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

December 12, 2019

Mrs. 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-20-01, UNIVERSITY OF MARYLAND

Dear Mrs. Johnson:

During the week of October 28, 2019, the U.S. Nuclear Regulatory Commission (NRC) administered an operator licensing examination at your University of Maryland nuclear 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 Ms. Michele DeSouza at (301) 415-0747 or via internet e-mail Michele.DeSouza@nrc.gov.

Sincerely,

Anthony J. Mendiola, Chief
Non-Power Production and Utilization Facility
Oversight Branch
Division of Advanced Reactors and Non-Power
Production and Utilization Facilities
Office of Nuclear Reactor Regulation

Docket No. 50-166

Enclosures:
1. Examination Report No. 50-166/OL-20-01
2. Written Examination

cc: w/o enclosures: See next page

cc:

Director, Maryland Department
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Dr. Ji-Cheng Zhao, Chair
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Test, Research and Training
Reactor Newsletter
Attention: Ms. Amber Johnson
Dept of Materials Science and Engineering
University of Maryland
4418 Stadium Drive
College Park, MD 20742-2115

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

REPORT NO.: 50-166/OL-20-01

FACILITY DOCKET NO.: 50-166

FACILITY LICENSE NO.: R-70

FACILITY: MUTR

EXAMINATION DATES: October 28-30, 2019

SUBMITTED BY: Michele DeSouza 11/18/2019
Michele DeSouza, Chief Examiner Date

SUMMARY:
During the week of October 28, 2019, the NRC administered an operator licensing examination to three Reactor Operator (RO) candidates. The candidates passed all applicable portions of the examinations.

REPORT DETAILS

1. Examiner: Michele DeSouza, Chief Examiner, NRC

2. Results:

	RO PASS/FAIL	SRO PASS/FAIL	TOTAL PASS/FAIL
Written	3/0	0/0	3/0
Operating Tests	3/0	0/0	3/0
Overall	3/0	0/0	3/0

3. Exit Meeting:
Michele C. DeSouza, Chief Examiner, NRC
Amber Johnson, Reactor Director, MUTR
Luke Gilde, Reactor Supervisor, MUTR

Per discussion with the facility, prior to administration of the examination, adjustments were accepted. Upon completion of the examination, the NRC Examiner met with facility staff representatives to discuss the results. At the conclusion of the meeting, the NRC examiner thanked the facility for their support in the administration of the examination.

ENCLOSURE 1

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

FACILITY: MUTR

REACTOR TYPE: TRIGA

DATE ADMINISTERED: 10/30/2019

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.

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

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 ___ (0.25 each)

A05 a b c d ___

A06 a b c d ___

A07 a b c d ___

A08 a b c d ___

A09 a b c d ___

A10 a b c d ___

A11 a b c d ___

A12 a b c d ___

A13 a b c d ___

A14 a b c d ___

A15 a b c d ___

A16 a b c d ___

A17 a b c d ___

A18 a b c d ___

A19 a b c d ___

A20 a b c d ___

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

Category B – Normal/Emergency Operating Procedures and Radiological Controls

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 ___ (0.25 each)

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

Category C – Facility and Radiation 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 _____ (0.50 each)

C02 a b c d ___

C03 a b c d ___

C04 a b c d ___

C05 a b c d ___

C06 a b c d ___

C07 a b c d ___

C08 a b c d ___

C09 a b c d ___

C10 a b c d ___

C11 a b c d ___

C12 a b c d ___

C13 a b c d ___

C14 a b c d ___

C15 a b c d ___

C16 a b c d ___

C17 a b c d ___

C18 a ___ b ___ c ___ d ___ (0.50 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 limited and only one candidate at a time may leave. You must avoid all contacts with anyone outside the examination room to avoid even the appearance or possibility of cheating.

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

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

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

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

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

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

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

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

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

EQUATION SHEET

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

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

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

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

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

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

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

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

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

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

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

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

$$M = \frac{1 - K_{eff_1}}{1 - K_{eff_2}}$$

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

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

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

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

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

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

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

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

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

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

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

1 Curie = 3.7 x 10^{10} dis/sec

1 Horsepower = 2.54 x 10^3 BTU/hr

1 BTU = 778 ft-lb

1 gal (H_2O) ≈ 8 lb

c_P = 1.0 BTU/hr/lb/°F

1 kg = 2.21 lb

1 Mw = 3.41 x 10^6 BTU/hr

°F = 9/5 °C + 32

°C = 5/9 (°F - 32)

c_p = 1 cal/sec/gm/°C

U.S.NRC

UNITED STATES NUCLEAR REGULATORY COMMISSION

Protecting People and the Environment

University of Maryland

Operator Licensing Examination

Week of October 28, 2019

Question A.01 [1.0 point]
Which ONE of the following statements best defines the reactor excess reactivity?

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.02 [1.0 point]
A reactor is slightly supercritical with the following values for each of the factors in the six-factor formula:

Fast Fission Factor = 1.03
Resonance Escape Probability = 0.96
Thermal Utilization Factor = 0.70
Fast non-leakage probability = 0.84
Thermal non-leakage probability = 0.88
Reproduction Factor = 1.96

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. 0.708

Question A.03 [1.0 point]
What is reactivity needed to bring the reactor to critical if the k_{eff} for the reactor is 0.955?

a. +0.0478

b. -0.0459

c. +0.0471

d. -0.0456

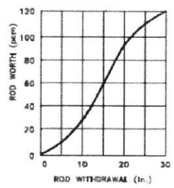
Category A: Theory, Thermodynamics & Facility Operating Characteristics

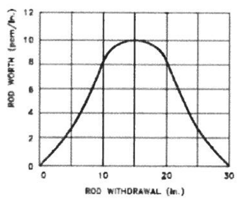
Question A.04 [1.0 point, 0.25 points each]
Identify if the descriptions or graphs in Column A describe or depict integral control rod worth or differential rod worth?

Column A

a. total reactivity worth of the control rod at that height

b. reactivity change per unit movement of a control rod

c. 

d. 

Column B

1. Differential Rod Worth

2. Integral Rod Worth

Question A.05 [1.0 point]
What is the principal source of heat in the reactor after a shutdown from an extended operation at 100 kW?

a. Production of delayed neutrons

b. Subcritical reaction of photoneutrons

c. Decay of fission fragments

d. Spontaneous fission of U^{238}

Question A.06 [1.0 point]
The reactor is critical at 100 watts. A control rod is withdrawn to insert a positive reactivity of 0.126% $\Delta k/k$. Which ONE of the following will be the stable reactor period as a result of the reactivity insertion? Given Beta effective = 0.0078

a. 13 seconds

b. 46 seconds

c. 52 seconds

d. 80 seconds

Question A.07 [1.0 point]
Which ONE of the following conditions will DECREASE the Core Excess of a reactor?

a. Fuel depletion

b. Burnout of a burnable poison

c. Insertion of a positive reactivity worth experiment

d. Lowering moderator temperature (assume a negative temperature coefficient)

Question A.08 [1.0 point]
Which ONE of the following isotopes has the **LEAST** thermal neutron cross section?

a. Cadmium-112

b. Samarium-149

c. Xenon-135

d. Uranium-235

Question A.09 [1.0 point]

FAST FISSION FACTOR is defined as a ratio of which ONE of the following?

a. The number of neutrons that reach thermal energy over the number of fast neutrons that start to slow down.

b. The number of fast neutrons produced from fission in a generation over the number of fast neutrons produced from fission in the previous generation.

c. The number of fast neutrons produced from U-238 over the number of thermal neutrons produced from U-235.

d. The number of fast neutrons produced from all fission over the number of fast neutrons produced from thermal fission.

Category A: Theory, Thermodynamics & Facility Operating Characteristics

Question A.10 [1.0 point]
Reactor power is rising on a 10 second period. Approximately how long will it take for power to quadruple?

a. 14 seconds

b. 29 seconds

c. 55 seconds

d. 72 seconds

Question A.11 [1.0 point]
Which ONE of the following describes the difference between differential rod worth (DRW) and integral rod worth (IRW)?

a. DRW relates the time rate of reactivity change to rod position. IRW relates the total reactivity in the core to the time rate of reactivity change

b. IRW relates the worth of the rod per increment of movement to rod position. DRW relates the total reactivity added by the rod to the rod position

c. IRW is the slope of the DRW at a given position

d. DRW relates the worth of the rod per increment of movement to rod position. IRW relates the total reactivity added by the rod to the rod position

Question A.12 [1.0 point]
The following shows part of a decay chain for the radioactive element Pa-234:
$_{91}Pa^{234} \rightarrow {}_{92}U^{234}$?

a. Alpha

b. Beta

c. Gamma

d. Neutron

Question A.13 [1.0 point]
Which ONE of the following describes the NEGATIVE moderator temperature coefficient?

a. When moderator temperature decreases, negative reactivity is added

b. When the moderator temperature increases, negative reactivity is added

c. When moderator temperature increases, positive reactivity is added

d. When moderator temperature increases, no change in reactivity occurs

Question A.14 [1.0 point]
In a subcritical reactor, K_{eff} is increased from 0.885 to 0.943. Which one of the following is the amount of reactivity that was added to the core?

a. 4.68 %Δk/k

b. 5.58 %Δk/k

c. 6.94 %Δk/k

d. 7.45 %Δk/k

Question A.15 [1.0 point]
Which ONE of the following is the MAIN reason for operating the reactor with thermal neutrons instead of fast neutrons?

a. The atomic weight of thermal neutrons is larger than fast neutrons, so thermal neutrons are easier 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. The fission cross section of the fuel is much higher for thermal energy neutrons than fast neutrons

d. Fast neutrons give off higher radiation than thermal neutrons and the reactor needs to reduce the radiation limit by using thermal neutrons

Question A.16 [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.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 proton or vice versa is called:

a. Gamma decay

b. Beta decay

c. Alpha decay

d. Photoelectric effect

Question A.19 [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.20 [1.0 point]
Which ONE of the reactions below describes a method of production and removal of Xenon?

a. ${}_{52}Te^{134} \rightarrow \gamma + {}_{53}I^{134} \rightarrow p + {}_{54}Xe^{135} \rightarrow \beta^- + {}_{55}Cs^{135} \rightarrow \beta^- + {}_{56}Ba^{135}$

b. ${}_{52}Te^{135} \rightarrow \gamma + {}_{53}I^{135} \rightarrow \beta^- + {}_{54}Xe^{135} \rightarrow {}_{0}n^1 + {}_{54}Xe^{136} \rightarrow \beta^- + {}_{56}Ba^{135}$

c. ${}_{52}Te^{135} \rightarrow \beta^- + {}_{53}I^{135} \rightarrow \beta^- + {}_{54}Xe^{135} \rightarrow \beta^- + {}_{55}Cs^{135} \rightarrow \beta^- + {}_{56}Ba^{135}$

d. ${}_{52}Te^{134} \rightarrow \beta^- + {}_{53}I^{135} \rightarrow \beta^- + {}_{54}Xe^{135} \rightarrow \gamma + {}_{55}Cs^{135} \rightarrow \beta^+ + {}_{56}Ba^{135}$

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

Category B: Normal/Emergency Procedures and Radiological Controls

Question B.01 [1.0 point]
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? (In accordance with SP202, Power Calibration)

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

Question B.02 [1.0 point]
How long will it take a 1 Curie source, with a half-life of 1 year, to decay to 0.01 Curie?

a. 4.6 years

b. 6.6 years

c. 10.6 years

d. 16.6 years

Question B.03 [1.0 point]
A Reactor Operator (RO) works in a High Radiation Area (HRA), with a dose rate of 100 mR/hr, for eight hours a day. Which ONE of the following is the MAXIMUM number of days in which the RO may perform his duties WITHOUT exceeding 10CFR20 limits?

a. 5 days

b. 6 days

c. 7 days

d. 12 days

Question B.04 [1.0 point]
An irradiated sample provides a dose rate of 0.5 rem/hr at 2 feet. Approximately how far from the sample reads 5 mrem/hr?

a. 6 feet

b. 9 feet

c. 14 feet

d. 20 feet

Question B.05 [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.06 [1.0 point]
In accordance with MUTR procedures and Technical Specifications, which ONE of the following is NOT considered an UNSCHEDULED SHUTDOWN?

a. Operator was not watching reactor period when it reached 4 seconds 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 inadvertently leaned on the scram bar with their elbow and caused all the safety rods to scram

d. Loss of power to the building removed the high voltage to the reactor console and caused all the safety rods to scram

Question B.07 [1.0 point]
Assuming there is no leak from outside of the demineralizer tank, you use a survey instrument to measure the dose rate from it. Compare the reading of the window probe with the window CLOSED and the reading with the window OPEN will:

a. increase, because it can receive an additional alpha radiation from [(Al-27)(n,α)→(Na-24)] reaction

b. remain the same, because the Quality Factors for Gamma and Beta radiation are the same

c. increase, because the Quality Factors for Beta and Alpha is greater than for Gamma

d. remain the same, because the survey instrument would not be detecting Beta and Alpha radiation from the demineralizer tank

Question B.08 [1.0 point]
According to the MUTR Emergency Plan, which ONE of the following individuals can authorize emergency exposures in excess of normal occupational limits during rescue and recovery activities?

a. MUTR Police Chief

b. MUTR Public Relations Coordinator

c. MUTR Radiation Protection Officer

d. MUTR Emergency Director

Question B.09 [1.0 point]
Which ONE of the following statements correctly describes the relationship between the Safety Limit (SL) and the Limiting Safety System Setting (LSSS)?

a. The SL is a maximum operationally limiting value that prevents exceeding the LSSS during normal operations.

b. The SL is a parameter that assures the integrity of the fuel cladding. The LSSS initiates protective actions to preclude reaching the SL.

c. The SL is a maximum setpoint for instrumentation response. The LSSS is the minimum number of channels required to be operable.

d. The LSSS is a parameter that assures the integrity of the fuel cladding. The SL initiates protective action to preclude reaching the LSSS.

Question B.10 [1.0 point]
Which ONE of the following is the definition of the Total Effective Dose Equivalent (TEDE)?

a. The sum of the thyroid dose and external dose

b. The sum of the external deep dose and the organ dose

c. The sum of the deep dose equivalent and the committed effective dose equivalent

d. The dose that your whole body is received from the source, but excluded from the deep dose

Question B.11 [1.0 point]
Which ONE of the following is the correct definition of a CHANNEL CHECK?

a. The combination of sensor, line, amplifier, and output device which are connected for the purpose of measuring the value of a parameter.

b. The introduction of a signal into the channel for verification that it is operable.

c. A qualitative verification of acceptable performance by observation of channel behavior.

d. An adjustment of the channel such that its output corresponds with acceptable accuracy to known values of the parameter which the channel measures.

Question B.12 [1.0 point]
Which ONE of the following is the definition for "Annual Limit on Intake (ALI)"?

a. Projected dose commitment values to individuals that warrant protective action following a release of radioactive material.

b. 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 millirem.

c. The effluent concentration of a radio-nuclide in air which, if inhaled continuously over a year, would result in a total effective dose equivalent of 50 millirem for noble gases.

d. 10CFR20 derived limit, based on a Committed Effective Dose Equivalent of 5 Rems whole body or 50 Rems to any individual organ, for the amount of radioactive material inhaled or ingested in a year by an adult worker.

Question B.13 [1.0 point]
Which ONE of the following events does NOT require the presence of a Licensed Senior Reactor Operator at the scene?

a. Fuel relocations within the core region

b. Removal of safety control rod for inspection

c. Insertion of experiment worth of $0.70

d. Reactor startup and approach to power

Question B.14 [1.0 point]
Which ONE of the following is an example of a Byproduct Material?

a. Pu-239

b. U-238

c. U-235

d. Co-60

Question B.15 [1.0 point]
Per MUTR emergency classifications, which ONE of the following is the classification of a personnel exposure in excess of 10 CFR 20 limits?

a. Alert

b. Notification of Unusual Event

c. Safety Event – (non-reactor related)

d. Personnel Emergency

Question B.16 [1.0 point]
Which ONE of the following parts in 10CFR requires all applicants for an RO and SRO license to submit NRC Form 396 and NRC Form 398 to the US NRC before taking a licensing examination?

a. Part 19

b. Part 20

c. Part 50

d. Part 55

Question B.17 [1.0 point]
In what series can reactor building evacuation be found?

a. 100

b. 200

c. 300

d. 400

Question B.18 [1.0 point]
10 CFR 50.59 would require MUTR submit a request to the NRC for which ONE of the following modifications?

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 Technical Specification from five to three

Question B.19 [1.0 point]
You are currently the licensed operator at MUTR reactor. Which ONE of the following will violate 10CFR55.53 (Conditions of Licenses)?

a. Last licensed renewal was 60 months ago

b. Last requalification operating test was 18 months ago

c. Last quarter you were the licensed operator for 5 hours

d. Last requalification written examination was 12 months ago

Category B: Normal/Emergency Procedures and Radiological Controls

Question B.20 [1.0 point, 0.25 each]
Match each of the Technical Specification limits in Column A with its corresponding value in Column B. (Answers in Column B may be used once, more than once, or not at all)

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

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

Category C: Facility and Radiation Monitoring Systems

Question C.01 [2.0 points, 0.50 each]
Reactor is in operation. Match the input signals listed in Column A with their AUTOMATIC responses 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 = 170°C	1. Normal Operation
b. Source Count Rate < 1 cps	2. Alarm ONLY
c. Wide Range Linear Channel = 120% power	3. Interlock
d. Exhaust Radiation Monitor = exceed second setpoint	4. Scram (with or without alarm)

Question C.02 [1.0 point]
Which ONE of the following elements is MAINLY used as the neutron absorber in the MUTR control rods?

a. Gadolinium

b. Borated Graphite

c. Zirconium-Hydride

d. Gold-Indium-Cadmium

Question C.03 [1.0 point]
What is the MAIN purpose for setting a pool water conductivity limit?

a. Minimize Ar-41 released to the public

b. Extend integrity of resin bed in the demineralizer

c. Minimize the possibility of corrosion of the fuel element cladding

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

Category C: Facility and Radiation Monitoring Systems

Question C.04 [1.0 point]
Which ONE of the following is the MAIN 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.05 [1.0 point]
Which ONE of the following is an ACCEPTABLE value when conducting a Safety Control Rod drop test?

a. 800 msec

b. 1000 msec

c. 1200 msec

d. 1500 msec

Question C.06 [1.0 point]
In the event of emergency power loss, where will emergency power distribute?

a. Coolant pumps

b. Reactor Console

c. Building Security System

d. Radiation Monitoring Systems

Category C: Facility and Radiation Monitoring Systems

Question C.07 [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, particle filter, flow orifice, demineralizer column

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

Question C.08 [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 temperature induced reactivity effects

c. Avoiding the maximum reactivity insertion rate

d. Preventing the possibility of a rod withdraw prohibit

Question C.09 [1.0 point]
What is the location of the MUTR neutron source?

a. B row

b. C row

c. D row

d. E row

Category C: Facility and Radiation Monitoring Systems

Question C.10 [1.0 point]
What is the location the thermocouple in an instrumented TRIGA fuel element measures temperature?

a. Surface of the cladding

b. Interior of the fuel section

c. Surface of graphite reflector

d. Center of the zirconium rod

Question C.11 [1.0 point]
How is the coolant flow measured in the Primary Coolant loop of the reactor coolant system?

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]
When the reactor is in 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 a 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.13 [1.0 point]
When is the CHANNEL TEST for the Bridge Radiation Monitor performed?

a. Prior to starting up the reactor

b. Daily

c. Monthly

d. Annually

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 Cambelling technique?

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

b. It uses an output DC signal from a ion 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 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 ZrHx): 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

Category C: Facility and Radiation Monitoring Systems

Question C.16 [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

Question C.17 [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

Category C: Facility and Radiation Monitoring Systems

Question C.18 [2.0 points, 0.50 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. 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°C	4. Fuel Element Temperature

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

Category A: Theory, Thermodynamics & Facility Operating Characteristics

A.01
Answer: b
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, Sec 6.2

A.02
Answer: a
Reference: 1.03 x 0.96 x 0.84 x 0.88 x 1.96 x 0.70 = 1.00
1 / (1.03 x 0.96 x 0.84 x 0.88 x 1.96) = 0.698

A.03
Answer: c
Reference: $\Delta\rho$ = (Keff1-Keff2)/(Keff1*Keff2); (1.0000-0.955)/((0.955*1.0000)
$\Delta\rho$ = 0.0450 / 0.9550 = 0.0471

A.04
Answer: a. 2; b. 1; c. 2; d. 1
Reference: DOE Fundamentals Handbook, NPRT, Vol. 2, Module 3, EO 5.4, EO 5.5, EO 5.6, pp 51-53

A.05
Answer: c
Reference: DOE Fundamentals Handbook, NPRT, Vol. 1, Module 1, EO 4.9, page 61

A.06
Answer: c
Reference: Reactivity added = 0.126%Δk/k=0.00126Δk/k; $T=\beta-\rho/\lambda_{eff}\rho$;
(0.0078-0.00126)/(0.1)(0.00126) = 51.9 seconds

A.07
Answer: a
Reference: Decreasing the reactivity worth in the core will decrease the core excess

A.08
Answer: d
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, Table 2.5, page 2-59

A.09
Answer: d
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, Sec 3.3.1, page 3-16

A.10
Answer: a
Reference: $P=P_oe^{t/T}$ ln(4)=time / 10 seconds Time = ln(4)x10 seconds 1.386 x10 = 13.8 seconds

A.11
Answer: d
Reference: NRC Standard Question

Category A: Theory, Thermodynamics & Facility Operating Characteristics

A.12
Answer b
Reference: Chart of the Nuclides, KAPL. Seventeenth Edition

A.13
Answer: b
Reference: Burn, R., Introduction to Nuclear Reactor Operations, 1988, Sec 6.4

A.14
Answer: c
Reference: Burn, R., Introduction to Nuclear Reactor Operations, Sec 3.3.4
$\Delta\rho$ = (Keff1-Keff2)/(Keff1*Keff2) = (0.943-0.885)/((0.943*0.885)
0.0694Δk/k = 6.94%Δk/k

A.15
Answer: c
Reference: Burn, R., Introduction to Nuclear Reactor Operations, 1982, Figure 2.6, page 2-39

A.16
Answer: d
Reference: Burn, R., Introduction to Nuclear Reactor Operations, 1988, Sec 2.5.3

A.17
Answer: a
Reference: $P=P_o e^{t/T} \rightarrow t=T*\ln(P/P_o)$ T = 10/Ln(100/10), T = 4.34 seconds

A.18
Answer: b
Reference: NRC Standard Question

A.19
Answer: c
Reference: Burn, R., Introduction to Nuclear Reactor Operations, 1982, page 4-21

A.20
Answer: c
Reference: Chart of Nuclides; Production and decay of radionuclides

Category B: Normal/Emergency Procedures and Radiological Controls

B.01
Answer: d
Reference: MUTR SP 202, 2.0

B.02
Answer: b
Reference: $A=A_o^{e-\lambda t}$ $0.01Ci=1Ci^{e-\lambda t}$; $\ln(0.01/1) = -0.693(t)$ $-4.60/-0.693$; 6.6 years

B.03
Answer: b
Reference: 10CFR20.1201(a)(1) [5000 mR x (1 hr/100mR) x (day/8 hr)] = 6.25 days

B.04
Answer: d
Reference: $500mrem(2)^2=5mrem(d)^2$ D=20 feet

B.05
Answer: c
Reference: MUTR Technical Specification 6.1.3

B.06
Answer: b
Reference: MUTR Technical Specification 1.30

B.07
Answer: d
Reference: Basic radiological techniques; Beta and Alpha radiation don't make it through the demineralizer tank

B.08
Answer: d
Reference: MUTR Emergency Plan, Section 3.0

B.09
Answer: b
Reference: MUTR 2.1.2 and 2.2.1, Objective

B.10
Answer: d
Reference: 10CFR20.1003

B.11
Answer: c
Reference: MUTR Technical Specifications, Definitions

B.12
Answer: d
Reference: 10CFR20.1003

Category B: Normal/Emergency Procedures and Radiological Controls

B.13
Answer: c
Reference: MUTR Technical Specification 6.1.3

B.14
Answer: d
Reference: 10CFR20.1003; byproduct material is any radioactive material, except special nuclear material, made radioactive by the process of producing or using special nuclear material

B.15
Answer: d
Reference: MUTR Emergency Preparedness Plan 4.0

B.16
Answer: d
Reference: 10CFR55

B.17
Answer: d
Reference: MUTR Procedure Index

B.18
Answer: d
Reference: 10CFR50.59; Change to Technical Specification

B.19
Answer: b
Reference: 10CFR55.53; 55.53(i)- licensee shall have a biennial medical exam, 55.53(h) 55.59(c) – annual operating tests; 55.53(e) 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) requalification program must be conducted for a continuous period not to exceed 2 years; License renewal – 6 years

B.20
Answer: a. 3, b. 3, c. 2, d. 4
Reference: MUTR Technical Specifications 3.1 and 3.5

Category C: Facility and Radiation Monitoring Systems

C.01
Answer: a. 1 b. 3 c. 4 d. 4
Reference: MUTR Technical Specification Section 3 and MUTR SAR Chapter 7

C.02
Answer: b
Reference: MUTR SAR 4.2.2.1

C.03
Answer: c
Reference: MUTR Technical Specification 4.1.2

C.04
Answer: c
Reference: MUTR SAR 7.4.1.1.1

C.05
Answer: a
Reference: MUTR Technical Specification 3.2

C.06
Answer: c
Reference: MUTR SAR 8.2

C.07
Answer: a
Reference: MUTR SAR, Figure 5.1

C.08
Answer: b
Reference: MUTR OP-204

C.09
Answer: a
Reference: MUTR SAR, Figure 4.9

C.10
Answer: b
Reference: MUTR SAR 4.2.1.2

C.11
Answer: c
Reference: MUTR SAR 5.2

C.12
Answer: d
Reference: MUTR Technical Specification Table 3.4

Category C: Facility and Radiation Monitoring Systems

C.13
Answer: a
Reference: MUTR Technical Specification 4.6.1

C.14
Answer: d
Reference: MUTR SAR 7.4.1.1.1 and NRC previous exam 16-01

C.15
Answer: b
Reference: MUTR Technical Specification 5.3.1

C.16
Answer: b
Reference: MUTR SAR 5.6

C.17
Answer: c
Reference: MUTR SP 204

C.18
Answer: a. 2 b. 3 c. 1 d. 4
Reference: MUTR Technical Specification 3.2 and SAR 7.4.1

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