March 14, 2016

Mr. Ralph A. Butler, Director
University of Missouri - Columbia
Research Reactor Center
1513 Research Park Drive
Columbia, MO 65211

SUBJECT: EXAMINATION REPORT NO. 50-186/OL-16-01, UNIVERSITY OF MISSOURI – COLUMBIA

Dear Mr. Butler:

During the week of March 7, 2016, the Nuclear Regulatory Commission (NRC) administered an operator licensing examination at the University of Missouri – Columbia reactor. The examination was conducted according to NUREG-1478, "Operator Licensing Examiner Standards for Research and Test Reactors," Revision 2. Examination questions and preliminary findings were discussed with you 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 enclosure 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 Mrs. Paulette Torres at (301) 415-5656 or via e-mail Paulette.Torres@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. 50-186

Enclosures: 1. Examination Report No. 50-186/OL-16-01
2. Facility Comments with NRC Resolution
3. Written Examination

cc: John Fruits, Reactor Manager
cc w/o enclosure: See next page

March 24, 2016

Mr. Ralph A. Butler, Director
University of Missouri - Columbia
Research Reactor Center
1513 Research Park Drive
Columbia, MO 65211

SUBJECT: EXAMINATION REPORT NO.: 50-186/OL-16-01, UNIVERSITY OF MISSOURI – COLUMBIA

Dear Mr. Butler:

During the week of March 7, 2016, the Nuclear Regulatory Commission (NRC) administered an operator licensing examination at the University of Missouri – Columbia reactor. The examination was conducted according to NUREG-1478, "Operator Licensing Examiner Standards for Research and Test Reactors," Revision 2. Examination questions and preliminary findings were discussed with you 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 enclosure 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 Mrs. Paulette Torres at (301) 415-5656 or via e-mail Paulette.Torres@nrc.gov.

Sincerely,
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Anthony J. Mendiola, Chief
Research and Test Reactors Oversight Branch
Division of Policy and Rulemaking
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Docket No. 50-186
Enclosures: 1. Examination Report No. 50-186/OL-16-01
2. Facility Comments with NRC Resolution
3. Written Examination
cc: John Fruits, Reactor Manager
cc w/o enclosure: See next page
DISTRIBUTION w/ encl.
Public RidsNrrDprPrtb RidsNrrDprPrta
ADAMS Accession No. ML16081A309 NRR-079

OFFICE	NRR/DPR/PROB/CE	NRR/DIRS/IOLB/OLA	NRR/DPR/PROB/BC
NAME	PTorres	CRevelle	AMendiola
DATE	3/15/2016	3/21/2016	3/24/2016

OFFICIAL RECORD COPY

University Of Missouri – Columbia Docket NO: 50-186
cc:

Les Foyto, Associate Director
University of Missouri-Columbia
Research Reactor Center
1513 Research Park Drive
Columbia, MO 65211

Homeland Security Coordinator
Missouri Office of Homeland Security
P.O. Box 749
Jefferson City, MO 65102

Planner, Dept. of Health and Senior Services
Section for Environmental Public Health
P.O. Box 570
Jefferson City, MO 65102-0570

Deputy Director for Policy
Department of Natural Resources
1101 Riverside Drive
Fourth Floor East
Jefferson City, MO 65101

A-95 Coordinator
Division of Planning
Office of Administration
P.O. Box 809, State Capitol Building
Jefferson City, MO 65101

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.: 50-186/OL-16-01

FACILITY DOCKET NO.: 50-186

FACILITY LICENSE NO.: R-103

FACILITY: University of Missouri – Columbia Reactor

EXAMINATION DATE: March 7, 2016

SUBMITTED BY: _____ _____
Paulette Torres, Chief Examiner Date

SUMMARY:

During the week of March 7, 2016 the NRC administered a licensing examination to one Reactor Operator (RO) applicant. The applicant passed all portions of the examination.

REPORT DETAILS

1. Examiner: Paulette Torres, Chief Examiner, NRC

2. Results:

	RO PASS/FAIL	SRO PASS/FAIL	TOTAL PASS/FAIL
Written	1/0	0/0	1/0
Operating Tests	1/0	0/0	1/0
Overall	1/0	0/0	1/0

3. Exit Meeting:

Paulette Torres, Chief Examiner, NRC
John Fruits, Reactor Manager, MURR

The facility licensee agreed to email their comments on the written examination that were incorporated into the examination report (see Enclosure 2).

ENCLOSURE 1

FACILITY COMMENTS ON THE WRITTEN EXAM WITH NRC RESOLUTION

QUESTION A.02 [1.0 point]
A reactor has been operating at 500 kW using manual rod control for approximately 15 minutes. The operator inserts a control rod in order to maintain power constant. The rod must be inserted to compensate for which of the following conditions:

a. Increase in xenon

b. Increase in fuel temperature

c. Increase in moderator temperature

d. Decrease in fuel concentration

Answer: c
REF: DOE Fundamentals Handbook, Vol. 2, Module 3, pg. 26
Burns, Section 6.4, pg. 6-4

Facility Comments &
Recommendations: No correct answer is provided. Inserting the control rod adds negative reactivity to counter a positive reactivity addition. Answer Key indicated 'C' to be the correct response. MURR has a negative temperature coefficient of reactivity for the primary coolant system; therefore an increase in moderator temperature would add negative reactivity requiring the control rod to be withdrawn. Request question be deleted. Reference: MURR Technical Specifications, Reactivity, 3.1.a.

NRC Resolution: The NRC agrees with the facility comment and question A.02 will be deleted from the examination.

QUESTION A.05 [1.0 point]
Which of the following statements is the predominant factor for the change in Xenon concentration following a reactor scram? Xe-135 concentration will _____.

a. Increase due to reduced nuclear flux.

b. Increase due to the decay of the I-135 inventory.

c. Decrease by natural decay into I-135.

d. Remain constant until it is removed via neutron burnout during the subsequent reactor startup.

Answer: b
REF: DOE Handbook, Vol 2, Section NP-3, pg. 38
Knief, Nuclear Engineering, 2nd ed., pg. 173

Facility Comments &
Recommendations: Answer Key indicated answer 'B' to be the correct response. MURR believes answer 'A" should be the correct response. Immediately following a scram Xenon concentration increases due to the loss of the Xenon burnout term. Agree that Xenon is still being produced through the decay of I-135 and will peak in 6-7 hours, but the loss of the burnout term is dominate following a reactor scram. Request answer 'A' to be the correct response. Reference: DOE Module 3, "Fuel Temperature Coefficient", page 26.

NRC Resolution: The NRC will accept "a" as the correct answer for question A.05.

QUESTION A.17 [1.0 point]
Which ONE of the following is true about the nuclear Doppler effect?

a. The total area under the resonance remains essentially constant.

b. At high temperatures the resonance peak is narrow.

c. As the temperature decreases, the resonance peak broadens and lowers, allowing neutrons of more energies to be absorbed.

d. As the temperature decreases, the resonance escape probability and k_{eff} decreases.

Answer: a
REF: Lamarsh 3rd ed., pg. 367

Facility Comments &
Recommendations: MURR is a physically small core which utilizes highly enriched fuel at low temperatures. There is essentially no Doppler effect at MURR; and as such there is really no correct answer. The reference listed in the Answer Key is unavailable at MURR. However, DOE Reactor Theory Handbook, Module 3 refers to the Doppler Effect occurring in reactor with low enriched fuel. Request question be deleted because this is not applicable to MURR. Reference: DOE Module 3, "Fuel Temperature Coefficient", page 26.

NRC Resolution: The NRC will delete question A.17 from the examination since it is not applicable to MURR.

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

FACILITY: University Of Missouri – Columbia

REACTOR TYPE: TANK

DATE ADMINISTERED: 03/07/2016

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
18.00 ~~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
58.00 ~~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 3

A. Reactor Theory, Thermohydraulics & Facility Operating Characteristics

A N S W E R S H E E T

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

A01 a ___ b ___ c ___ d ___

~~A02 a b c d ___~~ Deleted per Facility Comment

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 ___~~ Deleted per Facility Comment

A18 a ___ b ___ c ___ d ___

A19 a b c d ___

A20 a b c d ___

(***** END OF SECTION A *****)

B. Normal/Emergency Procedures and Radiological Controls

A N S W E R S H E E T

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

B01 a b c d ___

B02 a b c d ___

B03 a b c d ___

B04 a b c d ___

B05 a b c d ___

B06 a b c d ___

B07 a b c d ___

B08 a b c d ___

B09 a ___ b ___ c ___ d ___

B10 a b c d ___

B11 a b c d ___

B12 a b c d ___

B13 a b c d ___

B14 a b c d ___

B15 a b c d ___

B16 a b c d ___

B17 a b c d ___

B18 a b c d ___

B19 a b c d ___

B20 a b c d ___

(***** END OF SECTION B *****)

C. Facility and Radiation Monitoring Systems

A N S W E R S H E E T

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

C01 a b c d ___

C02 a b c d ___

C03 a b c d ___

C04 a b c d ___

C05 a b c d ___

C06 a b c d ___

C07 a b c d ___

C08 a b c d ___

C09 a b c d ___

C10 a b c d ___

C11 a b c d ___

C12 a b c d ___

C13 a b c d ___

C14 a b c d ___

C15 a b c d ___

C16 a b c d ___

C17 a b c d ___

C18 a b c d ___

C19 a b c d ___

C20 a b c d ___

(***** END OF SECTION 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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

1 kg = 2.21 lbm

1 Horsepower = 2.54 x 10^3 BTU/hr

1 Mw = 3.41 x 10^6 BTU/hr

1 BTU = 778 ft-lbf

°F = 9/5 °C + 32

1 gal (H_2O) ≈ 8 lbm

°C = 5/9 (°F - 32)

c_P = 1.0 BTU/hr/lbm/°F

c_p = 1 cal/sec/gm/°C

U.S.NRC

UNITED STATES NUCLEAR REGULATORY COMMISSION

Protecting People and the Environment

UNIVERSITY OF MISSOURI – COLUMBIA

Operator Licensing Examination

Week of March 7, 2016

QUESTION A.01 [1.0 point, 0.25 each]
Match the following neutron interactions with its net result. Answers can be used more than once.

Column A	Column B
a. Elastic Scattering	1. γ – Rays
b. Inelastic Scattering	2. Positive Ions
c. Nuclear Reactions	3. Protons
d. Capture	

~~**QUESTION A.02 [1.0 point]**~~
~~A reactor has been operating at 500 kW using manual rod control for approximately 15 minutes. The operator inserts a control rod in order to maintain power constant. The rod must be inserted to compensate for which of the following conditions:~~

~~a. Increase in xenon~~

~~b. Increase in fuel temperature~~

~~c. Increase in moderator temperature~~

~~d. Decrease in fuel concentration~~

QUESTION A.03 [1.0 point]
Shutdown Margin is defined as:

a. The negative reactivity inserted by an increase in moderator temperature within the core when the reactor is brought from zero to full power.

b. Provides a measure of excess reactivity available to overcome fission product buildup, fuel burnup, and power defect.

c. The amount of negative reactivity that would be added to a core if the rods in a critical, cold, clean reactor were fully inserted.

d. The amount of reactivity available above what is required to keep the reactor critical.

QUESTION A.04 [1.0 point]
The count rate is 100 cps. An experimenter inserts an experiment into the core, and the count rate decreases to 60 cps. Given the initial K_{eff} of the reactor was 0.92, what is the worth of the experiment?

a. $\Delta\rho = - 0.07$

b. $\Delta\rho = + 0.07$

c. $\Delta\rho = - 0.02$

d. $\Delta\rho = + 0.02$

QUESTION A.05 [1.0 point]
Which of the following statements is the predominant factor for the change in Xenon concentration following a reactor scram? Xe-135 concentration will _____.

a. Increase due to reduced nuclear flux.

b. Increase due to the decay of the I-135 inventory.

c. Decrease by natural decay into I-135.

d. Remain constant until it is removed via neutron burnout during the subsequent reactor startup.

QUESTION A.06 [1.0 point]
What happens to the mass number and the atomic number of an element when it undergoes beta decay?

a. The mass number decreases by 4 and the atomic number decreases by 2.

b. The mass number does not change and the atomic number decreases by 2.

c. The mass number increases by 2 and the atomic number increases by 1.

d. The mass number does not change and the atomic number increases by 1.

QUESTION A.07 [1.0 point]
The reactor is critical at 5 watts. Which ONE of the following correctly describes the reactor behavior when a reactivity worth of 0.50 % ΔK/K is IMMEDIATELY inserted to the reactor core?

a. Subcritical

b. Critical

c. Supercritical

d. Delayed critical

QUESTION A.08 [1.0 point]
Which ONE of the following statements correctly describes the term neutron lifetime?

a. The mean time required for fission neutrons to slow down to thermal energies.

b. The average time that thermal neutrons diffuse before being lost in some way.

c. The time between succeeding neutron generations and is the sum of fission time, slowing down time, and diffusion time.

d. The average time between the release of a neutron in a fission reaction and its loss from the system by absorption or escape.

QUESTION A.09 [1.0 point]
Most text books list β for a U^{235} fueled reactor as 0.0065 ΔK/K and β_{eff} as being 0.0075 ΔK/K. Why is β_{eff} larger than β?

a. Delayed neutrons are born at lower energies than prompt neutrons resulting in a less loss due to leakage for these neutrons.

b. Delayed neutrons are born at higher energies than prompt neutrons resulting in a greater worth for these neutrons.

c. The fuel includes U^{238} which has a relatively large for fast fission.

d. Some U^{238} in the core becomes Pu^{239} (by neutron absorption) which has a larger for fission.

QUESTION A.10 [1.0 point]
The neutron microscopic cross-section for absorption σ_a generally:

a. Increases as neutron energy increases.

b. Decreases as neutron energy increases.

c. Increases as the mass of the target nucleus increases.

d. Decreases as the mass of the target nucleus increases.

QUESTION A.11 [1.0 point]
Which ONE is true about "subcritical multiplication"? As the reactor approaches criticality, the parameter:

a. k_{eff} approaches zero.

b. 1/M approaches zero.

c. M approaches one.

d. ρ approaches infinity.

QUESTION A.12 [1.0 point]
Which ONE defines an integral rod worth curve?

a. Conforms to an axial flux shape.

b. Any point on the curve represents the amount of reactivity that one inch of rod motion would insert at that position in the core.

c. Represents the cumulative area under the differential curve starting from the bottom of the core.

d. Reactivity is highest at the top of the core and lowest at bottom of the core.

QUESTION A.13 [1.0 point]
Which ONE of the following is the correct reason for the 80 second negative period following a reactor scram?

a. The fuel temperature coefficient adding positive reactivity due to the fuel temperature decrease following a scram.

b. The ability of U-235 to fission with source neutrons.

c. The decay constant for the longest lived precursor.

d. The amount of negative reactivity added on a cram being greater that the shutdown margin.

QUESTION A.14 [1.0 point]
A reactor is operating at a power of 10 W. If there is a reactivity insertion of $\rho = 0.00065$, how long is it before the reactor power reaches 10 kW? (Assume $\beta_{eff} = 0.0065$, $\lambda = 0.07\ sec^{-1}$ and T = 129 sec)

a. 2 min

b. 10 min

c. 15 min

d. 20 min

QUESTION A.15 [1.0 point]
The term _____ defines the condition where no delay neutrons are required.

a. Prompt Jump

b. Prompt Drop

c. Asymptotic Period

d. Prompt Critical

QUESTION A.16 [1.0 point]
A subcritical reactor is being started up. A control blade is raised in four equal steps. Which ONE of the following statement most accurately describes the expected reactor response?

a. Power increases by the same amount for each withdrawal.

b. Each withdrawal will add the same amount of reactivity.

c. The time for power to stabilize after each successive withdrawal increases.

d. A lower critical rod height is attained by decreasing the time intervals between withdrawals.

~~**QUESTION A.17 [1.0 point]**~~
~~Which ONE of the following is true about the nuclear Doppler effect?~~

~~a. The total area under the resonance remains essentially constant.~~

~~b. At high temperatures the resonance peak is narrow.~~

~~c. As the temperature decreases, the resonance peak broadens and lowers, allowing neutrons of more energies to be absorbed.~~

~~d. As the temperature decreases, the resonance escape probability and k_{eff} decreases.~~

QUESTION A.18 [1.0 point, 0.25 each]
The six factor formula is stated as $k_{eff} = \epsilon L_f p L_t f \eta$.
Match with the correct answer:

Column A	Column B
a. Thermal utilization factor (f)	1. Change as fertile material is converted to fissile material.
b. f and p factors	2. Can be changed, by inserting movable control rods in and out.
c. f, p, Reproduction (η) factors	3. Changes reactor power.
d. Resonance escape probability (p)	4. Change as fuel is burned.

QUESTION A.19 [1.0 point]
Reactor period is defined as _____.

a. The time required for a reactor to change by a factor of *e*.

b. The time required for the reactor power to double.

c. The number of factors of ten that reactor power changes in one minute.

d. The fraction of all neutrons that are born as delayed neutrons.

QUESTION A.20 [1.0 point]
Which ONE of the following is the best approximation of the amount of energy released by the fission of one atom of U-235?

a. 5 - 10 MeV

b. 50 - 70 MeV

c. 100 - 120 MeV

d. 180 - 210 MeV

********** End of Section A **********

QUESTION B.01 [1.0 point]
Which ONE of the following Technical Specification requirements provides assurance that any inadvertent insertion/removal or credible malfunction of a Secure Removable Experiment would not introduce positive reactivity whose consequences would lead to doses in excess of the 10 CFR 20 limits?

a. The reactivity worth of each secured removable experiment shall be limited to 0.006 ΔK.

b. Each movable experiment or the movable parts of any individual experiment shall have a maximum absolute reactivity worth of 0.001 ΔK.

c. The magnitude of the reactivity worth of each unsecured experiment shall not exceed 0.0025 ΔK.

d. The sum of the magnitudes of the reactivity worths of all unsecured experiments which are in the reactor shall not exceed 0.006 ΔK.

QUESTION B.02 [1.0 point]
Which ONE of the following safety system channels requires two (2) OPERABLE instrument channels in all modes of operation?

a. Period

b. High Power

c. Reactor Outlet Temperature

d. Primary Coolant Low Pressure

QUESTION B.03 [1.0 point]
“The core excess reactivity above cold clean critical shall not exceed 0.098 ΔK/K.” This is an example of a:

a. Safety Limit.

b. Limiting Safety System Setting.

c. Limiting Condition of Operation.

d. Surveillance Requirement.

QUESTION B.04 [1.0 point]
The fuel meat of the Extended Life Aluminide Fuel (ELAF) may also contain _____.

a. Aluminum

b. Boron Carbide

c. Cadmium

d. Polyethylene

QUESTION B.05 [1.0 point]
Per Technical Specifications, the utility seal trench is filled with water to the depth required to maintain a minimum water seal of _____.

a. 4.25 feet

b. 4.80 feet

c. 5.25 feet

d. 6.00 feet

QUESTION B.06 [1.0 point]
In accordance with 10 CFR Part 50.47(b)(11), under what conditions a radiation worker can have exposure in excess of 10 CFR 20 limits?

a. During any emergency.

b. In an emergency situation, a voluntary whole body exposure up to 75 rem dose equivalent per individual for life-saving actions.

c. As long as the radiation worker don't exceed 50 rem whole body to save vital reactor equipment.

d. In an emergency declared by the Emergency Director with concurrence of the Lead Senior Reactor Operator.

QUESTION B.07 [1.0 point]
Reactor Operator works in a high radiation area for eight (8) hours a day. The dose rate in the area is 100 mR/hour. Which ONE of the following is the MAXIMUM number of days in which
Reactor Operator may perform his duties WITHOUT exceeding 10 CFR 20 limits?

a. 5 days

b. 6 days

c. 7 days

d. 12 days

QUESTION B.08 [1.0 point]
Per Emergency Procedure EP-R0-015, if an Emergency Event is in progress and has been classified as Notification of Unusual Event, Alert, or Site Area Emergency, _____ shall be made to the Nuclear Regulatory Commission (USNRC) as well as notification to the American Nuclear Insurers (ANI) and the State Emergency Management Agency (SEMA).

a. Immediate notification

b. 1 hour notification

c. 24 day notification

d. No notification to the USNRC, ANI or SEMA needed

QUESTION B.09 [1.0 point, 0.25 each]
Match the 10 CFR 55 requirements for maintaining an active operator license in column A with the corresponding time period from column B (answers can be used more than once).

Column A	Column B
a. Medical Exam	1 year
b. Pass Requalification Operating Test	2 years
c. Renewal Application of Existing License	4 years
d. Pass Requalification Written Examination	6 years

QUESTION B.10 [1.0 point]
The Protective Actions for all classifications are based on _____ dose equivalent thyroid to members of the general public and MURR staff onsite.

a. 0.1 rem

b. 5.0 rem

c. 50 mrem

d. 1000 mrem

QUESTION B.11 [1.0 point]
The _____ be delegated the responsibility for radiological assessments including onsite and offsite.

a. Emergency Director

b. Emergency Coordinator

c. Health Physics Manager

d. Reactor Manager

QUESTION B.12 [1.0 point]
Which ONE of the following emergency situations may lead to an ALERT?

a. Significant releases of radioactive materials as a result of experiment failures.

b. Several natural phenomena such as earthquakes, tornados, etc.

c. Major damage to fuel has occurred with actual or imminent failure of primary system integrity and containment integrity.

d. Prolonged fires or significant fuel damage indicated by high coolant fission product activity.

QUESTION B.13 [1.0 point]
Which ONE of the following is the 10 CFR 20 definition of Total Effective Dose Equivalent (TEDE)?

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

b. The dose that your whole body receives from sources outside the body.

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

d. The dose to a specific organ or tissue resulting from an intake of radioactive material.

QUESTION B.14 [1.0 point]
If a gamma source measures 425 mR/hr at one foot, what will it measure at three feet?

a. 0.021 mR/hr

b. 47 mR/hr

c. 142 mR/hr

d. 207 mR/hr

QUESTION B.15 [1.0 point]
In case of an emergency, the level of staffing may be reduced to:

a. Two licensed operators, where one must be in the control room.

b. One Senior Reactor Operator and one knowledgeable person.

c. One Senior Reactor Operator and one Reactor Operator.

d. One licensed operator and the Reactor Manager.

QUESTION B.16 [1.0 point]
A 1/M criticality calculation shall be performed for all:

a. Normal reactor startups.

b. Hot reactor startups.

c. Startups following experiment changes.

d. Startups following an unscheduled shutdown.

QUESTION B.17 [1.0 point]
All water drained from the Beamports contains high levels of _____.

a. Super Water

b. Deuterium

c. Tritium

d. Helium

QUESTION B.18 [1.0 point]
Automatic reactor control will be terminated by any of the following EXCEPT:

a. Depressing the Rod Control Mode “MAN” Switch S1-2.

b. Moving the Regulating Blade Operate Switch 1S5.

c. Activating any Scram or Rod Run-In.

d. Wide Range Monitor Level Recorder indicating greater than the auto prohibit set point.

QUESTION B.19 [1.0 point]
The SRO announces to the facility, “Commencing a Hot Reactor Startup”. Which ONE of the following is a precaution and/or limitations of this particular startup?

a. The reactor must be shutdown to adjust the Rod Position Indication zero setting.

b. Gang Control Rod withdrawal is only permitted to 2.0 inches below the Estimated Critical Position (ECP).

c. Period is limited to no longer than 100 seconds above 1 MW.

d. The startup is performed because the ability to override Xenon is in doubt.

QUESTION B.20 [1.0 point]
Which ONE of following types of radiation is the HIGHEST Quality Factor specified in 10CFR20?

a. Alpha

b. Beta

c. Gamma

d. Neutron (unknown energy)

********** End of Section B **********

QUESTION C.01 [1.0 point]
Which ONE of the following Primary Coolant System components is connected to the primary coolant loop, at the highest points of the inverted loop and the In-Pool Heat Exchanger, through half inch lines?

a. Anti-Siphon System

b. Pool Skimmer System

c. Pressurizer System

d. Vent Tank System

QUESTION C.02 [1.0 point]
The “island tube”, part of the reactor core assembly support structure, is a single component of the:

a. Inner Pressure Vessel

b. Lower Reflector Plenum

c. Outer Pressure Vessel

d. Upper Reflector Tank

QUESTION C.03 [1.0 point]
Which ONE of the following is the purpose of the spacers set between the pressure vessel and the beryllium reflector?

a. To allow for natural circulation during operations below 100 kW.

b. To increase control blades travel speed.

c. To reduce the possibility of rod binding.

d. To signal control blade position indication.

QUESTION C.04 [1.0 point]
The _____ is/are primarily used for neutron scattering useful in determining the structure of solids and liquids.

a. Beamports

b. Flux Trap

c. Thermal Column

d. Pneumatic Tube System

QUESTION C.05 [1.0 point]
If a "Nuclear Instrument Anomaly" is detected, which ONE of the following output channels will not send a scram signal to the Reactor Safety System?

a. Signal Processor 1

b. Signal Processor 2

c. Wide Range Monitor (WRM)

d. Power Range Monitor (PRM6)

QUESTION C.06 [1.0 point]
The Rod Withdrawal Prohibit circuit prevents the drives from being withdrawn unless the following conditions have been satisfied EXCEPT:

a. Master control switch (1S1) in the "TEST" position.

b. All shim blades are not bottomed and in contact with their electromagnets.

c. Intermediate range level recorder indication is greater than 1×10^{-5}% power.

d. Thermal column door is closed.

QUESTION C.07 [1.0 point]
In accordance with Technical Specifications, which ONE of the following statements is TRUE?

a. All experiments in the center test hole shall be removed or installed when the reactor is operating.

b. Experiments containing corrosive materials to reactor components and encapsulated in corrosion resistant containers shall not be irradiated in the reactor.

c. Explosive materials shall not be irradiated or allowed to generate in any experiment in quantities over 25 milligrams.

d. Each fuel experiment shall be limited such that the total inventory of Iodine isotopes 131 thru 135 in the experiment is no greater than 1.5 curies.

QUESTION C.08 [1.0 point]
Which ONE of the following radiation monitors is not required by Technical Specifications?

a. Stack Radiation Monitor

b. Reactor Bridge Radiation Monitor

c. Reactor Building Exhaust Air Plenum Radiation Monitor

d. Beam Hole Floor Radiation Monitor

QUESTION C.09 [1.0 point]
Which ONE of the following is true for the Eberline Stack Monitor?

a. Monitors for iodine right above the reactor core.

b. Monitors for Xe-125 entering the facility exhaust stack.

c. Monitors for Ar-41 entering the gas channel chamber.

d. Monitors for radioactive particulate using a gamma scintillation detector.

QUESTION C.10 [1.0 point]
Which ONE of the following Area Radiation Monitors utilize aluminum house (NaI) scintillation detectors to detect for gammas?

a. Bridge ALARA

b. Fuel Vault

c. Room 114

d. Fission Product monitor

QUESTION C.11 [1.0 point]
The MURR fuel elements shall be a fuel plate made of:

a. UAlx, enriched to 93% U-235, clad with aluminum.

b. UAlx, enriched to 93% U-235, clad with stainless steel.

c. U_3Si_2, enriched to 93% U-235, clad with aluminum.

d. U_3Si_2, enriched to 93% U-235, clad with stainless steel.

QUESTION C.12 [1.0 point]
The Emergency Power Panel provides 480V power to which ONE of the following?

a. The Pneumatic Tube System.

b. The Emergency Air Compressor.

c. The Emergency Lighting Panel 1 (ELP-1).

d. The Emergency Lighting Panel 2A (ELP-2A.

QUESTION C.13 [1.0 point]
A Reactor Isolation Manual Initiation will cause all of the following EXEPT:

a. Containment building ventilation supply and exhaust isolation doors 504 and 505 closure.

b. Containment building exhaust isolation valves 16A and 16B closure.

c. Containment building ventilation exhaust plenum backup doors closure.

d. Reactor isolation horns sound throughout the containment building

QUESTION C.14 [1.0 point]
The drop time of each of the four reactor shim blades shall be measured _____.

a. Monthly

b. Quarterly

c. Every Six Months

d. Every Two Years

QUESTION C.15 [1.0 point]
Which ONE of the following is true about the low pool level scram?

a. Provides assurance that the radiation level above the pool from direct core radiation remains below 2.5 mR/hr.

b. Provides assurance that the reactor will be shut down during a high pressure transient before the relief valve set pressure or the primary system pressure limit is reached.

c. Provides a backup to the low pool coolant flow scram.

d. Provides a backup to the primary coolant low flow scrams.

QUESTION C.16 [1.0 point]
Which ONE of the following design features prevents the core from being drained by a siphoning action?

a. The venting of gases of the Vent Tank System from portions of the primary coolant piping.

b. Maintain Primary Coolant System pressure.

c. A positive pressure difference between the shells inside the In-Pool Heat Exchanger.

d. Pressurized air is admitted to the reactor loop at the highest point in the invert loop.

QUESTION C.17 [1.0 point]
The following statements are all true about the Reactor Inlet & Outlet Isolation Valves EXCEPT:

a. If reactor pressure decreases to a critical level the isolation valves close, isolating the in-pool portions of the reactor coolant system.

b. They are located on the west side of Room 114, between the primary heat exchangers and the Pressurizer.

c. Isolation valve actuation de-energize the primary coolant pumps.

d. Isolation valve actuation activate the reactor in-pool convective loop.

QUESTION C.18 [1.0 point]
The purpose of the Pool Demineralizer System is to:

a. Provides for purification of pool coolant water.

b. Lower reactor pool water level to the elevation of the lower bridge.

c. Remove debris from the reactor pool surface.

d. Provide a path for makeup water to the reactor pool.

QUESTION C.19 [1.0 point]
The beryllium reflector has an ability to effectively decouple the reactor core or minimize any reactivity effects from experiments. The only experimental facility not decoupled from the reactor is the _____.

a. Center Test Hole

b. Beamports

c. Bulk Pool

d. Graphite Reflector

QUESTION C.20 [1.0 point]
The reactor is in SHUTDOWN condition, as defined by MURR Technical Specifications, when:

a. All shim rods are fully inserted.

b. When all shim rods are fully inserted and power is unavailable to the control rod magnets.

c. No work is in progress involving transferring fuel in or out of the core.

d. The “Master Control" switch is in the "off" position with the key locked in the key box or in custody of a licensed operator.

********** End of Section C **********
********** End of the Exam **********

A.01
Answer: a,3 b,1 c,2 d,1
REF: Denaro and Jayson, Fundamentals of Radiation Chemistry, pg. 51

~~**A.02**~~
~~Answer: c~~
~~REF: DOE Fundamentals Handbook, Vol. 2, Module 3, pg. 26~~
~~Burns, Section 6.4, pg. 6-4~~

A.03
Answer: c
REF: Burns, example 6.2.3 (a), pg. 6-4

A.04
Answer: a
REF: $CR_1 / CR_2 = (1 – K_{eff2}) / (1 – K_{eff1})$
$100 / 60 = (1 – K_{eff2}) / (1 – 0.92)$
Therefore $K_{eff2} = 0.867$
$\Delta\rho = (K_{eff2} – K_{eff1}) / (K_{eff2} * K_{eff1})$
$\Delta\rho = (0.867 – 0.92) / (0.867 * 0.92)$
$\Delta\rho = - 0.0664$

A.05
Answer: a
REF: DOE Handbook, Vol 2, Section NP-3, pg. 26

A.06
Answer: d
REF: DOE Handbook volume 1, NP-01, pg. 24, β decay = $ZX^A \rightarrow Z+1Y^A + e + v$,
A = atomic mass = proton + neutrons
Z = # protons

A.07
Answer: c
REF: Burn, Section 4.2, Figure 4-1, pg. 4-2
0.5 % $\Delta K/K = 0.005$ $\Delta K/K = \rho$, $\rho > 0$
$\rho = (k_{eff} -1) / k_{eff}$, then $k_{eff} = 1.005$
When $k > 1$, $\rho > 0$ and reactor is supercritical

A.08
Answer: d
REF: Burns, section 3.3.5, pg. 3-23

A.09
Answer: a
REF: Burns, Section 3.2.4, pg. 3-12

A.10
Answer: b
REF: Foster & Wright, "Basic Nuclear Engineering" 4th ed., Figure 8.3, pg. 202

A.11
Answer: b
REF: Burns, Table 5.5, pg. 5-15

A.12
Answer: c
REF: Burns, Section 7.3, pg. 7-5 to 7-7

A.13
Answer: c
REF: Lamarsh, 3rd ed., pg. 345

A.14
Answer: c
REF: Reactor power: $P(t) = P(0) \exp(t/T)$
Solving for t, we find $t = T \ln [P(t)/P(0)] = 129 \ln (10{,}000/10) = 891$ s = 14.9 min
Also, $\rho = 0.00065$, then
$T = (\beta_{eff} - \rho)/(\rho \lambda) = (0.0065 - 0.00065)/(0.07)(0.00065) =$ 129 seconds

A.15
Answer: d
REF: Knief, Nuclear Engineering, 2nd ed., pg. 142

A.16
Answer: c
REF: Burns, Section 5.3, pg. 5-7

~~**A.17**~~
~~Answer: a~~
~~REF: Lamarsh 3rd ed., pg. 367~~

A.18
Answer: a,2 b,4 c,1 d,3
REF: DOE Handbook part 2, module 3, pg. 10, 15

A.19
Answer: A.14 a
REF: DOE Handbook part 2, module 4, pg. 21

A.20
Answer: d
REF: Lamarsh, Table 3.6, pg. 88
Foster and Wright, Basic Nuclear Engineering, 4th ed., table 4.2, pg. 76, "The energy release per fission is approximately 200 MeV."

B.01
Answer: a
REF: TS 3.1.g basis, pg. 3 of 4

B.02
Answer: a
REF: TS 3.3, pg. 1 of 5

B.03
Answer: c
REF: TS, Section 3.1 f., pg. 2 of 4

B.04
Answer: b
REF: TS 4.1, pg. 1 of 2

B.05
Answer: a
REF: TS 1.15b, pg. 5 of 9

B.06
Answer: b
REF: Emergency Plan (Rev.17), Section 5.0.1, pg. 12

B.07
Answer: b
REF: 10 CFR 20.1201(a)(1)

$$5000mR * \frac{1hr}{100mR} * \frac{1day}{8hr} = 6.25days$$

B.08
Answer: b
REF: EP-R0-015, pg. 2
Emergency Plan (Rev.17), Section 5.1.5, pg. 13
Emergency Plan (Rev.17), Section 5.2.5, pg. 14
Emergency Plan (Rev.17), Section 5.3.5, pg. 15

B.09
Answer: a, 2 years (10 CFR 55.53)
b, 1 years (10 CFR 55.59)
c, 6 years (10 CFR 55.55)
d, 2 years (10 CFR 55.59)

REF: 10 CFR 55.53 “Conditions of Operator Licenses”
10 CFR 55.55 “Expiration”
10 CFR 55.59 “Requalification”
MURR Operator Requalification Program, Section 2.0, pg. 1

B.10
Answer: b
REF: Emergency Plan (Rev.17), Section 5.0.1., pg. 12

B.11
Answer: c
REF: Emergency Plan (Rev.17), Section 2.1, pg. 5

B.12
Answer: a
REF: Emergency Plan (Rev.17), Section 3.3 2., pg. 9

B.13
Answer: a
REF: 10 CFR 20.1003, Definitions

B.14
Answer: b
REF: Given $DR_1(d_1)^2 = DR_2\ (d_2)^2$
Then $DR_2 = \frac{DR_1}{(d_2/d_1)^2}$

$DR_2 = \frac{425\ mR}{(3/1)^2}$

$DR_2 = 47.2$ mR/hr

B.15
Answer: b
REF: AP-RO-110, Section 6.5.1 b., pg. 11, Section 6.5.3 d., pg. 12

B.16
Answer: a
REF: AP-RO-110, Section 6.6.5 c., pg. 17

B.17
Answer: c
REF: EX-RO-120, Section 4.5, pg. 3

B.18
Answer: d
REF: OP-RO-210, Section 5.2.30 2nd NOTE, pg. 10
OP-RO-211, Section 5.2.22 2nd NOTE, pg. 8
OP-RO-212, Section 4.0 2nd NOTE, pg. 7
OP-RO-230, Section 4.0 2nd NOTE, pg. 6

B.19
Answer: d
REF: OP-RO-211, Section 3.2, pg. 3

B.20
Answer: a
REF: 10 CFR 20.1004

C.01
Answer: d
REF: MURR Operations Training Manual, II. System Description/Operation, pg. 2-4A and 2-4D

C.02
Answer: a
REF: MURR Operations Training Manual, II. System Description/Operation, pg. 2-8B

C.03
Answer: c
REF: MURR Operations Training Manual, II. System Description/Operation, pg. 1-8C

C.04
Answer: a
REF: MURR Operations Training Manual, II. System Description/Operation, pg. 1-8F

C.05
Answer: c
REF: MURR Operations Training Manual, II. System Description/Operation, pg. 3-9A

C.06
Answer: a
REF: MURR Operations Training Manual, II. System Description/Operation, pg. 2-10B

C.07
Answer: c
a is only with the reactor shutdown
b shall be double encapsulated
d is no ≥ 150 Ci
REF: TS 3.6 d, pg. 2 of 5

C.08
Answer: d
REF: TS 3.4 a, pg. 1 of 6 and HSR 8.3, pg. 8.8

C.09
Answer: c
REF: MURR Operations Training Manual, II. System Description/Operation, pg. 2-9F

C.10
Answer: d
REF: MURR Operations Training Manual, II. System Description/Operation, pg. 1-9B, 3-9B, 1-9C

C.11
Answer: a
REF: MURR Operations Training Manual, II. System Description/Operation, pg. 1-8D

C.12
Answer: b
REF: MURR Operations Training Manual, II. System Description/Operation, pg. 2-2B

C.13
Answer: c
REF: MURR Operations Training Manual, II. System Description/Operation, pg. 2-3B

C.14
Answer: b
REF: TS 5.3 a., pg. 1 of 1

C.15
Answer: a
REF: TS 3.3 Bases, pg. 4 of 5

C.16
Answer: d
REF: MURR Operations Training Manual, II. System Description/Operation, pg. 2-4A
HSU, Section 5.25, pg. 5-7

C.17
Answer: b
REF: MURR Operations Training Manual, II. System Description/Operation, pg. 2-4A and III. System Details, pg. 2-4A & 3-4A.
HSU, Section 5.2.6, pg. 5-17

C.18
Answer: a
REF: MURR Operations Training Manual, I. System Introduction, pg. 1-5E

C.19
Answer: a
REF: MURR Operations Training Manual, II. System Description/Operation, pg. 3-8A
HSU, Section 8.1, pg. 8-1
HSU, Section 9.1, pg. 9-1

C.20
Answer: b
REF: TS 1.21, pg. 8 of 9