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

December 26, 2024

Mr. 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-25-01, MISSOURI UNIVERSITY OF SCIENCE AND TECHNOLOGY

Dear Mr. Taber:

During the week of November 4, 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 Paulette Torres at 301-415-5656 or via email at Paulette.Torres@nrc.gov.

Sincerely,

Signed by Brown, Tony
on 12/26/24

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-25-01
2. Written examination

cc: w/enclosures to GovDelivery Subscribers

SUBJECT: EXAMINATION REPORT NO. 50-123/OL-25-01, MISSOURI UNIVERSITY OF SCIENCE AND TECHNOLOGY DATED: DECEMBER 26, 2024

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

REPORT NO.: 50-123/OL-25-01

FACILITY DOCKET NO.: 50-123

FACILITY LICENSE NO.: R-79

FACILITY: Missouri University of Science and Technology

EXAMINATION DATES: Week of November 4, 2024

SUBMITTED BY: Paulette A. Torres 11/13/2024
Paulette Torres, Chief Examiner Date

SUMMARY:
During the week of 11/4/2024, the NRC administered operator licensing examinations to two Reactor Operators (RO) candidates, two Senior Reactor Operator-Upgrade (SRO-U) candidates, and one Senior Reactor Operator-Instant (SRO-I) candidate. One RO candidate failed Categories A and C on the written examination. All candidates passed all applicable portions of the operating examination.

REPORT DETAILS

1. Examiner: Paulette Torres, Chief Examiner, NRC

2. Results:

	RO PASS/FAIL	SRO PASS/FAIL	TOTAL PASS/FAIL
Written	1/1	1/0	2/1
Operating Tests	2/0	3/0	5/0
Overall	1/1	3/0	4/1

3. Exit Meeting:
Paulette Torres, RTR Chief Examiner, NRC
Dr. Joseph Graham, Reactor Director, MSTR
Ethan Taber, Reactor Manager, MSTR
Nathan Jackson, Training Coordinator, MSTR

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. 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 and Technology (Rolla)

Operator Licensing Examination

Week of November 4, 2024

Enclosure 2

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

FACILITY: Missouri University of Science and Technology (Rolla)

REACTOR TYPE: Pool

DATE ADMINISTERED: 11/07/2024

CANDIDATE: _____

INSTRUCTIONS TO CANDIDATE:
Answers are to be written on the Answer sheet provided. Attach all Answer sheets to the examination. Point values are indicated in parentheses for each question. A 70% in each category is required to pass the examination. Examinations will be picked up three (3) hours after the examination starts.

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

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

_____
Candidate's Signature

Category A: Reactor Theory, Thermodynamics & Facility Operating Characteristics

A N S W E R S H E E T

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

A01 a b c d ___

A02 a b c d ___

A03 a b c d ___

A04 a b c d ___

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 ___

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 *****)

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 ___

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 **********)

NRC RULES AND GUIDELINES FOR LICENSE EXAMINATIONS

During the administration of this examination the following rules apply:

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

2. After the examination has been completed, you must sign the statement on the cover sheet indicating that the work is your own and you have neither received nor given assistance in completing the examination. This must be done after you complete the examination.

3. Restroom trips are to be limited and only one candidate at a time may leave. You must avoid all contacts with anyone outside the examination room to avoid even the appearance or possibility of cheating.

4. Use black ink or dark pencil only to facilitate legible reproductions.

5. Print your name in the blank provided in the upper right-hand corner of the examination cover sheet and each Answer sheet.

6. Mark your Answers on the Answer sheet provided. USE ONLY THE PAPER PROVIDED AND DO NOT WRITE ON THE BACK SIDE OF THE PAGE.

7. The point value for each question is indicated in [brackets] after the question.

8. If the intent of a question is unclear, ask questions of the examiner only.

9. When turning in your examination, assemble the completed examination with examination questions, examination aids and Answer sheets. In addition turn in all scrap paper.

10. Ensure all information you wish to have evaluated as part of your Answer is on your Answer sheet. Scrap paper will be disposed of immediately following the examination.

11. To pass the examination you must achieve a grade of 70 percent or greater in each category.

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

EQUATION SHEET

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$T_{\frac{1}{2}} = \frac{0.693}{\lambda} \qquad \Delta\rho = \frac{K_{eff_2}-K_{eff_1}}{K_{eff_1}K_{eff_2}}$$

$$P = P_0 2^{(t/DT)}$$

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

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

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

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

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

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-lbf

1 gal (H_2O) ≈ 8 lbm

c_P = 1.0 BTU/hr/lbm/°F

1ft = 30.48 cm

1 kg = 2.21 lbm

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 & Facility Operating Characteristics

QUESTION A.01 [1.0 point]
If the macroscopic cross section of U-235 is 0.367 cm^{-1}, what is the Mean Free Path?

a. 0.25 cm

b. 0.94 cm

c. 1.89 cm

d. 2.72 cm

QUESTION A.02 [1.0 point]
When a radioactive atom undergoes beta decay, essentially all of the energy that is released will be:

a. Carried away by prompt and delay gamma rays.

b. Distributed between the beta particle and the antineutrino as kinetic energy.

c. Distributed between the parent atom and the decay product as kinetic energy.

d. Carried away by the beta particle since the mass of the antineutrino is so small.

QUESTION A.03 [1.0 point]
The _____ of an atom is calculated by multiplying the mass defect by the total amount of energy that would be transformed from 1 atomic mass unit.

a. Kinetic Energy

b. Binding Energy

c. Neutron Energy

d. Potential Energy

Category A: Reactor Theory, Thermodynamics & Facility Operating Characteristics

QUESTION A.04 [1.0 point]
Flux distribution flattens due to fuel burnup _____ due to high flux.

a. At the top of the fuel.

b. In the center of the core.

c. At the bottom of the core.

d. On the outside of the core.

QUESTION A.05 [1.0 point]
Which ONE of the following is the main factor that limits the negative reactivity in a reactor after shutdown?

a. Xe-135 production.

b. The heat from the fuel.

c. The decay of the delayed neutron precursors.

d. The absorption cross section of the control rods.

QUESTION A.06 [1.0 point]
Which ONE of the following changes does not require the movement of control rods in order to maintain constant reactor power?

a. Fuel burnup.

b. N-16 production.

c. Xe-135 production.

d. Decreasing reactor pool water temperature.

Category A: Reactor Theory, Thermodynamics & Facility Operating Characteristics

QUESTION A.07 [1.0 point]
Which ONE of the following is the energy that prompt neutrons are generally born?

a. High neutron energy, greater than 10 MeV

b. Probable neutron energy, about 0.7 MeV

c. Average neutron energy, about 2 MeV

d. Slow neutron energy, less than 1 eV

QUESTION A.08 [1.0 point]
How K_{eff} varies as a function of Moderator to Fuel ratio for an overmoderated core? K_{eff} decreases, as _____.

a. Fast fission factor increases.

b. Non-leakage probabilities decreases.

c. Thermal utilization factor decreases.

d. Resonance escape probability decreases.

QUESTION A.09 [1.0 point]
If the doubling time is 20 seconds, how long will it take for power to increase from 25kW to 3MW?

a. Approximately 20 seconds.

b. Approximately 140 seconds.

c. Approximately 300 seconds.

d. Approximately 480 seconds.

Category A: Reactor Theory, Thermodynamics & Facility Operating Characteristics

QUESTION A.10 [1.0 point]
Which ONE of the following is a use of subcritical multiplication?

a. Ensures the startup source is present.

b. Verifies that all control rods are fully inserted after a scram.

c. Measures the approach to criticality by uranium fuel addition.

d. Calculates the maximum negative period of a reactor based on delayed neutron precursors.

QUESTION A.11 [1.0 point]
If the reactor has a subcritical multiplication factor of 50, what is the value of K_{eff}?

a. 0.67

b. 0.85

c. 0.98

d. 1.05

QUESTION A.12 [1.0 point]
Which ONE of the following is used as a material for the purpose of thermalizing neutrons?

a. Poison

b. Absorber

c. Moderator

d. Void coefficient

Category A: Reactor Theory, Thermodynamics & Facility Operating Characteristics

QUESTION A.13 [1.0 point]
Photoelectric effect is the most probable photon interaction for which of the following conditions?

a. Low energy photons interacting in low density material.

b. High energy photons interacting in low density material.

c. Low energy photons interactiong in high density material.

d. High energy beta particles interacting in high density material.

QUESTION A.14 [1.0 point]
On the Chart of the Nuclides, the vertical “column” represents nuclides known as _____.

a. Isobars

b. Isomers

c. Isotones

d. Isotopes

QUESTION A.15 [1.0 point]
Following a significant reactor power increase, the moderator temperature coefficient becomes increasingly more negative. This is because:

a. As moderator density decreases, less thermal neutrons are absorbed by the moderator than by the fuel.

b. The change in the thermal utilization factor dominates the change in the resonance escape probability.

c. A greater density change per °F occurs at higher reactor coolant temperatures.

d. The core transitions from an under-moderated condition to an over-moderated condition.

QUESTION A.16 [1.0 point]
The use of a reflector results in _____.

a. The production of neutrons.

b. A high neutron absorption cross section.

c. A decrease in the critical mass of fissile material.

d. The decrease of the average power output for a given peak neutron flux.

QUESTION A.17 [1.0 point]
Which ONE of the following defines prompt critical?

a. $K_{eff} = 1$ and $\rho = 0$

b. $K_{eff} > 1$ and $\rho = \beta_{eff}$

c. $K_{eff} < 1$ and $\rho = 1$

d. $K_{eff} > 1$ and $0 < \rho < \beta_{eff}$

QUESTION A.18 [1.0 point, 0.25 each]
Match the following Neutron Interactions in Column A with the appropriate Definition in Column B (each definition used only once).

Column A	Column B
a. Fission	1. Neutron enters nucleus, forms a compound nucleus, then decays by gamma emission.
b. Radiative Capture	2. Particle enters nucleus, forms a compound nucleus and is excited enough to eject a new particle with incident neutron remaining in nucleus.
c. Scattering	3. Nucleus absorbs neutron and splits into two similarly sized parts.
d. Particle Ejection	4. Nucleus is struck by a neutron and emits a single neutron.

QUESTION A.19 [1.0 point]
A reactor contains a neutron source that produces 10,000 neutrons/second. The reactor has a Keff = 0.80. What is the stable total neutron production rate in the reactor?

a. 20,000 neutrons/second

b. 50,000 neutrons/second

c. 80,000 neutrons/second

d. 200,000 neutrons/second

QUESTION A.20 [1.0 point]
What effect does Doppler Broadening for U-238 have on neutrons in a critical core?

a. More absorption.

b. More scattering.

c. Increasing the reproduction factor.

d. Increasing the resonance escape probability.

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

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.01 [1.0 point]
The security system, pool conductivity, and low pool water scram shall be checked:

a. Daily

b. Weekly

c. Monthly

d. Annually

QUESTION B.02 [1.0 point]
Proposed quantities of explosive materials less than 25 milligrams require approval by the _____ to be irradiated in or near the reactor core.

a. USNRC

b. Reactor Manager

c. Radiation Safety Committee

d. Licensed Senior Reactor Operator

QUESTION B.03 [1.0 point]
The OPERATIONS BOUNDARY is defined as:

a. The campus of Missouri S&T.

b. The geographical area that is beyond the site boundary.

c. The outside walls of the Missouri S&T Reactor confinement building.

d. The part of the Missouri S&T owned and controlled grounds that lie within the site boundary.

QUESTION B.04 [1.0 point]
The Cs-137 source is used at the facility for:

a. Reactor Startup

b. Power calibration

c. Gamma RAM calibration

d. Neutron RAM calibration

QUESTION B.05 [1.0 point]
As an employee at the MSTR, if you worked continuously in an area of radiation which read 250 mrem/hr, how long could you stay before you exceeded your limit for exposure?

a. 24 minutes

b. 2 hours

c. 8 hours

d. 20 hours

QUESTION B.06 [1.0 point]
Radiation exposures for all personnel monitored shall be retained for _____.

a. Five years.

b. Life of the facility.

c. Two years or one requalification cycle.

d. Twenty years from the date of the facility license issuance.

QUESTION B.07 [1.0 point]
Any individual who receives exposure greater than _____ per quarter shall be restricted from any further radiation work.

a. 25 rem

b. 50 rem

c. 75 rem

d. 1.25 rem

QUESTION B.08 [1.0 point]
Per Technical Specifications, for a period of time not to exceed _____, the RAM channel(s) may be taken out of service for maintenance if it is replaced with a portable gamma radiation instrument where the reactor operator can visually monitor the radiation level of the portable unit.

a. 8 hours

b. 1 day

c. 2 days

d. 1 week

QUESTION B.09 [1.0 point]
The shutdown margin determination procedure, calculates the shutdown margin by subtracting all of the following from the sum of the Total Rod Worths EXCEPT:

a. Critical Rod Worth

b. Excess Reactivity

c. Total High Rod Worth

d. Total Regulating Rod Worth

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.10 [1.0 point]
During an emergency, which ONE of the following individuals will act as the Emergency Support Center (ESC) Manager until relieved by another authorized member?

a. Reactor Manager

b. Radiation Safety Officer

c. Senior Reactor Operator on duty

d. Chair of Nuclear Engineering and Radiation Science

QUESTION B.11 [1.0 point]
The _____ multiplication factor of the fully loaded storage pit shall not exceed 0.9 under any conditions.

a. Neutron

b. Excess

c. Infinite

d. Core

QUESTION B.12 [1.0 point]
Which ONE of the following is not a Rod Prohibit?

a. Recorders Off

b. Source Range <2 cps

c. Inlet Temperature >135°F

d. Regulating Rod on Insert Limit on Auto

QUESTION B.13 [1.0 point]
A worker is exposed to a mixed gamma and neutron radiation field. The absorbed dose from gamma is 30 rad and the absorbed dose from neutrons (unknown energy) is 4 rad. What is the worker's total effective dose equivalent, assuming no internal exposures occurred?

a. 34 rem

b. 70 rem

c. 110 rem

d. 340 rem

QUESTION B.14 [1.0 point]
Which ONE of the following conditions requires NRC APPROVAL for changes?

a. Revise the MSTR pre-startup checklist.

b. Add more personnel requirements to the inspection of control rods procedure.

c. Revise a frequency of requalification written examination from biennial to annual.

d. Reduce the minimum number of the Radiation Safety Committee members listed in Technical Specifications from five to three.

QUESTION B.15 [1.0 point]
The licensed operator requires to pass a comprehensive requalification written examination and an annual operating test. This requirement can be found in:

a. 10 CFR Part 20

b. 10 CFR Part 50

c. 10 CFR Part 55

d. 10 CFR Part 73

QUESTION B.16 [1.0 point]
Any smoke detector or fire manual pull station activation causes a fire alarm to sound in the reactor building and at the _____.

a. Phelps Health

b. Missouri S&T Police Station

c. Rolla Fire and Rescue Department

d. Rolla Emergency Management Agency

QUESTION B.17 [1.0 point]
_____ element(s) have nine plates fueled with low-enriched uranium (LEU).

a. Plate fuel

b. Half-fueled

c. Irradiation fuel

d. Control rod fuel

QUESTION B.18 [1.0 point]
Which ONE of the following is a purpose of the ALERT emergency class?

a. To bring the operating staff to a state of readiness.

b. To provide offsite authorities with current status information.

c. To assure that response centers are manned and monitoring teams are dispatched.

d. To assure that the first step in any response later found to be necessary has been carried out.

QUESTION B.19 [1.0 point]
The dose rate from a mixed beta-gamma point source is 100 mrem/hour at a distance of one foot and is 0.1 mrem/hour at a distance of twenty feet. What percentage of the source consists of beta radiation?

a. 20%

b. 40%

c. 60%

d. 80%

QUESTION B.20 [1.0 point]
The Weekly Checklist is to be maintained for a period of at least:

a. One year

b. Five years

c. Life of the Facility

d. One Requalification Cycle

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

Category C: Facility and Radiation Monitoring Systems

QUESTION C.01 [1.0 point]
Which ONE of the following, the detector output signal is fed into the picoammeter within the signal processing drawer?

a. Startup Channel

b. Linear Power Channel

c. Safety Channel #1

d. Safety Channel #2

QUESTION C.02 [1.0 point]
Which ONE of the following conditions occur if the Reactor Control System (RCS) Programmable Logic Controller (PLC) control program indicates a rod height above 12.5 inches? A _____ light is displayed on the PLC and the regulating rod will be permitted to be withdrawn.

a. "Insert Limit"

b. “Withdraw Limit"

c. “Power Range”

d. “Shim Range”

QUESTION C.03 [1.0 point]
Which ONE of the following is an example of a bypass key that may only be authorized by the Facility Director and manager?

a. 80% High Voltage trip

b. Rod Withdrawal Prohibit trip

c. Rod Height Indicator calibration

d. Radiation Area Monitor calibration

Category C: Facility and Radiation Monitoring Systems

QUESTION C.04 [1.0 point]
Which ONE of the following scrams is NOT caused by a loss of regulated 120 VAC power?

a. Manual Scram

b. Bridge Motion Scram

c. Period < 5 Seconds Scram

d. Log and Linear Not Operative Scram

QUESTION C.05 [1.0 point]
The flow path for the Reactor Pool Water System, starting at bottom of pool or skimmer on surface, is:

a. Pump, filter, flow meter, ion bed, back to the pool.

b. Filter, ion bed, pump, conductivity cell, back to the pool.

c. Ion bed, conductivity cell, flow meter, filter, back to the pool.

d. Flow meter, pump, conductivity cell, ion bed, back to the pool.

QUESTION C.06 [1.0 point]
Which ONE of the following is the corresponding protective action for the “Recorder Off” input signal?

a. Alarm

b. Rundown

c. Rod Withdrawal Prohibit

d. Scram

Category C: Facility and Radiation Monitoring Systems

QUESTION C.07 [1.0 point]
In MSTR, the most important fission product is Xe-135 because of its:

a. LOW scattering cross-section.

b. LARGE thermal absorption cross section.

c. HIGH atomic mass number.

d. SMALL neutron capture cross sections

QUESTION C.08 [1.0 point]
The purpose of the Nitrogen-16 diffuser is to _____.

a. Reduce radiation levels at the pool surface.

b. Assist with natural circulation through the reactor core.

c. Sweep the air from the reactor bay and experimental area.

d. Take a suction on the primary coolant system and discharge it to the demineralizer system.

QUESTION C.09 [1.0 point]
Which ONE of the following isotopes identify a leaking fuel element after pool water analysis?

a. H-3

b. N-16

c. Xe-135

d. Cs-137

Category C: Facility and Radiation Monitoring Systems

QUESTION C.10 [1.0 point]
Which ONE of the following conditions would NOT activate an interlock preventing reactor startup?

a. Pool water temperature = 125 °C

b. Reactor period = 10 seconds.

c. Log power recorder out of service.

d. Fission chamber not operable.

QUESTION C.11 [1 point]
Select the location where the exhaust fans can be turn on/off.

a. West wall in the bay area.

b. South wall of the lower level.

c. Adjacent wall to the control room.

d. Wall behind the demineralizer system.

QUESTION C.12 [1.0 point]
Dependent upon core configuration, the/each _____ provides approximately 3% Δk/k of reactivity worth.

a. Regulating Rod

b. Shim/Safety Rod

c. Thermal Column

d. Standard Fuel Element at Core Periphery

Category C: Facility and Radiation Monitoring Systems

QUESTION C.13 [1.0 point]
An experiment is inserted into the core using the pneumatic sample transfer (rabbit) system. The flexible tubing that connects the stainless-steel tubes to the glove box and gas system for the rabbit system gets disconnected. With the reactor running at 100% power, which ONE of the following would most likely be a concern?

a. Radiation level increases due to N-16 activation.

b. Radiation level increases due to Ar-41 activation.

c. Radiation level increases due to neutron streaming.

d. Radiation level increases due to fission products released.

QUESTION C.14 [1.0 point]
Which ONE of the following experimental facilities has a shutter plug assembly and a rotating shutter assembly?

a. Void Tube

b. Beam Port

c. Rabbit System

d. Thermal Column

QUESTION C.15 [1.0 point]
The material of the poison section of the regulating rod is:

a. Boral

b. Graphite

c. Aluminum

d. Stainless Steel

Category C: Facility and Radiation Monitoring Systems

QUESTION C.16 [1.0 point]
Loss of Regulated 120 VAC power, depowers the:

a. Overhead Crane.

b. Auxiliary Chiller System.

c. Magnet Power and Scram Relays.

d. Log and Linear Channel and Safety Channels.

QUESTION C.17 [1.0 point]
MSTR is allowed to receive, possess, and use, in connection with operation of the facility, up to 50.0 grams of highly enriched, contained uranium-235 in the form of:

a. Foil Targets

b. Startup Sources

c. Byproduct Materials

d. Material Test Reactor Type Fuel

QUESTION C.18 [1.0 point]
Fueled experiments are experiments containing more than trace quantities of all of the following EXCEPT:

a. Au-198

b. U-233

c. U-235

d. Pu-239

Category C: Facility and Radiation Monitoring Systems

QUESTION C.19 [1.0 point]
Reactor power is at 100 W. A reactor staff accidentally opens the Thermal Column door and plugs. The corresponding Reactor Instrumentation Protective Action will be:

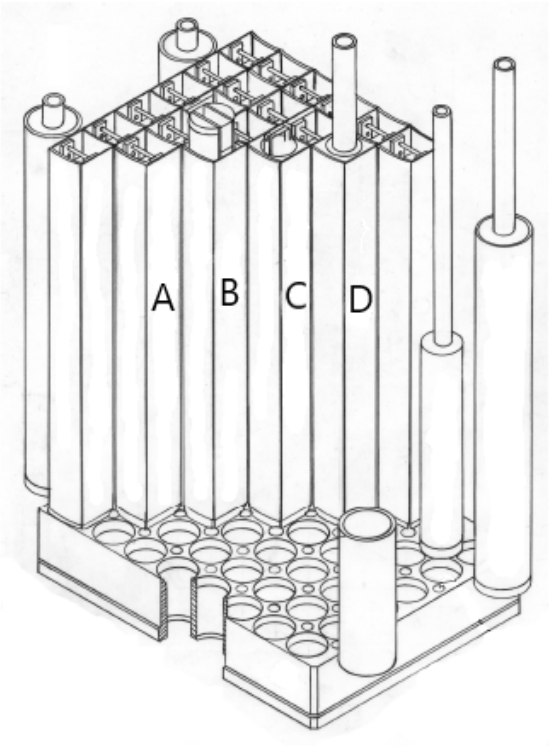
a. An Operator Response.

b. A reactor Rundown.

c. A reactor Scram.

d. An Alarm.

QUESTION C.20 [1.0 point]
Which ONE of following elements indicates position “D” in the grid plate?



a. Fuel Element

b. Control Rod Element

c. Core Access Element

d. Isotope Production Element

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

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

A.01
Answer: d
REF: Burn, Section 2.5.2, pg. 2-43 lists the Mean Free Path (λ) equation as the reciprocal of the macroscopic cross section, $\lambda=1/\sum$.
If $\sum=0.367$, then $\lambda= 1/0.367 = 2.72$

A.02
Answer: b
REF: DOE Handbook, Vol. 1, Module 1, pg. 24

A.03
Answer: b
REF: DOE Handbook, Vol. 1, Module 1, pg. 18

A.04
Answer: b
REF: Burn, Section 9.2, pg. 9-1, Neutrons will tend to move from a location of high flux (core center) to a position of lower flux (core edge).
Burn, Section 9.4, pg. 9-12, Flux distribution flattens due to: a. Fuel burnup in the center of the core due to high flux.

A.05
Answer: c
REF: DOE Handbook, Vol. 2, Module 4, pg. 31
Burn, Section 4.5, pg. 4-12

A.06
Answer: b
REF: Burn, Problem 7.7.4 (c), pg. 7-17

A.07
Answer: c
REF: Burn, Section 3.2.4, pg. 3-12

A.08
Answer: c
REF: Burn, Section 6.4.1.1, pg. 6-7 to 6-9
Burn, Figure 6.3, pg. 6-8
Burn, Example 6.4.1.1(a), pg. 6-9
DOE Handbook, Vol. 2, Module 3, pg. 25

A.09
Answer: b
REF: DOE Handbook, Vol. 2, Module 4, pg. 18, Equation (4-12): $P=P_0 2^{t/DT}$.
If DT = 20 seconds, then 3,000,000 watts = 25,000 watts (2) $^{t/20\ sec}$.
If 120 = 2 $^{t/20\ sec}$, then ln 120 = ln 2 (t/20 sec), $t = \frac{20 ln 120}{ln 2}$, t = 138 sec ~ 140 seconds.

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

A.10
Answer: c
REF: Burn, Section 5.4, pg. 5-14

A.11
Answer: c
REF: DOE Handbook, Vol. 2, Module 4, pg. 2, equation (4-1): $M = \frac{1}{1-Keff}$. Use the equation $M = \frac{1}{1-Keff}$ where M = 50 and re-write it as 1-K_{eff} = 1/50 = 0.02. Then rewrite as 1-0.02 = K_{eff} and solve for K_{eff}.

A.12
Answer: c
REF: DOE Handbook, Vol. 1, Module 2, pg. 23

A.13
Answer: c
REF: Burn, Section 2.4.1, pg. 2-19 to 2-23

A.14
Answer: a
REF: Chart of the Nuclides

A.15
Answer: c
REF: Burn, Section 6.4.1, pg. 6-5

A.16
Answer: c
REF: Glasstone & Sesonske, Nuclear Reactor Engineering, Section 4.46-4.48, pg. 170-171

A.17
Answer: b
REF: Burn, Figure 4.1 (d), pg. 4-2

A.18
Answer: a (3), b (1), c (4), d (2)
REF: DOE Handbook, Vol. 1, Module 1, pg. 43-46

A.19
Answer: b
REF: N = (10,000)/(1-0.8) = 50,000 neutrons/second
DOE Handbook, Vol. 2, Module 4, Equation 4-3, pg. 4

A.20
Answer: a
REF: Burn, Section 3.3.2, pg. 3-19
DOE Handbook, Vol. 2, Module 3, pg. 4, 28

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

Category B: Normal/Emergency Operating Procedures and Radiological Controls

B.01
Answer: b
REF: SOP 108, Section B.2, pg. 1 of 13

B.02
Answer: c
REF: TS 3.7.2, pg. 16

B.03
Answer: c
REF: EP 2, pg. 2-1

B.04
Answer: c
REF: SOP 653, Section B.2, pg. 1 of 2
SOP 655, Section C.1, pg. 1 of 6

B.05
Answer: d
REF: Per 10 CFR 20.1201(a)(1)(i), TEDE = 5 rems, then 5000 mrem/250 mrem/hr = 20 hours

B.06
Answer: b
REF: TS 6.8.3, pg. 34

B.07
Answer: d
REF: EP 7.4.6, pg. 7-5

B.08
Answer: d
REF: TS 3.6.1, pg. 13

B.09
Answer: a
REF: SOP 111, Section D, pg. 3 of 3

B.10
Answer: c
REF: EP 3.1, pg. 3-1

B.11
Answer: a
REF: TS 5.4, pg. 24

B.12
Answer: d
REF: SOP 108, Section C.2.e, pg. 5 of 15
SOP 108, Weekly Surveillance Checklist, Section 1 and 2, pg. 12 of 13

Category B: Normal/Emergency Operating Procedures and Radiological Controls

B.13
Answer: b
REF: Per 10 CFR 20.1004, the dose equivalent in rems is equal to the absorbed dose in rads multiplied by the quality factor. The quality factor for gamma is 1 and the quality factor for neutrons (unknown energy) is 10.

B.14
Answer: d
REF: TS 6.2.1, pg. 28

B.15
Answer: c
REF: 10 CFR 55.59(a)(2)

B.16
Answer: b
REF: EP 8.2.1, pg. 8-1

B.17
Answer: b
REF: TS 5.3.2(3), pg. 23

B.18
Answer: b
REF: EP Table 4.1, pg. 4-3

B.19
Answer: c
REF: Per 10 CFR 20, at 20 feet, there is no beta radiation. Gamma at 20 feet = 0.1 mrem/hour, gamma at 1 foot = 40 mrem/hour. Therefore, beta at 1 foot = 60 mrem/hour = 60%.

B.20
Answer: b
REF: SOP 108, Section D, pg. 11 of 13
TS 6.8.1, pg. 33

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

Category C: Facility and Radiation Monitoring Systems

C.01
Answer: b
REF: SAR 7.2.2.2

C.02
Answer: d
REF: SAR 7.2.2.7, pg. 7-12

C.03
Answer: c
REF: SAR 7.2.2.6, pg. 7-11

C.04
Answer: b
REF: SAR 7.2.2.5, pg. 7-10

C.05
Answer: a
REF: SAR Figure 5.1, pg. 5-3

C.06
Answer: c
REF: SAR Table 7.2, pg. 7-18
TS 3.1, pg. 9

C.07
Answer: b
REF: SAR 4.5.2.3, pg. 4-15

C.08
Answer: a
REF: SOP 5.2, pg. 5-2
SOP 11.1.1.1, pg. 11-1

C.09
Answer: d
REF: SAR Rev. B, Section 11.1.4.2, pg. 11-14.

C.10
Answer: a
REF: SAR 7.2.2.1, pg. 7-5

C.11
Answer: c
REF: SAR 9.1, pg. 9-1

C.12
Answer: b
REF: SAR 4.5.1, pg. 4-14

Category C: Facility and Radiation Monitoring Systems

C.13
Answer: b
REF: SAR 10.2.3, pg. 10-4

C.14
Answer: b
REF: SAR 10.2.2, pg. 10-3
SAR Figure 10.2, pg. 10-3

C.15
Answer: d
REF: TS 5.3.3, pg. 23
SAR 4.2.2, pg. 4-9

C.16
Answer: d
REF: SAR 7.2.2.5, pg. 7-10
SAR 8.2, pg. 8-1

C.17
Answer: a
REF: Renewed Facility Operating License, II.B.2.b

C.18
Answer: a
REF: SAR 10.3, pg. 10-7
TS 1.2, pg. 2

C.19
Answer: a
REF: SAR Table 7.2, pg. 7-14

C.20
Answer: c
REF: SAR Figure 4.3, pg. 4-5
SAR 10.2.5, pg. 10-5

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