November 3, 2016

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-16-01, UNIVERSITY OF MARYLAND

Dear Dr. Koeth:

During the week of September 26, 2016, 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 e-mail John.Nguyen@nrc.gov.

Sincerely,

/RA/

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

Docket No. 50-166

Enclosures: 1. Examination Report No. 50-166/OL-16-01
2. Written examination

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

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DISTRIBUTION w/ encls.:
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ADAMS ACCESSION #: ML16299A013 **TEMPLATE #:NRR-074**

OFFICE	NRR/DPR/PROB/CE	NRR/DPR/PROB/OLA	NRR/DPR/PROB/BC
NAME	JNguyen	CRevelle	AMendiola
DATE	10/12/2016	10/25/2016	11/03/2016

OFFICIAL RECORD COPY

cc:

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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-16-01

FACILITY DOCKET NO.: 50-166

FACILITY LICENSE NO.: R-70

FACILITY: TRIGA

EXAMINATION DATES: September 26-28, 2016

SUBMUTRTED BY: **/RA/** **10/12/16**
John T. Nguyen, Chief Examiner Date

SUMMARY:
During the week of September 26, 2016, the NRC administered operator licensing examinations to one Senior Reactor Operator-Instant (SRO-I), one Senior Reactor Operator-Upgrade (SRO-U), and three 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	3/0	1/0	4/0
Operating Tests	3/0	2/0	5/0
Overall	3/0	2/0	5/0

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. The facility licensee had no comments on the written examination. The examiner also discussed the weaknesses observed during the examination. Two reactor operator candidates have shown the weaknesses in a basic understanding of 10 CFR 50.59, a lack of knowledge in the operations of nuclear instrumentation channels, and unfamiliar with a condition when nuclear instrumentation channels are out of calibration. The facility licensee promised to take actions to improve program performance in the training programs.

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

FACILITY: Pool

REACTOR TYPE: TRIGA

DATE ADMINISTERED: 9/27/2016

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

ENCLOSURE 2

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 ___

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 *****)

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 ___ (0.25 each)

B03 a ___ b ___ c ___ d ___ (0.25 each)

B04 a b c d ___

B05 a b c d ___

B06 a ___ b ___ c ___ d ___ (0.25 each)

B07 a b c d ___

B08 a b c d ___

B09 a b c d ___

B10 a b c d ___

B11 a b c d ___

B12 a b c d ___

B13 a b c d ___

B14 a b c d ___

B15 a b c d ___

B16 a b c d ___

B17 a b c d ___

B18 a b c d ___

B19 a b c d ___

B20 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 ___

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 ___ (0.50 each)

C07 a b c d ___

C08 a b c d ___

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 ___ (0.3 each)

(***** 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 <u>only</u> 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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

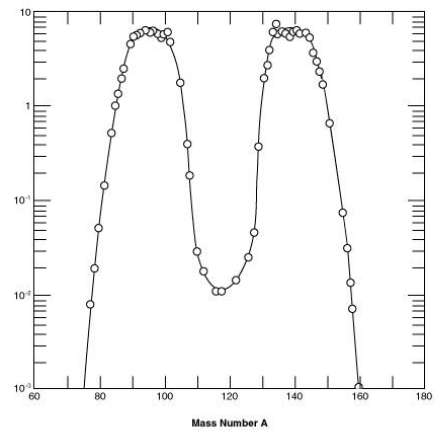
$\lambda_{eff} = 0.1/sec$

---

1 Curie = $3.7x10^{10}$ dps	1 kg = 2.21 lbm
1 hp = $2.54x10^{3}$ BTU/hr	1 Mw = $3.41x10^{6}$ BTU/hr
1 BTU = 778 ft-lbf	°F = 9/5°C + 32
931 Mev = 1 amu	°C = 5/9 (°F - 32)

Section A L Theory, Thermo & Fac. Operating Characteristics

QUESTION A.01 [1.0 point]
The following graph for U-235 depicts:



a. differential rod worth curve in the core

b. distribution of fission product yield

c. radial flux distribution in the core

d. neutron energy distribution in the moderator

QUESTION A.02 [1.0 point]
You're increasing reactor power on a steady +26 second period. How long will it take to increase power by a factor of 10?

a. 1 minute

b. 3 minutes

c. 5 minutes

d. 60 minutes

QUESTION A.03 [1.0 point]
Which ONE of the following is a number of neutrons in the tritium nucleus ($_1T^3$ or $_1H^3$)?

a. 1

b. 2

c. 3

d. 4

QUESTION A.04 [1.0 point]
The MUTR Reactor is critical at 100 W. A reactor operator makes a mistake by inserting a sample worth of $1.5 into the reactor core. Which ONE of the following best describes the values of K_{eff} and ρ during the power increment?

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

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

c. $K_{eff} > 1$ and $\beta\text{-eff} < \rho < 1$

d. $K_{eff} > 1$ and $0 < \rho < \beta\text{-eff}$

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 between:

a. 0.140 - 0.150

b. 0.160 – 0.170

c. 0.180 – 0.190

d. 0.190 - 0.200

QUESTION A.06 [1.0 point]
Which ONE of the following correctly describes the SIX- FACTOR FORMULA at MUTR?
Note: ∞ : infinitive and eff: effective

a. $K_{\infty} = K_{eff}$ * the thermal utilization factor

b. $K_{\infty} = K_{eff}$ * the total non-leakage probability

c. $K_{eff} = K_{\infty}$ * the total non-leakage probability

d. $K_{eff} = K_{\infty}$ * (the resonance escape probability * the reproduction factor)

QUESTION A.07 [1.0 point]
Which ONE of the following describes the term **PROMPT DROP**?

a. A reactor is subcritical at negative 80-second period

b. A reactor has attained criticality on prompt neutrons alone

c. The instantaneous change in power level due to inserting a control rod

d. The instantaneous change in power level due to withdrawing a control rod

QUESTION A.08 [1.0 point]
Which ONE of the following is the MAIN reason for operating reactor with thermal neutrons instead of fast neutrons?

a. The atomic weight of thermal neutrons is larger than fast neutrons, so thermal neutrons are easily to slow down and be captured by the fuel

b. The neutron lifetime of thermal neutrons is longer than fast neutrons, so the fuel has enough time to capture thermal neutrons

c. Fast neutrons give off higher radiation than thermal neutrons. Reactor needs to reduce radiation limit by using thermal neutrons

d. The fission cross section of the fuel is much higher for thermal energy neutrons than fast neutrons

QUESTION A.09 [1.0 point]
Which ONE of the following is the MINIMUM amount of reactivity that makes the MUTR (**finite)** critical reactor to be a prompt critical reactor? This MINIMUM amount is equal to:

a. the shutdown margin

b. the β-effective value

c. 1.0 % ΔK/K

d. the factor of “e”

QUESTION A.10 [1.0 point]
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 a reactor power level five minutes later from 4 kW?

a. 1500 W

b. 940 W

c. 94 W

d. 15 W

QUESTION A.11 [1.0 point]
Reactor A increases power from 10% to 20% with a period of 25 seconds. Reactor B increases power from 80% to 100% with a period of also 25 seconds. Compared to Reactor A, the time required for the power increase of Reactor B is:

a. longer than A

b. exactly the same as A

c. twice that of A

d. shorter than A

QUESTION A.12 [1.0 point]
Two common FISSION PRODUCTS that have especially large neutron capture cross sections and play a significant role in reactor physics. One is Sm-149 and the other is:

a. B-10

b. Ar-41

c. Xe-135

d. Cs-137

QUESTION A.13 [1.0 point]
Which ONE statement below describes a NEGATIVE moderator temperature coefficient?

a. When moderator temperature increases, negative reactivity is added

b. When moderator temperature decreases, negative reactivity is added

c. When moderator temperature increases, positive reactivity is added

d. When moderator temperature increases, no change in reactivity

QUESTION A.14 [1.0 point]
During the time following a reactor scram, reactor power decreases on an 80 second period, which corresponds to the half-life of the longest-lived delayed neutron precursors of:

a. 80 seconds

b. 55 seconds

c. 40 seconds

d. 20 seconds

QUESTION A.15 [1.0 point]
You enter the control room and note that all nuclear instrumentation show a steady neutron level, and no rods are in motion. Which ONE of the following conditions CANNOT be true?

a. The reactor is critical

b. The reactor is subcritical

c. The reactor is supercritical

d. The neutron source has been removed from the core

QUESTION A.16 [1.0 point]
Which ONE of the following nuclides will cause a fast neutron to lose its most energy per collision?

a. H-1

b. B-10

c. C-12

d. U-235

QUESTION A.17 [1.0 point]
Which ONE of the following is a correct statement describing prompt and delayed neutrons? Prompt neutrons:

a. are released during U-238 interacts with fast neutrons, while delayed neutrons are released during U-235 interacts with thermal neutrons

b. account for less than 1% of the neutron population, while delayed neutrons account for the rest

c. are released during the fission process, while delayed neutrons are released during the decayed process

d. are the dominating factor in determining reactor period, while delayed neutrons have no effect on reactor period

QUESTION A.18 [1.0 point]
Which **ONE** of the following conditions will **DECREASE** the Core Excess of a reactor?

a. Lowering moderator temperature (assume negative temperature coefficient)

b. Insertion of a positive reactivity worth experiment

c. Burnout of a burnable poison

d. Fuel depletion

QUESTION A.19 [1.0 point]
The effective target area in cm^2 presented by a single nucleus to an incident neutron beam is defined as:

a. a microscopic cross section

b. a macroscopic cross section

c. a mean free path

d. a neutron flux

QUESTION A.20 [1.0 point]
Which ONE of the following physical characteristics of the TRIGA fuel is the main contributor for the prompt negative temperature coefficient?

a. As the fuel heats up the resonance absorption peaks broaden and increases the likelihood of neutron absorption in U-238

b. As the fuel heats up a rapid increase in moderator temperature occurs through conduction and convection heat transfer mechanisms which adds negative reactivity

c. As the fuel heats up fission product poisons (e.g., Xe) increase in concentration within the fuel matrix and add negative reactivity via neutron absorption

d. As the fuel heats up the oscillating hydrogen in the ZrH lattice imparts energy to a thermal neutron, thereby increasing its mean free path and probability of escape

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

Section B Normal/Emergency Procedures and Radiological Controls

QUESTION B.01 [1.0 point]
Per MUTR Emergency Procedure, the individual who can authorize emergency exposures in excess of normal occupational limits during rescue and recovery activities is the:

a. MUTR Police Chief

b. Public Relations Coordinator

c. MUTR Radiation Protection Officer

d. MUTR Emergency Director

QUESTION B.02 [1.0 points, 0.25 each]
Match the radiation reading from Column A with its corresponding radiation area classification (per 10 CFR 20) listed in Column B. Answer in Column B can be used more than once, or not at all. Assume a Quality Factor of 1.

	Column A	Column B
a.	5 mrem/hr at 30 cm	1. Public Area
b.	50 mrem/hr at 30 cm	2. Radiation Area
c.	20 mrem/hr at 1 m	3. High Radiation Area
d.	550 rem/hr at 1 m	4. Very High Radiation Area

QUESTION B.03 [1.0 point, 0.25 each]
Identify each of the following surveillances as a channel check (**CHECK)**, a channel test (**TEST)**, or a channel calibration (**CAL)**.

a. During reactor operation, you compare readings of a reactor power level

b. During the startup, you verify the interlock system by performing simultaneous manual withdrawal of two control rods

c. During the startup, you press the manual scram to verify a reactor scram

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

QUESTION B.04 [1.0 point]
The radiation from an unshielded source is 500 mrem/hr. You insert a lead sheet with 30 mm thickness; the radiation level reduces to 125 mrem/hr. What is the half-value-layer (HVL) of lead? (HVL: thickness of lead required so that the original intensity will be reduced by half)?

a. 15 mm

b. 20 mm

c. 30 mm

d. 60 mm

QUESTION B.05 [1.0 point]
Which ONE of the following conditions requires the NRC APPROVAL for changes?

a. Revise the MUTR startup checklist

b. Add more responsibilities to facility staff requirements on the fuel movement procedure

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

d. Reduce a minimum number of Reactor Safety Committee members listed in Tech Spec from five to three

QUESTION B.06 [1.0 point, 0.25 each]
Match each of the Technical Specification Limits in column A with its corresponding value in column B. (Each limit has only one answer, values in Column B may be used once, more than once or not at all.)

	Column A		Column B
a.	Worth of single experiment	1.	$0.30
b.	Non-Secured experiment	2.	$0.50
c.	Excess reactivity	3.	$1.00
d.	Total worth of experiments	4.	$3.00
		5.	$3.50

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

a. An unanticipated change in reactivity of two dollars

b. Instrumented fuel temperature = 450 °C

c. Steady State power of 120 % full power

d. Coolant Height = 10 feet above top of fuel core

QUESTION B.08 [1.0 point]
A biennial test of the reactor shutdown margin was performed. Which ONE of the following is the latest the test that must be performed again?

a. 7.5 months after

b. 15 months after

c. 27 months after

d. 29 months after

QUESTION B.09 [1.0 point]
The reactor operator licensing candidate requires submitting an NRC Form 396, Medical Requirements, as part of his or her application. This requirement can be found in:

a. 10 CFR Part 20

b. 10 CFR Part 50.59

c. 10 CFR Part 55

d. 10 CFR Part 19

QUESTION B.10 [1.0 point]
During a reactor operation, a short circuit occurs in the reactor console and causing a small fire. Which ONE of the following classes of extinguisher would most likely be used with this type of fire?

a. Class A: Fires in ordinary combustibles, such as wood, paper, plastic, etc

b. Class B: Fires in flammable or combustible liquids, flammable gases, greases, etc

c. Class C: Fires in live electrical equipment

d. Class D: Fires involving combustible metals such as magnesium

QUESTION B.11 [1.0 point]
An example of Byproduct Material would be:

a. Pu-239

b. U-233

c. U-235

d. Au-198

QUESTION B.12 [1.0 point]
A radioactive source reads 2 Rem/hr on contact. Five hours later, the same source reads 1.0 Rem/hr. How long is the time for the source to decay from a reading of 2 Rem/hr to 20 mRem/hr?

a. 8 hours

b. 16 hours

c. 33 hours

d. 41 hours

QUESTION B.13 [1.0 point]
Which ONE of the following events does **NOT** require the presence of a licensed Senior Reactor Operator in the facility?

a. Fuel relocations within the core region

b. Removal of Safety control rod for inspection

c. Insertion of experiment worth of $0.40

d. Restart reactor following an unplanned shutdown

QUESTION B.14 [1.0 point]
A survey instrument with a window probe is used to measure the beta-gamma dose rate from an irradiated experiment. The dose rate is 240 mrem/hour with the window opened and 60 mrem/hour with the window closed. The gamma dose rate is:

a. 60 mrem/hour

b. 180 mrem/hour

c. 240 mrem/hour.

d. 300 mrem/hour

QUESTION B.15 [1.0 point]
What is the **HALF LIFE** of the isotope contained in a sample which produces the following count rates?

Time (Minutes)	Counts per Minute (cpm)
Initial	950
60	702
120	518
180	383
240	283

a. 124 minutes

b. 137 minutes

c. 201 minutes

d. 558 minutes

QUESTION B.16 [1.0 point]
Which ONE of the following radioactive gases poses the most significant hazard within the reactor room during normal operations at full power?

a. Tritium

b. Argon-41

c. Xenon-135

d. Nitrogen-16

QUESTION B.17 [1.0 point]
According to MUTR procedures and Technical Specifications, which ONE of the following is **NOT** considered an UNSCHEDULED SHUTDOWN?

a. Loss of Power to the building removed the high voltage supply to the reactor console and caused all the safety rods to scram

b. During the annual surveillance check, a channel input signal of 320 kW caused all the safety rods to scram

c. The operator was not watching reactor period when it reached 4 seconds and caused all the safety rods to scram

d. The operator inadvertently leaned on the scram bar with their elbow and caused all the safety rods to scram

QUESTION B.18 [1.0 point]
The procedures to follow for a reactor building evacuation can be found in the:

a. 100 Series

b. 200 Series

c. 400 Series

d. 500 Series

QUESTION B.19 [1.0 point]
The tygon tubing for the pneumatic (rabbit) system is disconnected. An experiment is inserted into the core via the remaining tubing of the rabbit system. With the reactor running at 100% power, which ONE of the following would most likely be a concern?

a. Radiation level increases due to Ar-41

b. Radiation level increases due to neutron streaming

c. Radiation level increases due to fission products released

d. Radiation level increases due to N-16

QUESTION B.20 [1.0 point]
A reactor operator works continuously in radiation area of 120 mrem/hr. What is the Maximum time he could stay there before exceeding a total dose limit (TEDE)?

a. 10 hours

b. 20 hours

c. 40 hours

d. 60 hours

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

Section C Facility and Radiation Monitoring Systems

QUESTION C.01 [1.0 point]
The MUTR control rods are located at C-row and:

a. B-row

b. D-row

c. E-row

d. F-row

QUESTION C.02 [1.0 point]
Use the following diagram of an instrumented fuel element. Which ONE of the following is the correct match for the position locator (Column A) to the correct component (Column B)?

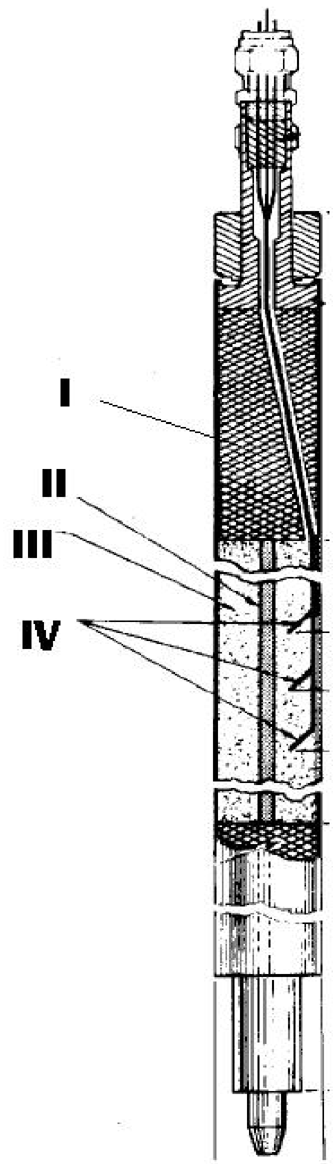
Column A	Column B
I	A. Zirconium Hydride-Uranium
II	B. Stainless steel
III	C. Samarium Burnable Poison
IV	D. Graphite Reflector
	E. Zirconium Rod
	F. Spacer
	G. Thermocouples

a. I-C, II-F, III-A, IV-C

b. I-D, II-A, III-E, IV-C

c. I-D, II-E, III-A, IV-G

d. I-C, II-B, III-E, IV-G


I
II
III
IV

Section C Facility and Radiation Monitoring Systems

QUESTION C.03 [1.0 point]
Graphite inserts are placed in the top and bottom of the fuel element. Which ONE of the following best describes the function of these inserts?

a. Reduce gamma radiation

b. Increase fast neutron flux

c. Absorb fission product gases

d. Reduce neutron leakage

QUESTION C.04 [1.0 point]
During reactor operation, which ONE of the following is the MAIN reason for not operating the coolant pumps in dry (no prime) for no longer than two minutes?

a. Increasing the amount of Ar-41 released to the reactor bay

b. Increasing the amount of N-16 in the reactor pool

c. Damaging the pump motor

d. Damaging the coolant pipes

QUESTION C.05 [1.0 point]
The low-source-interlock signal comes from:

a. Fuel Temperature Channel

b. Wide Range Linear Channel

c. Safety Channel 2

d. Log Power Level Channel

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

	Column A		Column B
a.	Fuel temperature = 170 °C	1.	Normal Operation
b.	Source count rate = 1 cps	2.	Alarm ONLY
c.	Wide Range Linear Channel = 120% power	3.	Interlock
d.	Bay Radiation Monitor = exceed second setpoint	4.	Scram (with or without Alarm)

QUESTION C.07 [1 point]
Which ONE of the following elements is MAINLY used as the neutron absorber on the MUTR control rods?

a. boron

b. zirconium-hydride

c. borated graphite

d. gold-indium-cadmium

QUESTION C.08 [1.0 point]
A neutron flux will activate isotopes in air. The primary isotope of concern in the pneumatic transfer system is:

a. N^{16} (O^{16} (n,p) N^{16})

b. Kr^{80} (Kr^{79} (n, γ) kr^{80})

c. Ar^{41} (Ar^{40} (n, γ) Ar^{41})

d. H^{2} (H^{1} (n, γ) H^{2})

QUESTION C.09 [1.0 point]
Which ONE of the following is the correct parameter used for the calibration of control rods by the procedure SP 204?

a. count rate vs. 1/M

b. temperature vs. period

c. pool level vs. coolant flow

d. reactivity vs. rod height

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

b. Armature

c. Dashpot Port

d. Pull Rod

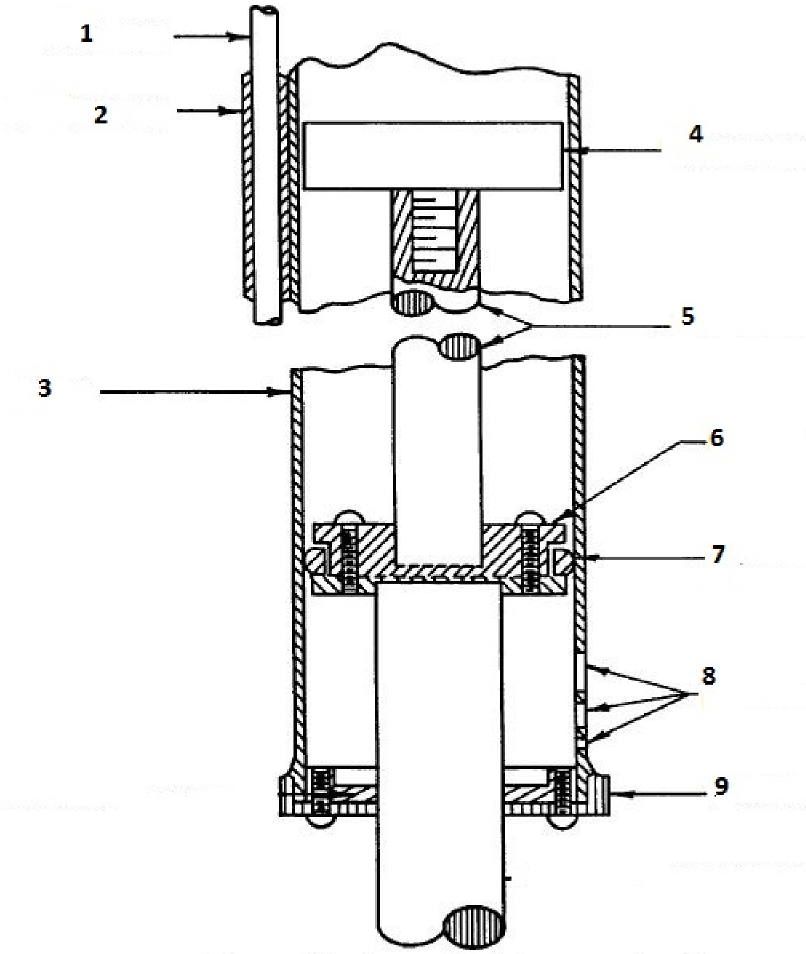


Figure 4.14: Control Rod Armature Details

QUESTION C.11 [1.0 point]

The Main purpose for setting a conductivity limit of the pool water is to:

a. Minimize the possibility of corrosion of the cladding on the fuel elements

b. Minimize Ar-41 released to the public

c. Extend integrity of resin bed on the demineralizer

d. Maximize the heat transfer rate between fuel elements and pool water

QUESTION C.12 [1.0 point]
If 120 gpm is the total flowrate for the primary coolant system, what is the flowrate through the coolant purification system?

a. 12 gpm

b. 18 gpm

c. 60 gpm

d. 80 gpm

QUESTION C.13 [1.0 point]
Which ONE of the following is the best description on how the Compensated Ion Chamber (CIC) operates?

	Material used in CIC	Interact with	Results
a.	Pu-239 +	neutron	B-10 + alpha --> N-14 + gamma
b.	B-10 +	neutron	B-11 --> Li-7 + alpha
c.	U-235 +	neutron	Fission fragments + gamma
d.	B-10 +	gamma	B-10 + gamma

QUESTION C.14 [1.0 point]
In an event of a loss of normal electrical power, an emergency power will distribute its power to:

a. Radiation monitoring systems

b. Coolant pumps

c. Building security system

d. Reactor console

QUESTION C.15 [1.0 point]
You conducted a control drop test for the Safety control rod. Which ONE of the following is an acceptable value?

a. 1500 msec

b. 1000 msec

c. 800 msec

d. 50 msec

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

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

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]
The MUTR fuel element contains:

a. a mixture of U-**Zn**-O alloy with a maximum of 9.0 weight percent uranium which has a maximum enrichment of 20 percent

b. a mixture of U-**Zn**-H alloy with a maximum of 20 weight percent uranium which has a maximum enrichment of 9 percent

c. a mixture of U-**Zr**-O alloy with a maximum of 20 weight percent uranium which has a maximum enrichment of 9 percent

d. a mixture of U-**Zr**-H alloy with a maximum of 9.0 weight percent uranium which has a maximum enrichment of 20 percent

Section C Facility and Radiation Monitoring Systems

QUESTION C.18 [1.0 point]
Which of the following is a correct flowpath through the primary water system? After leaving the primary coolant pump the water passes through:

a. Particle filter, flow orifice, heat exchange, demineralizer column

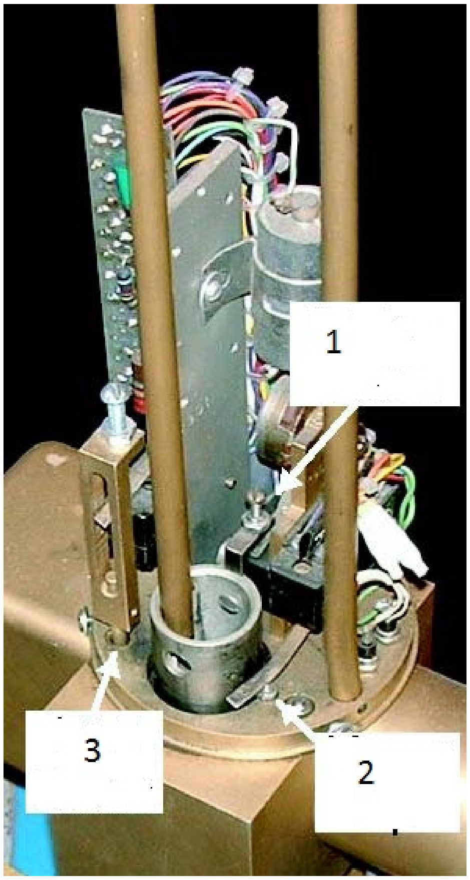
b. Flow orifice, particle filter, heat exchange, demineralizer column

c. Heat exchange, a particle filter, flow orifice, demineralizer column

d. Particle filter, heat exchange, flow orifice, demineralizer column

QUESTION C.19 [1.0 point, 0.33 each]
Use the following diagram of the control rod; match the Limit Switch (LS) components listed in Column B to the appropriate labels in Column A?

	Column A	Column B
a.	Magnet Down LS	1
b.	Magnet UP LS	2
c.	Rod Down LS	3


1
2
3

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

Section A L Theory, Thermo & Fac. Operating Characteristics

A.01
Answer: b
Reference: DOE Manual Vol. 1, pg. 57

A.02
Answer: a
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988
$\ln(P/P_0) \times \text{period} = \text{time}$, $\ln(10) \times 26 = 2.30 \times 26 = 59.9 \approx 60$ seconds = 1 min.

A.03
Answer: b
Reference: Nuclides and Isotopes
$N = A - Z$ 3-1 = 2

A.04
Answer: c
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Sec 4.2

A.05
Answer: d
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1982, Sec 3.3.3, page 3-21.
In order to solve the question A.05, the applicant can use one of the following methods:
At k=0.8; $\rho = \Delta K_{eff}/K_{eff}$ or $\rho = K_{eff}-1/K_{eff}$ = -0.2/0.8 =-0.25. At k=0.95, ρ =-0.05/0.95
ρ = -0.053. The difference between ρ is the answer ,i.e. -0.053-(-0.25)=0.197
$\Delta\rho = \rho 1 - \rho 2$ where $\rho 1 = Keff1-1/Keff1$ and $\rho 2 = Keff2-1/Keff2$. Substitute ρ1 and ρ2 with Keff1 and Keff2 into the equation above, the result is $\Delta\rho$ = keff1-keff2/(keff1 x keff2) = 0.95-0.8 /(0.8*0.95)=0.197

A.06
Answer: c
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Sec 3.3

A.07
Answer: c
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1982, Page 4-21.

A.08
Answer: d
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1982, Figure 2.6, page 2-39

A.09
Answer: b
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Sec 4.6

A.10
Answer: c
Reference: P = P0 $e^{-t/T}$ = 4 kW * e(300sec/-80sec) = 4 kW * exp(-3.75) = 0.0235 * 4 kW = 0.094 kW = 94 W

A.11
Answer: d
Reference: The power of reactor A increases by a factor of 2, while the power of reactor B increases by a factor of 1.25. Since the periods are the same (rate of change is the same), power increase B takes a shorter time.

A.12
Answer c
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, Sec 8.1

A.13
Answer a
Reference: Introduction to Nuclear Operation, Reed Burn, 1982, Sec 6.4

A.14
Answer: b
Reference: Group 1 is the longest-lived delayed neutron precursor for thermal fission in U-235, with a half-life of 55.72 sec.
Lamarsh, J. "Introduction to Nuclear Engineering" p. 88

A.15
Answer: c
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988,

A.16
Answer: a
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Sec 2.4.5

A.17
Answer: c
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1988

A.18
Answer: d
Reference: decreasing the reactivity worth in the core will decrease the core excess.

A.19
Answer: a
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, Section 8.2

A.20
Answer: d
Reference: TRIGA Fuel Design

Section B Normal/Emergency Procedures and Radiological Controls

B.01
Answer: d
Reference: EP 406, Section 3.0

B.02
Answer: a(2); b(2); c(3); d(4)
Reference: 10 CFR 20.1003 Definitions
For part c, 20 mrem/hr at 1m will be equal to 222 mrem/hr at 30 cm :=> high radiation area
550 rem/hr / (QF = 1)→ 550 rad/hr at 1 m ➔ very high radiation area
Definition
High Radiation Area: 100 mrem/hr at 30 cm
Radiation Area : 5 mrem/hr at 30 cm
Very High Radiation Area: 500 rads/hr at 1 m

B.03
Answer: a = CHECK; b = TEST; c = TEST; d = CAL
Reference: MUTR Technical specification, Definitions

B.04
Answer: a
Reference: $DR = DR_o * e^{-\mu X}$
Find μ : $125 = 500 * e^{-\mu * 30}$; μ = 0.0462
If insertion of an HVL (thickness of lead), the original intensity will be reduced by half.
Find X: $1 = 2 * e^{-0.0462 * X}$; X= 15 mm
Find HVL by shortcut:
500mR- 250 mR is the 1st HVL
250 mR – 125 mR is the 2nd HVL
So HVL=30mm/2 = 15 mm

B.05
Answer: d
Reference: TS change requires an amendment

B.06
Answer: a, 3 b,3 c,5 d,4
Reference: TS 3.1 and TS 3.5

B.07
Answer: b
Reference: TS 2.2

B.08
Answer: c
Reference: TS 4.1

B.09
Answer: c
Reference: 10 CFR 55

Section B Normal/Emergency Procedures and Radiological Controls

B.10
Answer: c
Reference: NRC standard question

B.11
Answer: d
Reference: Byproduct material is any radioactive material (except special nuclear material) made radioactive by the process of producing or using special nuclear material. 10 CFR Part 20.1003

B.12
Answer: c
Reference: $DR = DR_{\circ} * e^{-\lambda t}$
1 rem/hr =2 rem/hr* $e^{-\lambda(5hr)}$
Ln(1.0/2) = -λ*5 --> λ=0.1386; solve for t: Ln(.02/2)=-0.1386 (t) → t=33 hours

B.13
Answer: c
Reference: TS Section 6.1.3

B.14
Answer: a
Reference: Basic radiation instrumentation

B.15
Answer: b
Reference: $A = A_0 e^{-\lambda t}$, $283 = 950 e^{-\lambda(240)}$, $ln 0.29789 = \ln(e^{-\lambda(240)})$, λ = 0.00505
$t_{1/2} = \frac{0.693}{\lambda}$, $t_{1/2} = 137$ minutes

B.16
Answer: b
Reference: NRC Standard Question

B.17
Answer: b
Reference: TS 1.30

B.18
Answer: c
Reference: MUTR Procedure Index

B.19
Answer: a
Reference: MUTR SAR

B.20
Answer c
Reference: 5000 mrem/120 mr/hr= 41.7 hours will exceed the TEDE limit

Section C Facility and Radiation Monitoring Systems

C.01
Answer: c
Reference: SAR, Figure 4.9

C.02
Answer: c
Reference: SAR, Figure 4.2

C.03
Answer: d
Reference: SAR 4.1

C.04
Answer: c
Reference: NRC Standard Question

C.05
Answer: d
Reference: SAR Figure 7.7 and 7.3.3

C.06
Answer: a(1) b(3) c(4) d(4)
Reference: SAR, Chapter 7 and TS, Section 3

C.07
Answer: c
Reference: SAR 4.2.2.1

C.08
Answer: c
Reference: NRC Standard Question

C.09
Answer: d
Reference: SP 204

C.10
Answer: a(3) b(4) c(8) d(1)
Reference: SAR Figure 4.14

C.11
Answer: a
Reference: TS 4.1.2

C.12
Answer: a
Reference: SAR 5.4.2

C.13
Answer: b
Reference: NRC Standard Question

Section C Facility and Radiation Monitoring Systems

C.14
Answer: c
Reference: SAR 8.2

C.15
Answer: c
Reference: Technical Specifications 3.2 (d is within a TS but it is too short)

C.16
Answer: c
Reference: SAR 7.4.1.1.1

C.17
Answer: d
Reference: SAR 4.2.1.1

C.18
Answer: a
Reference: SAR, Figure 5.1

C.19
Answer: a(1) b(2) c(3)
Reference: SAR 4.2.2