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

May 23, 2024

Dr. James Adams, Acting Director
National Institute of Standards and Technology
NIST Center for Neutron Research
U.S. Department of Commerce
100 Bureau Drive, Mail Stop 6100
Gaithersburg, MD 20899 6100

SUBJECT: EXAMINATION REPORT NO. 50-184/OL-24-01, NATIONAL INSTTITUTE OF STANDARDS AND TECHNOLOGY

Dear Dr. Adams:

During the week of May 6, 2024, the U.S. Nuclear Regulatory Commission (NRC) administered operator licensing examinations at your National Institute of Standards and Technology 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 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) 415-8341 or via email at Amy.Beasten@nrc.gov.

Sincerely,

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. 50-184

Enclosures:
1. Examination Report No. 50-184/OL-24-01
2. Written examination

cc: w/enclosures to GovDelivery Subscribers

J. Adams

SUBJECT: EXAMINATION REPORT NO. 50-184/OL-24-01, NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY DATED: MAY 23, 2024

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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

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

REPORT NO.: 50-184/OL 24-01

FACILITY DOCKET NO.: 50-184

FACILITY LICENSE NO.: TR-5

FACILITY: National Institute of Standards and Technology

EXAMINATION DATES: Week of May 6, 2024

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

SUMMARY:
On May 8, 2024, written examination retakes were administered to two Senior Reactor Operator-Instant (SRO-I) candidates. Both candidates passed all applicable portions of the written exams.

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	2/0	2/0
Operating Tests	0/0	0/0	0/0
Overall	0/0	0/0	2/0

3. Exit Meeting:
Amy E. Beasten, PhD, Chief Examiner, NRC
Jacob Seiter, Training Program Manager

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.

U.S.NRC

UNITED STATES NUCLEAR REGULATORY COMMISSION

Protecting People and the Environment

NIST Center for Neutron Research

Operator Licensing Examination

Week of May 6, 2024

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

FACILITY: NIST Center for Neutron Research

REACTOR TYPE: Test Reactor

DATE ADMINISTERED: May 8, 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 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~~	~~N/A~~	~~N/A~~	~~C.~~	~~FACILITY AND RADIATION MONITORING SYSTEMS~~
20.00		_____ FINAL GRADE	_____ %		TOTALS

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

_____
Candidate's Signature

NRC RULES AND GUIDELINES FOR LICENSE EXAMINATIONS

During the administration of this examination the following rules apply:

1. Cheating on the examination means an automatic denial of your application and could result in more severe penalties.

2. 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.

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 _____ (0.25 each)

A05 a b c d ___

A06 a b c d ___

A07 a b c d ___

A08 a _____ b _____ c _____ d _____ (0.25 each)

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 _____ (0.25 each)

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 ___

A20 a b c d ___

(***** END OF CATEGORY A *****)
(***** END OF 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 _____ (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 _____ (0.25 each)

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

EQUATION SHEET

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

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

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

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

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

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

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

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

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

Gn,

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

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

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

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

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

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

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

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

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

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

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

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

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

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

---

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

1 kg = 2.21 lb

1 Horsepower = 2.54 x 10^3 BTU/hr

1 Mw = 3.41 x 10^6 BTU/hr

1 BTU = 778 ft-lb

°F = 9/5 °C + 32

1 gal (H_2O) ≈ 8 lb

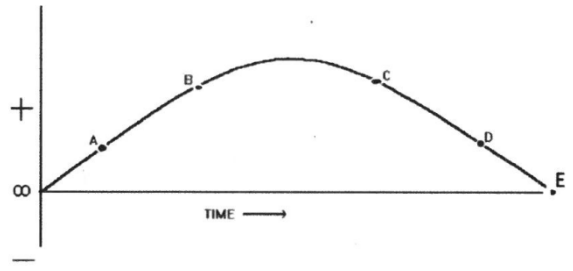
°C = 5/9 (°F - 32)

c_P = 1.0 BTU/hr/lb/°F

c_p = 1 cal/sec/gm/°C

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

QUESTION A.01 [1.0 point]
The figure below shows a trace of reactor period as a function of time. Which ONE of the following describes reactor power from point A to point C?



a. Reactor power is constant.

b. Reactor power is increasing continually.

c. Reactor power is increasing, then stable.

d. Reactor power is increasing, then decreasing, then stable.

QUESTION A.02 [1.0 point]
Which ONE of the following statements regarding fission product poisoning is true?

a. During normal reactor operation, Sm-149 is removed from the core by both radioactive decay and neutron absorption.

b. During normal reactor operation, Xe-135 is removed from the core only by radioactive decay.

c. Following a reactor shutdown, the concentration of Sm-149 reaches a peak because some fission is still occurring in the core.

d. Following a reactor shutdown, the concentration of Xe-135 reaches a peak based on the decay of I-135 in the core.

QUESTION A.03 [1.0 point]
Following a reactor scram, the period meter will indicate _____ because _____.

a. 0 seconds; the reactor is subcritical and reactor power is decreasing.

b. Slightly positive; the neutron source is providing detectable neutron count rate to keep the reactor slightly supercritical.

c. -120 seconds; of the decay constant for the longest-lived photo-neutron precursor.

d. -120 seconds; the fuel temperature coefficient adds positive reactivity as a result of the decrease in fuel temperature following a scram.

QUESTION A.04 [1.0 point, 0.25 each]
Complete the decay chain below by matching the blanks in Column A with the isotopes listed in Column B. Answers in Column B may be used once, more than once, or not at all.

$$\boldsymbol{A} \xrightarrow[19s]{} {}^{0}_{-1}\beta + \boldsymbol{B} \xrightarrow[6.57h]{} {}^{0}_{-1}\beta + {}^{135}_{54}Xe \xrightarrow[69.1h]{} {}^{0}_{-1}\beta + \boldsymbol{C} \xrightarrow[2.3E6y]{} {}^{0}_{-1}\beta + \boldsymbol{D}(\text{stable})$$

Column A	Column B
a. A	1. ${}^{135}_{53}\mathrm{I}$
b. B	2. ${}^{135}_{55}\mathrm{Cs}$
c. C	3. ${}^{135}_{56}\mathrm{Ba}$
d. D	4. ${}^{135}_{52}\mathrm{Te}$

QUESTION A.05 [1.0 point]
Given Isotope ${}_{92}U^{235}$, σ_f = 537 barns, σ_c = 156 barns, determine the fraction of thermal neutrons absorbed in U-235 by fission. Note: σ_f = fission cross section, σ_c = capture cross section

a. 0.23

b. 0.31

c. 0.77

d. 0.84

QUESTION A.06 [1.0 point]
Which ONE of the following statements regarding moderator properties is NOT true?

a. A good moderator has a large energy loss per collision.

b. A good moderator has a large absorption cross-section and a small scattering cross-section.

c. A good moderator slows neutrons to reduce the amount of neutron leakage from the core.

d. A good moderator has a small absorption cross-section and a large scattering cross-section.

QUESTION A.07 [1.0 point]
Reactor power is initially at 150kW. After 5 minutes, reactor power is at 2.5MW. What is reactor period?

a. 17.8 seconds

b. 40.4 seconds

c. 58.6 seconds

d. 106 seconds

QUESTION A.08 [1.0 point, 0.25 each]
Match the decay mode in Column A with the definition in Column B. Answers in Column B may be used once, more than once, or not at all.

Column A	Column B
a. Beta-plus decay	1. Emission of a helium atom from an unstable nucleus.
b. Electron capture	2. Conversion of a proton to a neutron and a positron, which is ejected from the nucleus.
c. Beta-minus decay	3. Conversion of a neutron to a proton and an electron, which is ejected from the nucleus.
d. Alpha decay	4. Nucleus absorbs an electron from the innermost orbital, which combines with a proton to form a neutron.

QUESTION A.09 [1.0 point]
Which ONE of the following defines β_{eff}?

a. The fraction of all fission neutrons born as delayed neutrons.

b. The fraction of neutrons at thermal energies born as delayed neutrons.

c. The average of the total delayed neutron fractions of the different types of fuel.

d. The fraction of neutrons at fast energies born as delayed neutrons.

QUESTION A.10 [1.0 point]
What is the condition of the reactor when $k = \frac{1}{1 - \beta_{\text{eff}}}$?

a. Critical

b. Prompt Critical

c. Supercritical

d. Subcritical

QUESTION A.11 [1.0 point]
The following data was obtained during a reactor fuel load.

Step	No. of Elements	Detector A (count/sec)
1	0	100
2	4	120
3	8	140
4	12	200
5	15	400

The estimated number of additional elements required to achieve criticality is between:

a. 8 to 10

b. 6 to 8

c. 4 to 5

d. 2 to 3

QUESTION A.12 [1.0 point]
Which ONE of the following statements regarding fission with thermal neutrons is true?

a. U-235 fissions with thermal neutrons because the binding energy released by the absorption of a neutron is less than the critical energy for fission.

b. U-235 fissions with thermal neutrons because the binding energy released by the absorption of a neutron is greater than the critical energy for fission.

c. U-238 fissions with thermal neutrons because the binding energy released by the absorption of a neutron is greater than the critical energy for fission.

d. U-238 fissions with thermal neutrons because the binding energy released by the absorption of a neutron is less than the critical energy for fission.

QUESTION A.13 [1.0 point, 0.25 each]
Match the isotope in Column A with the type of material in Column B. Options in Column B may be used once, more than once, or not at all.

Column A	Column B
a. Th-232	1. Fissionable
b. U-233	2. Fertile
c. U-235	3. Fissile
d. U-238	

QUESTION A.14 [1.0 point]
Which ONE of the following best describes the difference between prompt and delayed neutrons?

a. Prompt neutrons are responsible for the ability to control the rate at which power can rise in the reactor and delayed neutrons are responsible for the rate at which a reactor can be shut down.

b. Prompt neutrons ensure there is a sufficient neutron population to overcome the effects of fission product poisoning following a shutdown and delayed neutrons are responsible for lengthening the neutron generation time to ensure the reactor does not go prompt critical.

c. Prompt neutrons are produced from spontaneous fission of U-235 in the fuel, and delayed neutrons are the result of fission in U-238.

d. Prompt neutrons are produced immediately and directly from the fission event and delayed neutrons are produced immediately following the first beta decay of fission fragments.

QUESTION A.15 [1.0 point]
Which ONE of the following parameters is the MOST significant in determining the differential rod worth of a control rod?

a. Flux shape.

b. Fuel temperature.

c. Rod speed.

d. Reactor power.

QUESTION A.16 [1.0 point]
Which ONE of the following best describes the effect of Xe-135 on normal reactor operation?

a. Xe-135 is inert and therefore has no impact on reactor operations.

b. Xe-135 has a large thermal neutron absorption cross-section, which causes large removal of thermal neutrons from the core, causing negative reactivity addition.

c. When Xe-135 is formed, kinetic energy in the form of heat is released, causing increases in moderator temperature and subsequently decreases in reactor power over the course of normal reactor operation.

d. Xe-135 has a large mass which causes increased scattering collisions, slowing more neutrons to thermal energies as the concentration builds up over time.

QUESTION A.17 [1.0 point]
Which ONE of the following best describes inelastic scattering?

a. A neutron interacts with a target nucleus and momentum and kinetic energy are conserved.

b. A neutron is absorbed by the target nucleus to form a compound nucleus, which ejects an alpha particle or proton.

c. A neutron is absorbed by the target nucleus to form a compound nucleus, which releases its excitation energy by emitting a gamma ray.

d. A neutron is absorbed by the target nucleus to form a compound nucleus, which emits a neutron with lower kinetic energy, and the resulting excited state nucleus emits a gamma.

QUESTION A.18 [1.0 point]
Which ONE of the following best describes the effective multiplication factor, k_{eff}?

a. The ratio of the number of total neutrons produced by fission in one generation to the number of neutrons lost through leakage and absorption in the preceding generation.

b. The ratio of the number of fast neutrons produced by fission in one generation to the number of fast neutrons lost through leakage and absorption in the preceding generation.

c. The ratio of the number of total neutrons produced by fission in one generation to the number of neutrons lost through absorption in the preceding generation.

d. The ratio of the number of thermal neutrons produced by fission in one generation to the number of thermal neutrons lost through leakage and absorption in the preceding generation.

QUESTION A.19 [1.0 point]
During each fission event with a thermal neutron in U-235, _____ is released immediately, and _____ is delayed.

a. 200 MeV; 10 MeV

b. 210 MeV; 23 MeV

c. 187 MeV; 23 MeV

d. 167 MeV; 10 MeV

QUESTION A.20 [1.0 point]
Which ONE of the following statements best describes integral rod worth?

a. The area under the curve represents the cumulative effect of withdrawing a control rod a specific distance from the core.

b. The reactivity change per unit movement of a rod.

c. The area under the curve represents the cumulative effect of withdrawing a control rod at a specific rate from the core.

d. The total reactivity worth of the rod at a particular degree of withdrawal.

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

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.01 [1.0 point]
Which ONE of the following statements accurately describes when OI 1.1.3, Recovery from Reactor Shutdown less than 24 hours, must be performed?

a. Before restart following a reactor shutdown as part of a planned test.

b. Before restart following a normal plant shutdown that occurred less than 24 hours earlier.

c. Following an unintended reactor shutdown that has occurred less than 24 hours earlier during a planned plant procedure that has a high risk of shutdown.

d. Following a reactor rundown to a lower power level than starting, if this power level is maintained for greater than 5 minutes.

QUESTION B.02 [1.0 point]
The exposure rate for a point source is 625 mR/hr at a distance of 2 meters. What is the exposure rate at a distance of 7 meters?

a. 25.5 mR/hr

b. 51.0 mR/hr

c. 357 mR/hr

d. 116 mR/hr

QUESTION B.03 [1.0 point]
In accordance with OI 6.1.5, Insertion of Fresh Fuel into the Core, all of the following equipment requirements must be met EXCEPT:

a. Ventilation must be in isolation mode.

b. All shim arms must be at their bottom limit with control power and rod drive power keys off.

c. All D_2O flow to the reactor vessel shall be secured.

d. Confinement integrity shall be maintained.

QUESTION B.04 [1.0 point]
Which ONE of the following defines the term “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 NBSR Emergency Plan, which ONE of the following events would be classified as an ALERT?

a. An unauthorized individual gains access to the confinement building.

b. Fuel damage with loss of primary coolant such that pool level decreases below the level at which radiological effluents at the site area boundary exceed 1250 x EC.

c. Tornado touches down within the site area boundary.

d. A fire within the containment bay that cannot be extinguished within 15 minutes.

QUESTION B.06 [1.0 point]
The radiation from an unshielded source is 300 mrem/hr. A lead sheet of 20 mm thickness is inserted and the radiation level drops to 15 mrem/hr. What is the half-value-layer (HVL) of lead?

a. 4.63 mm

b. 10.9 mm

c. 15.7 mm

d. 36.1 mm

QUESTION B.07 [1.0 point]
You are the licensed operator on the console during performance of OI 6.3.1, 1/M Core Loading and Approach to Critical, when you observe that following loading of the last fuel element, indications on NC-3 suddenly increase by a factor of 10 and count rate on NC-2 is steadily increasing. Which ONE of the following actions should be taken?

a. Major scram the reactor to shut down the reactor.

b. Wait five minutes for instrumentation to stabilize.

c. Operate DVW-9, Moderator Dump valve to shut down the reactor.

d. Notify the Reactor Supervisor so the element can be removed from the core.

QUESTION B.08 [1.0 point]
In accordance with AP 4.12, Differential Temperature "A" High, all of the following conditions could have caused the alarm to come in EXCEPT:

a. Reactor power has increased.

b. A primary to secondary leak inside the heat exchanger is occurring.

c. Secondary flow has increased.

d. Primary flow has decreased.

QUESTION B.09 [1.0 point]
According to NBSR Technical Specifications, which ONE of the following conditions is NOT permissible?

a. Coolant flow < 60 gpm for the outer plenum and < 235 gpm for the inner plenum.

b. Reactor outlet temperature < 147° F.

c. Shutdown margin > 0.757% $\Delta\rho$.

d. Maximum reactivity insertion rate for the shim arms < 5×10^{-4} $\Delta\rho$/s.

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.

Column A	Column B
a. Cycling of moderator dump valve	1. Monthly
b. Verification of shim arm insertion speed	2. Quarterly
c. Channel test of Area Radiation Monitors	3. Semi-annually
d. Test of control valves in ECCS	4. Annually

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. 2 mrem/hr.

b. 20 mrem/hr.

c. 200 mrem/hr.

d. 2000 mrem/hr.

QUESTION B.12 [1.0 point]
In accordance with the NBSR Emergency Plan, which ONE of the following individuals may NOT serve as the Emergency Director?

a. Duty Reactor Supervisor

b. Chief, Reactor Operations

c. Director, NIST Center for Neutron Research

d. Any licensed Reactor Operator (RO)

QUESTION B.13 [1.0 point]
The radiation level in the control room is 175 mrem/hour, and the operator is in the control room for 19 minutes. How much dose will the operator receive?

a. 17.35 mrem

b. 26.7 mrem

c. 34.5 mrem

d. 55.4 mrem

QUESTION B.14 [1.0 point]
In accordance with EI 3.6, SA – Essential Personnel Evacuation, which ONE of the following statements regarding radiation exposures is correct regarding special exposures in excess of 10 CFR 20 limits?

a. Exposures up to 25 rem for lifesaving actions and 5 rem for actions to mitigate the emergency must be approved by the Emergency Director.

b. Exposures up to 5 rem for lifesaving actions and 25 rem for actions to mitigate the emergency must be approved by the Emergency Director.

c. Exposures up to 25 rem for lifesaving actions and 10 rem for actions to mitigate the emergency must be approved by the Emergency Director.

d. Exposures up to 25 rem for lifesaving actions and 100 rem for actions to mitigate the emergency must be approved by the Emergency Director.

QUESTION B.15 [1.0 point]
Match the definition in Column A with the term in Column B. Options in Column B may be used once, more than once, or not at all.

Column A	Column B
a. The dose equivalent to organs or tissues that will be received from an intake of radioactive material by an individual over a 50-year period following intake.	1. Annual Limit on Intake (ALI)
b. The derived limit for the amount of radioactive material taken into the body by inhalation or ingestion in a year.	2. Total Effective Dose Equivalent (TEDE)
c. The dose equivalent at a tissue depth of 1 cm.	3. Deep-Dose Equivalent (H^d)
d. The sum of the effective dose equivalent for internal exposures and the committed effective dose equivalent for internal exposure.	4. Committed Dose Equivalent (CDE)

QUESTION B.16 [1.0 point]
In accordance with 10 CFR 50.54(x), a licensee may take reasonable action that departs from a license condition or technical specification in an emergency when this action is immediately needed to protect the public health and safety. Which ONE of the following individuals may authorize this action?

a. A licensed Senior Reactor Operator.

b. NBSR Senior Health Physicist.

c. A licensed Reactor Operator.

d. Director, National Institute of Standards and Technology.

QUESTION B.17 [1.0 point]
In accordance AP 4.14, Vessel Level "Recorder" Low, which ONE of the following statements correctly describes the sequence of valve alignments when the reactor scrams?

a. Emergency cooling valve DWV-35 opens and Reactor Vessel Outlet Isolation valve DVW-19, and heat exchanger isolation valves DWV-95A, DWV-95B, DWV-100A, and DWV-100B close if a scram signal originated from the vessel level recorder channel.

b. Inner plenum valve DWV-1, outer plenum valve DWV-2, and Reactor Vessel Outlet Isolation valve DVW-19, and heat exchanger isolation valves DWV-95A, DWV-95B, DWV-100A, and DWV-100B all close if a scram signal originated from both the vessel level recorder and indicator channels.

c. Emergency cooling valve DWV-34 opens and Reactor Vessel Outlet Isolation valve DVW-19, and heat exchanger isolation valves DWV-95A, DWV-95B, DWV-100A, and DWV-100B close if a scram signal originated from the vessel level recorder channel.

d. Inner plenum valve DWV-1, outer plenum valve DWV-2, and Reactor Vessel Outlet Isolation valve DVW-19, and heat exchanger isolation valves DWV-95A, DWV-95B, DWV-100A, and DWV-100B all close if a scram signal originated from either the vessel level recorder or the indicator channel.

QUESTION B.18 [1.0 point]
In accordance with NBSR Technical Specifications, the Safety Evaluation Committee (SEC) has all of the following review functions EXCEPT:

a. Proposed administrative changes to the NBSR procedures required by Technical Specifications.

b. New experiments which are significantly different than any previously reviewed and approved.

c. Any operations that result in a violation of Technical Specifications.

d. Proposed changes to facility equipment required by Technical Specifications when such changes require a change to the Safety Analysis Report.

QUESTION B.19 [1.0 point]
In accordance with AP 4.6, Building Exhaust Activity High, high activity in all of the following areas could be releasing to the normal exhaust system to cause the alarm EXCEPT:

a. Reactor face (experimental level).

b. Upper trench around reactor top.

c. Helium system relief valve.

d. C200 around the elevator.

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.

Column A	Column B
a. Comparison of NC-3 channel indications with NC-5 channel indications of reactor power	1. Channel Check
b. Adjustment of NC-3 channel indications following performance of the thermal power calibration to correct for acceptable instrument drift	2. Channel Test
c. Verification of correct indication on NC-3 channel by raising reactor power to a known setpoint	3. Channel Calibration
d. Comparison of current NC-3 channel indications with NC-3 indications at the same reactor power levels during previous operations	

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

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

A.01
Answer: b.
Reference: Reactor power keeps increasing because period is positive.

A.02
Answer: d.
Reference: DOE Fundamentals Handbook, Volume 2, Module 3, p. 30-47

A.03
Answer: c.
Reference: DOE Handbook Nuclear Physics & Reactor Theory, Volume 1, Module 2, p. 7

A.04
Answer: a. 4 (Te-135); b. 1 (I-135); c. 2 (Cs-135); d. 3 (Ba-135)
Reference: DOE Fundamentals Handbook, Volume 2, p. 35

A.05
Answer: c.
Reference: Burn, Introduction to Nuclear Reactor Operations, Section 3.2, page 3-2.
U-235 Fission Capture = $\sigma_f / (\sigma_f + \sigma_c)$ = 537/(537+156) = 0.77

A.06
Answer: b.
Reference: DOE Fundamentals Handbook, Volume 1, Module 2, p 23-24.

A.07
Answer: d.
Reference: DOE Fundamentals Handbook, Volume 2, Module 4, p. 11
$P = P_0 e^{t/\tau}$
$2.5MW = 150kW \cdot e^{300s/\tau}$
$2.5MW = 0.15MW \cdot e^{300s/\tau}$
$16.67 = e^{300s/\tau}$
$\ln(16.67) = \ln(e^{300s/\tau})$
$2.81 = 300s/\tau$
$\tau = 300/2.81$
$\tau = 106$ seconds

A.08
Answer: a. 2; b. 4; c. 3; d. 1
Reference: DOE Fundamentals Handbook, Module 1, p. 29

A.09
Answer: b.
Reference: Burn, *Introduction to Nuclear Reactor Operations*, Section 3.2.3, p. 3-11

A.10
Answer: b.
Reference: LaMarsh, *Introduction to Nuclear Engineering*, Page 340-341
$(1-\beta)k = 1$ is a prompt critical condition. Rearranging this equation results in

$$k = \frac{1}{1-\beta}$$

A.11
Answer: d.
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1982, Sec 5.5, p. 5-18-5-25

A.12
Answer: b.
Reference: DOE Fundamentals Handbook, Vol. 1, p. 55

A.13
Answer: a. 2 (Fertile); b. 3 (Fissile); c. 3 (Fissile); d. 1 (Fissionable)
Reference: DOE Fundamentals Handbook, Volume 1, p. 50-52

A.14
Answer: d.
Reference: DOE Fundamentals Handbook, Vol. 1, p. 29

A.15
Answer: a.
Reference: Burn, *Introduction to Nuclear Reactor Operations*, Section 7, page 7-4

A.16
Answer: b.
Reference: DOE Fundamentals Handbook, Volume 2, p. 34

A.17
Answer: d.
Reference: DOE Fundamentals Handbook, Vol. 1, p. 47

A.18
Answer: a.
Reference: DOE Fundamentals Handbook, Vol. 2, p 15

A.19
Answer: c.
Reference: DOE Fundamentals Handbook, Volume 1, p. 61

A.20
Answer: d.
Reference: DOE Fundamentals Handbook, Module 3, p. 58

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

Category B: Normal/Emergency Operating Procedures and Radiological Controls

B.01
Answer: c.
Reference: OI 1.1.3, Recovery from Reactor Shutdown less than 24 hours

B.02
Answer: b.
Reference: $I_2 = I_1D_1^2/d_2^2$
$I_2 = (625\ mR/hr)(2m)^2 / (7m)^2$
$I_2 = 51\ mR$

B.03
Answer: a.
Reference: OI 6.1.5, Insertion of Fresh Fuel into the Core

B.04
Answer: c.
Reference: 10 CFR 20.1003

B.05
Answer: a.
Reference: NBSR Emergency Plan

B.06
Answer: a.
Reference: $DR = DR_0*e^{-\mu X}$
Find μ:
$15 = 300*e^{-\mu*20}$
$0.05 = e^{-\mu*20}$
$\ln(0.05) = \ln(e^{-\mu*20})$
$-2.996 = -\mu*20$
$\mu = 0.149$
If insertion of an HVL (thickness of lead), the original intensity will be reduced by half.
Find X:
$1 = 2*\ e^{-0.149*X}$
$0.5 = e^{-0.149*X}$
$\ln(0.5) = \ln(e^{-0.149*X})$
$-0.693 = -0.149*X$
X= 4.63 mm

B.07
Answer: c.
Reference: OI 6.3.1, 1/M Core Loading and Approach to Critical

B.08
Answer: b.
Reference: AP 4.12, Differential Temperature “A” High

B.09
Answer: a.
Reference: NBSR Technical Specifications 2.2, 3.1.2, 3.2.1

B.10
Answer: a. 4 (Annually); b. 3 (Semi-annually); c. 1 (Monthly); d. 2 (Quarterly)

Category B: Normal/Emergency Operating Procedures and Radiological Controls

Reference: NBSR Technical Specifications 4.2.1, 4.3.2, 4.3.3, 4.7

B.11
Answer: a.
Reference: 10 CFR 20.1301

B.12
Answer: d.
Reference: NBSR Emergency Plan

B.13
Answer: d.
Reference: Dose = DR*T
175 mRem/hr/60 minutes = 2.92 mRem/min
2.92 mRem/min * 19 min = 55.4 mRem

B.14
Answer: c.
Reference: EI 3.6, SA – Essential Personnel Evacuation

B.15
Answer: a. 4 (CDE); b. 1 (ALI); c. 3 (H^d); d. 2 (TEDE)
Reference: 10 CFR 20.1003

B.16
Answer: a.
Reference: 10 CFR 50.54(x) and 50.54(y)

B.17
Answer: b.
Reference: AP 4.14, Vessel Level “Recorder” Low

B.18
Answer: a.
Reference: NBSR Technical Specifications 6.2.3

B.19
Answer: c.
Reference: AP 4.6, Building Exhaust Activity High

B.20
Answer: a. 1 (Channel Check); b. 3 (Channel Calibration); c. 2 (Channel Test); d. 1 (Channel Check)
Reference: NBSR Technical Specifications 1.3.2

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