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

September 17, 2025

John P. Foster
Director of Reactor Operations
Nuclear Reactor Laboratory
Massachusetts Institute of Technology
138 Albany Street, Mail Stop NW12-110
Cambridge, MA 02139

SUBJECT: EXAMINATION REPORT NO. 50-020/OL-25-01, MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Dear John Foster:

During the week of August 25, 2025, the U.S. Nuclear Regulatory Commission (NRC) administered an operator licensing examination at your Massachusetts Institute of Technology Nuclear Reactor Laboratory. 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.

Sincerely,

Signed by Brown, Tony
on 09/17/25

Tony Brown, 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. 50-020

Enclosures:
1. Examination Report No. 50-020/OL-25-01
2. Facility Comments with NRC Resolutions
3. Written examination

cc: w/enclosures to GovDelivery Subscribers

SUBJECT: EXAMINATION REPORT NO. 50-020/OL-25-01, MASSACHUSETTS INSTITUTE OF TECHNOLOGY DATED: SEPTEMBER 17, 2025

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

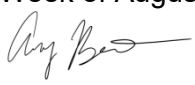
REPORT NO.: 50-020/OL 25-01

FACILITY DOCKET NO.: 50-020

FACILITY LICENSE NO.: R-37

FACILITY: Massachusetts Institute of Technology

EXAMINATION DATES: Week of August 25, 2025

SUBMITTED BY: 

Amy E. Beasten, Chief Examiner 9/2/2025 Date

SUMMARY:
During the week of August 25, 2025, operator licensing examinations were administered to three Reactor Operator (RO) and three Senior Reactor Operator-Instant (SRO-I) candidates. candidates. One SRO-I failed Category B of the written examination but passed the operating test. All other candidates passed all applicable examinations and tests.

REPORT DETAILS

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

2. Results:

	RO PASS/FAIL	SRO PASS/FAIL	TOTAL PASS/FAIL
Written	3/0	2/1	5/1
Operating Tests	3/0	3/0	6/0
Overall	3/0	2/1	5/1

3. Exit Meeting:
Amy E. Beasten, PhD, Chief Examiner, NRC
Dr. John Foster, Director for Reactor Operations
Edward Lau, Assistant Director for Reactor Operations
Jose Cortes, Training Coordinator
Andrew Reitz, Superintendent
Frank Warmsley, Assistant Superintendent
Susan Tucker, QA Supervisor

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.

FACILITY COMMENTS AND NRC RESOLUTION

QUESTION B.15 [1.0 point]
In accordance with the MITR Emergency Plan, which ONE of the following events could be classified as an Alert?

a. Radiation levels at the site boundary of 15 mrem/hr sustained for one hour.

b. An earthquake that causes tank water level to drop several inches but does not trigger any level alarms.

c. Fuel handling accident that could release radionuclides to the containment building.

d. A fire on the reactor console that affects the DWK channels.

Answer: d.
Reference: MITR Emergency Plan 4.5.3

Facility Comment B.15
The NRC answer key entry for this question is D, “A fire on the reactor console that affects the DWK channels.” However, we suggest that also acceptable is answer C, “Fuel handling accident that could release radionuclides to the containment building.” This is based on the MIT Emergency Plan Table 4.5.3-2 “EALs for an Alert”.

The table includes, “5. Loss of radioactive material control that causes radiation dose rates or airborne radionuclides to increase above permissible exposure levels by a factor of 1000 throughout the containment building,” which is a plausible consequence of a fuel handling accident, especially when handling spent fuel.

Furthermore, the table includes, “6. Radiation dose rates throughout the containment building in excess of 100 mR/hour sustained for one hour,” which is also a plausible consequence of a fuel handling accident, particularly one in which a spent fuel element falls out the bottom of the transfer cask, or heavy equipment crushes the element.

We note that Table 4.5.3-1 “EALs for Notification of Unusual Events” includes, “7. A fuel damage accident that could release radionuclides to the containment building.” However, we consider this a baseline that is intended to place any fuel damage into an emergency class, not a limitation on how severe a fuel damage or handling accident situation might be. Either type of accident has the potential to result in a rather significant consequence, which could be classified as an Alert.

NRC Resolution B.15
The requested answer option under consideration does not include any language that would support the criteria presented in the Emergency Plan for an Alert. Therefore, the NRC has determined the justification for two correct answers is not supported and the NRC does NOT accept this change.

U.S.NRC

UNITED STATES NUCLEAR REGULATORY COMMISSION

Protecting People and the Environment

Massachusetts Institute of Technology

Operator Licensing Examination

Week of August 25, 2025

Enclosure 3

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

FACILITY: Massachusetts Institute of Technology

REACTOR TYPE: Tank

DATE ADMINISTERED: August 29, 2025

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 and a 70% overall are 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	33.0	_____	_____	A. REACTOR THEORY, THERMODYNAMICS, AND FACILITY OPERATING CHARACTERISTICS
20.00	33.0	_____	_____	B. NORMAL AND EMERGENCY OPERATING PROCEDURES AND RADIOLOGICAL CONTROLS
20.00	33.0	_____	_____	C. FACILITY AND RADIATION MONITORING SYSTEMS
60.00		_____	_____%	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 and a 70 percent overall.

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

Candidate Name:_____

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

A N S W E R S H E E T

Multiple Choice (Circle your choice, or write on the line)
If you change your answer, write your selection in the blank. Answers written on the line will be taken as the final answer.

A01 a_____ b_____ c_____ d_____ (0.50 each)

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 ___

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

Candidate Name:_____

Category B: Normal/Emergency Operating Procedures and Radiological Controls

A N S W E R S H E E T

Multiple Choice (Circle your choice, or write on the line)
If you change your answer, write your selection in the blank. Answers written on the line will be taken as the final answer.

B01 a b c d ___

B02 a b c d ___

B03 a b c d ___

B04 a_____ b_____ c_____ d_____ (0.50 each)

B05 a b c d ___

B06 a_____ b_____ c_____ d_____ (0.25 each)

B07 a b c d ___

B08 a b c d ___

B09 a b c d ___

B10 a b c d ___

B11 a b c d ___

B12 a b c d ___

B13 a b c d ___

B14 a b c d ___

B15 a b c d ___

B16 a b c d ___

B17 a b c d ___

B18 a b c d ___

B19 a b c d ___

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

Candidate Name:_____

Category C: Facility and Radiation Monitoring Systems

A N S W E R S H E E T

Multiple Choice (Circle your choice, or write on the line)
If you change your answer, write your selection in the blank. Answers written on the line will be taken as the final answer.

C01 a b c d ___

C02 a b c d ___

C03 a b c d ___

C04 a b c d ___

C05 a b c d ___

C06 a b c d ___

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 ___

C20 a_____ b_____ c_____ d_____ (0.25 each)

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

EQUATION SHEET

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

1 Horsepower = 2.54 x 10^3 BTU/hr

1 BTU = 778 ft-lb

1 gal (H_2O) ≈ 8 lb

c_P = 1.0 BTU/hr/lb/°F

1 kg = 2.21 lb

1 Mw = 3.41 x 10^6 BTU/hr

°F = 9/5 °C + 32

°C = 5/9 (°F - 32)

c_p = 1 cal/sec/gm/°C

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

QUESTION A.01 [2.0 point, 0.50 each]
Match the equation in Column A with the reaction type in Column B. Options in Column B may be used once, more than once, or not at all.

Column A	Column B
a. $^{234}_{92}\mathrm{U} \rightarrow ^{230}_{90}\mathrm{Th} + \mathbf{X}$	1. Beta-Plus Decay
b. $^{239}_{93}\mathrm{Np} \rightarrow ^{239}_{94}\mathrm{Pu} + \mathbf{X}$	2. Beta-Minus Decay
c. $^{7}_{4}\mathrm{Be} + \mathbf{X} \rightarrow ^{7}_{3}\mathrm{Li}$	3. Alpha Decay
d. $^{13}_{7}\mathrm{N} \rightarrow ^{13}_{6}\mathrm{C} + \mathbf{X}$	4. Electron Capture

QUESTION A.02 [1.0 point]
Which ONE of the following statements best describes the resonance escape probability (p) in the Six-Factor Formula?

a. The ratio of the number of neutrons that escape resonance absorption by U-238 to reach thermal energy to the total number of neutrons.

b. The ratio of the number of neutrons that escape resonance absorption by U-238 to reach thermal energy to the number of fast neutrons that start to slow down.

c. The ratio of the number of fast neutrons that start to slow down to the number of fast neutrons produced by thermal fission.

d. The ratio of fast neutrons produced by thermal fission to the number of fast neutrons that start to slow down.

QUESTION A.03 [1.0 point]
Which ONE of the following statements best describes the mean free path?

a. The probability of a neutron being absorbed per centimeter of travel.

b. The probability of a neutron interacting with a nucleus per centimeter of travel.

c. The average distance a neutron travels before being absorbed.

d. The average distance a neutron travels between collisions.

QUESTION A.04 [1.0 point]
Which ONE of the following is the stable reactor period that will result in a power rise from 45% to 100% in 40 seconds?

a. 79 seconds

b. 50 seconds

c. 34 seconds

d. 26 seconds

QUESTION A.05 [1.0 point]
Which ONE of the following statements best describes a FISSILE material?

a. A material capable of fissioning after absorbing a thermal neutron.

b. A material capable of fissioning after absorbing a fast neutron.

c. A material capable of undergoing transmutation.

d. A material capable of absorbing a neutron to become fissionable.

QUESTION A.06 [1.0 point]
Which ONE of the following factors in the Six-Factor Formula is NOT affected by the enrichment of U-235?

a. Thermal utilization factor

b. Reproduction factor

c. Fast Fission Factor

d. Resonance escape probability

QUESTION A.07 [1.0 point]
All of the following statements regarding delayed neutrons are true EXCEPT:

a. Delayed neutrons are more likely than prompt neutrons to cause fast fission.

b. Delayed neutrons traverse a smaller energy range when slowing down to become thermal compared to prompt neutrons.

c. Delayed neutrons are less likely to be lost to leakage than prompt neutrons.

d. Delayed neutrons are born at an average energy of 0.4 MeV.

QUESTION A.08 [1.0 point]
What is the reactor period if $\beta = 0.007$ and $\rho = 0.005$?

a. 100.7 seconds

b. 20.5 seconds

c. 8.04 seconds

d. 4.02 seconds

QUESTION A.09 [1.0 point]
Which ONE of the following statements concerning source neutrons is TRUE?

a. Source neutrons provide enough neutrons to ensure that the reactor cannot go prompt critical.

b. Source neutrons provide enough neutrons to negate the effects of Xenon poisoning following extended operations.

c. Source neutrons provide enough neutrons to overcome the delayed neutron signal produced following a reactor scram.

d. Source neutrons provide enough neutrons to ensure neutron levels in the reactor during shutdown are high enough for subcritical multiplication to be detected by nuclear instruments at any time.

QUESTION A.10 [1.0 point]
Which ONE of the following statements best describes the moderator-to-fuel ratio?

a. Decreasing the moderator temperature will decrease the moderator-to-fuel ratio.

b. Increasing the moderator temperature will decrease the moderator-to-fuel ratio.

c. Increasing the moderator-to-fuel ratio will increase the thermal utilization factor

d. Decreasing the moderator-to-fuel ratio will increase the resonance escape probability.

QUESTION A.11 [1.0 point]
Which ONE of the following statements best describes what happens following a reactor scram from full power?

a. Reactor power drops immediately to zero due to the immediate insertion of all control rods.

b. Reactor power drops immediately to a low non-zero power level due to the immediate insertion of all control rods but then decreases slowly over time due to the longest-lived delayed neutron precursor.

c. Reactor power drops immediately to a low non-zero power level due to the immediate insertion of all control rods and never decreases fully to zero due to fission product poisons.

d. Reactor power slowly decreases over time due to the longest-lived delayed neutron precursor.

QUESTION A.12 [1.00 point]
Which ONE of the following isotopes will be more likely to absorb neutrons when it interacts with neutrons?

a. Uranium-235

b. Hydrogen-1

c. Argon-40

d. Boron-10

QUESTION A.13 [1.0 point]
Which ONE of the following statements BEST describes the Liquid-Drop Model of a nucleus?

a. The model explains nuclear fission where the travel path of an atom through a material is the same as flow path of a single drop of water in a larger body.

b. The size of an atom's nucleus compared to the size of the whole atom is comparable to the size of a drop of water compared to an ocean.

c. The energy required to displace all the subatomic particles is comparable to the energy required to disperse all water molecules in a drop of water.

d. The model explains nuclear fission, where a large nucleus absorbs a neutron and oscillates violently, like a drop of water, and breaks down into smaller fragments.

QUESTION A.14 [1.0 point]
If reactor power is at 85 W and $1.15 worth of reactivity is added resulting in a 7 second period, what will reactor power be after 1 minute?

a. 448.7 kW

b. 398.1 kW

c. 247.5 kW

d. 106.3 kW

QUESTION A.15 [1.0 point]
All of the following conditions will require movement of control rods to maintain constant reactor power EXCEPT:

a. Xe-135 buildup.

b. U-235 burnup.

c. Tank water temperature decrease.

d. Primary coolant conductivity increase.

QUESTION A.16 [1.0 point]
Which ONE of the following statements regarding fission with thermal neutrons is true?

a. 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.

b. 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.

c. 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.

d. 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.

QUESTION A.17 [1.0 point]
Which ONE of the following is the principal source of heat in the reactor a day after a normal shutdown from extended operation at full power?

a. Continued production of delayed neutrons.

b. Xe-135 peaking due to burnout.

c. Spontaneous fission of U-235.

d. Decay of fission fragments.

QUESTION A.18 [1.0 point]
Which ONE of the following is a characteristic of an effective reflector?

a. A high scattering to absorption cross section ratio.

b. A low resistance to radiation damage.

c. A small crystal expansion structure.

d. A low thermal conductivity.

QUESTION A.19 [1.0 point]
If K_{inf} = 1.36, determine K_{eff} for a reactor with a probability of fast non-leakage of 0.88 and a probability of thermal non-leakage of 0.93.

a. 1.26

b. 1.20

c. 1.11

d. 1.01

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

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.01 [1.0 point]
In accordance with PM 2.2, Preparations for Reactor Operation, when may the surveillance checklist, PM 3.1.1.4, Two Loop Restart Incorporating Required Quarterly Startup Surveillances, be used prior to a full-power reactor startup?

a. If the reactor has been shut down for more than 24 hours.

b. If the reactor has been shut down for less than 24 hours and a licensed operator has been on-duty continuously.

c. If a shutdown checklist has not been completed and full power checklists PM 3.1.1.1 and PM 3.1.1.2 have been completed within the last 90 days.

d. If a shutdown checklist has been completed but the reactor has been continuously attended, and full power checklists PM 3.1.1.1 and PM 3.1.1.2 have been completed within the last 90 days.

QUESTION B.02 [1.0 point]
In accordance with PM 5.1.11, Safety System Trouble, which ONE of the following conditions might be the cause of the alarm?

a. Any of the nuclear safety channels in test mode.

b. A failure of either of the two 24-V DC power supplies for the scram logic modules for the nuclear safety channels.

c. Reactor period is shorter than 30 seconds.

d. Loss of cooling to the control room instrumentation.

QUESTION B.03 [1.0 point]
While working on an experiment, you receive the following radiation doses: 90 mrem (β), 35 mrem (γ), and 5 mrem (thermal neutrons). Which ONE of the following is your total dose?

a. 175 mrem

b. 150 mrem

c. 130 mrem

d. 115 mrem

QUESTION B.04 [2.00 point, 0.50 each]
In accordance with 10 CFR 20, match the radiation readings from Column A with its corresponding radiation area classification in Column B. Assume all distances at 30 cm unless specified. Answers may be used once, more than once, or not at all.

Column A	Column B
a. 15 mR/hr	1. Unrestricted Area
b. 2 mR/hr	2. Radiation Area
c. 550 Rad/hr at 1 m	3. High Radiation Area
d. 5 R/hr	4. Very High Radiation Area

QUESTION B.05 [1.0 point]
In accordance with PM 4.4.4.12, Reactor Containment Evacuation, the reactor containment building may need to be evacuated in all of the following situations EXCEPT:

a. Overhead crane malfunction.

b. Medical emergency requiring first responder assistance.

c. Neutron beam line shielding failure

d. Fuel failure resulting in detectable fission product release.

QUESTION B.06 [1.00 point, 0.25 each]
Match the surveillance activity in Column A to the Technical Specification required interval in Column B. Options in Column B may be used once, more than once, or not at all.

Column A	Column B
a. Operability of the subcritical limit interlock	1. Quarterly
b. D_2O tritium levels	2. Semi-annual
c. Integral air leak rate test of the containment building	3. Annual
d. Voltage test of each battery cell of the emergency electrical power supply	4. Biennial

QUESTION B.07 [1.0 point]
A radiation survey instrument was used to measure an irradiated experiment. The results were 200 mR/hr with the window open and 140 mR/hr with the window closed. Not accounting for any Beta correction factor or instrument efficiencies, what is the estimated Beta dose?

a. 200 mR/hr

b. 140 mR/hr

c. 60 mR/hr

d. 40 mR/hr

QUESTION B.08 [1.0 point]
In accordance with PM 5.2.1, Low Flow MF-2, which ONE of the following actions is NOT required to be performed by the reactor operator on receipt of a low flow alarm on the primary cleanup loop?

a. Verify MM-2 is running.

b. Verify core tank level between 115” and 117”.

c. Shutdown via automatic rod insertion if primary storage tank level indication is dropping or below normal.

d. Minor scram the reactor.

QUESTION B.09 [1.0 point]
Which ONE of the following conditions during normal reactor operation does NOT violate Technical Specifications?

a. Primary coolant outlet temperature is 60°C with one primary pump running.

b. Subcritical Limit Interlock in bypass.

c. Reactor period 10s.

d. Reactor power level indicating 7.4 MW on multiple channels.

QUESTION B.10 [1.0 point]
In accordance with the MITR Emergency Plan, which ONE of the following statements best describes the Emergency Planning Zone (EPZ)?

a. The area within a 100-meter radius of the containment building.

b. The area within a 100-foot radius of NW-12, the parking lot, and the restricted area.

c. The area within the boundary of the NW-12 building, the parking lot, and the restricted area.

d. The area within the restricted area, which may change during a radiological release depending on wind conditions.

QUESTION B.11 [1.0 point]
In accordance with PM 1.4, Review and Approval of Plans, Procedures, and Facility, changes to all of the following systems would be considered Class B EXCEPT:

a. D_2O reflector tank

b. Effluent radiation monitors

c. Core tank cover gas system

d. Secondary piping systems

QUESTION B.12 [1.0 point]
The radiation from an unshielded source is 500 mrem/hr. A lead sheet of 15 mm thickness is inserted and the radiation level drops to 10 mrem/hr. What is the half-value-layer (HVL) of lead?

a. 26.7 mm

b. 15.7 mm

c. 4.63 mm

d. 2.66 mm

QUESTION B.13 [1.0 point]
In accordance with 10 CFR 20, which ONE of the following statements best describes the Committed Dose Equivalent (CDE)?

a. The concentration of a given radionuclide in air which, if breathed by the reference man for a working year of 2,000 hours under conditions of light work results in one yearly intake limit.

b. The dose equivalent to organs or tissues of reference (T) that will be received from an intake of radioactive material by an individual during the 50-year period following the intake.

c. The sum of the effective dose equivalent for external exposures and the committed effective dose equivalent for internal exposures.

d. Derived limit for the amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in a year.

QUESTION B.14 [1.0 point]
In accordance with PM 6.1.4.7, Shim Blade Drop Time, all of the following conditions must be met EXCEPT:

a. Individual shim blade drop times must be within ± 100 ms of the previous drop time for that blade.

b. Reactor power is maintained around 1 MW for the performance of the test to verify scram response times.

c. The time from initiation of a scram signal from 80% of full insertion is less than 700 ms.

d. Each shim blade is tested individually.

QUESTION B.15 [1.0 point]
In accordance with the MITR Emergency Plan, which ONE of the following events could be classified as an Alert?

a. Radiation levels at the site boundary of 15 mrem/hr sustained for one hour.

b. An earthquake that causes tank water level to drop several inches but does not trigger any level alarms.

c. Fuel handling accident that could release radionuclides to the containment building.

d. A fire on the reactor console that affects the DWK channels.

QUESTION B.16 [1.0 point]
What is the dose rate at 1 foot, given 80% of the decay of an 8 Curie source results in emission of a 450 keV gamma?

a. 17.28 R/hr

b. 15.79 R/hr

c. 9.34 R/hr

d. 1.73 R/hr

QUESTION B. 17 [1.0 point]
In accordance with MITR Technical Specifications, all of the following conditions regarding radiation monitoring operability are true EXCEPT:

a. A minimum of one area radiation monitor on the reactor floor must be operable whenever the reactor floor is occupied.

b. A continuous air monitor must be operable unless a portable monitor capable of being read daily is used.

c. A radiation monitor that samples stack effluent shall be operable when containment is not isolated and containment integrity is required.

d. A plenum effluent monitor which indicates and alarms in the control room shall be operable when containment is not isolated and containment integrity is required.

QUESTION B.18 [1.0 point]
During a reactor startup where you are the reactor operator, you discover that the actual critical shim bank position is 0.6” HIGHER than the estimated critical position (ECP). In accordance with PM 3.1.7, Criticality Not Attained Within 0.5 Inches of ECP, which ONE of the following actions must you take?

a. Lower the shim bank 1.0” or more below the ECP.

b. Lower the shim bank to the ECP.

c. Immediately shut down via All Rods In (ARI).

d. Notify the Senior Reactor Operator on Duty and continue with reactor startup.

QUESTION B.19 [1.0 point]
In accordance with the MITR Technical Specifications, all of the following experiments would be permissible during reactor operations EXCEPT:

a. Three movable experiments, with reactivity worths of -0.25% ΔK/K, 0.10% ΔK/K, and 0.05% ΔK/K.

b. Three non-secured experiments with reactivity worths of -0.25% ΔK/K, 0.25% ΔK/K, and -0.50% ΔK/K.

c. An experiment that contains 2.0 mg of TNT in a container rated to withstand the pressure from a detonation of 25 mg of TNT.

d. A doubly encapsulated experiment containing a small quantity of hydrochloric acid (HCl).

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

Category C: Facility and Radiation Monitoring Systems

QUESTION C.01 [1.0 point]
In accordance with the MITR Reactor Systems Manual, which ONE of the following statements best describes the purpose of the shim blade shear pin?

a. The shear pin detaches during a scram to ensure that even in the event of a loss of power all control rods fall into the core.

b. The shear pin prevents mechanical overload or jamming of the mechanism by breaking if too much force is applied to it.

c. The shear pin prevents shim blade drift during steady state operations.

d. The shear pin restricts movement of the shim blades during the bottom two inches of travel to prevent damage to the blade during a scram.

QUESTION C.02 [1.0 point]
In accordance with the MITR Reactor Systems Manual, all of the following conditions must be met to satisfy the Withdraw Permit Circuit to obtain a reactor start EXCEPT:

a. Reactor key switch is on.

b. All absorbers fully inserted.

c. Building differential pressure is at 0.15 to 0.25 inches of water.

d. Core tank at overflow.

QUESTION C.03 [1.0 point]
In accordance with the MITR Reactor Systems Manual and MITR Technical Specifications, which ONE of the following statements is TRUE?

a. MTS-1 alarms at 55°C and scrams at 60°

b. MT-5 alarms at 53°C and scrams at 55°C.

c. MT-5A only alarms at 60°C.

d. MTS-1A alarms at 53°C and scrams at 55°C.

Category C: Facility and Radiation Monitoring Systems

QUESTION C.04 [1.0 point]
While operating the reactor in steady state automatic mode at 5.9 MW, Shim Blade #3 (selected) begins to insert without operator action. Which ONE of the following conditions could have caused this to occur?

a. The regulating rod has reached its near-out position of 1.5" from fully withdrawn and the automatic rundown circuit has been initiated.

b. The regulating rod has reached its near-in position of 1.5" from fully inserted and the automatic rundown circuit has been initiated.

c. The deviation between the power set point and actual power level has exceeded 1.5% and the reactor is automatically reshimming.

d. The automatic mode circuit is automatically adjusting shim blade position according to an increase in fission product poisons.

QUESTION C.05 [1.0 point]
In accordance with the MITR Reactor Systems Manual, nuclear safety channels 1, 2, 3, and 4 have all of the following trips EXCEPT:

a. Low flux

b. High power

c. Short period

d. Low count rate

QUESTION C.06 [1.0 point]
In accordance with the MITR Reactor Systems Manual, which ONE of the following statements best describes the operation of the MITR area radiation monitors?

a. An NaI Scintillator Detector that emits varying intensities of light based on the energy of the radioactive particle incident on the detector.

b. An ion chamber specifically utilizing boron to distinguish between neutrons and gammas to provide an effective biological dose rate.

c. A Geiger Mueller that uses a bimetallic film to discriminate between high and low energy betas and gammas to produce a dose rate

d. A Geiger Mueller detector calibrated to a known energy to produce a dose rate.

Category C: Facility and Radiation Monitoring Systems

QUESTION C.07 [1.0 point]
In the event of a loss of power to the facility, all of the following components receive power from the backup power system EXCEPT:

a. Primary pump MM-1 and MM-1A

b. Primary coolant auxiliary pump MM-2

c. Radiation monitors

d. Stack instrumentation

QUESTION C.08 [1.0 point]
In accordance with the MITR Reactor Systems Manual, which ONE of the following statements best describes the exhaust air plenum?

a. The exhaust plenum is a long tube where facility air from all vented locations combines to ensure sufficient dilution through the exhaust stack.

b. The exhaust plenum is a series of charcoal and absolute filters used to scrub air before it goes through the exhaust duct to remove any radioactive particulates and prevent release to the environment.

c. The exhaust plenum has a hold-up chamber designed to delay the flow of air through the exhaust duct so that N-16 has sufficient time to decay to prevent spurious radiation alarms.

d. The exhaust plenum has a hold-up chamber designed to delay the flow of air through the exhaust duct so that upon detection of abnormal radiation levels the butterfly dampers have time to close and seal the building.

QUESTION C.09 [1.0 point]
In accordance with the MITR Reactor Systems Manual, which ONE of the following statements best describes the limit and/or proximity switches on the shim blades?

a. Drive in, subcritical, drive out, blade in

b. Drive in, subcritical, drive out, blade out

c. Near in, subcritical, near out, out

d. Drive in, near in, subcritical, blade in

Category C: Facility and Radiation Monitoring Systems

QUESTION C.10 [1.0 point]
In accordance with the MITR Reactor Systems Manual, which ONE of the following statements best describes the operation of the pneumatic tube system?

a. Compressed CO_2 is used to insert the rabbit through the insertion tube and remove the rabbit from the adjacent removal tube.

b. Compressed CO_2 is used to insert the rabbit through the sample tube, then a vacuum is applied to remove the rabbit via suction.

c. Differential air pressure is used to insert the rabbit through the insertion tube and remove the rabbit from the adjacent removal tube.

d. Differential air pressure is used to insert and remove rabbit through the sample tube.

QUESTION C.11 [1.0 point]
In accordance with the MITR Reactor Systems Manual, which ONE of the following statements best explains the function of the N-16 monitor?

a. The N-16 monitor measures the gamma radiation from the production of N-16 at the reactor top as a supplemental indication of radiation dose rates.

b. The N-16 monitor measures the gamma flux from the production of N-16 in the primary coolant outlet piping.

c. The N-16 monitor measures the gamma radiation from N-16 being exhausted through the plenum to ensure 10 CFR 20 release limits are not exceeded.

d. The N-16 monitor measures gamma flux from the production of N-16 in the primary coolant inlet piping.

QUESTION C.12 [1.0 point]
In accordance with the MITR Reactor Systems Manual, which ONE of the following statements best describes the off-gas system?

a. It circulates cooled air around the void above the primary water pool to maintain adequate cooling of the hold down grid.

b. It circulates air around the void above the primary water pool to provide adequate time for N-16 to decay to maintain safe radiation levels on the reactor top.

c. It prevents the accumulation of potentially irradiated air and from hydrogen buildup in the void above the primary water pool by discharging it to the main ventilation exhaust plenum.

d. It circulates CO_2 through the void above the primary water pool to prevent the accumulation of potentially irradiated air.

Category C: Facility and Radiation Monitoring Systems

QUESTION C.13 [1.0 point]
In accordance with the MITR Reactor Systems Manual, a building ventilation isolation signal is produced by all of the following signals EXCEPT:

a. Loss of flow through a plenum monitor.

b. High level alarm on a plenum monitor.

c. Major scram.

d. High level alarm on a stack monitor.

QUESTION C.14 [1.0 point]
In accordance with MITR Technical Specifications, which ONE of the following statements best describes ventilation operability?

a. If ventilation is lost, reactor operations may continue indefinitely in isolation mode.

b. If ventilation is lost, reactor operations may continue for up to an hour before a shutdown is required.

c. If ventilation is lost, operations may continue for five minutes before reactor power must be reduced to less than 250kW.

d. If ventilation is lost, operations may not continue and the reactor must be shutdown via ARI.

QUESTION C.15 [1.0 point]
In accordance with the MITR Reactor Systems Manual, which ONE of the following core tank level indicator provides a scram function?

a. ML-2

b. ML-3

c. ML-3A

d. ML-3B

Category C: Facility and Radiation Monitoring Systems

QUESTION C.16 [1.0 point]
In accordance with the MITR Reactor Systems Manual, which ONE of the following statements best describes the MITR fuel elements?

a. UAl_X enriched to about 93% U-238 clad in aluminum.

b. UAl_X enriched to about 93% U-238 clad in stainless steel.

c. UAl_X enriched to about 93% U-235 clad in aluminum.

d. UAl_X enriched to about 93% U-235 clad in stainless steel.

QUESTION C.17 [1.0 point]
In accordance with MITR Technical Specifications, which ONE of the following statements regarding the anti-siphon valves is true?

a. The anti-siphon valves automatically open to introduce air into the piping system to prevent siphoning of the coolant if there is a break in the primary coolant inlet pipe.

b. The anti-siphon valves automatically close to prevent siphoning of the coolant if there is a break in the primary coolant inlet pipe.

c. The anti-siphon valves are only required for operations below 100 kW.

d. The anti-siphon valves can be used for emergency pool fill in the event of a loss of coolant accident.

QUESTION C.18 [1.0 point]
In accordance with the MITR Reactor Systems Manual, which ONE of the following statements best describes the design/construction of the shim blades?

a. Borated carbon (B_4C) clad in stainless steel

b. Cadmium clad in aluminum

c. Natural boron impregnated stainless steel

d. Boron carbide impregnated aluminum

QUESTION C.19 [1.0 point]
In accordance with the MITR Reactor Systems Manual, the subcritical interlock has all of the following functions EXCEPT:

a. To ensure the maximum reactivity insertion rate is not exceeded during startup.

b. To maintain shim blade bank at a uniform height during final approach to criticality.

c. To establish a level below the critical position to which the shim blades may be individually withdrawn in one step.

d. To provide a convenient reference point for the operator to pause to make a complete instrument check prior to bringing the reactor critical.

QUESTION C.20 [1.0 point, 0.25 each]
Match the radiation monitor in Column A to the Detector Type in Column B. Options in Column B may be used once, more than once, or not at all.

Column A	**Column B**
a. Fission Converter Top Particulate Monitor	1. Pancake type Geiger Mueller
b. Control Room Noble Gas Monitor	2. Thin wall Geiger Mueller
c. Reactor Top Particulate Monitor	3. Solid state-alpha/beta
d. Plenum Gas Monitor	4. Energy Compensated Geiger Mueller

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

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

A.01
Answer: a. 3 (Alpha); b. 2 (Beta Minus); c. 4 (Electron Capture); d. 1 (Beta Plus)
Reference: DOE Fundamentals Handbook, Volume 1, Module 1, p. 24-25

A.02
Answer: b.
Reference: DOE Fundamentals Handbook, Volume 2, Module 3, p. 3

A.03
Answer: d.
Reference: Burn, Introduction to Nuclear Reactor Theory, p. 2-43

A.04
Answer: b.
Reference: $P = P_0 e^{t/T}$
$T = t / (\ln(P/P_0))$
$T = 40/\ln(100/45)$
$T = 40/(\ln(2.22))$
T = 50.09 seconds

A.05
Answer: a.
Reference: DOE Fundamentals Handbook, Volume 1, Module 1, p. 50

A.06
Answer: c.
Reference: DOE Fundamentals Handbook, Volume 2, Module 3, p. 3

A.07
Answer: a.
Reference: Burn, Introduction to Nuclear Reactor Theory, p. 3-12

A.08
Answer: d.
Reference: $T = \frac{\ell^*}{\rho} + \left[\frac{\overline{\beta} - \rho}{\lambda_{eff}\rho}\right]$

$T = \frac{1 * 10^{-4}}{0.005} + \left[\frac{\overline{0.007} - 0.005}{0.1 * 0.005}\right]$

T = 4.02

A.09
Answer: d.
Reference: DOE Fundamentals Handbook, Volume 1, Module 2, p. 3

A.10
Answer: b.
Reference: DOE Fundamentals Handbook, Volume 2, Module 3, p. 24-25

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

A.11
Answer: b.
Reference: Burn, Introduction to Nuclear Reactor Theory, p. 4-14

A.12
Answer: d.
Reference: Burn, *Introduction to Nuclear Reactor Operators,* Section 2.5.1, p. 2-38 to 2-43
Chart of the Nuclides

A.13
Answer: d.
Reference: Lamarsh, *Introduction to Nuclear Engineering*, p. 11

A.14
Answer: a.
Reference: $P = P_0 e^{\tau/T}$
$P = 85\ W * e^{60/7} = 448{,}686.555\ or\ 448.7\ kW$

A.15
Answer: d.
Reference: Burn, *Introduction to Nuclear Reactor Operators,* Volume 2, p. 7-17

A.16
Answer: c.
Reference: DOE Fundamentals Handbook, Vol. 1, Module 1, p. 55

A.17
Answer: d.
Reference: DOE Fundamentals Handbook, Vol. 1, Module 1, p. 61

A.18
Answer: a.
Reference: DOE Fundamentals Handbook, Vol. 2, Module 4, p. 25

A.19
Answer: c.
Reference: $K_{eff} = K_{inf} * P_{FNL} * P_{TNL} = 1.36 * 0.88 * 0.93 = 1.11$

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

Category B: Normal/Emergency Operating Procedures and Radiological Controls

B.01
Answer: c.
Reference: PM 2.2, Preparations for Reactor Operation

B.02
Answer: a.
Reference: PM 5.1.11, Safety System Trouble

B.03
Answer: c.
Reference: 90 mrem + 35 mrem + 5 mrem = 130 mrem

B.04
Answer: a. 2 (Radiation Area); b. 1 (RA); c. 4 (VHRA); d. 3 (HRA)
Reference: 10 CFR 20.1003 and 20.1004

B.05
Answer: b.
Reference: PM 4.4.4.12, Reactor Containment Evacuation

B.06
Answer: a. 3 (Annual); b. 1 (Quarterly); c. 4 (Biennially); d. 2 (Semi-annual)
Reference: MITR Technical Specifications 4.1, 4.3, 4.4, 4.6

B.07
Answer: c.
Reference: Window closed = γ dose only. Window open reads both β and γ dose. Therefore, β dose is window open dose less window closed dose. 200 – 140 = 60 mR/hour

B.08
Answer: d.
Reference: PM 5.2.1, Low Flow MF-2

B.09
Answer: c.
Reference: MITR Technical Specifications 3.2.3, 3.2.4

B.10
Answer: a.
Reference: MITR Emergency Plan 4.2

B.11
Answer: d.
Reference: PM 1.4, Review and Approval of Plans, Procedures, and Facility

Category B: Normal/Emergency Operating Procedures and Radiological Controls

B.12
Answer: d.
Reference: $DR = DR_0 * e^{-\mu X}$
Find μ:
$10 = 500 * e^{-\mu * 15}$
$0.02 = e^{-\mu * 15}$
$\ln(0.02) = \ln(e^{-\mu * 15})$
$-3.91 = -\mu * 15$
$\mu = 0.261$
If insertion of an HVL (thickness of lead), the original intensity will be reduced by half.
Find X:
$1 = 2 * e^{-0.261 * X}$
$0.5 = e^{-0.261 * X}$
$\ln(0.5) = \ln(e^{-0.261 * X})$
$-0.693 = -0.261 * X$
$X = 2.66$ mm

B.13
Answer: b.
Reference: 10 CFR 20.1003

B.14
Answer: b.
Reference: PM 6.1.4.7, Shim Blade Drop Time

B.15
Answer: d.
Reference: MITR Emergency Plan 4.5.3

B.16
Answer: a.
Reference: 6 Cen = R/hr at 1 ft
(6 * 8 Ci) x (0.8 * 0.450)
17.28 R/hr at 1 ft

B.17
Answer: b.
Reference: MITR Technical Specification 3.7.1

B.18
Answer: a.
Reference: PM 3.1.7, Criticality Not Attained Within 0.5 Inches of ECP

B.19
Answer: a.
Reference: MITR Technical Specification 6.1

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

Category C: Facility and Radiation Monitoring Systems

C.01
Answer: b.
Reference: MITR Reactor Systems Manual, 1.3

C.02
Answer: c.
Reference: MITR Reactor Systems Manual, 4.1

C.03
Answer: d.
Reference: MITR Reactor Systems Manual 3.2.2
MITR Technical Specification 3.2.3

C.04
Answer: b.
Reference: MITR Reactor Systems Manual 4.8

C.05
Answer: a.
Reference: MITR Reactor Systems Manual 5.5.2

C.06
Answer: d.
Reference: MITR Reactor Systems Manual 7.2

C.07
Answer: a.
Reference: MITR Reactor Systems Manual Table 8.8.3

C.08
Answer: d.
Reference: MITR Reactor Systems Manual 8.3.6

C.09
Answer: a.
Reference: MITR Reactor Systems Manual 4.10

C.10
Answer: d.
Reference: MITR Reactor Systems Manual 2.5

C.11
Answer: b.
Reference: MITR Reactor Systems Manual 5.3.4

C.12
Answer: c.
Reference: MITR Reactor Systems Manual 3.2.5

Category C: Facility and Radiation Monitoring Systems

C.13
Answer: d.
Reference: MITR Reactor Systems Manual 7.4.3

C.14
Answer: c.
Reference: MITR Technical Specification 3.5

C.15
Answer: b.
Reference: MITR Reactor Systems Manual 6.5.1

C.16
Answer: c.
Reference: MITR Reactor Systems Manual 1.2.1

C.17
Answer: a.
Reference: MITR Technical Specification 3.3.1

C.18
Answer: c.
Reference: MITR Reactor Systems Manual 1.3.1

C.19
Answer: a.
Reference: MITR Reactor Systems Manual 4.2

C.20
Answer: a. 3; b. 2; c. 1; d. 1
Reference: MITR Reactor Systems Manual Tables 7.2 and 7.5

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