



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

May 23, 2024

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-24-01, ARMED FORCES  
RADIOBIOLOGICAL RESEARCH INSTITUTE

Dear Mr. Cook:

During the week of May 6, 2024, the U.S. Nuclear Regulatory Commission (NRC) administered an operator licensing examination at your Armed Forces Radiobiological Research Institute reactor. The examination was 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 component of NRC's Agencywide Documents Access and Management System (ADAMS). ADAMS is accessible from the NRC website 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 Amy Beasten at 301-415-8347 or via email at [Amy.Beasten@nrc.gov](mailto:Amy.Beasten@nrc.gov).

Sincerely,

A handwritten signature in dark ink, appearing to read "Travis L. Tate".

Signed by Tate, Travis  
on 05/23/24

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-24-01
2. Written examination

cc: w/enclosures to GovDelivery Subscribers

SUBJECT: EXAMINATION REPORT NO. 50-170/OL-24-01, ARMED FORCES  
RADIOBIOLOGICAL RESEARCH INSTITUTE DATED: MAY 23, 2024

**DISTRIBUTION:**

PUBLIC

JBowen, NRR

TTate, NRR

HCruz, NRR

CMontgomery, NRR

PBoyle, NRR

AWaugh, NRR

ABeasten, NRR

NJones, NRR

DTift, RGN-I

JNick, RGN-I

**ADAMS Accession No.: ML24095A247****NRR-079**

OFFICE	NRR/DANU/UNPO/CE	NRR/DANU/UNPO/OLA	NRR/DANU/UNPO/BC
NAME	ABeasten	NJones	TTate
DATE	5/23/2024	5/23/2024	5/23/2024

**OFFICIAL RECORD COPY**

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

REPORT NO.: 50-170/OL-24-01

FACILITY DOCKET NO.: 50-170

FACILITY LICENSE NO.: R-120

FACILITY: Armed Forces Radiobiology Research Institute

EXAMINATION DATES: Week of May 6, 2024

SUBMITTED BY: Amy Beasten 5/8/2024  
Amy Beasten, Chief Examiner Date

**SUMMARY:**

A retake written examination was conducted for one Senior Reactor Operator-Instant (SRO-I) candidate. The candidate failed the retake written examination.

REPORT DETAILS

1. Examiner: Amy E. Beasten, PhD, Chief Examiner, NRC

2. Results:

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

3. Exit Meeting:  
Amy E. Beasten, PhD, Chief Examiner, NRC  
Andrew Smolinski, Reactor Operations Supervisor  
Benjamin Knibbe, Training Coordinator  
Andrew Cook, Interim Reactor Facility Director

Prior to administration of the written exam, 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. Upon completion of all operator licensing examinations, the NRC examiners met with facility staff representatives to discuss the results and observations. At the conclusion of the meeting, the NRC examiners thanked the facility for their support in the administration of the examination.



**Armed Forces Radiobiology  
Research Institute Research Reactor**

**Operator Licensing Examination**

**Week of May 6, 2024**

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

FACILITY: AFRRRI Research Reactor

REACTOR TYPE: TRIGA

DATE ADMINISTERED: May 7, 2024

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 % OF CANDIDATE'S			% OF	
			CATEGORY	
<u>VALUE</u>	<u>TOTAL</u>	<u>SCORE</u>	<u>VALUE</u>	<u>CATEGORY</u>
<u>20.00</u>	<u>33.3</u>	<u>N/A</u>	<u>N/A</u>	<del>A. REACTOR THEORY, THERMODYNAMICS AND FACILITY OPERATING CHARACTERISTICS</del>
<u>20.00</u>	<u>33.3</u>	_____	_____	B. NORMAL AND EMERGENCY OPERATING PROCEDURES AND RADIOLOGICAL CONTROLS
<u>20.00</u>	<u>33.3</u>	<u>N/A</u>	<u>N/A</u>	C. FACILITY AND RADIATION MONITORING SYSTEMS
<u>20.00</u>	_____	_____	_____ %	TOTALS
FINAL GRADE				

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

\_\_\_\_\_  
Candidate's Signature

## NRC RULES AND GUIDELINES FOR LICENSE EXAMINATIONS

During the administration of this examination the following rules apply:

1. Cheating on the examination means an automatic denial of your application and could result in more severe penalties.
2. 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 one (1) hour for completion of the examination.

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 \_\_\_\_ (0.25 each)

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 \_\_\_\_

B19 a b c d \_\_\_\_

B20 a \_\_\_\_ b \_\_\_\_ c \_\_\_\_ d \_\_\_\_ (0.25 each)

(\*\*\*\*\* END OF CATEGORY B \*\*\*\*\*)  
(\*\*\*\*\* END OF EXAMINATION \*\*\*\*\*)

# EQUATION SHEET

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

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

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

$$P = P_0 e^{\ell/T}$$

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

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

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

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

$$CR_1(1 - K_{\text{eff}_1}) = CR_2(1 - K_{\text{eff}_2})$$

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

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

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

$$M = \frac{1 - K_{\text{eff}_1}}{1 - K_{\text{eff}_2}}$$

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

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

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

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

$$\Delta \rho = \frac{K_{\text{eff}_2} - K_{\text{eff}_1}}{K_{\text{eff}_1} K_{\text{eff}_2}}$$

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

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

$$DR_1 d_1^2 = DR_2 d_2^2$$

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

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

**1 Curie = 3.7 x 10<sup>10</sup> dis/sec**

**1 kg = 2.21 lb**

**1 Horsepower = 2.54 x 10<sup>3</sup> BTU/hr**

**1 Mw = 3.41 x 10<sup>6</sup> BTU/hr**

**1 BTU = 778 ft-lb**

**°F = 9/5 °C + 32**

**1 gal (H<sub>2</sub>O) ≈ 8 lb**

**°C = 5/9 (°F - 32)**

**c<sub>p</sub> = 1.0 BTU/hr/lb/°F**

**c<sub>p</sub> = 1 cal/sec/gm/°C**



Category B: Normal/Emergency Operating Procedures and Radiological Controls

**QUESTION B.01 [1.0 point]**

In accordance with Procedure 004, SCRAMS, Alarms and Abnormal Conditions, which ONE of the following statements regarding scram recovery is NOT true?

- a. The SRO on-call must authorize restart following an inadvertent scram.
- b. All scrams, including manual scrams for routine operation, require the SRO on-call to be physically present to observe restart.
- c. Manual scrams for routine operation do not require approval for a restart.
- d. The Reactor Facility Director must authorize restart following an unexplained scram.

**QUESTION B.02 [1.0 point]**

An experiment reading 155 mrem/hr was removed from the reactor. Two hours later, it reads 40 mrem/h. What is the half-life of the experiment?

- a. 0.51 hr
- b. 0.98 hr
- c. 1.02 hr
- d. 3.21 hr

**QUESTION B.03 [1.0 point]**

Procedure 002, Reactor Operations, describes the Five Rules of Automatic Mode. Which ONE of the following statements best describes rod movement for power mismatches greater than 20%?

- a. Reactor power will increase on a 3 second period until the dead band is reached.
- b. Automatic control cannot be used for large power increases because the reactor automatically returns control to manual mode for mismatches of greater than 5% power.
- c. On a large power increase, the period term will overwhelm the mismatch term at about 10 seconds.
- d. Rod speed movement is scaled linearly so the rod will travel faster on shorter periods.

Category B: Normal/Emergency Operating Procedures and Radiological Controls

**QUESTION B.04 [1.0 point]**

Which ONE of the following defines the term “High Radiation Area”?

- a. Area where radiation exposure rates would result in a dose equivalent in excess of 0.1 rem (1 mSv) in one hour at 30 centimeters from the radiation source.
- b. Any area to which access is limited for any reason.
- c. Area where radiation exposure rates would result in a dose equivalent in excess of 5 mrem (0.05 mSv) in one hour at 30 centimeters from the radiation source.
- d. Any area to which access is limited for the purpose of protecting individuals against undue risks from exposure to radiation and radioactive materials.

**QUESTION B.05 [1.0 point]**

In accordance with the AFRRI Emergency Plan, which ONE of the following events would be classified as an ALERT?

- a. Fire within the reactor facility that cannot be extinguished within 15 minutes.
- b. Personnel exposures in excess of 10 CFR Part 20 limits.
- c. Unanticipated actuation of a reactor room continuous air monitor for 1 minute.
- d. Low pool level water alarm with an ongoing loss of pool water in excess of the normal and emergency makeup water systems.

**QUESTION B.06 [1.0 point]**

An irradiated sample has a dose rate of 20.0 rem/hr as indicated at a distance of 1.5 feet from the sample. How far from the irradiated sample will the dose rate read 700 mrem/hr?

- a. 2.54 ft.
- b. 4.28 ft.
- c. 6.55 ft.
- d. 8.02 ft.

Category B: Normal/Emergency Operating Procedures and Radiological Controls

**QUESTION B.07 [1.0 point]**

In accordance with procedure 010, Conduct of Experiments, all of the following experiments may be irradiated EXCEPT:

- a. Explosive material shall not be irradiated in the reactor in quantities greater than 25 milligrams.
- b. Corrosive materials shall be doubly encapsulated.
- c. The sum of the absolute reactivity worth of all experiments in the reactor and associated experimental facilities shall not exceed \$3.50.
- d. The absolute reactivity worth of any single moveable or unsecured experiment shall not exceed \$1.00.

**QUESTION B.08 [1.0 point]**

In accordance with procedure 004, SCRAMS, Alarms and Abnormal Conditions, all of the following conditions could cause an alarm EXCEPT:

- a. NFT1 > 500 °C.
- b. NP %Pwr 3 > 105%.
- c. NLW HV < 650V.
- d. Pool Temperature > 60 °C.

**QUESTION B.09 [1.0 point]**

According to AFRRl Technical Specifications, which ONE of the following statements is NOT permissible for operation?

- a. The reactor may be operated above 250 kW with one of the four control rod drives inoperable and the associated control rod drive fully inserted.
- b. Bulk water conductivity shall not exceed 5 µmhos/cm.
- c. If a Fuel Temperature Safety Channel becomes inoperable unexpectedly, the reactor shall be shut down if the channel cannot be restored within 5 minutes.
- d. In pulse mode, the maximum reactivity step insertion shall be \$3.50 or less.

Category B: Normal/Emergency Operating Procedures and Radiological Controls

**QUESTION B.10 [1.0 point, 0.25 each]**

Match the Technical Specification required surveillance in Column A with the surveillance frequency in Column B. Options in Column B may be used once, more than once, or not at all.

<u>Column A</u>	<u>Column B</u>
a. Reactivity worth of each standard control rod	1. Monthly
b. Chennel Test of stack gas monitoring system	2. Quarterly
c. Visual inspection of fuel elements in B, C, and D rings	3. Annually
d. Measurement of reactor coolant for radioactivity	4. Biennially

**QUESTION B.11 [1.0 point]**

In accordance with 10 CFR 20, individual members of the public are limited to a dose in an unrestricted area from an external source:

- a. 2000 mrem/hr.
- b. 200 mrem/hr.
- c. 20 mrem/hr.
- d. 2 mrem/hr.

**QUESTION B.12 [1.0 point]**

In accordance with procedure 201, Control Rods, which ONE of the following statements best describes the preliminary setup that must be performed if the control rod inspection?

- a. Performance of a shutdown margin calculation to determine the reactor will remain shutdown by a minimum of \$1.00 with the most reactive control rod removed from the core.
- b. Performance of a shutdown margin calculation and removal of three fuel elements from the B ring to determine the reactor will remain shutdown by a minimum of \$1.00 with the most reactive control rod removed from the core.
- c. Performance of a shutdown margin calculation and removal of enough fuel to determine the reactor will remain shutdown by a minimum of \$1.00 with any control rod removed from the core.
- d. Performance of a shutdown margin calculation and removal of enough fuel to determine the reactor will remain shutdown by a minimum of \$1.00 with any control rod removed from the core and a fuel followed control rod in the fuel section of the core.

Category B: Normal/Emergency Operating Procedures and Radiological Controls

**QUESTION B.13 [1.0 point]**

The radiation level in the control room is 90 mrem/hour, and the operator is in the control room for 21 minutes. How much dose will the operator receive?

- a. 31.5 mrem
- b. 27.3 mrem
- c. 17.8 mrem
- d. 12.4 mrem

**QUESTION B.14 [1.0 point]**

In accordance with procedure 004, SCRAMS, Alarms and Abnormal Conditions, all of the following are actions to be taken in the event of a Low Pool Level Scram Alarm EXCEPT:

- a. Turn off the primary pump to prevent cavitation.
- b. Initiate pool fill from the auxiliary console.
- c. Restore the alarming channel to operable within five minutes or shutdown the reactor.
- d. Verify the reactor has scrammed and power level is decreasing.

**QUESTION B.15 [1.0 point]**

You are currently a licensed operator at AFRRI. Which ONE of the following conditions would be a violation of 10 CFR 55.53, "Conditions of licenses"?

- a. The new requalification program cycle started 30 months ago.
- b. Your last requalification written examination was 13 months ago.
- c. Last quarter, you were the licensed operator for 8 hours.
- d. Your last medical exam was 16 months ago.

**QUESTION B.16 [1.0 point]**

In accordance with the AFRRI Emergency Plan, which ONE all of the following statements about the Emergency Response Team commander is true?

- a. The ERT commander makes formal emergency action level classifications and notifications.
- b. The ERT commander must hold a reactor operator license.
- c. The ERT commander may authorize special radiation exposures in excess of 10 CFR 20 limits.
- d. The ERT commander has the authority to terminate an emergency event.

Category B: Normal/Emergency Operating Procedures and Radiological Controls

**QUESTION B.17 [1.0 point]**

In accordance with AFRRI Technical Specifications, the Reactor and Radiation Facilities Safety Subcommittee (RRFSS) has all of the following review functions EXCEPT:

- a. Proposed changes to Technical Specifications or Safety Analysis Report.
- b. New experiments which could affect reactivity or result in an uncontrolled release of radioactivity.
- c. Any operations that result in a violation of Technical Specifications.
- d. Administrative changes to Technical Specification required procedures.

**QUESTION B.18 [1.0 point]**

All of the following are true statements regarding AFRRI Technical Specification surveillance requirements EXCEPT:

- a. Most surveillance requirements may be deferred during a reactor shutdown, except for ventilation and radiation monitoring surveillance requirements.
- b. All surveillance requirements must be completed within the grace period of the specified interval.
- c. Surveillance requirements that are deferred during reactor shutdown must be performed as soon as possible after the reactor is restarted.
- d. Surveillances which cannot be performed while the reactor is operating may be deferred until a planned shutdown.

**QUESTION B.19 [1.0 point]**

In accordance with procedure 215, Thermal Power Calibration and Power Coefficient, which ONE of the following steps is required to be performed?

- a. Bring reactor to a power level between 100kW and 1MW and allow power to stabilize for at least 15 minutes.
- b. Bypass the heat exchanger to ensure uniform flow of primary coolant through the core without cooling.
- c. Turn on pool lights.
- d. Use console indications of pool temperature to obtain temperature data points.

Category B: Normal/Emergency Operating Procedures and Radiological Controls

**QUESTION B.20 [1.0 point]**

Match the function in Column A with the definition in Column B. Options in Column B may be used once, more than once, or not at all.

<u>Column A</u>	<u>Column B</u>
a. Comparison of NLW-1000 indications with NMP-1000 indications of reactor power	1. Channel Check
b. Adjustment of NLW-1000 indications following performance of the thermal power calibration to correct for acceptable instrument drift	2. Channel Test
c. Verification of correct indication on NLW-1000 by raising reactor power to a known setpoint	3. Channel Calibration
d. Comparison of current NLW-1000 indications with NLW-1000 indications at the same reactor power levels during previous operations	

(\*\*\*\*\* END OF CATEGORY B \*\*\*\*\*)  
(\*\*\*\*\* END OF EXAMINATION \*\*\*\*\*)

**B.01**

Answer: b.

Reference: 004, SCRAMS, Alarms and Abnormal Conditions

**B.02**

Answer: c.

Reference:  $DR = DR_0 e^{-\lambda t}$ ,  $T_{1/2} = \frac{0.693}{\lambda}$   
 $DR = DR_0 e^{-.693(t)/T_{1/2}}$   
 $40 = 155 e^{-(.693)(2)/T_{1/2}}$   
 $0.258 = e^{-(.693)(2)/T_{1/2}}$   
 $\ln(0.258) = \ln(e^{-(.693)(2)/T_{1/2}})$   
 $-1.355 = -1.386 / T_{1/2}$   
 $T_{1/2} = -1.386 / -1.355$   
 $T_{1/2} = 1.02 \text{ hr}$

**B.03**

Answer: c.

Reference: 002, Reactor Operations

**B.04**

Answer: a.

Reference: 10 CFR 20.1003

**B.05**

Answer: d.

Reference: 402, Emergency Procedure Classification

**B.06**

Answer: d.

Reference:  $DR_1^*(D_1)^2 = DR_2^*(D_2)^2$   
 $20000 \text{ mrem} (1.5 \text{ ft})^2 = 700 \text{ mrem} (d)^2$   
 $45000 \text{ mrem-ft}^2 = 700 \text{ mrem} (d)^2$   
 $64.3 \text{ ft}^2 = d^2$   
 $D = 8.02 \text{ ft.}$

**B.07**

Answer: c.

Reference: 010, Conduct of Experiments

**B.08**

Answer: b.

Reference: 004, SCRAMS, Alarms and Abnormal Conditions

**B.09**

Answer: a.

Reference: AFRRRI Technical Specifications 3.1.2, 3.2.1, 3.3

**B.10**

Answer: a. 3 (Annually); b. 2 (Quarterly); c. 4 (Biennially); d. 2 (Quarterly)

Reference: AFRRRI Technical Specifications 4.1, 4.3, 4.5.1, 4.6

**B.11**

Answer: d.



## Category C: Facility and Radiation Monitoring Systems

Reference: 10 CFR 20.1301

### **B.12**

Answer: d.

Reference: 201, Control Rods

### **B.13**

Answer: a.

Reference: Dose = DR\*T

90 mRem/hr/60 minutes = 1.50 mRem/min

1.50 mRem/min \* 21 min = 31.5 mRem

### **B.14**

Answer: c.

Reference: 004, SCRAMS, Alarms and Abnormal Conditions

### **B.15**

Answer: a.

Reference: 10 CFR 55.53

### **B.16**

Answer: b.

Reference: AFRRRI Emergency Plan

### **B.17**

Answer: d.

Reference: AFRRRI Technical Specifications 6.2.4

### **B.18**

Answer: c.

Reference: AFRRRI Technical Specifications

### **B.19**

Answer: a.

Reference: 215, Thermal Power Calibration and Power Coefficient

### **B.20**

Answer: a. 1 (Channel Check); b. 3 (Channel Calibration); c. 2 (Channel Test); d. 1 (Channel Check)

Reference: AFRRRI Technical Specifications 1.3, 1.4, 1.5

(\*\*\*\*\* END OF CATEGORY B \*\*\*\*\*)  
(\*\*\*\*\* END OF EXAMINATION \*\*\*\*\*)