December 26, 2017

Dr. Timothy Koeth, Director
The University of Maryland
Radiation Facilities and Nuclear Reactor
Department of Materials Science and Engineering
2309D Chemical and Nuclear Engineering Building
Building 090, Stadium Drive
College Park, MD 20742-2115

SUBJECT: EXAMINATION REPORT NO. 50-166/OL-18-01, UNIVERSITY OF MARYLAND

Dear Dr. Koeth:

During the week of November 27, 2017, the U.S. Nuclear Regulatory Commission (NRC) administered an operator licensing examination at your Maryland University Training reactor. The examinations were conducted according to NUREG-1478, "Operator Licensing Examiner Standards for Research and Test Reactors," Revision 2. Examination questions and preliminary findings were discussed with those members of your staff identified in the enclosed report at the conclusion of the examination.

In accordance with Title 10 of the *Code of Federal Regulations,* Section 2.390, a copy of this letter and the enclosures will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records (PARS) component of NRC's Agencywide Documents Access and Management System (ADAMS). ADAMS is accessible from the NRC Web site 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 Mr. John T. Nguyen at (301) 415-4007 or via internet e-mail John.Nguyen@nrc.gov.

Sincerely,

/RA/

Anthony J. Mendiola, Chief
Research and Test Reactors Oversight Branch
Division of Licensing Projects
Office of Nuclear Reactor Regulation

Docket No. 50-166

Enclosures:
1. Examination Report No. 50-166/OL-18-01
2. Written examination

cc: Amber Johnson
cc: w/o enclosures: See next page

SUBJECT: EXAMINATION REPORT NO. 50-166/OL-18-01, UNIVERSITY OF MARYLAND DATED DECEMBER 26, 2017.

DISTRIBUTION w/ encl.
Public
JNguyen AMendiola AAdams CMontgomery

ADAMS Accession No. ML17354A656 **NRR-074**

OFFICE	NRR/DPR/PROB	NRR/DIRS/IOLB/OLA	NRR/DLP/PROB/BC
NAME	JNguyen	ABaxter	AMendiola
DATE	12/15/2017	12/21/2017	12/26/2017

OFFICIAL RECORD COPY

cc:
Director, Maryland Department
of Natural Resources
Power Plant Research Program
Tawes State Office Building
Annapolis, MD 21401

Roland Fletcher
Manager, Radiological Health Program
Maryland Department of the Environment
1800 Washington Blvd., Suite 750
Baltimore, MD 21230

Amber Johnson
Associate Director, Nuclear Reactor
and Radiation Facilities
University of Maryland
Department of Materials Science
and Engineering
4418 Stadium Drive
College Park, MD 20742-2115

Mary J. Dorman
Radiation Safety Officer
Department of Environmental Safety
Sustainability & Risk
University of Maryland
4716 Pontiac Street
Seneca Building Suite 0103
College Park, MD 20742

Dr. Ray Phaneuf
Professor and Acting Chair
University of Maryland
Department of Materials Science
and Engineering
4418 Stadium Drive
College Park, MD 20742-2115

Test, Research, and Training Reactor Newsletter
University of Florida
202 Nuclear Sciences Center
Gainesville, FL 32611

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

REPORT NO.: 50-166/OL-18-01

FACILITY DOCKET NO.: 50-166

FACILITY LICENSE NO.: R-70

FACILITY: Triga

EXAMINATION DATES: November 27-29, 2017

SUBMUTRTED BY: _____/RA/_____ _12/18/17___
John T. Nguyen, Chief Examiner Date

SUMMARY:
During the week of November 27, 2017, the NRC administered operator licensing examinations to two Senior Reactor Operator-Upgrade (SRO-U), and two Reactor Operator (RO) candidates. The candidates passed all applicable portions of the examinations.

REPORT DETAILS

1. Examiners: John T. Nguyen, Chief Examiner, NRC

2. Results:

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

3. Exit Meeting:
John T. Nguyen, Chief Examiner, NRC
Timothy Koeth, Director, MUTR
Amber Johnson, Training Supervisor, MUTR

At the conclusion of the meeting, the NRC Examiner thanked the facility for their support in the administration of the examinations. There is no weaknesses observed during the examination.

.

U.S.NRC

UNITED STATES NUCLEAR REGULATORY COMMISSION

Protecting People and the Environment

Operator Written Examination

University of Maryland

Week of November 27, 2017

Enclosure 2

FACILITY COMMENT

Question B.08

Which ONE of the following events would be an initiating condition for an ALERT?

a. Experiment tube broken that causes radiation levels on the bay radiation area monitor exceed 200 mrem/hr.

b. Loss of pool water to be within the capabilities of the normal and emergency makeup water system.

c. Sustained fire within the reactor building.

d. Threatened compromise of security.

There is no correct answer listed in the distractors (see table 5.1 below). Request the Question B.08 be deleted.

TABLE 5.1: EMERGENCY CLASSIFCATION CODES

EMERGENCY CLASS	ACTION LEVEL
Personnel Emergency	• Personal Injury
Unusual Event (Class 1)	• Receipt of bomb threat • Report or observation of severe natural phenomenon. • Sustained fire or minor explosion within the reactor building. • Any event that causes or likely causes radiation levels as indicated on any radiation area monitors to be above 100 mrem/hr.
Alert (Class 2)	• Any event that causes or likely causes radiation levels as indicated on any radiation area monitors to be above 500 mrem/hr.

NRC RESPONSE

Facility comment accepted.

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

FACILITY: University of Maryland

REACTOR TYPE: TRIGA

DATE ADMINISTERED: 11/28/2017

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

A. RX THEORY, THERMO & FAC OP CHARS

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 ___ (0.25 each)

A02 a b c d ___

A03 a ___ b ___ c ___ d ___ (0.25 each)

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 *****)

B. NORMAL/EMERG PROCEDURES & RAD CON

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 ___

B.10 a ___ b ___ c ___ d ___ (0.5 each)

B11 a b c d ___

B12 a b c d ___

B13 a b c d ___

B14 a b c d ___

B15 a b c d ___

B16 a b c d ___

B17 a b c d ___

B18 a b c d ___

B19 a b c d ___

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

C. PLANT AND RAD 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 ___ (0.25 each)

C02 a b c d ___

C03 a ___ b ___ c ___ d ___ (0.25 each)

C04 a b c d ___

C05 a b c d ___

C06 a ___ b ___ c ___ d ___ (0.50 each)

C07 a b c d ___

C08 a ___ b ___ c ___ d ___ (0.25 each)

C09 a b c d ___

C10 a ___ b ___ c ___ d ___ (0.25 each)

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 ___

(***** 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 MUTR 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

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

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

$$\lambda^* = 1 \times 10^{-4} \text{ seconds}$$

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

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

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

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

$$M = \frac{1 - K_{eff_0}}{1 - K_{eff_1}}$$

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

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

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

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

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

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

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

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

$$T_{‰} = \frac{0.693}{\lambda}$$

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

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

$$DR = \frac{6CiE(n)}{R^2}$$

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

$\lambda_{eff} = 0.1/\text{sec}$

---

1 Curie = 3.7×10^{10} dps	1 kg = 2.21 lbm
1 hp = 2.54×10^{3} BTU/hr	1 Mw = 3.41×10^{6} BTU/hr
1 BTU = 778 ft-lbf	°F = 9/5°C + 32
931 Mev = 1 amu	°C = 5/9 (°F - 32)

Section A: Theory, Thermo & Fac. Operating Characteristics

QUESTION A.01 [1.0 point, 0.25 each]
Identify whether each of the following conditions will INCREASE or DECREASE the shutdown margin of a reactor.

a. Raising moderator temperature (Assume negative temperature coefficient).

b. Insertion of a cadmium foil to the reactor core.

c. Replacing an old fuel with a new fuel.

d. Burnout of a burnable poison.

QUESTION A.02 [1.0 point]
Which ONE of the following statement best defines the reactor excess reactivity? The reactor excess reactivity is:

a. a measure of the additional fuel loaded to overcome fission product poisoning.

b. a measure of remaining control rod worth when the reactor is exactly critical.

c. the combined control rod negative reactivity worth required to keep the reactor shutdown.

d. the maximum reactivity by which the reactor can be shutdown with one control rod fully withdrawn.

QUESTION A.03 [1.0 point, 0.25 each]
Replace "X" with the type of decay necessary (Alpha, Beta, Gamma or Neutron emission) to produce the following reactions.

a. $_{92}U^{238} \rightarrow {}_{90}Th^{234} + X$

b. $_{83}Bi^{203} \rightarrow {}_{82}Pb^{203} + X$

c. $_{2}He^{4} + {}_{4}Be^{9} \rightarrow {}_{6}C^{12} + X$

d. $_{84}Po^{210} \rightarrow {}_{82}Pb^{206} + X$

Section A: Theory, Thermo & Fac. Operating Characteristics

QUESTION A.04 [1.0 point]
Given the thermal neutron flux (Ø) is 1.0×10^{13} neutrons/cm^2/second, and the macroscopic cross-section (Σ_f) for fission is 0.1 cm^{-1}. The fission rate is:

a. 1.0×10^{12} fissions/cm/second

b. 1.0×10^{14} fissions /cm/second

c. 1.0×10^{12} fissions/cm^3/second

d. 1.0×10^{14} fissions /cm^3 / second

QUESTION A.05 [1.0 point]
If the multiplication factor, k, is increased from 0.800 to 0.950, the amount of reactivity added is: (given: beta effect = 0.007)

a. $2.1

b. $2.8

c. $21

d. $28

QUESTION A.06 [1.0 point]
Reactor power is rising on a 30 second period. Approximately how long will it take for power to triple?

a. 11 seconds

b. 33 seconds

c. 66 seconds

d. 80 seconds

Section A: Theory, Thermo & Fac. Operating Characteristics

QUESTION A.07 [1.0 point]
The number of neutrons passing through a one square centimeter of target material per second is described as:

a. Microscopic cross section.

b. Macroscopic cross section.

c. Neutron Flux.

d. Fission rate.

QUESTION A.08 [1.0 point]
You are assigned to check the operation of a new nuclear instrumentation channel. A few minutes following a reactor scram at full power, the reactor period has stabilized and the power level is decreasing at a CONSTANT rate. What is the time for power to decrease by a factor of 10? (Note: conversion may be needed)

a. 3 minutes

b. 60 minutes

c. 80 minutes

d. 184 minutes

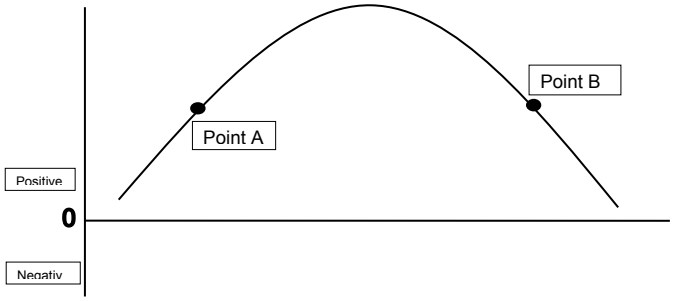
QUESTION A.09 [1.0 point]
Shown below is a trace of reactor period as a function of time. Between points A and B reactor power is:

a. continually increasing.

b. continually decreasing.

c. increasing, then decreasing.

d. constant.



QUESTION A.10 [1.0 point]
A reactor is slightly supercritical, with the thermal utilization factor = 0.700. A control rod is inserted to bring the reactor back to critical. Assuming all other factors remain unchanged, the new value for the thermal utilization factor is:

a. 0.698

b. 0.702

c. 0.704

d. 0.706

QUESTION A.11 [1.0 point]
Delayed neutrons are considered to cause "fission" easier than prompt neutrons because delayed neutrons have a:

a. higher energies than prompt fission neutrons.

b. higher fast non-leakage probability.

c. lower reproduction factor.

d. lower thermal utilization factor.

QUESTION A.12 [1.0 point]
Two critical reactors at low power are identical except that Reactor 1 has a beta fraction of 0.0072 and Reactor 2 has a beta fraction of 0.0060. An equal amount of positive reactivity is inserted into both reactors. Which ONE of the following will be the response of Reactor 1 compared to Reactor 2?

a. The final power level will be lower.

b. The final power level will be higher.

c. The resulting period will be longer.

d. The resulting period will be shorter.

Section A: Theory, Thermo & Fac. Operating Characteristics

QUESTION A.13 [1.0 point]
A reactor is critical at 18.1 inches on a controlling rod. The controlling rod is withdrawn to 18.4 inches. The reactivity inserted is 14.4 cents. What is the differential rod worth?

a. 14.4 cents/inch at 18.25 inches.

b. 48 cents/inch at 18.4 inches.

c. 48 cents/inch at 18.25 inches.

d. 14.4 cents/inch only between 18.1 and 18.4 inches.

QUESTION A.14 [1.0 point]
Which ONE of the following atoms will cause a neutron to lose the most energy in an elastic collision?

a. U-238

b. Ar-40

c. O-16

d. H-1

QUESTION A.15 [1.0 point]
You are conducting a reactor startup after installing 2 new fuel assemblies in the core. Given the following rod withdrawal data, estimate the rod position when criticality would occur. The initial count rate on the nuclear instrumentation prior to rod withdrawal is 55 cps.

a. 10 in

b. 11 in

c. 12 in

d. 13 in

Rod Withdrawal (Inches)	Count Rate (cps)
0	55
2	58
4	60
6	61
8	69
10	85
12	275

Section A: Theory, Thermo & Fac. Operating Characteristics

QUESTION A.16 [1.0 point]
The reactor is critical at 10 watts. A rod is withdrawn to insert a positive reactivity of $0.18. Which ONE of the following will be the stable reactor period as a result of this reactivity insertion? Given beta effective = 0.007

a. 10 seconds

b. 46 seconds

c. 55 seconds

d. 66 seconds

QUESTION A.17 [1.0 point]
Given the following Core Reactivity Data (not at MUTR):

Control Rod	Total Worth ($)	Rod excess ($) at 10 watts)
Rod 1	1.60	Full up
Rod 2	3.00	1.80
Rod 3	2.70	1.70
Rod 4	1.20	0.80

Which one of the following is the calculated shutdown margin that would satisfy the Technical Specification Minimum Shutdown Margin? Assume that all rods are scrammable.

a. $1.2

b. $4.2

c. $4.3

d. $8.5

QUESTION A.18 [1.0 point]
Which ONE of the following is the principal source of energy (heat generation) in the reactor following a reactor shutdown from extended operation at 100% power?

a. Fission product beta and gamma decay.

b. Xenon concentration buildup.

c. Spontaneous fission of U-238.

d. Decay of fission products.

QUESTION A.19 [1.0 point]
Which ONE of the following describes the response of the subcritical reactor to equal insertions of positive reactivity as the reactor approaches critical? Each reactivity insertion causes:

a. a SMALLER increase in the neutron flux, resulting in a LONGER time to reach equilibrium.

b. a SMALLER increase in the neutron flux, resulting in a SHORTER time to reach equilibrium.

c. a LARGER increase in the neutron flux, resulting in a LONGER time to reach equilibrium.

d. a LARGER increase in the neutron flux, resulting in a SHORTER time to reach equilibrium.

QUESTION A.20 [1.0 point]
Which ONE of the following factors of the Six Factor formula is most affected by changing the core materials?

a. Thermal Utilization Factor (f)

b. Reproduction Factor (η)

c. Fast Fission Factor (ε)

d. Fast Non-Leakage Factor (L_f)

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

Section B: Normal/Emergency Procedures and Radiological Controls

QUESTION B.01 [1.0 point]
A radiation survey of an area reveals a general radiation reading of 1 mrem/hr. There is, however, a small pipe which reads 10 mrem/hr at one (1) meter. Which ONE of the following defines the posting requirements for the area in accordance with 10CFR20?

a. Restricted Area.

b. Caution, Radiation Area.

c. Caution, High Radiation Area.

d. Grave Danger, Very High Radiation Area.

QUESTION B.02 [1.0 points]
Two point sources have the same curie strength. Source A's gammas have an energy of 2 Mev, whereas Source B's gammas have an energy of 4 Mev. You obtain a reading from the same GM tube at 10 feet from each source. Concerning the two readings, which ONE of the following statements is correct?

a. The reading from Source B is four times that of Source A.

b. The reading from Source B is twice that of Source A.

c. The reading from Source B is half that of Source A.

d. Both readings are the same.

QUESTION B.03 [1.0 point]
Which ONE of the following surveillances identifies as a channel check?

a. Press a manual button to verify the reactor scram.

b. Verify an interlock system by moving the neutron source away from the core.

c. Compare readings of gamma radiation area monitors at full power.

d. Adjust the Linear Power Channel in accordance with recent data collected on the reactor thermal power calibration.

Section B: Normal/Emergency Procedures and Radiological Controls

QUESTION B.04 [1.0 point]
Which ONE of the following conditions will violate the MUTR Technical Specifications?

a. The shutdown margin exceeds $1.0.

b. Inserting a non-secured experiment worth of $0.80.

c. Causing an unintentional pulse with reactivity insertion of $1.10.

d. The sum of the absolute reactivity worth of in-core experiments exceeds $2.0.

QUESTION B.05 [1.0 point]
In accordance with 10CFR20.1301, individual members of the public are limited to a TEDE in one year of:

a. 10 mrem.

b. 100 mrem.

c. 500 mrem.

d. 1250 mrem.

QUESTION B.06 [1.0 point]
An irradiated sample having a half-life of 20 minutes provides a dose rate of 100 mrem/hr at 2 ft. Approximately how far from the sample must a Radiation Area sign be posted?

a. 6 ft.

b. 9 ft.

c. 18 ft.

d. 80 ft.

Section B: Normal/Emergency Procedures and Radiological Controls

QUESTION B.07 [1.0 point]
Per MUTR Technical Specifications, which ONE of the following will violate the Limiting Safety System Settings?

a. An unanticipated change in reactivity of one dollar.

b. Instrumented fuel temperature exceeds 200 °C.

c. Steady State power exceeds 120 % full power.

d. A major loss of reactor pool water.

~~**QUESTION B.08 [1.0 point]**~~ **deleted per facility comment**
~~Which ONE of the following events would be an initiating condition for an ALERT?~~

~~a. Experiment tube broken that causes radiation levels on the bay radiation area monitor exceed 200 mrem/hr.~~

~~b. Loss of pool water to be within the capabilities of the normal and emergency makeup water system.~~

~~c. Sustained fire within the reactor building.~~

~~d. Threatened compromise of security.~~

QUESTION B.09 [1.0 point]
The dose rate from a mixed beta-gamma point source is 100 mrem/hour at a distance of one (1) foot, and is 0.1 mrem/hour at a distance of twenty (20) feet. What percentage of the source consists of beta radiation?

a. 20%

b. 40%

c. 60%

d. 80%

Section B: Normal/Emergency Procedures and Radiological Controls

QUESTION B.10 [2.0 points, 0.5 each]
Match the 10 CFR Part 55 requirements listed in Column A for an actively licensed operator with the correct time period from Column B. Column B answers may be used once, more than once, or not at all.

	Column A	Column B	
a.	License Expiration	1.	1 year
b.	Medical Examination	2.	2 years
c.	Requalification Written Examination	3.	4 years
d.	Requalification Operating Test	4.	6 years

QUESTION B.11 [1.0 point]
Per MUTR Emergency Plan, the area within the confines of the nuclear reactor building and the fenced area enclosing the north side of the reactor building is defined as the:

a. Reactor Boundary.

b. Emergency Planning Zone.

c. Restricted Area.

d. Control Access Area.

QUESTION B.12 [1.0 point]
Per MUTR Technical Specifications, which ONE of the following statements is true?

a. Liquid fissionable materials shall be doubly encapsulated.

b. Explosive materials in quantities less than 5 grams may be irradiated in the reactor or experimental facilities.

c. The reactivity worth of any single experiment shall be less than $2.00.

d. Each fuel experiment shall be controlled such that the total inventory of Iodine isotopes 131 thru 135 in the experiment is no greater than 5 curies.

Section B: Normal/Emergency Procedures and Radiological Controls

QUESTION B.13 [1.0 point]
Per MUTR Technical Specifications, which ONE of the following events does **NOT** require the presence of a licensed Senior Reactor Operator in the control room?

a. Resumption of operation following unexpected significant reduction in power.

b. Performance of the channel calibration for the Radiation Area Monitoring Systems.

c. Removal of Safety control rod for inspection.

d. Insertion of experiment worth of $0.90.

QUESTION B.14 [1.0 point]
Which ONE of the following is NOT a responsibility of the Emergency Director during an emergency?

a. Authorization for reentry and roof access.

b. Terminating an emergency and initiating recovery actions.

c. Coordinating medical, ambulance, fire, and police assistance as necessary.

d. Authorization for emergency exposures in excess of occupational limits during rescue and recovery activities.

QUESTION B.15 [1.0 point]
What is a minimum level of authority that has the power to approve minor changes such as typographical error correction or any other change that does not change the effectiveness or the intent of the procedure?

a. Reactor Safety Committee

b. Reactor Director

c. Reactor Supervisor

d. Senior Reactor Operator

Section B: Normal/Emergency Procedures and Radiological Controls

QUESTION B.16 [1.0 point]
The primary coolant ion exchange column should be replaced when the OUTLET conductivity meter exceeds its limit. The limit is set:

a. below 5 micromho/cm.

b. higher than 5 micromho /cm.

c. below 10 micromho /cm.

d. higher than 10 micromho /cm.

QUESTION B.17 [1.0 point]
The reactor shall NOT be operated unless the following measuring channels are operable:

a. 1 linear power channel and 1 fuel element temperature channel

b. 2 reactor power level channels and 1 fuel element temperature channel

c. 2 linear power channels and 2 fuel element temperature channels

d. 2 fuel element temperature channels and 2 log power channels

QUESTION B.18 [1.0 point]
How long will it take a 50 Curie source, with a half-life of 5.26 years, to decay to 2 Curie?

a. 10.5 Years

b. 15.5 Years

c. 24.5 Years

d. 35.5 Years

Section B: Normal/Emergency Procedures and Radiological Controls

QUESTION B.19 [1.0 point]
Per UMTR Technical Specifications, the control rod poison section shall be inspected:

a. Biennially

b. Annually

c. Semi-annually

d. Quarterly

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

Section C Facility and Radiation Monitoring Systems

QUESTION C.01 [1.0 point, 0.25 each]
Match the purification system functions in column A with the purification component listed in column B. (Note: items from column B may be used more than once, or not at all.)

	Column A		Column B
a.	Prevent clogging in the demineralizer.	1.	Resin in demineralizer
b.	Remove dissolved impurities	2.	Filter
c.	Remove suspended solids		
d.	Maintain pH		

QUESTION C.02 [1.0 point]
The MUTR neutron source is located at:

a. B row.

b. C row.

c. D row.

d. E row.

QUESTION C.03 [1.0 point. 0.25 each]
Match the item provided in column A, with the correct Nuclear Instrumentation Channel from column B. (Items in column B may be used once, more than once, or not at all.)

	Column A		Column B
a.	< 1 cps rod withdrawal inhibit	1.	Wide Range Linear Power
b.	Compensated Ion Chamber	2.	Wide Range Log Power
c.	Uncompensated Ion Chamber	3.	Safety Channel 2
d.	Output signal using Campbell technique		

QUESTION C.04 [1.0 point]
Figure 7.4 depicts the motor control rod and drive circuit. The MAIN function of the capacitor, C, listed in the diagram is to:

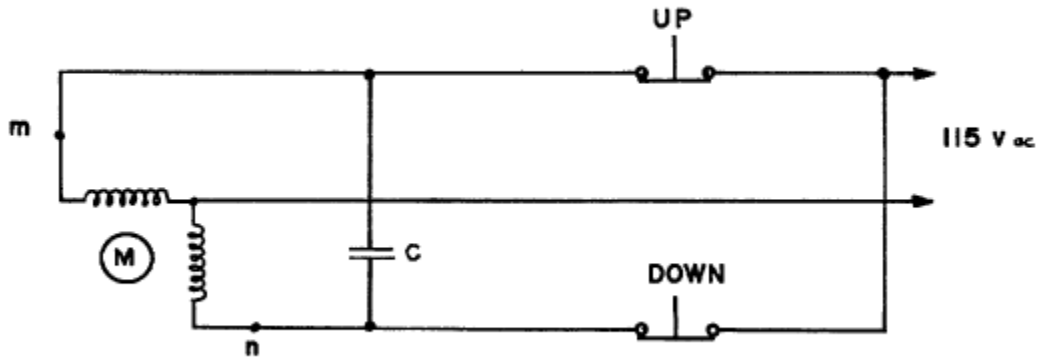


Figure 7.4: Simplified Motor Control Circuit

a. Provide enough phase-shifting with the motor coil M to cause the motor to rotate when UP or DOWN button is depressed.

b. Prevent a short circuit when UP and DOWN buttons are pressed simultaneously.

c. Prevent manual withdrawal of more than one control rods simultaneously.

d. Converse the 115 VAC to 115 VDC for the motor power.

QUESTION C.05 [1.0 point]
The CHANNEL TEST for the Bridge Radiation Area monitor is performed:

a. Prior to starting up the reactor

b. Daily

c. Monthly

d. Annually

Section C Facility and Radiation Monitoring Systems

QUESTION C.06 [2.0 points, 0.5 each]
Reactor is in operation. Match the input signals listed in column A with their AUTOMATIC response listed in column B. (Items in column B may be used once, more than once, or not at all.)

	Column A		Column B
a.	Fuel temperature = 175 °C	1.	Indication
b.	Source count rate = 10 cps	2.	Interlock
c.	Wide Range Linear Channel = 130% power	3.	Scram
d.	Beam Port plug is removed		

QUESTION C.07 [1 point]
Water returning to the pool from the primary system is ejected through an angled nozzle, which causes a swirling motion in the pool. Which ONE of the following is the PRIMARY purpose for this design?

a. To increase the heat transfer rate due to increased convective flow.

b. To increase the transport time for N^{16} to reach the surface of the pool.

c. To break up O^{16} bubbles in the pool thereby decreasing the production of N^{16}.

d. To decrease the activation rate of O^{16} to N^{16} due to a decrease in time within the core.

QUESTION C.08 [1.0 point, 0.25 each]
When reactor is at full power, identify the transfer mechanism (Forced Convection, Natural Convection or Conduction) for each of the following:

a. Cooling the Core.

b. Cooling the Pool.

c. Remove ions by demineralizer.

c. Transfer of heat across the tubes of the heat exchanger.

Section C Facility and Radiation Monitoring Systems

QUESTION C.09 [1.0 point]
Which ONE of the following will have an emergency power during a loss of the electrical building power?

a. Building security system, emergency lights, and exit signs.

b. Building security system and Bridge Radiation Area monitor.

c. Reactor console, emergency lights, and exit signs.

d. Primary coolant pump and Bridge Radiation Area monitor.

QUESTION C.10 [1.0 point, 0.25 each]
Use the following diagram of the control rod armature; match the components listed in Column A to the appropriate position locator listed in the diagram.

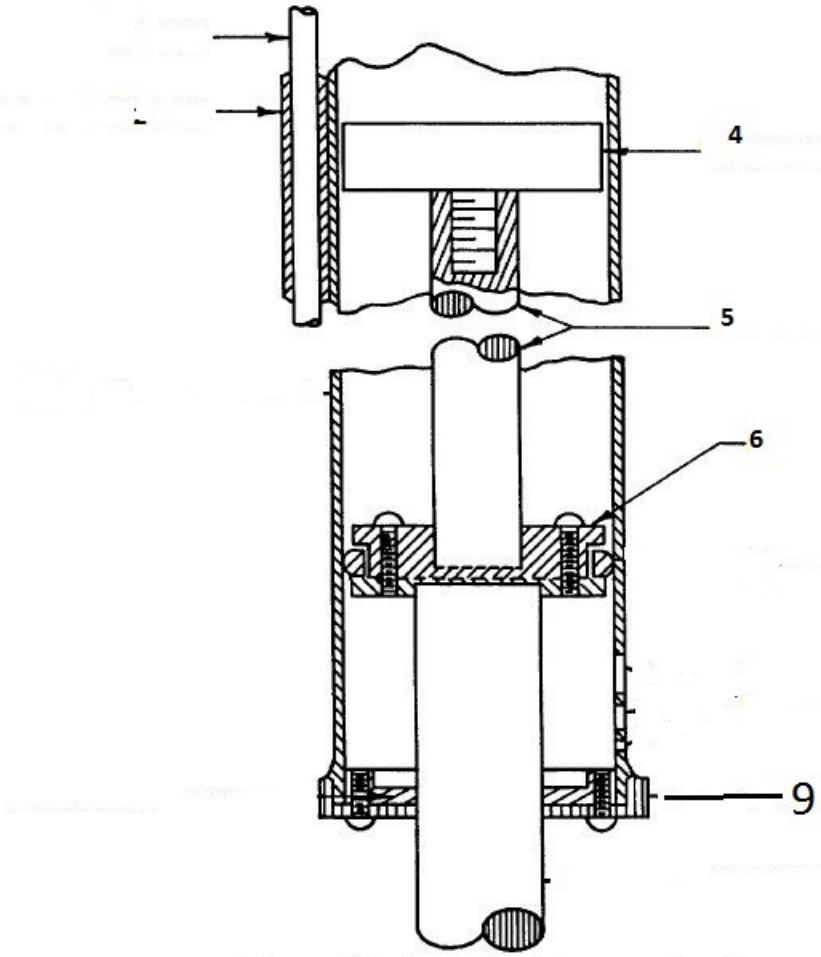
Column A

a. Barrel End

b. Piston

c. Armature

d. Connecting Rod


4
5
6
9

Section C Facility and Radiation Monitoring Systems

QUESTION C.11 [1.0 point]
Coolant flow in the demineralizer loop of the reactor coolant system is measured by:

a. a differential pressure across the filter.

b. a flow meter at the outlet of the demineralizer.

c. an orifice at the inlet to the heat exchanger.

d. a flowmeter at the inlet of the primary pump.

QUESTION C.12 [1.0 point]
Thermocouples in an instrumented TRIGA fuel element measure temperature at the:

a. surface of the cladding.

b. interior of the fuel section.

c. surface of graphite reflector.

d. center of the zirconium rod.

QUESTION C.13 [1.0 point]
When the OUTLET conductivity of the demineralizer reads 0.1 micromho and the INLET conductivity reads 1 micromho, it indicates that:

a. the resin bed has been depleted and it needs to be changed.

b. the outlet leg of the demineralizer has been logged.

c. the inlet leg of the demineralizer has been logged.

d. The demineralizer is operable and no need to change the resin bed.

Section C Facility and Radiation Monitoring Systems

QUESTION C.14 [1.0 point]
The Wide Range Log Power channel is used for the neutron flux measurement. What kind of signal from a fission chamber is used for the Campbelling technique?

a. It uses an output AC signal from a fission chamber to determine the neutron flux.

b. It uses an output DC signal from a fission chamber to determine the neutron flux.

c. It counts a number of pulses from a fission chamber to determine the neutron flux.

d. It combines an output AC and DC signals from a fission chamber to determine the neutron flux.

QUESTION C.15 [1.0 point]
Which ONE of the following describes the action of the rod control system to drive the magnet draw tube down after a dropped rod?

a. When the "ROD DOWN" limit switch and the MAGNET DOWN limit switch are activated by the reactor console, the rod will drop and the magnet tube drives down simultaneously.

b. When the connecting rod reaches the lowermost rest position, the "Rod Up" limit switch, S901, will reverse. S901A will open the circuit in series with the UP pushbutton and the motor automatically drives the magnet down.

c. When the connecting rod reaches the lowermost rest position, the "Rod Down" limit switch, S903, will reverse. S903A will open the circuit in series with the UP pushbutton and the motor automatically drives the magnet down.

d. When the connecting rod reaches the lowermost rest position, the "Rod Down" limit switch, S903, will reverse. S903A will open the circuit in series with the DOWN pushbutton and the motor automatically drives the magnet down.

QUESTION C.16 [1.0 point]
Which ONE of the following is the main function of the **DISCRIMINATOR** circuit in the Wide Range Log Power Channel?

a. Convert a number of pulses per second to reactor period.

b. Convert the signal from a fission counter to **LINEAR** output over a range of 10^{-8} to 150 percent of full power.

c. Filter out small pulses due to gamma interactions, passing only pulses due to neutron events within the Wide Range Log Power Channel

d. Generate a current signal equal and of opposite polarity as the signal due to gamma generated within the Wide Range Log Power Channel

QUESTION C.17 [1.0 point]
When the reactor is in the steady state mode, two or more control rods may not be withdrawn simultaneously. The purpose of this interlock is to:

a. prevent the possibility of a source-less startup.

b. prevent the inadvertent pulsing of a reactor in the steady state mode.

c. assure sufficient amount of startup neutrons are available to achieve a controlled approach to criticality.

d. prevent violation of the maximum reactivity insertion rate for steady state operation.

QUESTION C.18 [1.0 point]
When going to automatic from manual rod control the Regulating Rod will automatically be limited to a _____ reactor period until the power has reached the demand setpoint on the % DEMAND controller for the current range selected on the REACTOR POWER RANGE SWITCH.

a. 5 second

b. 10 second

c. 15 second

d. 25 second

Section C Facility and Radiation Monitoring Systems

QUESTION C.19 [1.0 point]
What is the MAIN reason that you would NOT bring the power level to exceed 500 watts during the control rod calibration?

a. Taking too long to obtain the reactor period.

b. Avoiding the maximum reactivity insertion rate.

c. Avoiding temperature induced reactivity effects.

d. Preventing the possibility of a rod withdraw prohibit.

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

Section A: Theory, Thermo & Fac. Operating Characteristics

A.01
Answer: a, INCREASE; b, INCREASE; c, DECREASE; d, DECREASE
Reference: DOE Fundamentals Handbook, Volume 2, Module 4, Reactor Theory (Reactor Operations), Enabling Objective 3.6

A.02
Answer: b
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Sec 6.2

A.03
Answer: a, alpha b, $_{+1}\beta^{0}$ c, neutron d, alpha
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Sec 2.8

A.04
Answer: c
Reference: Fission rate = thermal flux (Ø) x macroscopic cross-section. (Σ_f) = 1.0 x 10^{13} x 0.1 cm^{-1} = 1.0 × 10^{12} neutrons/cm^3/second
Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Sec 2.6.2

A.05
Answer: d
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1982, Sec 3.3.3, page 3-21.
$\Delta\rho$ = keff1-keff2/(keff1 x keff2) = 0.95-0.8 /(0.8*0.95)=0.197
Or = \$0.197/0.007 = \$28

A.06
Answer: b
Reference: $P = P_0 e^{t/T}$ —> ln(3) = time ÷ 30 seconds –> time = ln (3) x 30 sec. 1.1 x 30 ≈ 33 sec.

A.07
Answer: c
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Sec 2.6.1

A.08
Answer: a
Reference: $P/P_0 = e^{-T/\tau}$ ln(0.1) = - T(time)/τ(-80sec) Time = ln (0.1) × -80 sec = 184 seconds ≈ 3 minutes

A.09
Answer: a
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Sec 4.3

A.10
Answer: a
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Sec 3.3.1

Section A: Theory, Thermo & Fac. Operating Characteristics

A.11
Answer: b
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Sec 3.3.1

A.12
Answer: c
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Sec 4.9

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

A.13
Answer: c
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Sec 7.3
Differential position is between 18.1 and 18.4 = 18.25
Differential rod worth ($\Delta k/k/in$) = ($\Delta k/k$) / (Δrod position)
= 14.4 cents /0.3 = 48 cents

A.14
Answer: d
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Sec 2.5.3

A.15
Answer: d
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1982, Sec 5.5 -5.7
A subcritical multiplication factor, k, closer to 1 produces a larger subcritical neutron population, C. You see a big jump from 10 to 12 in. However, at 12 in reactor is still under subcritical k < 1 due to 1/M = 55 cps/275 cps =0.2. Best guess, it must be higher than 12 in.

A.16
Answer: b
Reference: Reactivity added = \$0.18 x .007 = 0.00126

$$\tau = (\beta-\rho)/\lambda_{eff}\rho = \frac{0.007 - 0.00126}{(0.1)\,(0.00126)} = 45.6 \text{ seconds}$$

A.17
Answer: a
Reference: Shutdown = Total rod worth – rod excess
\$8.5 – \$4.3 = \$4.2
Minimum SDM = Shut down – highest worth of control rod
(\$1.80 + \$1.70 + \$.8) - \$3 (rod number 2) = \$4.20 - \$3.0 = \$1.2

Section A: Theory, Thermo & Fac. Operating Characteristics

A.18
Answer: d
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Sec 3.2.1

A.19
Answer: c
Reference: NRC Standard Question

A.20
Answer: a
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Sec 3.3.1

Section B Normal/Emergency Procedures and Radiological Controls

B.01
Answer: c
Reference: $DR_1D_1^2 = DR_2D_2^2$;
10 mrem/hr at one meter (100 cm.)
results in 111.1 mrem/hr at 30 cm.

B.02
Answer: d
Reference: GM tube cannot distinguish between energies.

B.03
Answer: c
Reference: TS, Definition

B.04
Answer: c
Reference: MUTR Tech Spec is not permissible to conduct a pulse.

B.05
Answer: b
Reference: 10CFR20

B.06
Answer: b
Reference: $DR_1D_1^2 = DR_2D_2^2$;
Radiation area > 5 mrem/hour.
100 mrem $(2)^2$ = 5 mrem $(d)^2$
D = 8.9 ft

B.07
Answer: b
Reference: TS 2.2

~~**B.08**~~ Deleted per facility comment
~~Answer: a~~
~~Reference: EP 5.0~~

B.09
Answer: c
Reference: 10CFR20 - 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.10
Answer: a,4 b,2 c,2 d,1.
Reference: 10CFR55

Section B Normal/Emergency Procedures and Radiological Controls

B.11
Answer: a
Reference: EP 2.9
"c"and "d" cannot be the correct answers because the question asked related to the Emergency Plan, not the Security Plan.

B.12
Answer: a
Reference: TS 3.7

B.13
Answer: b
Reference: TS 6.1.3

B.14
Answer: c
Reference: EP 3.1.3

B.15
Answer: b
Reference: TS 6.4

B.16
Answer: a
Reference: TS 3.7

B.17
Answer: b
Reference: TS Table 3.1

B.18
Answer: c
Reference: $T\ A = A_{\circ} * e^{-\lambda t}$
$2Ci = 50Ci * e^{-\lambda(t)}$
$Ln(2/50) = -ln2/5.27\ yr*(t) \rightarrow -3.2189/-0.1315$
solve for t: 24.47 years

B.19
Answer: b
Reference: SP 201

Section C Facility and Radiation Monitoring Systems

C.01
Answer: a = 2; b = 1; c = 2; d= 1
Reference: Standard NRC purification system question.

C.02
Answer: a
Reference: SAR, Figure 4.9

C.03
Answer: a = 2; b = 1; c = 3; d= 2
Reference: SAR 7.4

C.04
Answer: a
Reference: SAR 7.2.1.2

C.05
Answer: a
Reference: TS 4.6.1

C.06
Answer: a = 3 b = 1; c = 1; d= 2
Reference: TS 3.1 and 3.2 and walk through information

C.07
Answer: b
Reference: SAR 5.6

C.08
Answer: a = NC; b = FC; c = FC d = Con
Reference: Standard NRC question

C.09
Answer: a
Reference: SAR 8.1

C.10
Answer: a(9) b(6) c(4) d(5)
Reference: SAR Figure 4.14

C.11
Answer: a
Reference: SAR 5.2

C.12
Answer: b
Reference: SAR 4.2.1.2

Section C Facility and Radiation Monitoring Systems

C.13
Answer: d
Reference: SAR 5.4.2
0.1 micromho = 10 MΩ at outlet
1 micromho = 1 MΩ at inlet
So, the demineralizer is working!

C.14
Answer: d
Reference: Information from walkthrough

C.15
Answer: d
Reference: SAR 7.3.1.1

C.16
Answer: c
Reference: SAR 7.4.1.1.1

C.17
Answer: d
Reference: TS, Table 3.4

C.18
Answer: c
Reference: OP-104 step 6.5

C.19
Answer: c
Reference: OP-204