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

May 4, 2026

Dr. Ayodeji Alajo, Director
Nuclear Reactor Facility
Missouri University of Science
and Technology
219 Fulton Hall
Rolla, MO 65409-0170

SUBJECT: EXAMINATION REPORT NO. 50-123/OL-26-01, THE CURATORS OF THE UNIVERSITY OF MISSOURI

Dear Dr. Alajo:

During the week of April 20, 2026, the U.S. Nuclear Regulatory Commission (NRC) administered an operator licensing examination at your Missouri University of Science and Technology Research 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 Michele DeSouza at (301) 415-0747, or via email at Michele.DeSouza@nrc.gov.

Sincerely,

Signed by Brown, Tony
on 05/04/26

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. 50-123

Enclosures:
1. Examination Report No. 50-123/OL-26-01
2. Written examination

cc: w/ enclosures to GovDelivery Subscribers

SUBJECT: EXAMINATION REPORT NO. 50-123/OL-26-01, THE CURATORS OF THE UNIVERSITY OF MISSOURI DATED: MAY 4, 2026

DISTRIBUTION:
PUBLIC
MReisi-Fard, NRR
TBrown, NRR
JRady, NRR
SMontanez, NRR
MBalazik, NRR
MDeSouza, NRR
ABeasten, NRR
JNadel, NRR
NJones, NRR
RAlexander, RGN-IV

ADAMS Accession Nos.:
Pkg: ML25342A087
Report: ML25342A286
e-Concurrence case: 20260326-70029 **NRR-079**

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

REPORT NO.: OL-26-01

FACILITY DOCKET NO.: 50-123

FACILITY LICENSE NO.: R-79

FACILITY: Missouri University of Science and Technology Research Reactor

EXAMINATION DATE(S): Week of April 20, 2026

SUBMITTED BY: 

Michele C. DeSouza, Chief Examiner

April 24, 2026
Date

SUMMARY:
During the week of April 20, 2026, the NRC administered operator licensing examinations to seven Reactor Operator (RO) candidates, one RO Retake candidate and two Senior Reactor Operator Upgrade (SRO-U) candidates. All candidates passed all applicable portions of the examinations and tests.

REPORT DETAILS

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

2. Results:

	RO PASS/FAIL	SRO PASS/FAIL	TOTAL PASS/FAIL
Written	8/0	0/0	8/0
Operating Tests	7/0	2/0	9/0
Overall	8/0	2/0	10/0

3. Exit Meeting:
Michele C. DeSouza, Chief Examiner, NRC
Amy E. Beasten, PhD, NRC Chief Examiner, NRC
Ethan Taber, Reactor Supervisor, MSTR

Prior to administration, adjustments to the written exam were accepted based on facility comments. These 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 examiner met with facility staff representatives to discuss the results. At the conclusion of the meeting, the NRC examiner thanked the facility for their support in the administration of the examination.

U.S.NRC

UNITED STATES NUCLEAR REGULATORY COMMISSION

Protecting People and the Environment

Missouri University of Science & Technology Research Reactor

Operator Licensing Examination

Week of April 20, 2026

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

FACILITY: MS&T

REACTOR TYPE: Pool MTR

DATE ADMINISTERED: April 20, 2026

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. Answers written on the line will be taken as the final answer. 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 on the line. Answers written on the line will be taken as the final answer.

A01 a b c d ___

A02 a b c d ___

A03 a b c d ___

A04 a _____ b _____ c _____ d _____ (0.50 each)

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 _____ (0.25 each)

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 on the line. Answers written on the line will be taken as the final answer.

B01 a b c d ___

B02 a _____ b _____ c _____ d _____ (0.50 each)

B03 a b c d ___

B04 a b c d ___

B05 a b c d ___

B06 a b c d ___

B07 a b c d ___

B08 a b c d ___

B09 a b c d ___

B10 a b c d ___

B11 a b c d ___

B12 a b c d ___

B13 a b c d ___

B14 a b c d ___

B15 a b c d ___

B16 a b c d ___

B17 a b c d ___

B18 a b c d ___

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 on the line. 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 _____ (0.50 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 [1.00 point]
Which ONE of the following is NOT an effective neutron moderator characteristic?

a. Low atomic density

b. Low neutron absorption cross section

c. Large neutron scattering cross section

d. Large neutron energy loss per collision

QUESTION A.02 [1.00 point]
Which ONE of the following has a long-term effect on k_{eff} but is of no consequence during short term and transient operation?

a. Fuel burnup

b. Increase in fuel temperature

c. Increase in moderator temperature

d. Xenon and Samarium fission products

QUESTION A.03 [1.00 point]
How high will the reactor power get given the following: the lowest of the reactor high power scram set points is 120%, the scram delay time is 0.7 seconds, the reactor is operating at 100% power prior to the scram, and the reactor period is positive 30 seconds?

a. 106%

b. 111%

c. 123%

d. 139%

QUESTION A.04 [2.00 points, 0.50 each]
Match the reaction type in Column A with the equation in Column B. Options in Column B may be used once, more than once, or not at all.

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

QUESTION A.05 [1.00 point]
Which ONE of the following types of neutrons has a core lifetime of approximately 5 x10^{-5}s?

a. Delayed neutrons

b. Prompt neutrons

c. Thermal neutrons

d. Resonance neutrons

QUESTION A.06 [1.00 point]
Which ONE of the following is the phenomenon where the resonance peaks of the neutron absorption cross section increase in width due to thermal motion of the nuclei?

a. Mass defect

b. Doppler broadening

c. Spectrum hardening

d. Moderator negative temperature coefficient

QUESTION A.07 [1.00 point]
Which ONE of the following describes the Integral Rod Worth?

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

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

c. The capability of overriding xenon poisoning.

d. The plot of the slope of the change in reactivity over the change in rod position ($\Delta\rho/\Delta x$).

QUESTION A.08 [1.00 point]
What is the remaining power following the prompt drop in the reactor power when a rod worth of 0.59 ΔK/K is rapidly inserted into a critical reactor? Assume βeff = 0.0067

a. 1.82%

b. 2.77%

c. 3.92%

d. 4.54%

QUESTION A.09 [1.00 point]
Which ONE of the following conditions would INCREASE the shutdown margin of a reactor?

a. Depletion of uranium fuel

b. Depletion of burnable poison

c. Inserting an experiment adding positive reactivity

d. Lowering moderator temperature if the moderator temperature coefficient is negative

QUESTION A.10 [1.00 point]
Which ONE of the following is a correct statement of how delayed neutrons enhance the ability to control reactor power?

a. Delayed neutrons are born at a higher energy level than prompt neutrons.

b. Delayed neutrons increase the average neutron lifetime that allows a reactor to be controlled.

c. Prompt neutrons can cause fissions in both uranium-235 and uranium-238 and delayed neutrons can only cause fissions in uranium-235.

d. The average number of delayed neutrons produced per fission is higher than the average number of prompt neutrons.

QUESTION A.11 [1.00 point]
An experimenter inserts an experiment into the core, and the count rate increases from 55 cps to 175 cps. Given the initial K_{eff} of the reactor was 0.85, what is the worth of the experiment?

a. $\Delta\rho$ = + 0.112

b. $\Delta\rho$ = - 0.171

c. $\Delta\rho$ = + 0.127

d. $\Delta\rho$ = - 0.195

QUESTION A.12 [1.00 point]
Which ONE of the following best describes the effects of moderator temperature DECREASE on neutron multiplication? L_f - Fast non-leakage probability L_t – Thermal non-leakage probability?

a. $\downarrow L_f$, $\downarrow L_t$, $\downarrow$rod worth

b. $\uparrow L_f$, $\downarrow L_t$, $\uparrow$rod worth

c. $\downarrow L_f$, $\downarrow L_t$, $\uparrow$rod worth

d. $\uparrow L_f$, $\uparrow L_t$, $\downarrow$rod worth

QUESTION A.13 [1.00 point]
Which ONE of the following statements regarding fission product poisoning is true?

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

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

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

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

QUESTION A.14 [1.00 point]
The reactor operator is using a 1/M plot to monitor core loading while new fuel is being loaded into the core. Which ONE of the following conditions could result in the reactor reaching critical mass at a value greater than the predicted critical mass?

a. The detector and source are too far from each other.

b. Too much time elapses between subsequent core loadings.

c. The detector is located so that core load starts away from the detector and subsequent loading proceeds towards the detector.

d. The detector is located so that core load starts at a point close to the detector and subsequent loadings move farther from the detector.

QUESTION A.15 [1.00 point]
Which ONE of the following statements correctly describes thermal neutrons?

a. A neutron at resonant epithermal energy levels that causes fissions to occur in uranium-238.

b. A neutron that experiences no net change in energy after several collisions with atoms of the moderator.

c. A neutron that experiences a linear decrease in energy as the temperature of the moderator increases.

d. A neutron that experiences an increase in energy levels after collisions with larger atoms of the moderator.

QUESTION A.16 [1.00 point, 0.25 each]
For each scenario in Column A, identify the direction in Column B that control rods would need to be moved to maintain constant reactor power. Answers in Column B may be used once, more than once, or not at all.

Column A	**Column B**
a. Buildup of Xe-135	1. Insert
b. Burnup of U-238	2. Withdraw
c. Removal of neutron source	3. No movement
d. Fuel temperature decrease	

QUESTION A.17 [1.00 point]
Which ONE of the following delayed neutron precursors results in the greatest negative period following a reactor scram?

a. Bromine-87 ($T_{1/2}$ = 55.5s)

b. Rubidium-93 ($T_{1/2}$ =5.8s)

c. Iodine-137 ($T_{1/2}$ = 22.7s)

d. Xenon-143 ($T_{1/2}$ = 0.5s)

QUESTION A.18 [1.00 point]
Which ONE of the following is the definition of shutdown margin (SDM)?

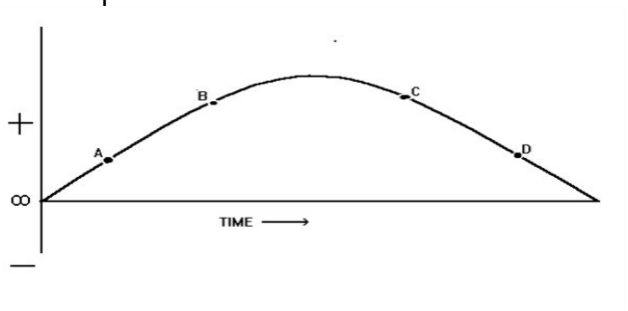
a. The total negative reactivity added to the core during a reactor scram from full power conditions.

b. The difference between the total control rod worth and the total reactivity added by a change in moderator temperature from full power to standby mode.

c. The instantaneous amount of reactivity by which the reactor is subcritical or would be subcritical from its present condition, assuming all control rods are fully inserted.

d. The amount of negative reactivity that would be inserted into a reactor core if all rods were dropped from critical height.

QUESTION A.19 [1.00 point]
The following diagram is a trace of reactor period as a function of time. Between points C and D reactor power is:



a. constant

b. continually increasing

c. continually decreasing

d. increasing, then constant

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

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.01 [1.00 point]
In accordance with the MS&T Emergency Plan, a _____ evacuation is initiated when the radiation area monitor reaches _____.

a. site, less than or equal to 5 mrem/hr

b. area, less than or equal to 10 mrem/hr

c. building, less than or equal to 50 mrem/hr

d. campus, less than or equal to 100 mrem/hr

QUESTION B.02 [2.00 points, 0.50 each]
Given a mother isotope of $_{35}Br^{87}$ identify each of the daughter isotopes as a result of: α, β+, β-, γ, or n? (Answers may be used once, more than once or not at all).

a. $_{33}As^{83}$

b. $_{34}Se^{87}$

c. $_{35}Br^{86}$

d. $_{36}Kr^{87}$

QUESTION B.03 [1.00 point]
Which ONE of the following is the requalification operating test requirement for maintaining an active operator license?

a. 1 year

b. 2 years

c. 4 years

d. 6 years

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.04 [1.00 point]
What is the approximate half-life of the isotope contained in a sample which produces the following count rates?

Time (minutes)	Counts per minute (cpm)
Initial count	840
30	740
60	615
90	512
180	270

a. 110 minutes

b. 170 minutes

c. 210 minutes

d. 323 minutes

QUESTION B.05 [1.00 point]
Which ONE of the following materials shall NOT be irradiated in the reactor core?

a. Any fissionable material

b. Any secured experiment worth 0.4% Δk/k

c. Any buoyant material on a stringer

d. Any unencapsulated corrosive material

QUESTION B.06 [1.00 point]
How long will it take a 50 Curie source, with a half-life of 5.26 years, to decay to 2 Curies?

a. 17.31 years

b. 24.48 years

c. 38.99 years

d. 46.52 years

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.07 [1.00 point]
Which ONE of the following conditions would be a violation of 10 CFR Part 55?

a. Your last medical exam was 26 months ago.

b. Last quarter, you were the console operator for 6 hours.

c. Your last operating test was 10 months ago.

d. Your last written examination was 22 months ago.

QUESTION B.08 [1.00 point]
In accordance with MS&T Emergency Plan, which ONE of the following is NOT an unusual event?

a. A tornado in the vicinity of the reactor.

b. A civil disturbance impacting the reactor.

c. A threat of reactor security.

d. A significant release of radioactive material (75 Rem) from an experiment.

QUESTION B.09 [1.00 point]
In accordance with the MS&T SOP 109, Determination of Control Rod Worth, which ONE of the following is the correct method.

a. Asymptotic period

b. Inverse kinetic

c. Rod drop

d. Compensation

QUESTION B.10 [1.00 point]
In accordance with MS&T SOP 111, Measurement of Core Excess Reactivity and Determination of Shutdown Margin, which ONE of the following conditions is NOT part of the shutdown margin procedure?

a. Sum the total reactivity of all rods fully withdrawn.

b. Measure excess reactivity by static method only.

c. Determine total rod worth for highest worth rod when fully withdrawn.

d. Determine total worth of the regulating rod when fully withdrawn.

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.11 [1.00 point]
Which ONE of the following is the definition for Annual Limit on Intake (ALI)?

a. Projected dose commitment values to individuals that warrant protective action following a release of radioactive material.

b. The concentration of a radionuclide in air which, if inhaled by an adult worker for a year, results in a total effective dose equivalent of 100 mrem.

c. The effluent concentration of a radionuclide in air which, if inhaled continuously over a year, would result in a total effective dose equivalent of 50 mrem for noble gases.

d. 10 CFR 20 derived limit, based on a committed dose equivalent of 5 rem whole body or 50 rem to any individual organ, for the amount of radioactive material inhaled or ingested in a year by an adult worker.

QUESTION B.12 [1.00 point]
In accordance with MS&T SOP 101, which ONE of the following is the minimum level of authority needed to disregard certain SOPs provided that no safety requirements are violated?

a. Reactor Operator

b. Senior Reactor Operator on duty

c. Facility Director

d. Nuclear Regulatory Commission

QUESTION B.13 [1.00 point]
In accordance with MS&T SOP 101, General Operational Procedures, which ONE of the following conditions does NOT require an SRO presence at the facility?

a. Relocating a movable experiment with a reactivity worth of $1.25.

b. Control rod relocations within the reactor core region.

c. Significant reactor power increases.

d. Recovery from an unscheduled shutdown.

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.14 [1.00 point]
In accordance with MS&T Technical Specifications, which ONE of the following is NOT a requirement for experiments > 0.4% Δk/k?

a. Inserted with the reactor shutdown.

b. Removed with the reactor shutdown.

c. Inserted and removed only with an approved procedure by the Reactor Safety Committee.

d. Movable experiments as long as their insertion rate is greater than +.0.05% Δk/k.

QUESTION B.15 [1.00 point]
Which ONE of the following changes would NOT require a 10 CFR 50.59 evaluation?

a. An administrative update to the Safety Analysis Report to correct spelling and formatting errors.

b. A modification to eliminate paper logbook requirements and move to digital log keeping.

c. Changing the safety channel #1 scram 140% to 145%.

d. Analyzing a reactivity insertion using a new approach.

QUESTION B.16 [1.00 point]
The exposure rate for a point source is 300 mR/hr at a distance of 1.5 meters. What is the exposure rate at a distance of 5 meters?

a. 15 mR/h

b. 27 mR/hr

c. 48 mR/hr

d. 67 mR/hr

QUESTION B.17 [1.00 point]
In accordance with the MS&T Emergency Plan, all of the following are alternative emergency actions to be considered EXCEPT:

a. capping the air intake screens.

b. sealing all external doors with tape.

c. turning off all water supplies to the building.

d. opening all drain lines to sewer system and storm sewers.

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.18 [1.00 point]
In accordance with MS&T Technical Specifications, which ONE of the following is NOT a MINIMUM surveillance requirement concerning the safety channels?

a. Thermal power calibration verified on an annual basis.

b. Reactor power range safety channel and period channel calibration on an annual basis.

c. Daily channel test of the reactor safety system channels before reactor operations.

d. Daily channel test of the loss of coolant and bridge motion monitor.

QUESTION B.19 [1.00 point]
In accordance with MS&T SOP 501, Emergency Procedures for Reactor Building Evacuation, all of the following shall declare when the emergency no longer exists EXCEPT:

a. Senior Reactor Operator on Duty

b. Emergency Director

c. Reactor Manager

d. Radiation Safety Officer

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

Category C: Facility and Radiation Monitoring Systems

QUESTION C.01 [1.00 point]
In accordance with the MS&T SOP 651, Contamination Surveys, a swipe of 100 cm^2 is deemed contaminated at what level?

a. 100 cpm

b. 200 dpm

c. 100 pCi

d. 200 µCi

QUESTION C.02 [1.00 point]
In accordance with the MS&T Safety Analysis Report, which ONE of the following is the pool temperature limit and the basis for maintaining that limit?

a. 20.2ºC, to ensure nucleate boiling is maintained at the lowest temperature possible.

b. 43.1ºC, to support fuel temperatures are maintained with Technical Specifications.

c. 57.2ºC, to limit the temperature to the resin exchange beds for maximum performance.

d. 98.4ºC, to provide the maximum level permissible in support of pump operability.

QUESTION C.03 [1.00 point]
In accordance with the MS&T SAR, which ONE of the following period requirements can be bypassed by the Senior Reactor Operator on duty?

a. < 5 second period scram

b. < 15 second period rundown

c. < 30 second rod withdrawal prohibit

d. None of the above

QUESTION C.04 [1.00 point]
Which ONE of the following describes the composition of a fuel plate?

a. U2Si3-Al enriched to < 20% U-235

b. U2Si3-Al enriched to < 20% U-238

c. U3Si2-Al enriched to < 20% U-238

d. U3Si2-Al enriched to < 20% U-235

Category C: Facility and Radiation Monitoring Systems

QUESTION C.05 [1.00 point]
In accordance with the MS&T Safety Analysis Report, the reactor bay is maintained at a slight _____ differential pressure in order to _____.

a. negative; ensures all Ar-41 produced during operation is contained within the reactor bay to prevent uncontrolled radiological releases to the environment.

b. negative; ensures all Ar-41 produced during operation is released in a controlled manner to ensure personnel working within the reactor bay are adequately protected.

c. positive; ensures all Ar-41 produced during operation is contained within the reactor bay to prevent uncontrolled radiological releases to the environment.

d. positive; ensures all Ar-41 produced during operation is released in a controlled manner to ensure personnel working within the reactor bay are adequately protected.

QUESTION C.06 [1.00 point]
While raising rods during reactor startup, high-voltage power supply for the Log/Linear Drawer drops to 0 volts during operations. What is the result?

a. A rod withdrawal prohibit prevents further rod motion until the RWP alarm is cleared.

b. Log and Linear Drawer goes into Not Operate mode, energizing the rundown/scram relay, causing a reactor rundown and a reactor scram.

c. Log and Linear Drawer goes into Not Operate mode, de-energizing the rundown/scram relay, causing a reactor rundown and a reactor scram.

d. There is no effect on the reactor because the signal from this channel is still output to a functional digital chart recorder.

QUESTION C.07 [1.00 point]
All of the following statements regarding control rod worth is true EXCEPT:

a. The maximum rate of change in reactivity for the regulating rod is 0.014% Δk/k.

b. The rate of change in reactivity for any one safety rod is about 0.02% Δk/k-sec.

c. The regulating rod provides approximately 0.5% Δk/k worth.

d. The total ganged worth of all three safety rods is about 6% Δk/k.

Category C: Facility and Radiation Monitoring Systems

QUESTION C.08 [1.00 point]
All of the following statements regarding startup channel is true EXCEPT:

a. The startup channel is gradually withdrawn from the core as neutron count rate increases in order to provide an absolute indication of reactor power.

b. The startup channel provides a signal to prevent control rod movement if neutron count rate is less than 2 cps.

c. The startup channel may be withdrawn from the core once positive indications register on the linear power channels.

d. When fully inserted into the core, the startup channel can monitor neutron population up to a reactor power of approximately 20 W.

QUESTION C.09 [1.00 point]
Which ONE of the following best describes why fuel elements may need to be removed from the core during control rod maintenance?

a. To comply with core excess requirements.

b. To minimize radiation dose to operators on the reactor pool top.

c. To ensure the core is less than 50% critical mass to prevent prompt criticality from occurring.

d. Control rod maintenance is usually done concurrently with fuel shuffle, so the procedure allows for both core manipulations to be performed simultaneously.

QUESTION C.10 [1.00 point]
Which ONE of the following best describes a half fuel element?

a. they are 17” tall.

b. they contain nine fueled plates surrounding a control rod guide tube.

c. they are identical to standard fuel elements, except only nine plates contain fuel, and the other nine plates contain aluminum.

d. they contain nine aluminum plates and nine fueled plates, because these plates are of higher U-235 enrichment than standard fuel elements.

Category C: Facility and Radiation Monitoring Systems

QUESTION C.11 [1.00 point]
In accordance with the MS&T Technical Specifications, which ONE of the following statements regarding pool water quality is NOT true?

a. Pool water conductivity shall be measured monthly if the reactor is not operated.

b. Pool water resistivity must be greater than 0.2 MΩ-cm while fuel elements are in the pool.

c. Pool water resistivity to be measured at least once every 4 weeks during periods when the reactor is operating.

d. Pool water resistivity measurements can be temporarily exceeded for a period of up to three weeks once every three years as a matter of operational convenience.

QUESTION C.12 [1.00 point]
All of the following statements regarding reflector mode operation is false EXCEPT:

a. The excess reactivity Technical Specification limit may be waived for operation in the “T-mode”.

b. The Technical Specification maximum excess reactivity for the core is 1.5% Δk/k in the “W-mode” and 1.0% Δk/k.

c. Following any change in core configuration, the excess reactivity of the core shall be determined for both the “W-mode” and the “T-mode.”.

d. When operating in the “T-mode,” one or more fuel elements must be removed to ensure the Technical Specification maximum excess reactivity is not exceeded.

QUESTION C.13 [1.00 point]
Which ONE of the following is NOT categorized as closure equipment that ensures the reactor bay is operable?

a. Ventilation fans

b. Ventilation inlet

c. Exhaust duct louvers

d. Personnel security door

Category C: Facility and Radiation Monitoring Systems

QUESTION C.14 [1.00 point]
Which ONE of the following situations have a Motion Switch Initiating Action with a corresponding reactor scram Protective Action?

a. Bridge Motion

b. Basement Sump Level High

c. Beam Port or Thermal Column 'open'

d. Regulating Rod Insert Limit on Auto-Control

QUESTION C.15 [1.00 point]
In accordance with the MS&T Technical Specifications, which ONE of the following is the true in regard to regulating rod reactivity worth?

a. shall be no more than 0.7% Δk/k

b. shall be no more than 0.85% Δk/k

c. shall be greater than 2.5% Δk/k

.

d. shall be greater than 3.5% Δk/k

QUESTION C.16 [1.00 point]
Which ONE of the following nuclides requires a semi-annual pool water analysis?

a. Tritium, H-3

b. Nitrogen-16

c. Fluorine-18.

d. Sodium-24

QUESTION C.17 [1.00 point]
In accordance with MS&T Technical Specifications, which ONE of the following statements regarding the inoperable radiation area monitors is true?

a. portable neutron environmental monitors can substitute for continuing operations.

b. electronic personnel monitoring can substitute for 1 day.

c. portable gamma radiation instruments can substitute for 1 week.

d. cannot substitute alternate equipment nor operate until the radiation area monitors are operable.

Category C: Facility and Radiation Monitoring Systems

QUESTION C.18 [1.00 point]
In accordance with the MS&T Safety Analysis Report, all of the following receive power from a battery backup in the event of a loss of power to the facility EXCEPT:

a. Fire alarm system

b. Evacuation alarm

c. Nuclear Instrumentation

d. Security system

QUESTION C.19 [2.00 points, 0.50 each]
Match the alarm in Column A with the type of automatic engineered protective actions provided with the MS&T instrumentation in Column B. Answers may be used once, more than once, or not at all.

Column A	**Column B**
a. WHITE alarms	1. Reactor Rundown with audio/visual
b. YELLOW alarms	2. Informational with audio/visual
c. BLUE alarms	3. Rod withdrawal prohibit (RWP) with audio/visual
d. RED alarms	4. Reactor scram with audio/visual

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

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

A.01
Answer: a
Reference: DOE Fundamentals Handbook, Volume 2, Module 3, p 24.

A.02
Answer: a
Reference: Standard NRC question

A.03
Answer: c
Reference: $P/P_o = 120\%$, T = 30 seconds, t = 0.7, $P/P_o = 120\ e^{\wedge 0.7/30} = 123\%$

A.04
Answer: a. 3; b. 2; c. 4; d. 1
Reference: DOE Fundamentals Handbook, Volume 1, Module 1, p. 24-25

A.05
Answer: b
Reference: DOE Fundamentals Handbook, Volume 1, Module 2, p. 32

A.06
Answer: b
Reference: DOE Fundamentals Handbook, Volume 2, Module 3, p.4

A.07
Answer: b
Reference: Burn, *Introduction to Nuclear Reactor Operations*, Section 7.3, p. 7-5

A.08
Answer: a
Reference: $\frac{P_1}{P_0} = \frac{\beta_{eff} \cdot (1-p)}{\beta_{eff} - p}$
$P_1/P_0 = (0.0067 \times (1+0.59)) / (0.0067+0.59)$
$P_1/P_0 = 0.01815$
$P_1/P_0 = 1.82\%$

A.09
Answer: a
Reference: Burn, *Introduction to Nuclear Reactor Operations*, Section 6.2.3

A.10
Answer: b
Reference: Burn, *Introduction to Nuclear Reactor Operations*, Section 3.3.2, p. 3-7

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

A.11
Answer: c
Reference: $CR_1 / CR_2 = (1 – K_{eff2}) / (1 – K_{eff1})$
$55 / 175 = (1 – K_{eff2}) / (1 – 0.85)$
$0.314 = (1 – K_{eff2}) / 0.15$
Therefore $K_{eff2} = 0.9529$
$\Delta\rho = (K_{eff2} – K_{eff1}) / (K_{eff2} * K_{eff1})$
$\Delta\rho = (0.9529 – 0.85) / (0.9529 * 0.85); 0.1029 / 0.809965$
$\Delta\rho = + 0.127$

A.12
Answer: d
Reference: Burn, *Introduction to Nuclear Reactor Operations*, Section 3.3.2

A.13
Answer: b
Reference: DOE Fundamentals Handbook, Volume 2, Module 3, p. 30-47

A.14
Answer: c
Reference: Burn, *Introduction to Nuclear Reactor Operations,* Section 5.5, p. 5-18

A.15
Answer: b
Reference: DOE Fundamentals Handbook, Volume 1, Module 2

A.16
Answer: a. 2 (Withdraw); b. 2 (Withdraw); c. 2 (Withdraw); d. 1 (Insert)
Reference: Burn, *Introduction to Nuclear Reactor Operations*, p. 7-17

A.17
Answer: a
Reference: DOE Fundamentals Handbook, Volume 2, Module 4, p. 32

A.18
Answer: d
Reference: Burn, *Introduction to Nuclear Reactor Operations*, Volume 3, Section 6.2.3, p.6-4

A.19
Answer: b
Reference: Reactor is continually increasing, since reactor period is still positive.

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

Category B: Normal/Emergency Operating Procedures and Radiological Controls

B.01
Answer: c
Reference: MS&T Emergency Plan, 7.4.1

B.02
Answer: a. α; b. β+; c. n; d. β-
Reference: Chart of Nuclides

B.03
Answer: a
Reference: 10 CFR 55.59(a)(2)

B.04
Answer: c
Reference: $A = A_0 e^{-\lambda t}$; $270 = 840e^{-180\lambda}$, $180\lambda = -\ln(0.321)$, $\lambda = 0.00631\ min^{-1}$
$t_{1/2} = 0.693 / \lambda$, $= 0.693 / 0.00631\ min^{-1} = 109.8$ minutes

B.05
Answer: d
Reference: MS&T Technical Specification 3.7.2

B.06
Answer: b
Reference: $A = A_\circ * e^{-\lambda t}$
$2Ci = 50Ci * e^{-\lambda(t)}$
$\ln(2/50) = -\ln 2/5.27\ yr * (t)$ --> $-3.2189/-0.1315$ →
solve for t: 24.48 years

B.07
Answer: a
Reference: 10 CFR Part 55

B.08
Answer: d
Reference: MS&T Emergency Plan 4.2 and 4.3

B.09
Answer: c
Reference: MS&T SOP 109, *Determination of Control Rod Worths by Rod Drop Method*

B.10
Answer: b
Reference: MS&T SOP 111, *Measurement of Core Excess Reactivity and Determination of Shutdown Margin*

B.11
Answer: d
Reference: 10 CFR 20.1003

Category B: Normal/Emergency Operating Procedures and Radiological Controls

B.12
Answer: b
Reference: MS&T SOP 101, General Operational Procedures

B.13
Answer: c
Reference: MS&T Procedure 101, General Operational Procedures

B.14
Answer: d
Reference: MS&T Technical Specifications 3.7.1

B.15
Answer: a
Reference: 10 CFR 50.59; Standard NRC question

B.16
Answer: b
Reference: $I_2 = I_1 D_1^2 / d_2^2$
$I_2 = (300 \text{ mR/hr})(1.5\text{m})^2 / (5\text{m})^2$
$I_2 = 27 \text{ mR/hr}$

B.17
Answer: d
Reference: MS&T Emergency Plan, 7.3

B.18
Answer: d
Reference: MS&T Technical Specifications 4.2.2

B.19
Answer: a
Reference: MS&T SOP 501, Emergency Procedures for Reactor Building Evacuation

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

Category C: Facility and Radiation Monitoring Systems

C.01
Answer: c
Reference: MS&T SOP 651, Contamination Survey

C.02
Answer: c
Reference: MS&T SAR 5.3

C.03
Answer: c
Reference: MS&T SAR 7.22.3

C.04
Answer: d
Reference: MS&T SAR 4.2

C.05
Answer: b
Reference: MS&T SAR 3 and MS&T Technical Specifications 3.4 and 3.5

C.06
Answer: c
Reference: MS&T SAR 7

C.07
Answer: d
Reference: MS&T SAR 4.5.1

C.08
Answer: a
Reference: MS&T SAR 11.1.1

C.09
Answer: c
Reference: MS&T SAR 7.2.2.1

C.10
Answer: c
Reference: MS&T SAR 4.2.1

C.11
Answer: c
Reference: MS&T Technical Specifications 3.3 and 4.3

C.12
Answer: c
Reference: MS&T Technical Specifications 3.1 and SOP 111

C.13
Answer: a
Reference: MS&T Technical Specifications 4.4 and SOP 812

Category C: Facility and Radiation Monitoring Systems

C.14
Answer: a
Reference: MS&T SAR Table 7.2

C.15
Answer: a
Reference: MS&T Technical Specifications 3.1.5

C.16
Answer: a
Reference: MS&T SAR 11.1.2.3

C.17
Answer: c
Reference: MS&T Technical Specifications 3.6.1

C.18
Answer: c
Reference: MS&T SAR 8.3

C.19
Answer: a. 2, b. 3, c. 1, d. 4
Reference: MS&T SAR 7.2.2

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