interval value in Column B. (Answers may be used once, more than once, or not at all)

Column A	Column B
a. Medical Examination	1. 1 year
b. License Expires	2. 2 years
c. Written Examination	3. 4 years
d. Operating Test	4. 6 years

QUESTION B.16 [1.0 point]
What is the exposure rate at a distance of 4 meters, if the initial exposure rate for a point source is 400 mR/hr at a distance of 2 meters?

a. 75 mR/hr

b. 100 mR/hr

c. 125 mR/hr

d. 45 mR/hr

Category B: Normal and Emergency Operating Procedures and Radiological Controls

QUESTION B.17 [1.0 point]
Which ONE of the following events does NOT require the presence of a licensed Senior Reactor Operator at the scene?

a. Initial reactor startup and approach to power

b. Insertion of experiment of $0.70

c. Relocation of Safety Rod

d. Fuel relocations within the reactor core

QUESTION B.18 [1.0 point]
According to the AFRRI Emergency Response Guidebook, who is the individual responsible for termination of an emergency?

a. Security Coordinator

b. OSH Advisor

c. ECP Commander

d. Health Physics Coordinator

QUESTION B.19 [1.0 point]
Which ONE of the following nuclides would most likely be present in the Continuous Air Monitor (CAM) in the event of a suspected fuel leak?

a. Argon-41

b. Krypton-85

c. Cobalt-60

d. Cesium-131

QUESTION B.20 [1.0 point]

There has been an observation of a tornado in the immediate Bethesda, Maryland local area. According to the AFRRI Emergency Response Guidebook, what is the emergency action level classification ?

a. Class 0, Event Less Severe than the Lowest Category

b. Class 1, Notification of Unusual Event

c. Class 2, Notification of Unusual Event

d. Class 2, Alert

(***** End of Category B *****)

Category C: Facility and Radiation Monitoring Systems

QUESTION C.01 [2.0 points, ~~0.5 each~~ 0.66 each]
Match the input signals listed in Column A with their AUTOMATIC control system responses in Column B (Items in Column B may be used once, more than once or not at all). Assume reactor is in operation.

_____	Column A	Column B
a.	NLW HV 20% loss	1. Indication ONLY
b.	Period = 4 seconds	2. Rod Withdrawal Prohibit
c.	~~Linear Power Channel = 1.1 MW~~ Multiple answers for c., this answer choice deleted	3. Scram
d.	Shim Rod withdrawal in Pulse Mode	

QUESTION C.02 [1.0 point]
Which ONE of the following best describes how to calculate the activity worth of experimental materials?

a. Measure the density and mass of the experimental materials

b. Calculate the radioactive decay of the experimental materials

c. Calculate the difference between k-excess with and without experimental materials

d. Calculate the difference in REG rod position at 10 kW with and without experimental material and then determine the worth

QUESTION C.03 [1.0 point]
What is the purpose of the neutron source in the reactor core?

a. Enables the reactor to go from subcritical to critical without moving rods

b. Acts as a reflector to prevent too many neutrons from escaping on initial startup

c. Prevents the reactor changing from manual to automatic if the period exceeds 10 seconds

d. Provides sufficient neutron population to ensure proper nuclear instrumentation response during initial startup

Category C: Facility and Radiation Monitoring Systems

QUESTION C.04 [1.0 point]
What is the nominal Hydrogen – Zirconium ratio in the TRIGA LEU fuel elements?

a. 1.7 Hydrogen atoms to 1.0 Zirconium atoms

b. 1.0 Hydrogen atoms to 1.6 Zirconium atoms

c. 30 Hydrogen atoms to 20 Zirconium atoms

d. 20 Hydrogen atoms to 30 Zirconium atoms

QUESTION C.05 [1.0 point]
Which ONE of the following provides an indication of the cleanliness of the pool water?

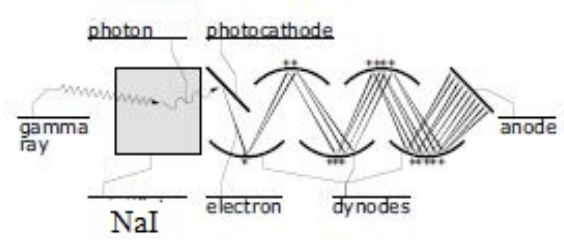
a. Highest pH

b. Highest resistivity

c. Highest conductivity

d. Highest flow rate

QUESTION C.06 [1.0 point]
Which ONE of the following is the basic design of the attached figure?



a. Film badge

b. Scintillation detector

c. Pocket ionization chamber

d. Thermoluminescent Dosimeter (TLD)

Category C: Facility and Radiation Monitoring Systems

QUESTION C.07 [1.0 point]
Which ONE of the following correctly explains how reactor pool level will be affected if, during reactor operation, a leak develops in the SECONDARY to PRIMARY heat exchanger?

a. Pool level will decrease because the Primary pressure is LOWER than Secondary pressure

b. Pool level will be the same because the Primary pressure is EQUAL to the Secondary pressure

c. Pool level will increase because the Primary pressure is LOWER than the Secondary pressure

d. Pool level will increase because the Primary pressure is HIGHER than the Secondary pressure

QUESTION C.08 [1.0 point]
What is the purpose of the diffuser system?

a. Prevents the pool water from being lost out of the pool through the primary outlet

b. Reflects neutrons back into the core

c. Limits the flow of water going into the demineralizer

d. Limits the radiation levels by keeping Nitrogen-16 from reaching the surface

QUESTION C.09 [1.0 point]
Which ONE of the following indications does the NPP-1000 provide after firing a pulse?

a. Peak Pulse Power and Energy

b. Peak Power and 1 kW Interlock

c. Peak Power and Reactor Period

d. Energy and Fuel Temperature

Category C: Facility and Radiation Monitoring Systems

QUESTION C.10 [1.0 point]
Where is the Safe Rod located in the reactor core?

a. D-1

b. D-7

c. D-13

d. E-1

QUESTION C.11 [1.0 point]
What is the purpose of the interlock to prevent withdrawal of more than one control rod at a time?

a. Prevent damage of control rod drive systems

b. Limits the amount of reactivity added per unit time

c. Limits the initiation of a pulse while on a positive period

d. Prevent increase of prompt neutrons when the reactor is in Square Wave mode

QUESTION C.12 [1.0 point]
Each fuel element storage rack permits temporary storage of _____ fuel elements submerged a minimum of _____ beneath the pool water surface.

a. 10, 9 meters

b. 9, 10 meters

c. 12, 10 feet

d. 12, 9 feet

QUESTION C.13 [1.0 point]
For calibration of the control rod, what is the technique called when '*the operator determines the rod reactivity by measuring the rate of decrease in power level by scram of the calibrated rod from the desired height*'?

a. Rod Drop Method

b. Positive Period Method

c. Thermal Power Calibration Method

d. Positive Period-Differential Worth Method

Category C: Facility and Radiation Monitoring Systems

QUESTION C.14 [1.0 point]
Which ONE of the following elements is MAINLY used as the neutron absorber on the AFRRI control rods?

a. Boron

b. Zirconium-Hydride

c. Enriched Uranium

d. Gold-Indium-Cadmium

QUESTION C.15 [1.0 point]
What is the MAIN purpose of the dashpots installed at the bottom of the barrel of a control rod?

a. Decrease friction during rod insertion

b. Reduce bottoming impact during a scram

c. Increase the rod scram time for the rod drop test

d. Increase the rod speed during an initial withdrawal

QUESTION C.16 [1.0 point]
The _____ neutron startup source utilizes a _____ reaction.

a. Am-Be; (α,η)

b. Sb-Be; (γ,η)

c. Am-Li; (α,η)

d. Am-Li; (γ,η)

Category C: Facility and Radiation Monitoring Systems

QUESTION C.17 [1.0 point]
Which ONE of the following best describes how the Uncompensated Ion Chamber (UIC) and Compensated Ion Chamber (CIC) operates?

a. The CIC has two chambers, both can detect gamma rays but only one is coated with Boron-10 for (n,α) reaction; whereas the UIC has only one chamber coated with Boron-1- for (n,α) reaction.

b. The CIC has two chambers, one is coated with U-235 for fission reaction and the other is coated with Boron-10 for (n,α); whereas the UIC has only one chamber coated with U-235 for fission reaction.

c. The CIC has only one chamber coated with Boron-10 for (n,α) reaction; whereas the UIC has two chambers, one is coated with U-235 for fission reaction and the other is coated with Boron-10 for (n,α) reaction.

d. The CIC has only one chamber coated with U-235 for fission reaction, whereas the UIC has two chambers, both can detect gamma rays but only one is coated with Boron-10 for (n,α) reaction.

QUESTION C.18 [1.0 point]
Which ONE of the following AFRRI experimental facility locations has the largest production rate of Ar-41?

a. Pneumatic transfer system with the reactor core at position adjacent to the pneumatic tubes

b. ER#2 with the reactor core at the extreme position closest to ER#2

c. ER#1 with the reactor core at the extreme position closest to ER#1

d. Facility In-Core Experimental Tubes

QUESTION C.19 [1.0 point]
Which ONE of the following lists the remote area monitors (RAMs) in the remote area monitoring system of primary concern to the reactor?

a. R-1, R-2, E-2 and E-3

b. R-1, R-3, E-1 and E-6

c. R-1, R-2, E-3 and E-6

d. R-1, R-2, E-1 and E-3

(***** End of Category C *****)
(********** End of the Exam **********)

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

A.01
Answer: b
Reference: Standard NRC Question

A.02
Answer: b
Reference: $P = P_o^{et}/T$
$800 = 10*e^{(90\ sec/T)}$
$T = 20.54sec$
$10\ kW = 4\ kW*e^{(t/20.54)}$
$t = 19\ sec$

A.03
Answer: d
Reference: DOE Fundamentals Handbook, NP-02

A.04
Answer: b
Reference: Burns, Section 3.3.1, page 3-16

A.05
Answer: a
Reference: Lamarsh, 3rd ed., page 345

A.06
Answer: c
Reference: Lamarsh, 3rd ed., Section 8.3, page 417

A.07
Answer: a
Reference: Standard NRC question

A.08
Answer: c
Reference: $CR_1 / CR_2 = (1 – K_{eff2}) / (1 – K_{eff1})$
$100 / 60 = (1 – K_{eff2}) / (1 – 0.92)$
Therefore $K_{eff2} = 0.867$
$\Delta\rho = (K_{eff2} – K_{eff1}) / (K_{eff2} * K_{eff1})$
$\Delta\rho = (0.867 – 0.92) / (0.867 * 0.92)$
$\Delta\rho = - 0.0664$

A.09
Answer: b
Reference: Burns, Section 3.2.1

A.10
Answer: c
Reference: DOE Fundamentals Handbook, NP-03, page 6

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

A.11
Answer: c
Reference: Burns, Section 2.4.5, page 2-29

A.12
Answer: b
Reference: Burns, Section 3.2.4, page 3-12 and Section 3.4.4, page 3-33

A.13
Answer: a
Reference: Burns, Example 7.2 (b), page 7-4

A.14
Answer: d
Reference: DOE Fundamentals of Engineering, Chapter 3, page 61

A.15
Answer: d
Reference: $P = P_0 e^{t/T}$
$3 = 1 \cdot e^{t/32}$
$t = 32 \cdot \ln(3)$
$t = 35.2$ sec

A.16
Answer: d
Reference: $CR = S/(1-K) \rightarrow 50000 = 10000/(1 - K) = 1 - X = 10000/50000$
$K = 0.8$

A.17
Answer: c
Reference: Chart of the Nuclides; 92 protons, 143 neutrons & 92 electrons

A.18
Answer: b
Reference: Lamarsh 3rd ed., Section 7.5, page 377 & Burns, Section 1.3.1, page 1-5

A.19
Answer: a. 2; b. 3; c. 4; d. 1
Reference: Lamarsh 3rd ed., Section 7.5, pg. 377 & Burns, Figure 8.1, page 8-6

A.20
Answer: b
Reference: Glasstone, Nuclear Reactor Engineering, Section 1.47 & Burns, Section 3.2.1, page 3-5

Category B: Normal and Emergency Operating Procedures and Radiological Controls

B.01
Answer: a
Reference: AFRRI SAR 7.7

B.02
Answer: a
Reference: 10 CFR 50.54(y)

B.03
Answer: a
Reference: 10 CFR 20

B.04
Answer: c
Reference: AFRRI Technical Specifications, Sections 3.1, 3.1.3 and 3.1.6

B.05
Answer: b
Reference: 6Cen = R/hr at 1 ft. 6 x (2 Ci) x (0.8 x 0.1) = 0.96 R/hr at 1 ft.

B.06
Answer: c
Reference: AFRRI Emergency Response Guidebook, pages 7-9

B.07
Answer: b
Reference: 10 CFR 55.53 (f)

B.08
Answer: d
Reference: Standard NRC question (betas cannot make it through the tank)

B.09
Answer: a
Reference: AFRRI Technical Specifications Sections 4.2 and 4.5

B.10
Answer: b
Reference: $DR = DR^{*}e^{-\mu X}$, Find μ; $150 = 600^{*} e^{-\mu^{*}40}$; μ = 0.0346
If insertion of an HVL (thickness of lead), the original intensity will be reduced by half.
Find X: $1 = 2^{*} e^{-0.0346^{*}X}$; X= 20 mm
Find HVL by shortcut: 600mR- 300 mR is the 1st HVL; 300 mR – 150 mR is the 2nd HVL; 150- mR – 75 mR is the 3rd HVL

Category B: Normal and Emergency Operating Procedures and Radiological Controls

B.11
Answer: a
Reference: AFRRI Emergency Plan Section 3.0

B.12
Answer: a. 3; b. 1; c. 2; d. 2
Reference: AFRRI Technical Specifications Definitions

B.13
Answer: d
Reference: 10 CFR 55.59(a)(1)

B.14
Answer: c
Reference: Safe rod + Shim rod + Reg rod = $5.70. Excess reactivity - $5.70 = - $3.70

B.15
Answer: a. 2 (2 years); b. 4 (6 years); c. 2 (2 years); d. 1 (1 year)
Reference: AFRRI Technical Specifications Definitions

B.16
Answer: b
Reference: $I_2 = I_1 D_1^2 / d_2^2$; $I_2 = (400 \text{ mR/hr})(2\text{m})^2 / (4\text{m})^2$; $I_2 = 100$ mR/hr

B.17
Answer: b
Reference: AFRRI Technical Specifications 6.1.3.2

B.18
Answer: c
Reference: AFRRI Emergency Response Guidebook J2 page 65 & 67

B.19
Answer: b
Reference: AFRRI SAR 7.8.2

B.20
Answer: b
Reference: AFRRI Emergency Response Guidebook, Page 8

Category C: Facility and Radiation Monitoring Systems

C.01
Answer: a. 2; b. 1; ~~c. 3~~; d. 2
Reference: AFRRI Technical Specifications 3.2, 3.3, SAR Table 7-1
Multiple answers for c., this answer choice deleted

C.02
Answer: c
Reference: AFRRI SOP-010, Conduct of Experiments

C.03
Answer: d
Reference: AFRRI Technical Specifications

C.04
Answer: a
Reference: AFRRI Technical Specifications 5.2

C.05
Answer: b
Reference: NRC Standard Question

C.06
Answer: b
Reference: Basic Radiological Knowledge Question

C.07
Answer: c
Reference: AFRRI SAR 5

C.08
Answer: d
Reference: AFFRI SAR 5.6

C.09
Answer: a
Reference: AFRRI SAR 7.2.2.1.4 & 7.6.4.2.5

C.10
Answer: b
Reference: AFRRI SAR Figure 4-6

Category C: Facility and Radiation Monitoring Systems

C.11
Answer: b
Reference: AFRRI Technical Specifications 3.2.2, page 15

C.12
Answer: d
Reference: AFRRI SAR 9.2

C.13
Answer: a
Reference: Standard NRC Question

C.14
Answer: a
Reference: AFRRI SAR 4.6

C.15
Answer: b
Reference: AFRRI SAR 4.6.2

C.16
Answer: a
Reference: AFRRI SAR 11.1.1.3 and Chart of Nuclides

C.17
Answer: a
Reference: NRC Previous Exam

C.18
Answer: b
Reference: AFRRI SAR 10.2.5, Table 10-2

C.19
Answer: c
Reference: AFRRI SAR 7.8.1, Table 7-10