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

April 9, 2025

Ethan Taber, Reactor Manager
Nuclear Reactor Facility
Missouri University of Science
and Technology
250 West 13th Street
Rolla, MO 65409-0630

SUBJECT: EXAMINATION REPORT NO. 50-123/OL-25-02, MISSOURI UNIVERSITY SCIENCE AND TECHNOLOGY

Dear Ethan Taber:

During the week of March 17, 2024, 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 Amy Beasten at 301-415-8341 or via email at Amy.Beasten@nrc.gov.

Sincerely,

Signed by Brown, Tony
on 04/09/25

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. 50-123

Enclosures:
1. Examination Report No. 50-123/OL-25-02
2. Written examination

cc: w/enclosures to GovDelivery Subscribers

SUBJECT: EXAMINATION REPORT NO. 50-123/OL-25-02, MISSOURI UNIVERSITY OF SCIENCE AND TECHNOLOGY DATED: APRIL 9, 2025

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DATE	4/9/2025	4/9/2025	4/9/2025

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

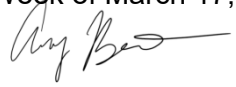
REPORT NO.: 50-123/OL 25-02

FACILITY DOCKET NO.: 50-123

FACILITY LICENSE NO.: R-79

FACILITY: Missouri University Science and Technology

EXAMINATION DATES: Week of March 17, 2025

SUBMITTED BY: 

Name, Chief Examiner

4/1/2025
Date

SUMMARY:
During the week of March 17, 2025, the NRC administered operator licensing examinations to six Reactor Operator (RO) candidates, one Senior Reactor Operator-Upgrade (SRO-U), candidate, and one RO Category B written examination retake candidate. All candidates passed all applicable portions of the examinations.

REPORT DETAILS

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

2. Results:

	RO PASS/FAIL	SRO PASS/FAIL	TOTAL PASS/FAIL
Written	7/0	0/0	7/0
Operating Tests	7/0	1/0	8/0
Overall	7/0	1/0	8/0

3. Exit Meeting:
Amy E. Beasten, PhD, NRC Chief Examiner
Ethan Taber, MSTR Reactor Manager
Dr. Joseph Graham, Reactor Director
Liatris Parker-Reece, Training Coordinator

Prior to administration of the written examination, based on facility comments, adjustments were accepted. Comments provided corrections and additional clarity to questions/answers and identified where changes were appropriate based on current facility conditions.

Upon completion of all operator licensing examinations, the NRC examiner met with facility staff representatives to discuss the results. The NRC examiner discussed some apparent weaknesses among the expected level of knowledge for RO and SRO candidates. Examiner observations include: general weakness of the expected level of knowledge concerning Radiation Health Physics, specifically common radiological isotope production and decay mechanisms, personal dosimetry, and some confusion surrounding federal dose limits for occupational workers and members of the public; gaps in fuel handling roles and

responsibilities, specifically at the RO level; facility ventilation systems and thermocouple operation. At the conclusion of the meeting, the NRC examiner thanked the facility for their support in the administration of the examination.

Missouri University of Science and Technology

Operator Licensing Examination

Week of March 17, 2025

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

FACILITY: Missouri University of Science and Technology

REACTOR TYPE: POOL

DATE ADMINISTERED: March 21, 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.

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 _____ (0.25 each)

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 ___

A20 a b c d ___

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

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 _____ (0.25 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 _____ (0.25 each)

B13 a b c d ___

B14 a b c d ___

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

B16 a b c d ___

B17 a b c d ___

B18 a b c d ___

B19 a b c d ___

B20 a b c d ___

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

Category C: Facility and Radiation Monitoring Systems

A N S W E R S H E E T

Multiple Choice (Circle or X your choice)
If you change your answer, write your selection in the blank.

C01 a b c 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 _____ (0.25 each)

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 ___

(***** 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 [1.0 point]
The Resonance Escape Probability is defined as the ratio of which ONE of the following statements?

a. The number of fast neutrons produced by all fissions over the number of thermal neutrons absorbed in the fuel.

b. The number of neutrons that reach thermal energies over the number of fast neutrons that start to slow down.

c. The number fast neutrons produced by all fissions over the number of fast neutrons produced by thermal fissions.

d. The number of neutrons that reach thermal energy over the number of fast neutrons produced by thermal fissions.

QUESTION A.02 [1.0 point, 0.25 each]
Match the neutron interaction in Column A with the reaction type (symbol) in Column B. Options in Column B may be used once, more than once, or not at all.

Column A	**Column B**
a. Inelastic Scattering	1. (n, n)
b. Charged Particle Reaction	2. (n, n')
c. Elastic Scattering	3. (n, γ)
d. Radiative Capture	4. (n, p)

QUESTION A.03 [1.0 point]
Given a reactor period of 27 seconds, how long will it take for reactor power to quadruple?

a. 69.3 seconds

b. 37.4 seconds

c. 18.7 seconds

d. 5.13 seconds

QUESTION A.04 [1.0 point]
Which ONE of the following is a characteristic of an effective core reflector?

a. A low thermal conductivity.

b. A small crystal expansion structure.

c. A low resistance to radiation damage.

d. A high scattering to absorption cross-section ratio.

QUESTION A.05 [1.0 point]
Which ONE of the following statements best describes the delayed neutron generation time?

a. The total time from the thermalization of a fast neutron to the emission of the longest-lived delayed neutron precursor.

b. The sum of the amount of time it takes for a thermal neutron to be absorbed and the amount of time between a fissionable nuclide absorbing a neuron and delayed neutrons being released.

c. The total time from the birth of the fast neutron to the emission of the delayed neutron in the next generation.

d. The sum of the amount of time it takes a fast neutron to thermalize, the amount of time the neutron exists as a thermal neutron begore being absorbed, and the amount of time before the delayed neutron is emitted in the next generation.

QUESTION A.06 [1.0 point]
Which ONE of the following statements is NOT an effect of increasing moderator temperature?

a. The moderator density decreases which reduces the number of water molecules in the core, decreasing the probability of absorption, which causes a decrease in thermal utilization.

b. The mean free path between scattering collisions increases which causes neutrons to travel further before slowing down and being absorbed.

c. Thermal non-leakage probability decreases because the probability of neutrons leaving the core increases.

d. The moderator density decreases which reduces the number of water molecules in the core, increasing the probability of absorption, which causes a decrease in resonance escape probability.

QUESTION A.07 [1.0 point]
Which ONE of the following statements best describes the relationship between the macroscopic cross-section and mean free path of a neutron in the core?

a. The macroscopic cross section is energy dependent and therefore has no impact on probability of interaction.

b. The greater the macroscopic cross section, the greater the distance the neutron must travels before interaction can occur.

c. The greater the macroscopic cross section, the shorter the distance the neutron travels before interaction occurs.

d. The smaller the macroscopic cross section, the smaller the distance the neutron travels before interaction occurs

QUESTION A.08 [1.0 point]
An experimenter inserts an experiment into the core, and the count rate increases to 135 cps from 50 cps. Given the initial k-effective of the reactor is 0.874, what is the worth of the experiment?

a. $\Delta\rho = + 0.047$

b. $\Delta\rho = - 0.047$

c. $\Delta\rho = - 0.095$

d. $\Delta\rho = + 0.095$

QUESTION A.09 [1.0 point]
Which ONE of the following best describes when a reactor is supercritical?

a. $k_{eff} = 1; \rho = 0$

b. $k_{eff} > 1; \rho < 0$

c. $k_{eff} > 1; \rho > 0$

d. $k_{eff} < 1; \rho = 0$

QUESTION A.10 [1.0 point]
A reactor is over-moderated when a/an _____ in the moderator-to-fuel ratio decreases k_{eff} due to a/an _____.

a. increase; decrease in the thermal utilization factor.

b. increase; increase in resonance absorption.

c. decrease; increase in the thermal utilization factor.

d. decrease; decrease in resonance absorption.

QUESTION A.11 [1.0 point]
Which ONE of the following statements best describes the reason why, following a reactor scram from full licensed power, indicated reactor power does not immediately decay to zero?

a. In-core nuclear instrumentation lags the prompt drop.

b. Core neutron population is sustained by spontaneous fission of U-235.

c. Core neutron population is sustained by the delayed neutron precursors.

d. Core neutron population is sustained by neutrons from the installed neutron source.

QUESTION A.12 [1.0 point]
Which ONE of the following statements best describes the relationship between the flux and fuel temperature profiles in the core?

a. Fuel temperature and core flux are both greatest in the center of the core.

b. Fuel temperature and neutron flux are both greatest at the top of the active fuel region, regardless of location within the core.

c. Fuel temperature and neutron flux are uniform throughout the core, except in the vicinity of the control rods, where both decrease.

d. Fuel temperature is greatest at the center of the core, but neutron flux is greatest at the periphery of the core away from the control rods.

QUESTION A.13 [1.0 point]
In a subcritical reactor, k-effective is decreased from 0.995 to 0.850. Which ONE of the following is the amount of reactivity that was added to the core?

a. - 17.1 %Δk/k

b. - 14.5 %Δk/k

c. - 3.23 %Δk/k

d. - 9.85 %Δk/k

QUESTION A.14 [1.0 point]
The instantaneous energy released from fission is equal to _____.

a. the difference in binding energy between the initial neutron and U-235 atom and the fission products.

b. the difference in thermal energy of the incident nucleus and the neutron.

c. the average energy of all prompt neutrons generated per fission.

d. the mass of released neutrons multiplied by the speed of light.

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. Fuel temperature

b. Rod speed

c. Reactor power

d. Flux shape

QUESTION A.16 [1.0 point]
As new fuel is being loaded into the core, the reactor operator is using a 1/M plot to monitor core loading. Which ONE of the following conditions could result in the reactor reaching criticality mass at a value greater than the predicted critical mass?

a. The detector and source are too close to 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.17 [1.0 point]
What is the remaining power following the prompt drop in the reactor power when a rod worth of 0.673 $\Delta k/k$ is rapidly inserted into a critical reactor? Assume $\beta eff = 0.0065$

a. 15.1%

b. 11.91%

c. 6.44%

d. 1.60%

QUESTION A.18 [1.0 point]
All of the following statements are possible effects of control rod shadowing EXCEPT:

a. Increase in time needed for in-core irradiation of a fixed experiment.

b. Decrease in bulk pool water temperature.

c. Decrease in indicated reactor power.

d. Increase in fuel temperature.

QUESTION A.19 [1.0 point]
Which ONE of the following statements best describes particle ejection reactions?

a. A neutron is absorbed with a target nucleus, forming a compound nucleus, which emits a neutron of lower kinetic energy, leaving the original nucleus in an excited state. The excited nucleus emits one or more gammas to return to ground state.

b. A neutron is absorbed by a target nucleus, resulting in an excited nucleus which releases its excitation energy in the form of a gamma ray.

c. A neutron is absorbed by a target nucleus, resulting in a compound nucleus which emits an alpha particle or a proton.

d. A neutron is absorbed by a target nucleus and splits into two similarly sized parts.

QUESTION A.20 [1.0 point]
A reactor is shutdown by 6.0% Δk/k. If control rods are withdrawn until the count rate increases by a factor of 7, and the reactor is still subcritical, what is the new Keff?

a. 0.998

b. 0.992

c. 0.943

d. 0.912

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

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.01 [1.0 point]
While increasing reactor power during a normal reactor startup, a rundown signal is received. In accordance with SOP 150, Response to Alarms, the reactor operator should take all of the following actions EXCEPT:

a. Verify the regulating rod and shim/safety rods are inserting.

b. Verify reactor power is decreasing.

c. Stop the rundown once the alarm condition has cleared.

d. Once the reactor has stabilized, resume reactor startup.

QUESTION B.02 [1.0 point, 0.25 each]
Match the event in Column A with the Emergency Action Level in Column B. Options in Column B may be used once, more than once, or not at all.

Column A	**Column B**
a. Experiment failure which results in off-gas release where radiation levels at the site boundary are 25 mrem/hr.	1. Unusual Event
b. Tornado sighted within the site boundary.	2. Alert
c. Credible security threat against the reactor.	3. Site Area Emergency
d. Indications of multiple fuel elements with fuel cladding failure with radiation levels at the site boundary of 20 mrem/hr over 1 hour.	

QUESTION B.03 [1.0 point]
In accordance with 10 CFR Part 20, all of the following statements regarding occupational dose limits are true EXCEPT:

a. Annual whole-body dose limit for minors is 500 mrem.

b. The annual shallow-dose equivalent to an adult occupational worker is 50 rem to the skin.

c. The total effective dose equivalent to an adult occupational worker is 5 rem per year.

d. The dose equivalent to a declared pregnant worker is 500 mrem per year.

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.04 [1.0 point]
In accordance with Technical Specifications, which ONE of the following statements regarding the facility Radiation Monitoring system operability is NOT true?

a. The Constant Air Monitor must remain operable at all times.

b. Portable monitors may be substituted for one or more inoperable Radiation Area Monitors for periods not to exceed one month.

c. If the inoperable channel is the bridge Radiation Area Monitor, the control room operator must be able to visually monitor the radiation level of the portable unit.

d. Portable gamma radiation instrumentation substituted for an inoperable Radiation Area Monitor must have a local audible alarm setpoint of 20 mrem/hr or less.

QUESTION B.05 [1.0 point]
In accordance with SOP 104, Reactor Power Changes and Stable Operation, which ONE of the following statements regarding equipment required for operation is NOT true?

a. The Fission Chamber should be repositioned as needed during operations to prevent the Startup Channel from reading off-scale.

b. The Safety Channels and Power Range nuclear instruments should show turnaround at about 500 W.

c. At least one building exhaust fan shall be turned on for reactor operations at 200 kW.

d. Both nitrogen diffusor pumps are required when operating above 20 kW to ensure radiation levels on the bridge do not exceed 50 mrem/hr.

QUESTION B.06 [1.0 point]
If an experiment housed in an aluminum capsule is emitting a dose rate of 75 mrem/hr at 30 cm, what is the minimum decay time required to no longer require a radiation area posting? Note: half-life of aluminum is 2.25 minutes.

a. 12.1 min

b. 8.79 min

c. 6.38 min

d. 4.72 min

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.07 [1.0 point]
In accordance with Technical Specifications, which ONE of the following conditions would NOT be permissible during reactor operations?

a. The excess reactivity was determined to be 1.25% Δk/k.

b. The regulating rod worth was previously determined to be 0.8% Δk/k.

c. Pool level is 18 feet above the core.

d. Pool water resistivity was measured to be 0.25 MΩ-cm.

QUESTION B.08 [1.0 point]
In accordance with SOP 151, Response to a High Area Radiation Alarm, which ONE of the following statements regarding the use of the key-bypass is true?

a. The high dose field area is access controlled to prevent personnel overexposure.

b. The Reactor Operator on duty may authorize the use of the key-bypass.

c. The key-bypass may be used if the dose field in the occupied areas of the building are monitored and found to be less than 10 mrem/hr.

d. The key-bypass may be used if the high dose field is posted as a High Radiation Area if it is unanticipated.

QUESTION B.09 [1.0 point]
In accordance with SOP 702, Irradiation Request Forms, Radiation Safety Committee approval is required for all of the following experiments EXCEPT:

a. Experiments with moving parts worth 0.025% Δk/k/sec.

b. Experiments containing small quantities of C-4 explosive.

c. Experiments containing small quantities of Accident Tolerant Fuel.

d. Experiments containing small quantities of corrosive material.

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.10 [1.0 point]
In accordance with SOP 109, Determination of Control Rod Worths by the Rod Drop Method, which ONE of the following statements regarding performance of this procedure is correct?

a. Both nitrogen diffusor pumps and the pool lights must be on.

b. The reactor is brought to and stabilized at 600 W for each rod drop.

c. The rod being measured will be inserted in small increments and the power decrease timed.

d. The neutron source must be inserted into the source tube.

QUESTION B.11 [1.0 point]
What is the dose rate at 1 foot, given 85% of the decay of a 12 Curie source results in emission of a 450 keV gamma?

a. 2.76 R/hr

b. 4.59 R/hr

c. 14.83 R/hr

d. 27.54 R/hr

QUESTION B.12 [1.0 point, 0.25 each]
Match the setpoint in Column A with the automatic action in Column B. Options in Column B may be used once, more than once, or not at all.

Column A	**Column B**
a. Reactor Period = 5 s	1. Rod Withdrawal Prohibit
b. Core Inlet Pool Water Temperature = 135°F	2. Rundown
c. Linear Power Demand = 120%	3. Scram
d. Reactor Power = 240 kW	

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.13 [1.0 point]
Which ONE of the following events would result in a violation of 10 CFR Part 55?

a. Your last operating exam was 13 months ago.

b. Your last written examination was 19 months ago.

c. Your requalification cycle began 22 months ago.

d. Last quarter, you operated for 8 hours.

QUESTION B.14 [1.0 point]
In accordance with the MSTR Emergency Plan, which ONE of the following individuals may assume the role of Emergency Support Center Manager?

a. Reactor Operator

b. Senior Reactor Operator, on Duty

c. Radiation Safety Officer

d. Missouri S&T Police Chief

QUESTION B.15 [1.0 point, 0.25 each]
Match the Technical Specification surveillance activity in Column A with the 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. Channel calibration of period channel	1. Quarterly
b. Control rod drop times	2. Semiannually
c. Visual inspection of the shim and safety rods	3. Annually
d. Ventilation inlet and exhaust duct louver tests	

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.16 [1.0 point]
An irradiated sample has a dose rate of 12.0 R/hr as indicated at a distance of 5 feet from the sample. How far from the irradiated sample will the dose rate read 500 mrem/hr?

a. 7.75 ft

b. 10.9 ft

c. 17.3 ft

d. 24.5 ft

QUESTION B. 17 [1.0 point]
In accordance with Technical Specifications, a Senior Reactor Operator must be present at the reactor facility for all of the following evolutions EXCEPT:

a. Relocation of a secured experiment with reactivity worth of $1.50.

b. Performance of control rod visual inspections.

c. Reactor operations performed by students or trainees where the excess reactivity is less than 0.7% Δk/k.

d. Recovery from a reactor rundown following a valid bridge Radiation Area Monitor alarm.

QUESTION B.18 [1.0 point]
In accordance with SOP 615, Radiation Work Permit, when is a Radiation Work Permit NOT required?

a. When the radiation level is greater than 5 mrem/hr at 2 feet from the source.

b. When maintenance is done on a potentially radioactive piece of equipment.

c. When handling radioactive samples.

d. When performing repairs on contaminated equipment.

QUESTION B.19 [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. 55.4 mrem

b. 35.6 mrem

c. 17.5 mrem

d. 9.2 mrem

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.20 [1.0 point]
In accordance with SOP 509, Fire, the reactor operator should take all of the following actions EXCEPT:

a. Scram the reactor.

b. Pull the nearest fire alarm.

c. Announce over the building PA that all personnel are to immediately proceed to the rear of mid-level basement.

d. Remove magnet power key.

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

Category C: Facility and Radiation Monitoring Systems

QUESTION C.01 [1.0 point]
Which ONE of the following statements best describes the purpose of the MSTR siphon break?

a. It ensures the demineralizer resins will not be siphoned into the reactor pool water in the event of a pipe break on the demineralizer system.

b. It prevents the possibility of uncovering the core in a loss of coolant event.

c. It prevents the glycol-water mixture from the chillers from entering the pool water supply if there is a fault in the heat exchanger.

d. It agitates the water near the pool surface to ensure sufficient time for N-16 to decay.

QUESTION C.02 [1.0 point]
The Log and Linear power channel monitors all of the following parameters EXCEPT:

a. Power Range (0 to 125%)

b. Log Power (10^{-6}% to 140%)

c. Period

d. Linear Power (0 to 150%)

QUESTION C.03 [1.0 point]
All of the following statements regarding the MSTR Pneumatic Sample Transfer System are true EXCEPT:

a. A differential pressure is used to transport samples into and out of the reactor.

b. Each rabbit system consists of two stainless steel tubes, with samples going through one tube into the reactor and being removed through the other tube.

c. One of the rabbit tubes is cadmium lined to reduce thermal neutron activation.

d. Two of the tubes terminate in a glove box near the reactor pool.

Category C: Facility and Radiation Monitoring Systems

QUESTION C.04 [1.0 point]
Which ONE of the following statements best describes a standard MSTR fuel element?

a. A standard fuel element contains 18 fuel plates consisting of U_3Si_2-Al enriched to less than 20% in U-235.

b. A standard fuel element contains 9 fuel plates consisting of U_3Si_2-Al enriched to less than 20% in U-235.

c. A standard fuel element contains 9 fuel plates consisting of U_3Si_2-Al enriched to less than 20% in U-238.

d. A standard fuel element contains 18 fuel plates consisting of U_3Si_2-Al enriched to less than 20% in U-238.

QUESTION C.05 [1.0 point]
Which ONE of the following statements best describes the normal method for primary cooling at MSTR?

a. Natural convection, where heat is dissipated through evaporation.

b. Natural circulation, where cool water flows down around the fuel plates and warmer water rises around the grid plates to the surface, where heat is dissipated through evaporation.

c. Forced circulation through the demineralizer system and heat exchanger.

d. Forced convection through the three-loop chiller system.

QUESTION C.06 [1.0 point]
Which ONE of the following statements best describes the shim and safety control rod limit switches?

a. The “Insert Limit” and “Withdraw Limit” indicate when the rod is fully inserted or withdrawn, and the “Shim Range” light indicates when the rod drive is connected to the rod.

b. The “Insert Limit” and “Withdraw Limit” indicate when the rod drive is fully inserted or withdrawn, and the “Top Half Travel” light indicates when the rod is moving.

c. The “Insert Limit” and “Withdraw Limit” indicate when the rod drive is fully inserted or withdrawn, and the “Shim Range” light indicates when the rod is at least 12.5” withdrawn.

d. The “Insert Limit” and “Withdraw Limit” indicate when the rod drive is fully inserted or withdrawn, and the “Top Half Travel” light indicates when the rod drive is connected to the rod.

Category C: Facility and Radiation Monitoring Systems

QUESTION C.07 [1.0 point]
Which ONE of the following statements correctly reflects the MSTR shim/safety rod composition?

a. Cadmium stainless steel rod.

b. Boron aluminum rod.

c. Boron stainless steel rod.

d. Cadmium aluminum rod.

QUESTION C.08 [1.0 point]
In accordance with Technical Specifications, which ONE of the following statements best describes the basis for the Safety Channel scram setpoint?

a. The scram setpoint of 240 kW is to ensure that the Limiting Safety System Setting will not be exceeded.

b. The scram setpoint of 300 kW is to ensure that the reactor power level is limited to protect against abnormally high fuel temperatures.

c. The scram setpoint of 240 kW is to ensure the Safety Limit is not exceeded.

d. The scram setpoint of 300 kW is to ensure that the maximum licensed power level is not exceeded.

QUESTION C.09 [1.0 point]
In accordance with Technical Specifications, which ONE of the following statements best explains the reason for the minimum reactor pool water temperature?

a. This protects the in-core nuclear instrumentation from thermal shock.

b. This ensures the integrity of the demineralizer resins.

c. This ensures that the excess reactivity will not significantly decrease, and the shutdown margin will not increase.

d. This ensures that the excess reactivity will not significantly increase, and the shutdown margin will not decrease.

Category C: Facility and Radiation Monitoring Systems

QUESTION C.10 [1.0 point]
Which ONE of the following options correctly describes how primary coolant temperature is measured?

a. Two core inlet thermocouples located several feet above the core, and one outlet thermocouple located just below the grid plate.

b. Two core outlet thermocouples located several feet above the core, and one inlet thermocouple located just below the grid plate.

c. Two core inlet thermocouples located just below the grid plate, and one outlet thermocouple located several feet above the core.

d. Two core outlet thermocouples located just below the grid plate, and one inlet thermocouple located several feet above the core.

QUESTION C.11 [1.0 point, 0.25 each]
Match the radiation detector used at MSTR in Column A with 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. Reactor Bridge Monitor	1. BF_3 detector
b. Basement Neutron Monitor	2. Energy-compensated Geiger Muller
c. Experiment Room Monitor	3. Proportional Counter
d. Constant Air Monitor	

QUESTION C.12 [1.0 point]
A gaseous effluent commonly produced from MSTR reactor operation is _____ which is _____.

a. Ar-41; produced as a byproduct of fission.

b. O-15; produced from the irradiation of air.

c. N-16; produced from the irradiation of water.

d. Na-24; produced from activation of aluminum reactor components.

Category C: Facility and Radiation Monitoring Systems

QUESTION C.13 [1.0 point]
Which ONE of the following statements best describes the sequence of events that occur when reactor bay ventilation is isolated?

a. All exhaust fans are turned off, and the intake and exhaust louvers close automatically.

b. All exhaust fans are turned off, and the intake and exhaust louvers remain open to facility a negative differential pressure.

c. All exhaust fans are turned on to purge the radioactive release from the facility to provide adequate radiation protection for emergency team members responding to the event.

d. The running exhaust fan (if operating at 200 kW) is turned off, and the associated intake and exhaust louvers close. The remaining two exhaust fans are turned on to provide adequate radiation protection for emergency team members responding to the event.

QUESTION C.14 [1.0 point]
Which ONE of the following statements best describes how the Startup Channel functions?

a. Neutrons fission with the B-10 lining of the uncompensated ion chamber to produce alpha particles which ionize the gas. Gammas also ionize the fill gas. The combined signal provides an indication of reactor power.

b. Neutrons fission with the B-10 outer lining of the compensated ion chamber to produce alpha particles which ionize the gas. Gammas also ionize the fill gas. The inner chamber is unlined and detects only gammas. The gamma signal is subtracted from the neutron signal to provide an indication of reactor power.

c. Neutrons interact with the U-235 lining the fission chamber to produce fission, which ionize the fill gas. Gammas also ionize the fill gas. At low powers, the circuitry uses a pulse height discriminator to differentiate the neutrons from the gammas to provide an indication of reactor power.

d. Neutrons interact with the BF_3 fill gas inside the proportional counter to produce alpha particles, which ionize the fill gas. Gammas also ionize the fill gas. At low powers, the circuitry uses a pulse height discriminator to differentiate the neutrons from the gammas to provide an indication of reactor power.

QUESTION C.15 [1.0 point]
All of the following statements regarding void tubes experiments at the MSTR are true EXCEPT:

a. Experiments utilizing void tubes are considered moveable.

b. Void tubes may be air-filled, water-filled, or both.

c. Void tubes fit into the grid plate.

d. Void tubes may be placed at various locations within the reactor pool.

Category C: Facility and Radiation Monitoring Systems

QUESTION C.16 [1.0 point]
All of the following statements concerning the Startup Channel are true EXCEPT:

a. When the detector is fully inserted near the core, it is sensitive enough to monitor reactor neutrons from startup to 10 W.

b. A rod withdrawal prohibit occurs if the Startup Channel rate recorder is off.

c. The fission chamber is only used to provide relative power trends, not absolute power.

d. If the detector is not retracted from the core once the Log and Linear Channel comes on scale, a reactor rundown occurs.

QUESTION C.17 [1.0 point]
Which ONE of the following statements correctly describes how the primary coolant thermocouples function?

a. A thermocouple detects changes in pool temperature by measuring the voltage difference between two wires of dissimilar metals.

b. A thermocouple detects changes in pool temperature by measuring changes in resistance to the flow of electricity resulting from changes in temperature of the resistive metal element.

c. A thermocouple detects changes in pool temperature by using a thermally sensitive resistor that exhibits a continuous, small, incremental change in resistance correlated to variations in temperature.

d. A thermocouple detects changes in pool temperature by utilizing two identical diodes with temperature-sensitive voltage vs current characteristics that are used to monitor changes in temperature.

QUESTION C.18 [1.0 point]
Which ONE of the following best describes the standard control rod drive mechanism used at MSTR?

a. An electric-stepping, motor-actuated linear drive equipped with a magnetic coupler and a positive feedback potentiometer.

b. A five-phase stepping motor drives a pinion gear and a 10-turn potentiometer.

c. A leadscrew assembly is connected to the control rod by a bayonet coupling.

d. An electro-mechanical linear actuator with a ball-bearing type screw through a gear reduction unit.

Category C: Facility and Radiation Monitoring Systems

QUESTION C.19 [1.0 point]
Which ONE of the following best describes the reason for the high sensitivity of a Geiger-Mueller detector?

a. Any incident radiation event causing primary ionization results in ionization of the entire detector.

b. It is coated with special nuclear material that causes high ionizations at low concentrations.

c. The lower voltage applied to the detector helps to amplify all incident events.

d. b. It has a large tube, so the target area is bigger for all incident events.

QUESTION C.20 [1.0 point]
The core inlet water temperature is limited to _____ in order to _____.

a. 60 °C; protect the ion exchange resin.

b. 140 °C; ensure the safety limit is not exceeded.

c. 15 °C; prevent departure from nucleate boiling.

d. 60 °C; ensure the shutdown margin will not decrease.

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

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

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

A.02
Answer: a. 2; b. 4; c. 1; d. 3
Reference: Burn, *Introduction to Nuclear Reactor Operations*, Section 2.4.5, 2-28

A.03
Answer: b.
Reference: $P = P_0 \cdot e^{t/27}$
$4 = 1 \cdot e^{t/27}$
$\ln(4) = \ln(e^{t/27})$
$1.386 = t/27$
$T = 37.4$ seconds

A.04
Answer: d.
Reference: DOE Fundamentals Handbook, Volume 2, Module 4, p. 25

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

A.06
Answer: a.
Reference: Burn, *Introduction to Nuclear Reactor Operations*, Section 3.3.2, p. 3-16
DOE Fundamentals Handbook, Volume 2, Module 3, p. 4

A.07
Answer: c.
Reference: Burn, *Introduction to Nuclear Reactor Operations*, Section 2.5, p. 2-43

A.08
Answer: d.
Reference: $CR_1 / CR_2 = (1 - k_{eff2}) / (1 - k_{eff1})$
$50 / 135 = (1 - k_{eff2}) / (1 - 0.87)$
$0.370 = (1 - k_{eff2}) / 0.126$
$0.0467 = (1 - k_{eff2})$
Therefore $k_{eff2} = 0.953$
$\Delta\rho = (k_{eff2} - k_{eff1}) / (k_{eff2} * k_{eff1})$
$\Delta\rho = (0.953 - 0.874) / (0.953 * 0.874)$
$\Delta\rho = + 0.095$

A.09
Answer: c.
Reference: Burn, *Introduction to Nuclear Reactor Operations*, Section 3.3.4, p. 3-21

A.10
Answer: a.
Reference: DOE Fundamentals Handbook, Volume 2, Module 3, p. 28

A.11
Answer: c.
Reference: Burn, *Introduction to Nuclear Reactor Operations*, p. 3-7

A.12
Answer: a.
Reference: Burn, *Introduction to Nuclear Reactor Operations*, p. 9-12

A.13
Answer: a.
Reference: $\Delta\rho = (k_{eff2} - k_{eff1}) / (k_{eff2} * k_{eff1})$
$\Delta\rho = (0.850-0.995) / (0.850*0.995)$
$-0.145 / 0.846 = -0.171 = - 17.1\ \%\Delta k/k$

A.14
Answer: a.
Reference: DOE Fundamentals Handbook, Volume 1, Module 1, p. 57-59

A.15
Answer: d.
Reference: Burn, *Introduction to Nuclear Reactor Operations*, p. 7-4

A.16
Answer: d.
Reference: Burn, *Introduction to Nuclear Reactor Operations*, p. 5-18

A.17
Answer: d.
Reference: $\frac{P_1}{P_0} = \frac{\beta_{eff} \cdot (1-p)}{\beta_{eff} - p}$
$P_1/P_0 = (0.0065 \text{ x } (1+0.673)) / (0.0065+0.673)$
$P_1/P_0 = 0.0160$
$P_1/P_0 = 1.60\%$

A.18
Answer: b.
Reference: Burn, *Introduction to Nuclear Reactor Operations*, p. 7-12

A.19
Answer: c.
Reference: DOE Fundamentals Handbook, Volume 1, Module 1, p. 46

A.20

Answer: b.

Reference: Burn, *Introduction to Nuclear Reactor Operations*, Section 5.7.10, page 5-33.

$SCR_1 = S / (1 – K_{eff1})$ AND $SCR_2 = S / (1 – K_{eff2})$

$\rho_1 = -6.0\%\ \Delta K/K$

$\rho_1 = -0.060\ \Delta K/K$

$K_{1eff} = 1 / (1 – \rho_1)$

$K_{1eff} = 1 / (1 + 0.060)$

$K_{1eff} = 0.9434;$

$SCR_2/SCR_1 = S * (1 – 0.9434) / S * (1 – K_{eff2})$

$7 = 0.0566 / (1 – K_{eff2})$

$1 – K_{eff2} = 0.00808$

$K_{eff2} = 1 – 0.00808$

$K_{eff2} = 0.992$

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

Category B: Normal/Emergency Operating Procedures and Radiological Controls

B.01
Answer: d.
Reference: SOP 150, Response to Alarms

B.02
Answer: a. 2 (Alert); b. 1 (Unusual Event); c. 1 (Unusual Event); d. 2 (Alert)
Reference: MSTR Emergency Plan, Section 4

B.03
Answer: d.
Reference: 10 CFR 20.1201, 20.1207, and 20.1208

B.04
Answer: b.
Reference: MSTR Technical Specifications 3.6.1

B.05
Answer: d.
Reference: SOP 104, Reactor Power Changes and Stable Operations

B.06
Answer: b.
Reference: $D = D_0 \cdot e^{-\lambda t}$, where $\lambda = \ln(2)/2.25 \text{ min} = 0.308$
$5 = 75 \cdot e^{-0.308t}$
$0.0667 = e^{-0.308t}$
$\ln(0.0667) = e^{-0.308t}$
$-2.708 = -0.308t$
$t = 8.79$ min

B.07
Answer: b.
Reference: MSTR Technical Specifications 3.1 and 3.2

B.08
Answer: a.
Reference: SOP 151, Response to High Area Radiation Alarm

B.09
Answer: a.
Reference: SOP 702, Irradiation Request Forms

B.10
Answer: b.
Reference: SOP 109, Determination of Control Rod Worths by the Rod Drop Method

B.11
Answer: d.
Reference: 6 Cen = R/hr at 1 ft
(6 * 12 Ci) x (0.85 * 0.45)
27.54 R/hr at 1 ft

Category B: Normal/Emergency Operating Procedures and Radiological Controls

B.12
Answer: a. 3 (Scram); b. 1 (RWP); c. 2 (Rundown); d. 2 (Rundown)
Reference: MSTR Technical Specifications 3.2.1 and 3.2.2

B.13
Answer: a.
Reference: 10 CFR 55.59

B.14
Answer: b.
Reference: MSTR Emergency Plan

B.15
Answer: a. 3 (Annually); b. 2 (Semiannually); c. 3 (Annually); d. 1 (Quarterly)
Reference: MSTR Technical Specifications 4.2.1, 4.2.2, and 4.4

B.16
Answer: d.
Reference: $DR_1*(D_1)^2 = DR_2*(D_2)^2$
12000 mrem $(5\ ft)^2$ = 500 mrem $(d)^2$
300000 mrem-ft^2 = 500 mrem $(d)^2$
600 $ft^2 = d^2$
D = 24.49 ft.

B.17
Answer: c.
Reference: MSTR Technical Specifications 6.1.3 and 6.1.4

B.18
Answer: c.
Reference: SOP 615, Radiation Work Permit

B.19
Answer: a.
Reference: Dose = DR*T
175 mRem/hr/60 minutes = 2.91 mRem/min
2.08 mRem/min * 17 min = 55.4 mRem

B.20
Answer: c.
Reference: SOP 509, Fire

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

Category C: Facility and Radiation Monitoring Systems

C.01
Answer: b.
Reference: MSTR SAR 5.3

C.02
Answer: d.
Reference: MSTR SAR 7.2.2

C.03
Answer: b.
Reference: MSTR SAR 10.2.3

C.04
Answer: a.
Reference: MSTR SAR 4.2.1.1

C.05
Answer: a.
Reference: MSTR SAR 5.1

C.06
Answer: c.
Reference: MSTR SAR 7.2.2.7

C.07
Answer: c.
Reference: MSTR SAR 4.2.2

C.08
Answer: b.
Reference: MST Technical Specifications 3.2.2

C.09
Answer: d.
Reference: MSTR Technical Specifications 3.3

C.10
Answer: c.
Reference: MSTR SAR 7.2.2.8

C.11
Answer: a. 2; b. 1; c. 2; d. 3
Reference: MSTR SAR 7.4

C.12
Answer: c.
Reference: MSTR 11.1.1.1

C.13
Answer: a.
Reference: MSTR SAR 9.1

Category C: Facility and Radiation Monitoring Systems

C.14
Answer: c.
Reference: MSTR SAR 7.2.2.1

C.15
Answer: d.
Reference: MSTR SAR 10.2.6

C.16
Answer: d.
Reference: MSTR SAR 7.2.2.1

C.17
Answer: a.
Reference: Standard NRC question

C.18
Answer: d.
Reference: MSTR SAR 4.2.2

C.19
Answer: a.
Reference: NRC Standard Question

C.20
Answer: a.
Reference: MSTR SAR 5.3

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