



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

April 8, 2019

Amber Johnson, Director
Nuclear Reactor and Radiation Facilities
University of Maryland
Department of Materials Science
and Engineering
4418 Stadium Drive, Room 2303
College Park, MD 20742-2115

SUBJECT: EXAMINATION REPORT NO. 50-166/OL-19-01, UNIVERSITY OF MARYLAND

Dear Ms. Johnson:

During the week of February 18, 2019, the U.S. Nuclear Regulatory Commission (NRC) administered an operator licensing examination at your University of Maryland research 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-19-01
2. Written examination

cc: w/o enclosures: See next page

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DATED APRIL 8, 2019

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NRR-079

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NAME	JNguyen	ZTaru	AMendiola
DATE	03/19/2019	03/25/2019	04/8/2019

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University of Maryland

Docket No. 50-166

cc:

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Test, Research and Training
Reactor Newsletter
Attention: Amber Johnson
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4418 Stadium Drive
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U.S. NUCLEAR REGULATORY COMMISSION
NON-POWER REACTOR LICENSE EXAMINATION

FACILITY: University of Maryland

REACTOR TYPE: Pool

DATE ADMINISTERED: 2/19/2019

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.

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

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

ANSWER SHEET

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 ____ (0.25 each)

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 ____ (0.25 each)

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

Category B – Normal/Emergency Operating Procedures and Radiological Controls

ANSWER SHEET

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 ____

B20 a b c d ____

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

C. PLANT AND RAD MONITORING SYSTEMS

ANSWER SHEET

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 ____ (0.5 each)

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 ____

(**** 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

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

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

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

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

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

$$\ell^* = 1 \times 10^{-4} \text{ sec}$$

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

$$CR_1 (1 - K_{\text{eff}_1}) = CR_2 (1 - K_{\text{eff}_2})$$

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

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

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

$$M = \frac{1 - K_{\text{eff}_1}}{1 - K_{\text{eff}_2}}$$

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

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

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

$$\Delta \rho = \frac{K_{\text{eff}_1}^{0.693} K_{\text{eff}_2}}{K_{\text{eff}_1} \lambda_{\text{eff}_2}}$$

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

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

$$DR_1 d_1^2 = DR_2 d_2^2$$

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

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

DR – Rem, Ci – curies, E – Mev, R – feet

1 Curie = 3.7 x 10¹⁰ dis/sec

1 kg = 2.21 lb

1 Horsepower = 2.54 x 10³ BTU/hr

1 Mw = 3.41 x 10⁶ BTU/hr

1 BTU = 778 ft-lb

°F = 9/5 °C + 32

1 gal (H₂O) ≈ 8 lb

°C = 5/9 (°F - 32)

c_p = 1.0 BTU/hr/lb/°F

c_p = 1 cal/sec/gm/°C

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

QUESTION A.01 [1.0 point]

The reactor is critical and increasing in power. Power has increased from 20 mW to 80 mW in 30 seconds. How long will it take at this rate for power to increase from 0.080 W to 160 W?

- a. 0.3 minute
- b. 2.7 minutes
- c. 5.5 minutes
- d. 16.4 minutes

QUESTION A.02 [1.0 point]

Which ONE of the following conditions will require the control rod withdrawal to maintain constant power level after the following change?

- a. Adding of a fuel experiment such as U-235 into the core.
- b. Removal of an experiment containing borated graphite.
- c. Insert cadmium for an experiment into the core.
- d. Burnout of Xenon in the core.

QUESTION A.03 [1.0 point]

The reactor is critical at 10 watts. A control rod is withdrawn to insert a positive reactivity of 0.13% $\Delta k/k$. Which ONE of the following will be the stable reactor period as a result of this reactivity insertion? Given beta effective = 0.007

- a. 13 seconds
- b. 44 seconds
- c. 52 seconds
- d. 80 seconds

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

QUESTION A.04 [1.0 point]

For the ${}^0\beta_{-1}$ decay of a nuclide, the number of protons will _____ and its atomic mass number will _____.

- a. increase by 1 / be the same
- b. decrease by 1 / be the same
- c. decrease by 1 / decrease by 1
- d. increase by 1 / increase by 1

QUESTION A.05 [1.0 point]

Which ONE of the following best describes the likelihood of fission occurring in U-235 and U-238?

- a. Neutrons at low energy levels (eV) are more likely to cause fission with U-235 than neutrons at higher energy levels (MeV).
- b. Neutron cross section of U-235 increases with increasing neutron energy, whereas neutron cross section of U-238 decreases with increasing neutron energy.
- c. Neutrons at low energy levels (eV) are more likely to cause fission with U-238 than neutrons at higher energy levels (MeV).
- d. Neutron cross sections of U-235 and U-238 are independent from the neutron energy levels.

QUESTION A.06 [1.0 point, 0.25 each]

Match the term listed in Column A with its corresponding unit listed in column B.

<u>Column A</u>	<u>Column B</u>
a. 1 barn	1. cm^{-1}
b. Macroscopic Cross Section	2. 10^{-24} cm^2
c. Neutron Flux	3. Neutrons / cm^2/sec
d. Reaction Rate	4. Fissions / $\text{cm}^3 \text{ sec}$

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

QUESTION A.07 [1.0 point]

Reactor power is 100 watts. Reactor Operator inserts a sample worth of $0.008 \Delta k/k$ into the reactor core. Which ONE of the following best describes the reactor kinetic? The reactor is:

- a. subcritical
- b. critical
- c. supercritical
- d. prompt critical

QUESTION A.08 [1.0 point]

If the multiplication factor, k , is increased from 0.800 to 0.950, the amount of reactivity added is:

- a. $0.150 \Delta k/k$
- b. $0.197 \Delta k/k$
- c. $0.250 \Delta k/k$
- d. $0.297 \Delta k/k$

QUESTION A.09 [1.0 point]

Several processes occur that may increase or decrease the available number of neutrons. SELECT ONE of the following six-factor formula term that describes an INCREASE in the number of neutrons during the cycle.

- a. Reproduction Factor.
- b. Thermal Utilization Factor.
- c. Resonance Escape Probability.
- d. Thermal Non-leakage Probability.

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

QUESTION A.10 [1.0 point]

Given a source strength of 1000 neutrons per second (N/sec) and a multiplication factor of 0.8, which ONE of the following is the expected stable neutron count rate?

- a. 700 N/sec
- b. 5000 N/sec
- c. 10000 N/sec
- d. 20000 N/sec

QUESTION A.11 [1.0 point]

Reactor power is rising on a 20 second period. Approximately how long will it take for power to double?

- a. 14 seconds
- b. 29 seconds
- c. 55 seconds
- d. 72 seconds

QUESTION A.12 [1.0 point]

The following data was obtained during a reactor fuel load.

<u>Step</u>	<u>No. of Elements</u>	<u>Detector A (count/sec)</u>
1	0	200
2	4	220
3	8	300
4	12	500
5	15	800

The estimated total number of elements required to achieve criticality is between:

- a. 16 to 18
- b. 19 to 21
- c. 22 to 24
- d. 25 to 27

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

QUESTION A.13 [1.0 point]

Which one of the following is the principal source of heat in the reactor after a shutdown from extended operation at 100 KW?

- a. Production of delayed neutrons
- b. Subcritical reaction of photoneutrons
- c. Spontaneous fission of U^{238}
- d. Decay of fission fragments

QUESTION A.14 [1.0 point]

Select following isotopes from the largest to smallest microscopic absorption cross-section for thermal neutrons?

- a. Sm^{149} B^{10} Xe^{135} U^{235}
- b. B^{10} Sm^{149} Xe^{135} U^{235}
- c. Xe^{135} Sm^{149} B^{10} U^{235}
- d. Xe^{135} U^{235} Sm^{149} B^{10}

QUESTION A.15 [1.0 point]

The K_{eff} for the reactor is 0.955. The reactivity needed to bring the reactor to the criticality is:

- a. +0.0471
- b. +0.0450
- c. -0.0471
- d. -0.0450

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

QUESTION A.16 [1.0 point]

Which one of the following factors in the "six factor" formula is the most strongly affected by the Negative Temperature Coefficient?

- a. Fast fission factor (ϵ).
- b. Thermal utilization factor (f).
- c. Reproduction factor (η).
- d. Resonance escape probability (p).

QUESTION A.17 [1.0 point]

Which ONE of the following is the stable reactor period which will result in a power rise from 10% to 100% power in 10 seconds?

- a. 4 seconds
- b. 10 seconds
- c. 24 seconds
- d. 43 seconds

QUESTION A.18 [1.0 point]

A mechanism by which a nucleus can gain stability by converting a neutron to a proton or vice versa is called:

- a. gamma decay
- b. beta decay
- c. alpha decay
- d. photoelectric effect

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

QUESTION A.19 [1.0 point]

The term K_{eff} is defined as ...

- a. absorption/(production + leakage)
- b. (production + leakage)/absorption
- c. (absorption + leakage)/production
- d. production/(absorption + leakage)

QUESTION A.20 [1.0 point, 0.25 each]

A fissile material is one that will be fission upon absorption of a thermal neutron. A fertile material is one that absorbs a neutron and becomes a fissile material. Identify each of the listed isotopes as either fissile or fertile.

- a. Th-232
- b. U-235
- c. U-238
- d. Pu-239

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

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.01 [1.0 point]

Which ONE of the following changes requires NRC approval prior to being implemented?

- a. Replace a primary cooling pump with an identical pump.
- b. Change the person appointed to the MUTR Level 2 position.
- c. Deletion of a method of reactor operation listed in OP104, "Reactor Operations".
- d. Deletion of an administrative control requirement listed in the MUTR Technical Specification.

QUESTION B.02 [1.0 point]

Which ONE of the following would violate the Limiting Safety System Setting for the MUTR?

- a. Excess reactivity exceeds \$1.20
- b. Steady State reactor power exceeds 300kW
- c. Instrumented fuel temperature exceeds 175 °C
- d. An unanticipated change in reactivity exceeds one dollar

QUESTION B.03 [1.0 point]

During an emergency, who is responsible for assessing the radiological conditions OUTSIDE of the reactor building?

- a. Emergency Director
- b. Radiation Safety Office
- c. Emergency Coordinator
- d. Reactor Support Coordinator

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.04 [1.0 point]

Which of the following statements best states the MINIMUM staffing requirements for an initial startup of the reactor?

- a. 1 RO at the controls and 1 SRO in the control room
- b. 1 RO license in the control room and another RO license at the facility.
- c. 1 RO in the control room, 1 SRO present at facility, and a second designated person capable of performing a reactor shutdown
- d. 1 RO in the control room, 1 SRO immediately available on call, and a second designated person within 1000 feet of the facility.

QUESTION B.05 [1.0 point]

Which ONE of the following is an example of a record to be retained for the lifetime of the reactor facility?

- a. Reactor log book
- b. Drawings of the reactor facility
- c. Experiments performed with the reactor
- d. Records of meeting and audit reports of the RSC

QUESTION B.06 [1.0 point]

For steady state operations greater than one half hour, which ONE of the following indications is NOT required to be recorded in the Control Room Log Book?

- a. Fuel temperature
- b. Mode of operation
- c. Control rod positions
- d. Pool water temperature

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.07 [1.0 point]

Temporary changes to procedures that do not change their intent may be made by the responsible _____ or higher individual present. Such temporary changes shall be documented and reported to the _____ or designated alternate.

- a. SRO / Director
- b. RO / SRO on duty
- c. RO / Reactor Safety Committee
- d. SRO / Reactor Safety Committee

QUESTION B.08 [1.0 point]

Which ONE of the following radioactive GASES might be an indication of a fuel element leak?

- a. Xe^{135}
- b. Cs^{137}
- c. N^{16}
- d. Ar^{41}

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 ten (10) feet. What percentage of the source consists of beta radiation?

- a. 30%
- b. 50%
- c. 70%
- d. 90%

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.10 [1.0 point]

You are conducting the facility walk-through portion of your NRC licensing exam and enter a Radiation Area with a reading of 10 mrem/hr. How long can the NRC examiner stay before their 10 CFR 20 total ANNUAL effective dose limit is exceeded?

- a. 10 hours
- b. 5 hours
- c. 2 hours
- d. 1 hour

QUESTION B.11 [1.0 point]

Which of the following best describes the CORE CONFIGURATION in accordance with the MUTR Technical Specification?

- a. Uranium-zirconium hydride fuel-moderator bundles positioned in the reactor grid plate.
- b. The number, type, or arrangement of fuel assemblies (elements), reflector elements, reflector element configuration, and regulating/control rods occupying the core grid.
- c. The combination of 24 fuel bundles, with a total of 93 fuel elements, arranged in a rectangular array with one bundle displaced for the pneumatic experimental system; three control rods; and two graphite reflectors.
- d. The combination of 13 standard fuel assemblies, consisting of 14 fuel plates containing a maximum of 180 grams of U-235, and three control rods.

QUESTION B.12 [1.0 point]

“Deep Dose Equivalent” as defined in 10 CFR 20 is:

- a. The concentration of a radio-nuclide in air which, if inhaled by an adult worker for a year, results in a total effective dose equivalent of 100 mrem.
- b. The portion of the dose equivalent received from radiative material taken into the body.
- c. The portion of the dose equivalent received from radiation sources outside the body.
- d. The dose equivalent at a tissue depth of 1 cm.

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.13 [1.0 point]

A radiation survey of an area used to store Cobalt-60 sources indicates a radiation reading of 1 mrem at 1 meter. How should this area be posted in accordance with the requirements of 10 CFR 20?

- a. Restricted area
- b. Caution, radiation area
- c. Caution, high radiation area
- d. No posting required

QUESTION B.14 [1.0 point]

Which of the following is NOT considered an unscheduled shutdown?

- a. Loss of power to building resulting in loss of the high voltage supply to the reactor console and caused all the safety rods to scram.
- b. During the annual surveillance check, a reactor power level channel input signal of 320kW caused all the safety rods to scram.
- c. The operator was not watching reactor period when it reached 4 seconds and caused all of the safety rods to scram.
- d. The operator inadvertently leaned on the scram bar and caused all of the safety rods to scram.

QUESTION B.15 [1.0 point]

Per the MUTR emergency classifications, the occurrence of a personnel exposure in excess of 10 CFR 20 limits would be classified as which ONE of the following?

- a. Safety Event – (non-reactor related)
- b. Personnel Emergency
- c. Notification of Unusual Event
- d. Alert

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.16 [1.0 point]

A two-curie source, emitted 80% of 100 Kev gamma, is to be stored in the reactor building. How far from the source will it read 100 mrem/hr?

- a. 3 feet
- b. 10 feet
- c. 13 feet
- d. 100 feet

QUESTION B.17 [1.0 point]

A function of the Log Power Level Channel is to:

- a. Provide a neutron detector input signal to the startup rate channel.
- b. Limit the maximum positive reactivity insertion rate available for steady state operations.
- c. Assure sufficient amount of startup neutrons are available to achieve controlled approach to criticality.
- d. Limit the rate of change of power to ensure that the normally available reactivity and insertion rate does not exceed the safety limit.

QUESTION B.18 [1.0 point]

Which ONE of the following best describes the reactor in a secured state?

- a. The reactor is shut down which means subcritical by at least \$1.00.
- b. The core has been unloaded such that there is not enough fuel in the reactor to attain criticality in the optimum available conditions of moderator and reflection.
- c. The console key switch in the "OFF" position and the key is removed from the console and under the control of a licensed operator or stored in a locked storage area.
- d. No work is in progress involving core fuel, core structures, control rods, or control rod drives unless they are physically decoupled from the control rods.

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.19 [1.0 point]

You are currently the licensed operator at MUTR. Which ONE of the following will violate 10 CFR Part 55.53 "Conditions of licenses"?

- a. Last requalification operating test was 14 months ago.
- b. Last requalification written examination was 20 months ago.
- c. Last quarter you were the licensed operator for 8 hours.
- d. Last licensed renewal was 48 months ago.

QUESTION B.20 [1.0 point]

In accordance with SP202, "Power Calibration," when calculating the thermal output of the reactor core, the net heat up rate must be corrected for the rate of heat loss to which ONE of the following?

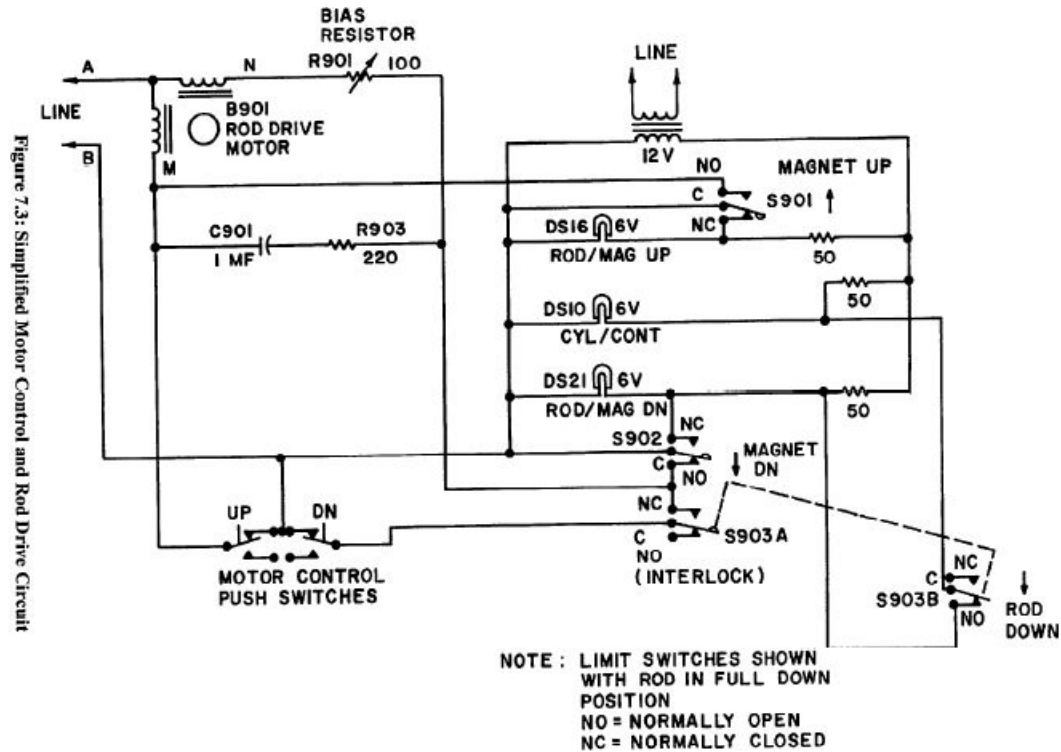
- a. Convective cooling by air.
- b. Conduction through the fuel element cladding.
- c. Forced convection via the primary coolant pump.
- d. Evaporation and conduction through the pool tank and concrete shield.

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

Category C: Facility and Radiation Monitoring Systems

QUESTION C.01 [1.0 point]

Figure 7.4 depicts the motor control rod/drive circuit. The MAIN reason in which the 220 Ω resistor installed in the circuit is to:



- Prevent manual withdrawal of more than one control rods simultaneously.
- Prevent a short circuit when UP and DOWN buttons are pressed simultaneously.
- Initialize current to the motor coil M so the motor can smoothly rotate when UP or DOWN button is depressed.
- Prevent damage to the switches by limiting the discharge current from the capacity C901 to the switches.

Category C: Facility and Radiation Monitoring Systems

QUESTION C.02 [1.0 point]

Per procedure SP206, if the OUTLET conductivity of the ion exchanger is 0.2 $\mu\text{mhos/cm}$ and the INLET conductivity is 0.1 $\mu\text{mhos/cm}$, you should:

- a. notify the Reactor Director and isolate the ion exchanger from the Primary Coolant System.
- a. continue the reactor operation. The result shows the ion exchanger is operable.
- c. stop the reactor operation and immediately report the result to the Reactor Director since it exceeds the administrative limits.
- d. stop the reactor operation and immediately report the result to the U.S. NRC since it is a TS violation.

QUESTION C.03 [1.0 point]

If a presence of ____ is found in the secondary side of the heat exchanger, a possible fuel leak occurs from the primary system to the secondary system.

- a. I-133
- b. Neutrons
- c. Ar-41
- d. N-16

QUESTION C.04 [1.0 point]

When radiation level located near the exhaust vent on the East wall exceeds the second alarm setpoint, which ONE of the following statements is correct?

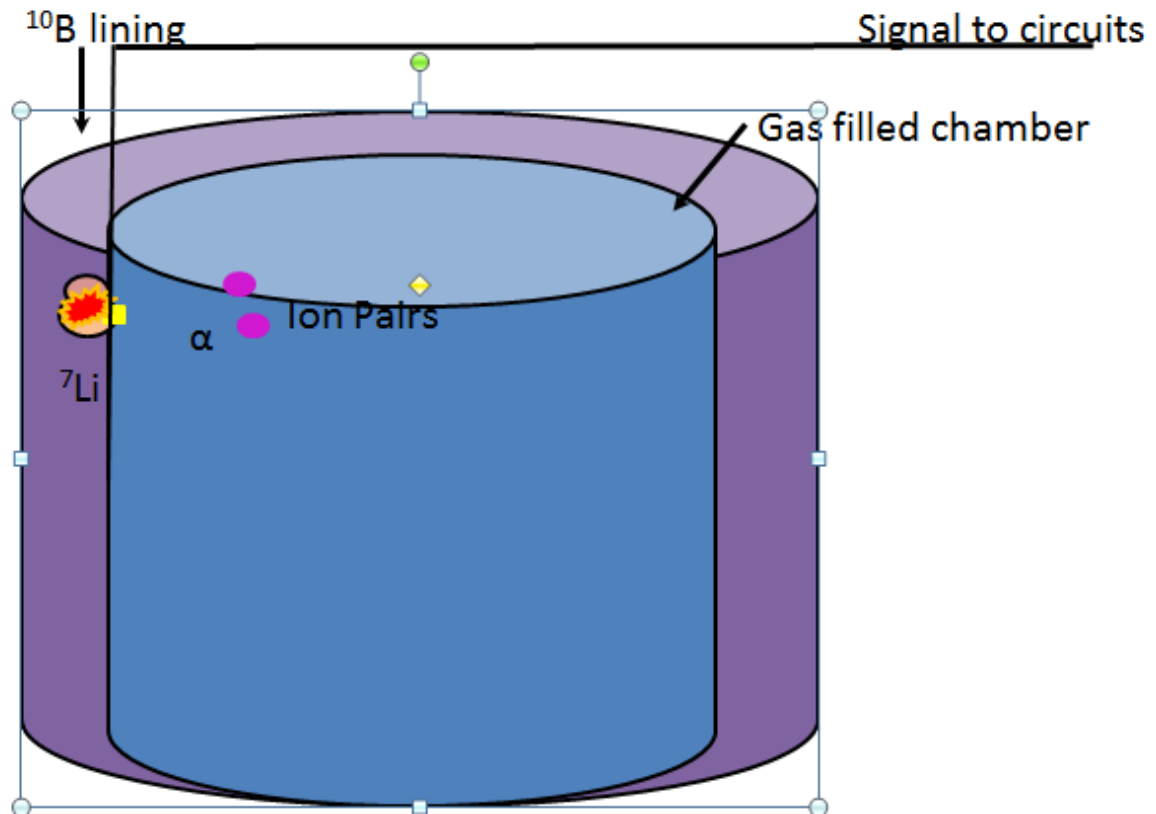
- a. An amber light will appear on the meter. An audible alarm will sound at the meter and the reactor console.
- b. A red light will appear on the meter. An audible alarm will sound at the meter and the reactor console.
- c. A red light will appear on the meter. An audible alarm will sound at the meter and the reactor console. A reactor will automatically scram.
- d. A red light will appear on the meter. An audible alarm will sound at the meter and the reactor console. Reactor will automatically scram and external ventilation system will be in the emergency mode.

Category C: Facility and Radiation Monitoring Systems

QUESTION C.05 [1.0 point]

The Figure below depicts:

- a. The Compensated Ion Chamber.
- b. The Uncompensated Ion Chamber.
- c. The Scintillation Chamber.
- d. The Fission Chamber.



QUESTION C.06 [1.0 point]

In the event of a loss of power at the MUTR, which of the following will be provided power from a battery backup source?

- a. Emergency lights
- b. Reactor console lights
- c. Reactor coolant pumps
- d. Radiation monitoring system

Category C: Facility and Radiation Monitoring Systems

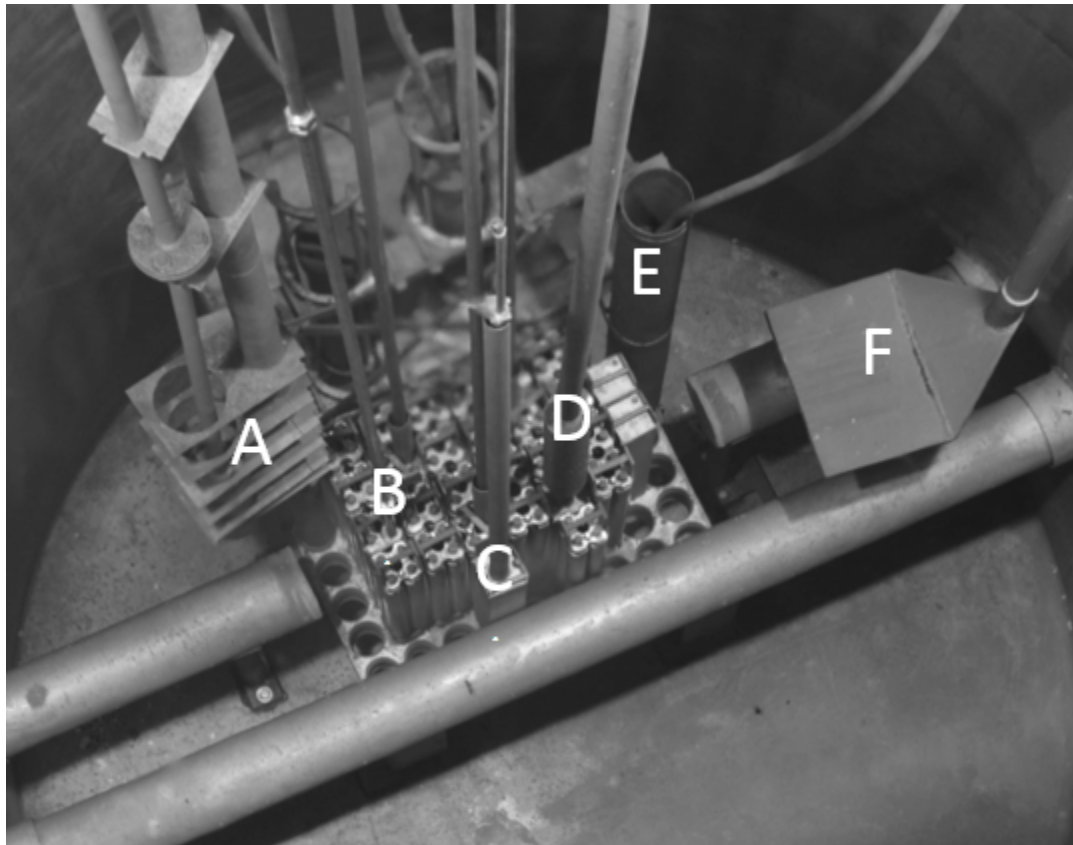
QUESTION C.07 [1.0 point]

Which ONE of the following systems is designed for preventing the withdrawal of two or more control rods in steady state mode?

- a. Rod drive control interlock
- b. Startup count rate interlock
- c. Log power level interlock
- d. Safety 1 trip test interlock

QUESTION C.08 [1.0 point]

Which ONE of following labels indicates the instrumented fuel element?



- a. A
- b. B
- c. C
- d. D

Category C: Facility and Radiation Monitoring Systems

QUESTION C.09 [2.0 points, 0.5 each]

Match the item provided in column A, with the correct Nuclear Instrumentation Channel from column B. (Items in column B can be used once for each item in column A)

<u>Column A</u>	<u>Column B</u>
a. < 1 cps rod withdrawal inhibit	1. Reactor Power Channel
b. Used for an automatic control	2. Log Power Level Channel
c. Scram at 120% of full power	3. Wide Range Linear Channel
d. Scram at 175 degree C	4. Fuel Element Temperature

QUESTION C.10 [1.0 point]

During reactor operation, the manual scram bar is accidentally pressed. Which ONE of the following is a correct reason why you cannot withdraw the control rods? The control rods cannot be withdrawn because:

- a. the rod down limit switches activated.
- b. the Log Power Level interlock activated.
- c. the Magnet Up limit switches activated.
- d. the scram relays K19, K20, and K24 haven't been reset.

QUESTION C.11 [1.0 point]

Per MUTR Technical Specifications, which ONE of the following statement is considered the Design Feature?

- a. The reactor core shall be cooled by natural convective water flow.
- b. Control rod drop times shall be measured annually; intervals not to exceed 15 months.
- c. The excess reactivity relative to the cold critical conditions, with or without experiments in place shall not be greater than \$3.50.
- d. The temperature in a standard TRIGA fuel element shall not exceed 1000 °C under any conditions of operation, with the fuel fully immersed in water.

Category C: Facility and Radiation Monitoring Systems

QUESTION C.12 [1.0 point]

Reactor power is at 100 W. A reactor staff accidentally opens the Through Tube plug. His action will cause:

- a. normal operation, no indication.
- b. a reactor run down.
- c. a reactor interlock.
- d. a reactor scram.

QUESTION C.13 [1.0 point]

Which ONE of the following is NOT true regarding the configuration of MUTR TRIGA-LEU fuel elements?

- a. Uranium content: Maximum of 9.0 weight % uranium enriched to less than 20% Uranium-235.
- b. Hydrogen-to-zirconium atom ratio (in the ZrH_x): nominal 1.0 H atom to 1.6 Zr atoms.
- c. The overall length of a fuel element shall be 30 inches, and the fuel length shall be 15 inches.
- d. Cladding: 304 stainless steel.

QUESTION C.14 [1.0 point]

An experiment with less than 25 mg TNT shall be:

- a. double encapsulated.
- b. limited to the reactivity worth of \$0.60.
- c. calculated a boiling point above 130 degree F.
- d. calculated to be less than the failure pressure of the container.

Category C: Facility and Radiation Monitoring Systems

QUESTION C.15 [1.0 point]

Which ONE of the following is the Main purpose of the thermal column design?

- a. Provide delay neutrons for activation studies.
- b. Provide a thermal neutron flux for activation studies.
- c. Prevent a radiation from the core to the reactor concrete.
- d. Shield a radiation from reactor core to the experiment area.

QUESTION C.16 [1.0 point]

Which ONE of the following is the correct parameter used for constructing the integral worth curve by the procedure SP 204?

- a. Count rate vs. $1/M$
- b. Reactivity vs. Period
- c. Rod height vs. Reactivity
- d. Rod height vs. Reactor power level

QUESTION C.17 [1.0 point]

Which of the following is a correct flow path through the primary water system? After leaving the primary coolant pump the water passes through:

- a. Heat exchange, flow orifice, demineralizer column, particle filter
- b. Particle filter, flow orifice, heat exchange, demineralizer column
- c. Heat exchange, a particle filter, flow orifice, demineralizer column
- d. Demineralizer column, particle filter, heat exchange, flow orifice

Category C: Facility and Radiation Monitoring Systems

QUESTION C.18 [1.0 point]

If any significant buildup of radioactivity from the reactor pool, the conductivity of the pool water will be:

- a. increase.
- b. decrease.
- c. the same.
- d. no relationship between radioactivity and conductivity in the pool water.

QUESTION C.19 [1.0 point]

The MAIN purpose of the primary diffuser pump is to reduce radiation levels coming from:

- a. O-16 decay with beta radiation
- b. N-16 decay with gamma radiation.
- c. Ar-41 decay with gamma radiation.
- d. Fuel elements with gamma radiation.

(**** END OF CATEGORY C ****)
((**** END OF EXAM ****))

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

A.01

Answer: b
Reference: $P = P_0 e^{t/T}$ $80 = 20e^{30 \text{ sec}/T}$ $T = 21.64 \text{ sec}$ $160 \text{ watts} = 0.080e^{t/21.64}$
 $t = 164 \text{ sec} = 2.7 \text{ minutes}$

A.02

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

A.03

Answer: b
Reference: Reactivity added = 0.13 % $\Delta k/k = 0.0013 \Delta k/k$
 $\tau = (\beta - \rho) / \lambda_{\text{eff}} \rho = \frac{0.007 - 0.0013}{(0.1)(0.0013)} = 43.8 \text{ seconds}$

A.04

Answer: a
Reference: Chart of the Nuclides

A.05

Answer: a
Reference: Burn, R., *Introduction to Nuclear Reactor Operations*, © 1988, Section 3.2

A.06

Answer: a(2) b(1) c(3) d(4) (0.25 each)
Reference: Burn, R., *Introduction to Nuclear Reactor Operations*, © 1988, Sec 2.6

A.07

Answer: d
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Sec 4.2
When the insertion of $0.008 \Delta k/k > K_{\text{eff}}$, reactor is prompt critical.

A.08

Answer: b
Reference: Burn, R., *Introduction to Nuclear Reactor Operations*, © 1982, Sec 3.3.3, page 3-21.
 $\Delta \rho = \text{keff1} - \text{keff2} / (\text{keff1} \times \text{keff2}) = 0.95 - 0.8 / (0.8 \times 0.95) = 0.197 \Delta k/k$

A.09

Answer: a
Reference: Burn, R., *Introduction to Nuclear Reactor Operations*, ©3.3, 1988

A.10

Answer: b
Reference: $CR = S / (1 - K) \rightarrow CR = 1000 / (1 - 0.8) = 5000 \text{ N/sec}$

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

A.11

Answer: a
Reference: $P = P_0 e^{t/T} \rightarrow \ln(2) = \text{time} \div 20 \text{ seconds} \rightarrow \text{time} = \ln(2) \times 20 \text{ sec.}$
 $\approx 13.8 \text{ sec.}$

A.12

Answer: b
Reference: Burn, R., *Introduction to Nuclear Reactor Operations*, © 1982, Sec 5.5, page 5-18-5-25.

A.13

Answer: d
Reference: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory Volume 1, Module 1, Enabling Objective 4.9, p. 61.

A.14

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

A.15

Answer: a
Reference: $\Delta\rho = (K_{\text{eff}1} - K_{\text{eff}2}) \div (K_{\text{eff}1} * K_{\text{eff}2})$
 $\Delta\rho = (1.0000 - 0.9550) \div (0.9550 * 1.0000)$
 $\Delta\rho = 0.0450 \div 0.9550 = 0.0471$

A.16

Answer: d
Reference: Burn, R., *Introduction to Nuclear Reactor Operations*, © 1988, § 3.4

A.17

Answer: a
Reference: $P = P_0 e^{t/T} \rightarrow T = t / \ln(P / P_0)$
 $T = 10 / \ln(100/10)$; $T = 4.34 \text{ sec.}$

A.18

Answer: b
Reference: NRC Standard Question

A.19

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

A.20

Answer: a. = fertile; b. = fissile; c. = fertile; d. = fissile (0.25 each)
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Sec 3.2

Category B: Normal/Emergency Operating Procedures and Radiological Controls

B.01

Answer: d
Reference: 10CFR50.59, TS change requires an amendment

B.02

Answer: c
Reference: TS 2.2

B.03

Answer: b
Reference: Emergency Procedure 406

B.04

Answer: a
Reference: TS 6.1.3

B.05

Answer: b
Reference: TS 6.8.3

B.06

Answer: b
Reference: OP 104, 3.9

B.07

Answer: a
Reference: TS 6.4

B.08

Answer: a
Reference: TS 3.1
Cs is not gaseous.

B.09

Answer: d
Reference: 10CFR20 - At 10 feet, there is no beta radiation.
Calculate gamma at 1 ft.
 $DR_1 * (D_1)^2 = DR_2 * (D_2)^2$
 $0.1 * (10)^2 = DR_2 * (1)^2$
gamma at 1 foot = 10 mrem/hour.
Therefore, beta at 1 foot = 90 mrem/hour or 90%.

B.10

Answer: a
Reference: 10CFR21.1301, Dose = DR x Time
 $Time = \frac{100mrem}{10mrem/hr}$
Time = 10 hrs

Category B: Normal/Emergency Operating Procedures and Radiological Controls

B.11

Answer: c
Reference: TS 1.3

B.12

Answer: d
Reference: 10CFR20.1003, Definitions

B.13

Answer: b
Reference: 10CFR20.1902, posting requirements

B.14

Answer: b
Reference: TS 1.3

B.15

Answer: b
Reference: MUTR Emergency Preparedness Plan, 4.0

B.16

Answer: a
Reference: $6\text{CEN} = \text{R/hr @ } 1 \text{ ft.} \rightarrow 6 \times 2 \times 0.8 \times 0.1 = 0.96 \text{ R/hr at } 1\text{ft.}$
 $I_0 D_0^2 = I * D^2$
 $0.96 \text{ R/hr} * (1 \text{ ft})^2 = 0.1 \text{ R/hr} * D^2$
 $D = \text{sqrt}(0.96/0.1) = 3 \text{ ft.}$

B.17

Answer: a
Reference: TS 3.2

B.18

Answer: b
Reference: TS 1.3

Category B: Normal/Emergency Operating Procedures and Radiological Controls

B.19

Answer: a

Reference: 10 CFR Part 55.53

- 55.53(i) – the licensee shall have a biennial medical examination.
 - 55.53(h), 55.59(c) – annual operating tests
 - 55.53(e) – the licensee shall actively perform the functions of a licensed operator for a minimum of 4 hours per calendar quarter.
 - 55.53(h), 55.59(c)(1) – "The requalification program must be conducted for a continuous period not to exceed 2 years"
- License renewal: 6 years

B.20

Answer: d

Reference: SP202, 2.0

Category C: Facility and Radiation Monitoring Systems

C.01

Answer: d
Reference: SAR 7.3.1

C.02

Answer: a
Reference: SP206

C.03

Answer: a
Reference: SAR, Table 13.2

C.04

Answer: c
Reference: SAR 7.7

C.05

Answer: b
Reference: MUTR Presentation: Getting Mixed Signals: Signal and Detectors

C.06

Answer: a
Reference: SAR 8.2

C.07

Answer: a
Reference: TS 3.3, Table 3-1a

C.08

Answer: b
Reference: RTC Lab Book

C.09

Answer: a,2 b,3 c,1 d,4 (0.5 each)
Reference: SAR 7.4.1 and TS 3.2

C.10

Answer: d
Reference: SAR 7.4.2.4

C.11

Answer: a
Reference: TS 5.2

C.12

Answer: c
Reference: TS 3.2, Table 3.2

Category C: Facility and Radiation Monitoring Systems

C.13

Answer: b
Reference: TS 5.3.1

C.14

Answer: d
Reference: TS 3.6

C.15

Answer: b
Reference: SAR 10.2.1

C.16

Answer: c
Reference: SP 204

C.17

Answer: b
Reference: SAR, Figure 5.1

C.18

Answer: a
Reference: NRC Standard Question

C.19

Answer: b
Reference: SAR 5.6