December 2, 2013

Dr. Hyoung K. Lee, Reactor Facility Director
Missouri University of Science and Technology
Nuclear Engineering
222 Fulton Hall
Rolla, MO 65409-0170

SUBJECT: EXAMINATION REPORT NO. 50-123/OL-14-01, MISSOURI UNIVERSITY OF SCIENCE AND TECHNOLOGY

Dear Dr. Lee:

During the week of November 11, 2013, the U.S. Nuclear Regulatory Commission (NRC) administered operator licensing examinations at your Missouri University of Science and Technology Reactor. The examinations were conducted in accordance with NUREG-1478, "Operator Licensing Examiner Standards for Research and Test Reactors," Revision 2. Examination questions and preliminary findings were discussed at the conclusion of the examination with those members of your staff identified in the enclosed report.

In accordance with Title 10, Section 2.390 of the *Code of Federal Regulations*, 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 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 Public Electronic Reading Room). The NRC is forwarding the individual grades to you in a separate letter which will not be released publicly. If you have any questions concerning this examination, please contact Mr. John Nguyen at (301) 415-4007 or via internet e-mail John.Nguyen@nrc.gov.

Sincerely,

/RA/

Gregory T. Bowman, Chief
Research and Test Reactors Oversight Branch
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Docket No. 50-123

Enclosures:
1. Examination Report No. 50-123/OL-14-01
2. Written examination

cc: Bill Bonzer, Reactor Manager
w/o enclosures: See next page

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ADAMS Accession No.: ML13325A410

OFFICE	NRR/DPR/PROB	NRR/DPR/PROB	NRR/DPR/PROB
NAME	JNguyen	CRevelle	GBowman
DATE	11/21/13	12/02/13	12/02/13

OFFICIAL RECORD COPY

cc:

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

Planner, Dept of Health and Senior Services
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930 Wildwood Drive, P.O. Box 570
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1101 Riverside Drive
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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

Craig Reisner
University of Missouri-Rolla
Nuclear Reactor Facility
1870 Miner Circle
Rolla, MO 65409-0630

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

REPORT NO.: 50-123/OL-14-01

FACILITY DOCKET NO.: 50-123

FACILITY LICENSE NO.: R-79

FACILITY: Missouri University of Science and Technology

SUBMITTED BY: **/RA/** 11/21/2014
John T. Nguyen, Chief Examiner Date

SUMMARY:

During the week of November 11, 2014, the NRC administered operator licensing examinations to one Reactor Operator (RO). The candidate passed all applicable portions of the examinations.

REPORT DETAILS

1. Examiner: John T. Nguyen, Chief Examiner

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:

William Bonzer, MSTR, Reactor Manager
Craig Reisner, MSTR, Reactor Training Coordinator
John Nguyen, NRC, Chief Examiner

The NRC examiner thanked the facility for their support in the administration of the examinations. The NRC examiners noted that the license candidate was well prepared for the examinations. The facility licensee had no comments on the written examination.

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

FACILITY: Missouri University of Science and Technology (Rolla)

REACTOR TYPE: MTR

DATE ADMINISTERED: 11/13/2014

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	33.3	_____	_____	A. REACTOR THEORY, THERMODYNAMICS AND FACILITY OPERATING CHARACTERISTICS
18.00	33.3	_____	_____	B. NORMAL AND EMERGENCY OPERATING PROCEDURES AND RADIOLOGICAL CONTROLS
18.00	33.3	_____	_____	C. FACILITY AND RADIATION MONITORING SYSTEMS
54.00		_____ FINAL GRADE	_____ %	TOTALS

All work done on this examination is my own. I have neither given nor received aid.

_____
Candidate's Signature

A. RX THEORY, THERMO & FAC OP CHARS

A N S W E R S H E E T

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

A01 a ___ b ___ c ___ d ___ (0.25 each)

A02 a b c d ___

A03 a b c d ___

A04 a b c d ___

A05 a b c d ___

A06 a b c d ___

A07 a b c d ___

A08 a b c d ___

A09 a b c d ___

A10 a b c d ___

A11 a b c d ___

A12 a b c d ___

A13 a b c d ___

A14 a b c d ___

A15 a b c d ___

A16 a b c d ___

A17 a b c d ___

A18 a b c d ___

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

B. NORMAL/EMERG PROCEDURES & RAD CON

A N S W E R S H E E T

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

B01 a b c d ___

B02 a b c d ___

B03 a b c d ___

B04 a b c d ___

B05 a b c d ___

B06 a b c d ___

B07 a ___ b ___ c ___ d ___ (0.25 each)

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 ___

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

C. PLANT AND RAD MONITORING SYSTEMS

A N S W E R S H E E T

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

C01 a b c d ___

C02 a b c d ___

C03 a b c d ___

C04 a b c d ___

C05 a b c d ___

C06 a b c d ___

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 ___ (0.25 each)
e ___ f ___ g ___ h ___

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 ___

(***** 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

$Q = m\ c_p\ \Delta T$

$\dot{Q} = \dot{m}\ \Delta h$

$\dot{Q} = UA\ \Delta T$

$SUR = \dfrac{26.06\ (\lambda_{eff}\rho)}{(\beta - \rho)}$

$SUR = 26.06/\tau$

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

$P = P_0\ e^{(t/\tau)}$

$P = \dfrac{\beta(1-\rho)}{\beta-\rho}\ P_o$

$\tau = (\ell^*/\rho) + [(\bar{\beta}-\rho)/\lambda_{eff}\rho]$

$\rho = (Keff-1)/Keff$

$\rho = \Delta Keff/Keff$

$\bar{\beta} = 0.007$

$DR_1D_1^2 = DR_2D_2^2$

$Cp\ (H20) = 0.146\ \dfrac{kw}{gpm \cdot {}^\circ F}$

$\lambda_{eff} = 0.1/sec$

$SCR = S/(1-Keff)$

$CR_1\ (1-Keff)_1 = CR_2\ (1-Keff)_2$

$M = \dfrac{(1-Keff)_0}{(1-Keff)_1}$

$M = 1/(1-Keff) = CR_1/CR_0$

$SDM = (1-Keff)/Keff$

$I = I_o\ e^{-ux}$

neutron life time (ℓ^*) = 1×10^{-4} seconds

$\tau^* = \ell^*/(\bar{\rho})$

$R = 6\ C\ E\ n$

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

$DR = DR_oe^{-\lambda t}$

$P = S / (1 - Keff)$

---

1 Curie = 3.7×10^{10} dps

1 kg = 2.21 lbm

1 hp = 2.54×10^3 BTU/hr

1 Mw = 3.41×10^6 BTU/hr

1 BTU = 778 ft-lbf

°F = 9/5°C + 32

931 Mev = 1 amu

°C = 5/9 (°F - 32)

QUESTION A.1 [1.0 point]
The reactor is operating at full power. A malfunction of equipment in the secondary cooling system causes primary temperature to increase by 10 °C. Fill out the blank with INCREASE or DECREASE due to temperature effects.

a. Slowing down length _____

b. Thermal non-leakage probability _____

c. Fast non-leakage _____

d. Shut down margin _____

QUESTION A.2 [1.0 point]
The reactor is critical. The reactor operator accidentally inserts a fuel element in the core and K_{eff} changes to 1.010. What is the reactor period?

a. 0.001 sec

b. 0.01 sec

c. 0.10 sec

d. 1.0 sec

QUESTION A.3 [1.0 point]
Which ONE of the following describes the difference between a moderator and a reflector?

a. A reflector will increase the fast non-leakage factor whereas a moderator increases the thermal utilization factor.

b. A reflector will increase the reproduction factor whereas a moderator increases the fast fission factor.

c. A reflector will decrease the thermal utilization factor whereas a moderator increases the fast fission factor.

d. A reflector will decrease the neutron production factor whereas a moderator decreases the fast non-leakage factor.

QUESTION A.4 [1.0 point]
A subcritical nuclear reactor has a stable source range count rate of 150 cps with a shutdown reactivity of -2.0% ΔK/K. Approximately how much positive reactivity must be added to establish a stable count rate of 600 cps?

a. 0.53% ΔK/K

b. 1.02% ΔK/K

c. 1.54% ΔK/K

d. 2.00% ΔK/K

QUESTION A.5 [1.0 point]
Which ONE of the following correctly describes the SIX- FACTOR FORMULA?

a. $K_{eff} = K_{\infty}$ / the reproduction factor (η)

b. $K_{\infty} = K_{eff}$ * the total non-leakage probability ($L_f * L_{th}$)

c. $K_{\infty} = K_{eff}$ / the total non-leakage probability ($L_f * L_{th}$)

d. $K_{eff} = K_{\infty}$ * (the resonance escape probability (p)* fast fission factor (ε))

QUESTION A.6 [1.0 point]
A reactor with $K_{eff} = 0.8$ contributes 1000 neutrons in the first generation. Changing from the first generation to the THIRD generation, how many TOTAL neutrons are there after the third generation?

a. 1800

b. 2440

c. 3240

d. 6400

QUESTION A.7 [1.0 point]
Inelastic scattering can be described as a process whereby a neutron collides with a nucleus and a neutron:

a. is absorbed by the nucleus; the nucleus will emit an alpha particle.

b. reappears with the same kinetic energy that had prior to the collision.

c. reappears with a lower kinetic energy; the nucleus will emit gamma after the neutron has left.

d. reappears with a higher kinetic energy, the nucleus will emit gamma after the neutron has left.

QUESTION A.8 [1.0 point]
Which ONE of the following best describes the beta decay (β_{-1}) of a nuclide?

a. The atomic mass number unchanged, and the number of protons increases by 1.

b. The atomic mass number unchanged, and the number of protons decreases by 1.

c. The atomic mass number increases by 1, and the number of protons decrease by 1.

d. The atomic mass number increases by 2, and the number of protons increase by 1.

QUESTION A.9 [1.0 point]
Which ONE of the following describes the difference between prompt and delayed neutrons?
Prompt neutrons …

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

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

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

d. are the dominating factor in determining reactor period, while delayed neutrons have little effect on reactor period.

QUESTION A.10 [1.0 point]
A reactor is subcritical with a K_{eff} of 0.945. If you add 5.5% $\Delta k/k$ of positive reactivity into the core, the reactor will be …

a. subcritical

b. exactly critical

c. supercritical

d. prompt critical

QUESTION A.11 [1.0 point]
Few minutes after a scram, reactor power is at 10 kW with a steady period. Approximately how long will it take for power to reduce to 1 kW?

a. 1 minute

b. 2 minutes

c. 3 minutes

d. 4 minutes

QUESTION A.12 [1.0 point]
Which ONE of the following best describes the likelihood of fission reactions occurring in U-235 and U-238?

a. Neutron cross sections of U-235 and U-238 are independent of the neutron velocity.

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 of low energy levels (eV) are more likely to cause fission with U-238 than neutrons at higher energy levels (MeV).

d. Neutrons of low energy levels (eV) are more likely to cause fission with U-235 than neutrons at higher energy levels (MeV).

QUESTION A.13 [1.0 points]
The delayed neutron fraction, β, is defined as a ratio of:

a. Thermal utilization over fast fission factor.

b. The number of thermal neutrons over the number of fast neutrons in the core.

c. The number of delayed neutrons over the number of total neutrons in the core.

d. The number of thermal neutrons absorbed in fuel over the number of thermal neutrons absorbed in core materials including in fuel.

QUESTION A.14 [1.0 point]
The reactor is on a CONSTANT positive period. Which ONE of the following power changes will take the SHORTEST time to complete?

a. From 1 W to 5 W

b. From 10 W to 30 W

c. From 10 kW to 20 kW

d. From 100 kW to 150 kW

QUESTION A.15 [1.0 point]
Which ONE of the following statements best describes the MAJOR contributor to the production and depletion of Xenon at 200 kW power?

	Xe MAJORLY produced by	Xe MAJORLY depleted by
a.	Directly from fission	Neutron absorption
b.	Directly from fission	Radioactive Decay
c.	Radioactive decay of Iodine	Neutron absorption
d.	Radioactive decay of Iodine	Radioactive Decay

QUESTION A.16 [1.0 point]
The total amount of reactivity added by withdrawing a control rod from a reference height to any other rod height is called?

a. differential rod worth

b. shutdown reactivity

c. integral rod worth

d. reference reactivity

QUESTION A.17 [1.0 point]
The effective target area in cm^2 presented by a single nucleus to an incident neutron beam is defined as:

a. a macroscopic cross section

b. a microscopic cross section

c. a mean free path

d. a neutron flux

QUESTION A.18 [1.0 point]
Given the following Core Reactivity Data during startup:

Control Rod	Total Rod Worth (%Δk/k)	Rod Worth at Critical (%Δk/k)
Rod 1	1.90	1.30
REG Rod	1.20	1.00
Rod 2	1.80	1.00
Rod 3	2.60	1.20

The excess reactivity for the reference core is _____ (%Δk/k):

a. 1.9

b. 2.6

c. 3.0

d. 4.5

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

QUESTION B.1 [1.0 points]
Which ONE of the following does NOT require the NRC approval for changes?

a. Change a secured experiment from 0.4 to 0.6 % ΔK/K in the Technical Specifications

b. Drop the written examination requirement in the Requalification Plan

c. Delete Section 4.3, Site Area Emergency Class, in the Emergency Plan

d. Rearrange sections in SOP 503, Emergency Procedures for an Alert

QUESTION B.2 [1.0 point]
While the reactor is operating with experiments in the Beam Port, which ONE of the following is a violation of Tech Specs?

a. Prior to reactor operation, the Reactor Bridge Radiation Area Monitor (RAM) was inoperable. You replaced it with new operable RAM.

b. Prior to reactor operation, the continuous air monitor (CAM) has been in calibration. You replaced it with new operable RAM.

c. You review the irradiation request form and find that the current experiments contain 10 mg of explosive material.

d. You review the irradiation request form and find that the current experiments have -1.0 % Δk/k of reactivity worth.

QUESTION B.3 [1.0 point]
Per 10 CFR 20, a radiation worker can receive an annual limit of _____ to the skin of whole body.

a. the shallow-dose equivalent of 50 Rems

b. the deep-dose equivalent of 5 Rems

c. the committed-dose equivalent of 5 Rems

d. the sum of deep-dose equivalent and the committed-dose equivalent of 50 Rems

QUESTION B.4 [1.0 points]
Fuel experiments in the amount which would generate a power greater than _____ shall NOT be irradiated at MSTR.

a. 5 W

b. 15 W

c. 25 W

d. 50 W

QUESTION B.5 [1.0 point]
The Emergency Planning Zone (EPZ) is the area:

a. enclosed by the walls of the reactor facility.

b. enclosed by the boundary of the MST University.

c. with a calculated dose of 15 mrem TEDE in 24 hours.

d. with a calculated dose of 75 mrem TEDE in 24 hours.

QUESTION B.6 [1.0 point]
Which ONE of the following is the MINIMUM staffing requirement when the reactor is NOT secured?

a. 1 Reactor Manager in the control room + 1 health physics on call

b. 1 RO in the control room + 1 staff member + 1 RO on call

c. 1 RO in the control room +1 staff member + 1 SRO on call

d. 1 SRO in the control room + 1 RO in the control room + 1 staff member

QUESTION B.7 [1.0 points, 0.25 each]
For Research and Test reactors we primarily worry about two isotopes N^{16} and Ar^{41}. Identify the approximate half-life and gamma energy for each. (Each item has only one answer.)

	Isotope	Radiological Parameters			
a.	Ar^{41} half-life	1) 1.8 sec	2) 1.8 min	3) 1.8 hour	4) 1.8 day
b.	Ar^{41} gamma energy	1) 10 KeV	2) 100 KeV	3) 1 MeV	4) 10 MeV
c.	N^{16} half-life	1) 7 sec	2) 7 min	3) 7 hour	4) 7 day

d. N^{16} gamma energy 1) 6 kev 2) 60 keV 3) 600 keV 4) 6 Mev

QUESTION B.8 [1.0 point]
You are a licensed Reactor Operator (RO). Which ONE of the following persons is allowed to manipulate the control rod under your supervision?

a. School newspaper reporter who helps to write a story about the MST reactor

b. A student who is a member of Nuclear Physics class

c. A contractor who conducts an experiment at MSTR

d. An NRC examiner who administers the NRC examination

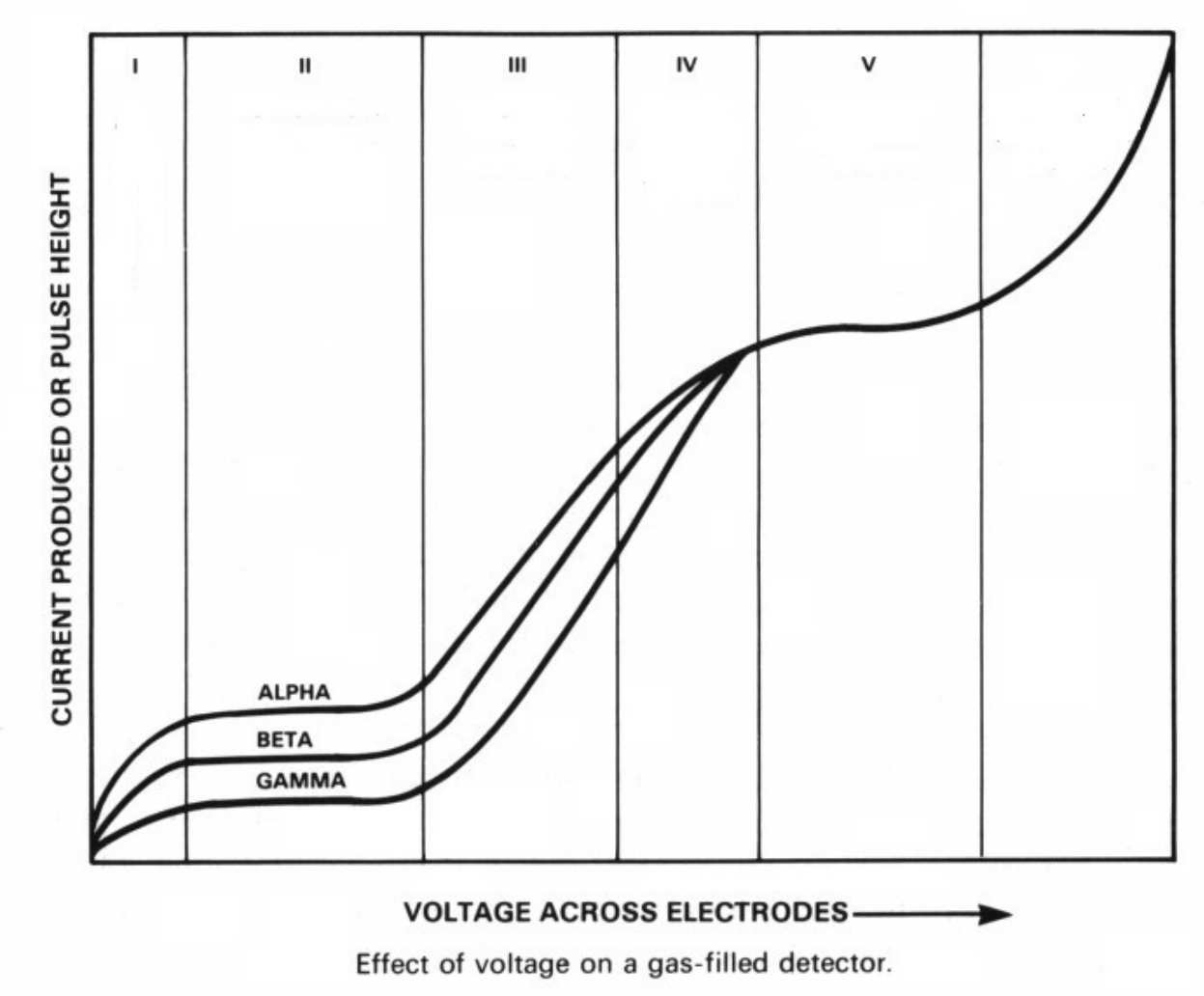
QUESTION B.9 [1.0 point]
Attached is the gas-filled detector curve (detector effect vs. voltage). Different regions of this curve are useful for different detectors. Which ONE of the following is the Geiger Mueller region?

a. II

b. III

c. IV

d. V



Effect of voltage on a gas-filled detector.

QUESTION B.10 [1.0 point]
The SHIM/Safety rod drop times shall be measured:

a. Biennially

b. Annually

c. Semiannually

d. Quarterly

QUESTION B.11 [1.0 point]
What is the minimum level of management who may authorize removing or installing reactor thermocouples?

a. SRO on call

b. SRO on duty

c. Reactor Manager

d. Reactor Director

QUESTION B.12 [1.0 point]
The CURIE content of a radioactive source is a measure of:

a. the amount of energy emitted per unit time by the source.

b. the amount of damage to soft body tissue per unit time.

c. the number of disintegrations per unit time.

d. the number of radioactive atoms in the source.

QUESTION B.13 [1.0 point]
The radiation from an unshielded source is 1 rem/hr. You insert 60 mm thickness of lead sheet; the radiation level reduces to 250 mrem/hr. What is the half-value-layer of lead? (HVL: thickness of lead required so that the original intensity will be reduced by half)?

a. 10 mm

b. 20 mm

c. 30 mm

d. 40 mm

QUESTION B.14 [1.0 point]
Per MST Technical Specifications, which ONE of the following is the MAXIMUM reactivity worth for a moveable experiment?

a. 0.40 % Δk/k

b. 0.50 % Δk/k

c. 0.70 % Δk/k

d. 1.20 % Δk/k

QUESTION B.15 [1.0 point]
A radiation survey of an experiment reveals a radiation reading of 2 mrem/hr at one (1) meter Assume that an experiment is a point source, which ONE of the following defines the posting requirements for the area in accordance with 10CFR Part 20?

a. Public Area

b. Radiation Area

c. High Radiation Area

d. Grave Danger, Very High Radiation Area

QUESTION B.16 [1.0 point]
Per MST Technical Specifications, which ONE of following reactivity values is NOT permissible for reactor operations?

a. Shutdown margin = 2.0% ΔK/K

b. Excess reactivity = 2.0% ΔK/K

c. Reactivity of Regulating rod = 0.50 % Δk/k

d. Reactivity worth of all secured experiment = 1.0 % ΔK/K

QUESTION B.17 [1.0 point, 0.25 each]
Match the following actions used in Column A with their respective definitions in Column B:

	COLUMN A	COLUMN B
a.	You compare the Log & Linear Channel with Linear Power Channel during 100 kW	1. Channel Check
		2. Channel Test
b.	During startup, you verify the reactor rundown at	

120 % power

3. Channel Calibration

c. You depress the Manual Scram button and verify the reactor scram

d. You perform 80% High Voltage Rundown test, and then adjust A4R4 to read 540 voltage

QUESTION B.18 [1.0 point]
Per MST Tech Specs, which ONE of the following does NOT require the direct supervision (i.e., presence) of a Senior Reactor Operator?

a. Initial startup with power approached

b. Recovery from an unplanned shutdown

c. Relocation of an in-core experiment with $0.75 worth

d. Control-rod relocation within the reactor core region

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

QUESTION C.1 [1.0 point]
The MAIN reason to have a hole in the top tube end plug of the regulating rod is to:

a. reduce the amount of Ar-41 release

b. minimize trapping air in the regulating rod

c. bolt the regulating rod to the drive mechanism

c. allow water to flow through in order to cool the regulating rod

QUESTION C.2 [1.0 point]
Which ONE of the following equipment can initiate a rod withdraw prohibit, a rundown, and a reactor scram?

a. CAM

b. RAM

c. Linear Recorder

d. Log & Linear Drawer

QUESTION C.3 [1.0 point]
Half-way through a 6-hour reactor operation at full power, you discover that the ventilation fans haven't been in operation. You try to turn ON, but they do not run. Which ONE of the following actions should you take?

a. Immediately secure reactor operations. This event is a Technical Specification (TS) violation.

b. Immediately secure reactor. This event is NOT a TS violation because the dampers are still opened.

c. Continue with reactor operations. Up to one week is allowed to repair the fans.

d. Continue with reactor operations. The MST Technical Specifications require the fan turn OFF during full power.

QUESTION C.4 [1.0 point]
The MAIN reason to maintain a minimum depth of water between the top of the core and the pool surface is to provide:

a. a proper thermal power calibration

b shielding against radiation at the pool surface

c. sufficient suction head for the purification pump

d. minimize the N-16 release at the pool surface

QUESTION C.5 [1.0 point]
During a loss of building electrical power, the power supplied to the reactor instrumentation will be:

a. automatically switched to the UPS backup.

b. automatically switched to the emergency power generator.

c. lost but it will be automatically restored when building power returns.

d. lost and it will not return until building power returns and the power supplies are manually reset.

QUESTION C.6 [1.0 point]
Which ONE of the following best describes the operation of the building ventilation system exhaust fans and intake louvers during a significant airborne release?

a. Fans #1 and #2 will open; Fan #3 will close. The intake louvers automatically close.

b. Fans #1 and #2 will close; Fan #3 will open. The intake louvers automatically open.

c. Fans #1, #2, and #3 will close. The intake louvers automatically close.

d. Fans #1, #2, and #3 will close. The intake louvers automatically open.

QUESTION C.7 [1.0 point]
You start the reactor at 200 kW with the pool temperature of 20 °C (68 °F) by NATURAL CONVECTION (no heat exchanger). What happens to the reactor if you keep running reactor for about 24 hours? The reactor will be in the _____ state.

a. Normal operation

b. Rod Withdrawal Prohibit

c. Run down

d. Scram

QUESTION C.8 [1.0 point]
During the reactor operation, you accidentally activate the bridge motion switch. Your action will cause:

a. reactor scram. Bridge Motion and Manual Scram annunciators illuminate.

b. reactor run down. Bridge Motion and % power annunciators illuminate.

c. reactor scram. Bridge Motion annunciator illuminates ONLY.

d. RWP. Bridge Motion annunciator illuminates ONLY.

QUESTION C.9 [1.0 point]
Which ONE of the following is the correct parameter used for the calibration of control rods by positive period method at MSTR? The operator will stabilize the reactor power at 10 W and determine:

a. Δ pool level vs. Δ time

b. Δ temperature vs. period

c. Δ pool level vs. Δ reactivity

d. Δ reactivity vs. Δ rod height

QUESTION C.10 [1.0 point]
The equations which describe the neutron startup source at MSTR are:

a. Am-241 -> alpha + Np-237 Be-9 + alpha -> N-12 + neutron

b. Pu-239 -> beta + Am-239 B-10 + beta -> Be-9 + neutron

c. Rb-93 -> beta + Sr-93 Sr-93 -> Sr-92 + neutron

d. Pu-239 -> alpha + U-235 Be-9 + alpha -> C-12 + neutron

QUESTION C.11 [2.0 points, 0.25 each]
Match the input signals listed in column A with their respective responses listed in column B. (Items in column B is to be used more than once or not at all.)

Column A		Column B	
a.	Period = 25 seconds	1.	Indication only
b.	Safety Channel 1 = 150% power	2.	Indication and rod prohibit
c.	Recorder turns off	3.	Indication and run down
d.	CIC voltage = 75%	4.	Indication and scram
e.	Log count rate = 1 cps		
f.	Log & Linear = 110 % full power		
g.	Radiation monitor at reactor top indicates 20 mRem/hr		
h.	Regulating rod insert limit on automatic		

QUESTION C.12 [1.0 point]
In order to comply with Tech Specs, a thermal power calibration is required on a regular interval. Which ONE of following is an INCORRECT procedure in accordance with SOP 816?

a. Turn on nitrogen diffusers and the pool lights.

b. Determine the average pool level drop vs. power.

c. When the reactor thermal output is between 30 to 50 kW- Hr, shutdown the reactor and note the shutdown time.

d. After calculation, if the power indicated on Linear Channel is NOT more than 10% of the calculated power, no adjust required for Linear Channel.

QUESTION C.13 [1.0 point]
SOP 101 specifies that in order to reduce radiological activity within the demineralizer tank, the reactor operator needs to:

a. encapsulate the corrosive material.

b. keep the resistivity of the pool water below 0.2 megohm-cm.

c. turn OFF the reactor pool's water pump after a high power run is performed.

d. close the input and output valves of the demineralizer tank before a high power run.

QUESTION C.14 [1.0 point]
Reactor is in Automatic Mode at 100 kW. You insert an experiment causing the reactor power to increase to 105 kW. Which ONE of the following correctly describes the reactor conditions due to this insertion?

a. Normal operation, reactor is still in Automatic Mode.

b. Rod Run Down, Visual and Audible alarms.

c. Revert to Manual; Visual and Audible alarms.

d. Reactor scram; Visual and Audible alarms.

QUESTION C.15 [1.0 point]
During full power, which ONE of the following methods will reduce the MOST buildup of N-16 in the reactor pool surface?

a. Turn purification system ON, so the demineralizer will absorb more O-16 from the reactor pool.

b. Turn primary pumps ON, so it increases the amount of time for N-16 to stay in the reactor pool.

c. Turn the ventilation system ON, so N-16 will be exhausted through the stack.

d. Turn diffuser pumps ON, so it increases the amount of time for N-16 to stay in the reactor pool.

QUESTION C.16 [1.0 point]
For a shim-safety rod, the "withdraw limit" light is ON, the "insert limit" light is OFF, and the "contact" light is OFF. Assume that no light bulb failure. This means that:

a. Normal condition, control drive is fully out and rod is fully in

b. Normal condition, the control drive and rod are fully out

c. Abnormal condition, misadjusted rod down limit switch

d. Abnormal condition, rod has stuck above lower limit

QUESTION C.17 [1.0 point]
Which ONE of the following experimental facilities will provide the high thermal neutron flux with low gamma flux during full power operation?

a. Pneumatic Sample Transfer System

b. Thermal Column in T mode

c. Sample Rotor Assembly

d. Beam Tube

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

A.1
Answer: a, Increase b, Decrease c, Decrease d, Increase
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Sec 3.3.2

A.2
Answer: b
Reference: Using equations provided in the equation sheet:

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

ρ = (1.01-1)/1.01
ρ = 0.01
For prompt with neutron life time =10^{-4} ,

$$T = \frac{\ell^*}{\rho} = 0.0001/0.01 = 0.01 \text{ sec}$$

A.3
Answer: a
Reference: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, Volume 2, Module 4, Reactor Theory (Reactor Operations), pp. 25-26

A.4
Answer: c
Reference: First, find K_{eff1} with ρ = -2.0% ΔK/K

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

$-0.02\ K_{eff1} = K_{eff1} - 1$ so $1.02\ K_{eff1} = 1$ $K_{eff1} = 0.980$
$CR_2/CR_1 = (1 - K_{eff1})/(1 - K_{eff2})$ $600/150 = (1 - 0.980)/(1 - K_{eff2})$
Then find: $K_{eff2} = 0.995$
$\Delta\rho = (Keff_2 - Keff_1)/(Keff_1 * Keff_2) = (0.995-0.980)/(0.995*0.98) = 1.54\%\ \Delta K/K$

A.5
Answer: c
Reference: DOE Handbook Vol 2, Theory (Nuclear Parameters), E.O. 1.1 a&b, pg. 9

A.6
Answer: b
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1982, § 5.3, p. 5.6
3-nd generation=n + K*n + K^2 *n=1000+800+640= 2440neutrons

A.7
Answer: c
Reference: DOE Fundamentals Handbook, Module 1, Neutron Interactions, page 45.

A.8
Answer a
Reference: Chart of the Nuclides

A.9
Answer: c
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1988

A.10
Answer: a
Reference: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, Volume 2, Module 4
SDM = (1- keff)/keff = (1-0.945)/0.945 = 0.0582 Δk/k, it means you need 0.0582 Δk/k to get criticality. Adding 0.055 Δk/k, the reactor is still subcritical.

A.11
Answer: c
Reference: $P = P_{0*} e^{t/T}$ —> ln(1/10)*-80sec = time; time = 184 sec or 3 min

A.12
Answer: d
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, Section 3.2

A.13
Answer: c
Reference: Introduction to Nuclear Operation, Reed Burn, 1988, Sec 3.3.3, page 3-11.

A.14
Answer: d
Reference: $P = P_0 e^{t/T}$ —> $t = T*Ln(P/P_0)$ assume constant period = 1
$t = Ln(P/P_0)$ —> the smallest ratio of P/P_0 is the shortest time to complete; so it is 150kW/100kW.

A.15
Answer: c
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, Section 8.2

A.16
Answer: c
Reference: Introduction to Nuclear Operation, Reed Burn, 1988, § 7.2 – 7.3 page. 7-1;7.5.

A.17
Answer: b
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, Section 8.2

A.18
Answer: c
Reference: total rod worth – total rod worth at critical
7.5 – 4.5 =3.0 %Δk/k

B.1
Answer: d
Reference: 10 CFR 50.54; 10 CFR 50.59; 10 CFR 55.59

B.2
Answer: b
Reference: TS 3.6 and 3.7

B.3
Answer: a
Reference: 10 CFR 20 (the committed-dose equivalent and the deep-dose equivalent used for individual organ)

B.4
Answer: c
Reference: TS 3.7.2

B.5
Answer: a
Reference: EP 6.0

B.6
Answer: c
Reference: TS 6.1.3

B.7
Answer: a(3); b(3) c(1); d(4) (0.25 each)
Reference: Standard NRC Question

B.8
Answer: b
Reference: TS 6.1.4

B.9
Answer: d
Reference: Standard NRC Question

B.10
Answer: c
Reference: TS Section 4.2.1

B.11
Answer: b
Reference: SOP 806

B.12
Answer: c
Reference: Standard Health Physics Definition

B.13
Answer: c
Reference: $DR = DR_{\circ} * e^{-\mu X}$
Find μ : $250 = 1000 * e^{-\mu * 60}$; μ = 0.0231
If insertion of an HVL (thickness of lead), the original intensity will be reduced by half.
Find X: $1 = 2 * e^{-0.0231 * X}$; X= 30 mm
Find HVL by shortcut:
1000mR- 500 mR is the 1st HVL
500 mR – 250 mR is the 2nd HVL
So HVL=60mm/2 = 30 mm

B.14
Answer: a
Reference: TS 3.7.1

B.15
Answer: b
Reference: 2 mrem/hr at 1 meter (100 cm.) = 22.2 mrem/hr. at 30 cm

B.16
Answer: b
Reference: TS 3.1, 3.7

B.17
Answer: a. = 1; b. = 2; c. = 2; d. = 3 (0.25 each)
Reference: TS 1.0

B.18
Answer: c
Reference: TS 6.1.3

C.1
Answer: b
Reference: SAR 4.2.2

C.2
Answer: d
Reference: SAR Table 7.2. (Due to reactor period of Log & Linear Channel)

C.3
Answer: a
Reference: TS 3.5

C.4
Answer: b
Reference: SAR 5.1

C.5
Answer: d
Reference: SOP 308

C.6
Answer: c
Reference: SAR 9.1

C.7
Answer: b
Reference: SAR 4.6 and Table 7.2 (RWP due to exceeding of operation limit of 135 °F)

C.8
Answer: a
Reference: SOP 810

C.9
Answer: d
Reference: SOP 110

C.10
Answer: d
Reference: SAR 4.2.4

C.11

Answer:	a(2)	b(4)	c(2)	d(3)	
	e(2)	f(1)	g(3)	h(3)	(0.25 each)

Reference: TS 3.2.1 and SAR Table 7.2

C.12
Answer: d
Reference: SOP 816

C.13
Answer: c
Reference: SOP 101, Sec B.5

C.14
Answer: c
Reference: SAR 7.2.2.6 (revert to manual because power level deviates outside of the ± 2 % limit in the Automatic Mode)

C.15
Answer: d
Reference: SAR 5.3

C.16
Answer: a
Reference: SAR 7.2.2.6 (The rod and drive are not in contact, the drive is full out and the rod is full in)

C.17
Answer: b
Reference: SAR 10.2.1