April 2, 2014

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-14-02, MISSOURI UNIVERSITY OF SCIENCE AND TECHNOLOGY

Dear Dr. Lee:

During the week of March 3, 2014, 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. Patrick Isaac at (301) 415-1019 or via internet e-mail Patrick.Isaac@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-14-02
2. Written examination

cc: Bill Bonzer, Reactor Manager
Craig Reisner, Reactor Training Coordinator
w/o enclosures: See next page

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DISTRIBUTION:
PUBLIC PROB r/f

ADAMS Accession No.: ML14080A245 **NRR-079**

OFFICE	NRR/DPR/PROB	NRR/DPR/PROB	NRR/DPR/PROB
NAME	PIsaac	CRevelle	GBowman
DATE	03/24/2014	03/31/2014	0402/2014

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
Section for Environmental Public Health
930 Wildwood Drive, 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>U. S. NUCLEAR REGULATORY COMMISSION</u>
<u>OPERATOR LICENSING INITIAL EXAMINATION REPORT</u>

REPORT NO.: 50-123/OL-14-02

FACILITY DOCKET NO.: 50-123

FACILITY LICENSE NO.: R-79

FACILITY: Missouri University of Science and Technology

SUBMITTED BY: __________/RA/______ ____03/21/2014______
Patrick Isaac, Chief Examiner Date

SUMMARY:

During the week of March 3, 2014, the NRC administered operator licensing examinations to five Reactor Operator (RO) candidates. Two candidates failed the written examination. The other candidates passed all applicable portions of the examinations.

REPORT DETAILS

1. Examiner: Patrick Isaac, Chief Examiner

2. Results:

	RO PASS/FAIL	SRO PASS/FAIL	TOTAL PASS/FAIL
Written	3/2	N/A	3/2
Operating Tests	5/0	N/A	5/0
Overall	3/2	N/A	3/2

3. Exit Meeting:

Craig Reisner, MSTR, Reactor Training Coordinator
Patrick Isaac, NRC, Chief Examiner

The NRC examiner noted that most of the candidates were unable to describe how to add makeup water to the reactor pool. The facility had installed a new “Culligan” water treatment system for adding water to the pool but a procedure to guide the staff in its usage was not developed.

The NRC examiner thanked the facility for their support in the administration of the examinations.

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

FACILITY: Missouri University of Science and Technology - (Rolla)

REACTOR TYPE: MTR

DATE ADMINISTERED: 03/03/2014

CANDIDATE: ______________________________

INSTRUCTIONS TO CANDIDATE:
Answers are to be written on the answer sheet provided. Attach the answer sheets to the examination. Points for each question are indicated in brackets for each question. A 70% in each section is required to pass the examination. Examinations will be picked up three (3) hours after the examination starts.

Category Value	% of Total	Candidates Score	% of Category Value	Category
16.0	33.3	______	____	A. Reactor Theory, Thermodynamics and Facility Operating Characteristics
16.0	33.3	______	____	B. Normal and Emergency Operating Procedures and Radiological Controls
16.0	33.3	______	____	C. Facility and Radiation Monitoring Systems
48.0		______	____% FINAL GRADE	TOTALS

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

____
Candidate's Signature

ENCLOSURE 2

Section A: ReactorTheory, Thermodynamics & Facility Operating Characteristics

ANSWER SHEET

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

MULTIPLE CHOICE

001 a b c d ___

002 a b c d ___

003 a b c d ___

004 a b c d ___

005 a b c d ___

006 a b c d ___

007 a b c d ___

008 a b c d ___

009 a b c d ___

010 a b c d ___

011 a b c d ___

012 a b c d ___

013 a b c d ___

014 a b c d ___

015 a b c d ___

016 a b c d ___

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

Section B Normal, Emergency and Radiological Control Procedures

ANSWER SHEET

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

MULTIPLE CHOICE

001 a b c d ___

002 a b c d ___

003 a b c d ___

004 a b c d ___

005 a b c d ___

006 a ____ b ____ c ____ d ____

007 a b c d ___

008 a b c d ___

009 a b c d ___

010 a b c d ___

011 a b c d ___

012 a b c d ___

013 a ____ b ____ c ____ d ____

014 a b c d ___

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

Section 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.

MULTIPLE CHOICE

001 a b c d ___

002 a ____ b ____ c ____ d ____

003 a b c d ___

004 a b c d ___

005 a b c d ___

006 a b c d ___

007 a b c d ___

008 a b c d ___

009 a b c d ___

010 a b c d ___

011 a b c d ___

012 a b c d ___

013 a b c d ___

014 a b c d ___

015 a b c d ___

016 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.
13. When you have completed and turned in you examination, leave the examination area. If you are observed in this area while the examination is still in progress, your license may be denied or revoked.

EQUATION SHEET

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

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

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

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

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

$$\ell^* = 1\times10^{-4}\sec$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$A_f = A_o(1 - e^{-\lambda t})$$

$$I = I_o e^{-\mu x}$$

$$\mu_m = \frac{\mu}{\rho}$$

DR – Rem/hr, 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

Section A _ Theory, Thermo & Fac. Operating Characteristics

Question A.1 [1.0 point]
Core excess reactivity changes with …

a. fuel element burnup

b. control rod height

c. neutron energy level

d. reactor power level

Question A.2 [1.0 point]
You enter the control room and note that all nuclear instrumentation show a steady neutron level, and no rods are in motion. Which ONE of the following conditions CANNOT be true?

a. The reactor is critical.

b. The reactor is subcritical.

c. The reactor is supercritical.

d. The neutron source has been removed from the core.

Question A.3 [1.0 point]
Which one of the following describes how delayed neutrons affect control of the reactor?

a. More delayed neutrons are produced than prompt neutrons resulting in a longer time to reach a stable subcritical countrate.

b. Delayed neutrons are born at higher energies than prompt neutrons resulting in a shorter reactor period from increased leakage.

c. Delayed neutrons take longer to thermalize than prompt neutrons resulting in a longer reactor period.

d. Delayed neutrons increase the average neutron lifetime resulting in a longer reactor period.

Section A _ Theory, Thermo & Fac. Operating Characteristics

Question A.4 [1.0 point]
Which one of the following describes the Technical Specifications “Minimum Shutdown Margin” of the Rolla reactor?

a. When the reactor is subcritical by at least one dollar in the reference core condition with the reactivity worth of all installed experiments included.

b. Whenever there is insufficient moderator available in the reactor to attain criticality.

c. Whenever the reactor is shutdown by more than 1.0% Δk/k with the highest worth control rod and the regulating rod fully withdrawn.

d. The amount of reactivity inserted if all the control rods are inserted and the reactor is subcritical by at least one dollar in the reference core condition.

Question A.5 [1.0 point]
Which one of the following describes "excess reactivity"?

a. Extra reactivity into the core due to the presence of the source neutrons.

b. A measure of the resultant reactivity if all of the control rods and other poisons were moved to the maximum reactive condition when the reactor is critical.

c. The combined reactivity worth of control rods and chemical poison needed to keep the reactor shutdown.

d. The sum of the absolute values of all experiments which shall be no greater than 1.2% Δk/k.

Question A.6 [1.0 point]
Which one of the following is the MAJOR source of energy released during fission? Kinetic Energy of the…

a. prompt gamma rays.

b. capture gammas.

c. Beta particles.

d. fission fragments.

Question A.7 [1.0 point]
Which one of the following describes the MAJOR contributor to the production and depletion of Xenon respectively in a STEADY-STATE OPERATING reactor?

	Production	Depletion
a.	Radioactive decay of Iodine	Radioactive Decay
b.	Radioactive decay of Iodine	Neutron Absorption
c.	Directly from fission	Radioactive Decay
d.	Directly from fission	Neutron Absorption

Question A.8 [1.0 point]
Following a scram, the value of the stable reactor period is:

a. Approximately 50 seconds, because the rate of negative reactivity insertion rapidly approaches zero.

b. Approximately -10 seconds, as determined by the rate of decay of the shortest lived delayed neutron precursors.

c. Approximately -80 seconds, as determined by the rate of decay of the longest lived delayed neutron precursors.

d. Infinity, since neutron production has been terminated.

Question A.9 [1.0 point]
A short reactor period is a greater hazard when reactor power is:

a. Close to 100%

b. Above the point where power level is producing enough energy to make up for the energy lost to ambient

c. Above 15 watts

d. Close to source counts

Section A _ Theory, Thermo & Fac. Operating Characteristics

Question A.10 [1.0 point]
Which one of the following explains the response of a SUBCRITICAL reactor to equal insertions of positive reactivity as the reactor approaches criticality? Each reactivity insertion causes:

a. a SMALLER increase in the neutron flux resulting in a LONGER time to stabilize.

b. a LARGER increase in the neutron flux resulting in a LONGER time to stabilize.

c. a SMALLER increase in the neutron flux resulting in a SHORTER time to stabilize.

d. a LARGER increase in the neutron flux resulting in a SHORTER time to stabilize.

Question A.11 [1.0 point]
A control rod is withdrawn from the core. Which of the following explains the reactivity addition from the rod?

a. Reactivity added will be equal for each inch of withdrawal.

b. Reactivity addition per inch will be greatest from 40% to 60% withdrawn.

c. Reactivity addition per inch will be greatest in the bottom fourth of the core.

d. Reactivity addition per inch will be greatest in the top fourth of the core.

Question A.12 [1.0 point]
Which one of the following is the reason for an installed neutron source within the core? A startup without an installed neutron source …

a. is impossible as there would be no neutrons available to start up the reactor.

b. would be very slow due to the long time to build up neutron population from so low a level.

c. could result in a very short period due to the reactor going critical before neutron population built up high enough to be read on nuclear instrumentation.

d. can be compensated for by adjusting the compensating voltage on the source range detector.

Section A _ Theory, Thermo & Fac. Operating Characteristics

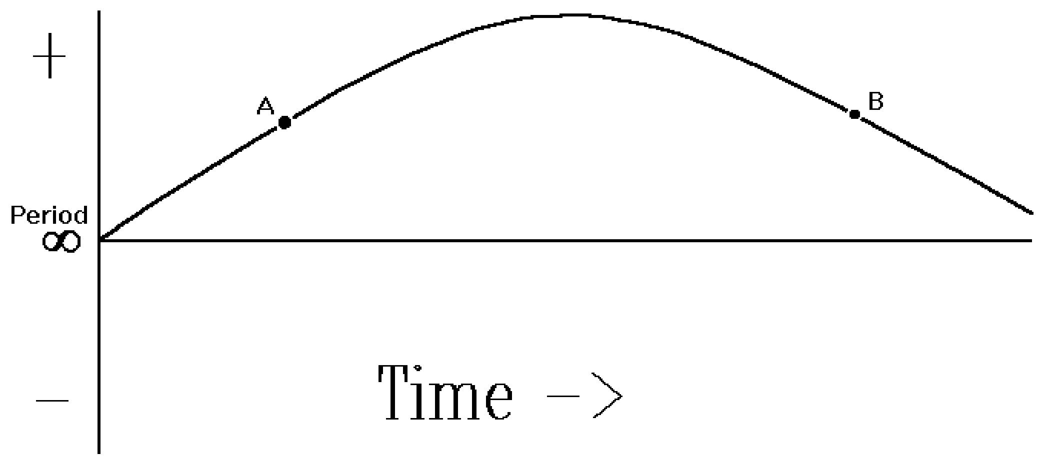
Question A.13 [1.0 point]
Shown below is a trace of reactor period as a function of time. Between points A and B reactor power is:

a. continually increasing.

b. increasing, then decreasing.

c. continually decreasing.

d. constant.



Question A.14 [1.0 point]
Which one of the following will be the resulting stable reactor period when a $0.25 reactivity insertion is made into an exactly critical reactor core? (Assume a β of 0.0070 and a λ of 0.1 sec^{-1})

a. 50 seconds

b. 38 seconds

c. 30 seconds

d. 18 seconds

Question A.15 [1.0 point]
By definition, an exactly critical reactor can be made prompt critical by adding positive reactivity equal to …

a. the shutdown margin

b. the K_{excess} margin

c. the β_{eff} value

d. 1.0 %ΔK/K.

Question A.16 [1.0 point]
Reactor power doubles in 42 seconds. Based on the period associated with this transient, how long will it take for reactor power to increase by a factor of 10?

a. 80 seconds

b. 110 seconds

c. 140 seconds

d. 170 seconds

Section B Normal and Emergency Operating Procedures and Radiological Controls

Question B.1 [1.0 point]
For the purpose of a reactor startup to low power, the reactor is considered “hot” if …

a. within the past 52 hours it has been operated above 200 kW.

b. after a shutdown the Startup channel count rate is still decreasing.

c. within the past 52 hours power levels have not exceeded 20 kW-hr.

d. the reactor is not considered “clean”.

Question B.2 [1.0 point]
An experimenter wishes to irradiate three specimens with reactivity worth’s of 0.5% Δk/k, 0.13% Δk/k and 0.27% Δk/k. Can these specimens be placed in the reactor as UNSECURED experiments and why (why not).

a. Yes, the sum of the three specimens is less than 1.2% Δk/k.

b. No, the sum of the three specimens is greater than 0.8% Δk/k.

c. Yes, each specimen is less than 0.6% Δk/k.

d. No, one of the specimens is greater than 0.4% Δk/k.

Question B.3 [1.0 point]
SOP 501 Emergency Procedures for Reactor Building Evacuation lists the actions for you (the RO) and the SRO on duty to take during this type of an emergency. The lowest level of management authorized to instruct you to proceed differently from the items listed in your checklist is …

a. SRO on Duty

b. Reactor Manager

c. Reactor Director

d. NRC Project Manager

Section B Normal and Emergency Operating Procedures and Radiological Controls

Question B.4 [1.0 point]

Your Reactor Operator license expires after _____ years.

a. 2

b. 4

c. 6

d. 8

Question B.5 [1.0 point]

While working on an experiment, you receive the following radiation doses: 100 mrem (β), 25 mrem (γ), and 5 mrem (thermal neutrons). Which one of the following is your total dose?

a. 175 mrem

b. 155 mrem

c. 145 mrem

d. 130 mrem

Question B.6 [2.0 points, 0.5 point each]

Identify each of the following actions as either a channel CHECK **(1)**, a channel TEST **(2)**, or a channel Calibration **(3)**.

a. Prior to startup you place a known radioactive source near a radiation detector, noting meter movement and alarm function operation.

b. Prior to the day's operation, you turn the Log Count Rate selector switch to 102, 103, and 104, verifying that the meter and recorder follow.

c. At power, you perform a heat balance (calorimetric) and determine you must adjust Nuclear Instrumentation readings.

d. During a reactor shutdown you note a -80 second period on Nuclear Instrumentation.

Section B Normal and Emergency Operating Procedures and Radiological Controls

Question B.7 [1.0 point]
In accordance with the Emergency Plan, the site boundary is:

a. the outside walls of the reactor confinement building.

b. a 500 meter radius from the reactor building.

c. the Emergency Support Center.

d. the UMR campus boundary.

Question B.8 [1.0 point]
A radioactive sample is to be removed from the reactor pool. The sample is surveyed and the dose rate is found to be 60 mR/hr at 1 foot. In accordance with SOP-601, the sample may be handled:

a. by the reactor staff.

b. only with permission from the Health Physicist.

c. by students with the permission of the reactor staff.

d. only by the Health Physicist.

Question B.9 [1.0 point]
The Technical Specifications require that experimental verification of calculated values of airborne radioactive effluents be performed annually. The purpose of this requirement is to measure the airborne radioactivity associated with:

a. Nitrogen-16.

b. Argon-41.

c. Iodine-131.

d. Cesium-137.

Section B Normal and Emergency Operating Procedures and Radiological Controls

Question B.10 [1.0 point]
Which one of the operations below does NOT require the authorization or supervision of the Senior Reactor Operator on Duty?

a. Bypass High Radiation Area alarm.

b. Place reactor in automatic control.

c. Power increase on a 35-second period.

d. Operation at greater than 20 kW with no nitrogen diffuser on.

Question B.11 [1.0 point]
According to SOP 104, “Reactor Power Changes and Stable Operations”, at least one diffuser pump should be turned on for operations above …

a. 1 Kilowatt

b. 2 Kilowatts

c. 10 Kilowatts

d. 20 Kilowatts

Question B.12 [1.0 point]
Which one of the following correctly defines a Safety Limit?

a. Limits on important process variables which are found to be necessary to reasonably protect the integrity of certain physical barriers which guard against the uncontrolled release of radioactivity.

b. The Lowest functional capability of performance levels of equipment required for safe operation of the facility.

c. Settings for automatic protective devices related to those variables having significant safety functions.

d. A measuring or protective channel in the reactor safety system.

Section B Normal and Emergency Operating Procedures and Radiological Controls

Question B.13 [2.0 points, 0.5 each]
Match the Control Channel in column A with its respective rundown setpoint in column B.

Control Channel	Setpoint
a. Linear power (%)	1. 15
b. Reactor period (seconds)	2. 20
c. Low CIC voltage (%)	3. 80
d. Radiation Monitors (mR/hr)	4. 120

Question B.14 [1.0 point]
Which one of the following is the definition of Emergency Action Level?

a. a condition that calls for immediate action, beyond the scope of normal operating procedures, to avoid an accident or to mitigate the consequences of one.

b. Specific instrument readings, or observations; radiation dose or dose rates; or specific contamination levels of airborne, waterborne, or surface-deposited radioactive materials that may be used as thresholds for establishing emergency classes and initiating appropriate emergency methods.

c. classes of accidents grouped by severity level for which predetermined emergency measures should be taken or considered.

d. a document that provides the basis for actions to cope with an emergency. It outlines the objectives to be met by the emergency procedures and defines the authority and responsibilities to achieve such objectives.

Section C Facility and Radiation Monitoring Systems

Question C.1 [1.0 point]
Which one of the following is the method used to minimize mechanical shock to the control rods on a scram?

a. A small spring located at the bottom of the rod.

b. An electrical-mechanical brake energizes when the rod down limit switch is energized.

c. A piston (part of the connecting rod) drives air out of a dashpot as the rod nears the bottom of travel.

d. A piston attached to the upper end of the safety rod enters a special damping cylinder as the rod approaches the full insert position.

Question C.2 [1.0 point, 0.25 each]
Correctly identify the correct protective action (items 1 through 6) with each of the following situations (a through d). *Items 1 through 6 may be used more than once or not at all*.

Situations	Protective Actions:
a. Period < 30 seconds	1. Scram
b. Log N and Period Amp. Not Operative	2. Rundown
c. Effluent Pool Demineralizer Conductivity high	3. Rod Withdrawal Prohibit
d. High Neutron Flux in Beam Room	4. Operator Response

Question C.3 [1.0 point]
Which one of the following radiation monitors will energize the evacuation alarm?

a. Experiment Room RAM

b. Demineralizer RAM

c. Reactor Bridge RAM

d. CAM

Section C Facility and Radiation Monitoring Systems

Question C.4 [1.0 point]
Each shim/safety rods consists of a grooved,

a. hafnium rod.

b. boron-carbide rod.

c. boral (boron and aluminum alloy) rod.

d. boron steel rod.

Question C.5 [1.0 point]
Which one of the listed radioisotopes is best detected by the Continuous Air Monitor?

a. Rb88

b. N16

c. Ar41

d. Xe136

Question C.6 [1.0 point]
Which one of the following conditions would activate an interlock preventing Shim-Safety Rod withdrawal?

a. Radiation Area Monitor = 25 mr/hour.

b. Reactor period = 15 seconds.

c. Log power recorder is out of service.

d. Period amplifier not operable.

Section C Facility and Radiation Monitoring Systems

Question C.7 [1.0 point]
On receipt of a scram signal, with the regulating rod controlling in AUTO, the regulating rod will:

a. remain at its position at the time of the scram.

b. receive a rod run-in signal and be driven into the core.

c. be magnetically decoupled from the drive, and drop into the core via gravity.

d. receive a mismatch signal and be driven out of the core attempting to maintain power stable.

Question C.8 [1.0 point]
During a loss of coolant accident the purification system may be used to refill the pool at a rate of …

a. 10 gpm

b. 20 gpm

c. 30 gpm

d. 40 gpm

Question C.9 [1.0 point]
Which ONE of the following is NOT a feature of the Pneumatic Sample Transfer system designed to reduce overall radiation levels in the facility?

a. The tube has a slight curve through the pool (preventing a beam of radiation directly from the core).

b. Exhaust of the system is sent through a high efficiency filter (Reduces the amount of radioactive particles released to the atmosphere in the reactor room).

c. The tubes are lined with Cadmium (reduces the fast neutron flux at the surface of the pool).

d. N_2 gas is used to move the rabbit (reduces the generation of gaseous radioisotopes).

Section C Facility and Radiation Monitoring Systems

Question C.10 [1.0 point]
Which one of the following types of detector is utilized in the continuous air monitoring system?

a. Geiger-Mueller tube.

b. Scintillation detector.

c. Ionization chamber.

d. Proportional counter.

Question C.11 [1.0 point]
Which one accident below is designated as the Maximum Hypothetical Accident for the MUSTR?

a. Failure of a fueled experiment.

b. Fuel element handling accident.

c. Loss of coolant accident.

d. Failure of a movable experiment.

Question C.12 [1.0 point]
Which one of the following methods is used to compensate for gamma radiation in a Fission Chamber?

a. Pulses smaller than a specific height are stopped by a pulse-height discriminator circuit from entering the instrument channel’s amplifier.

b. The chamber contains concentric tubes one of which detects both neutrons and gammas the other only gammas, are wired electronically to subtract the gamma signal, leaving only the signal due to neutrons.

c. The signal travels through a Resistance-Capacitance (RC) circuit, converting the signal to a power change per time period effectively deleting the signal due to gammas.

d. A compensating voltage equal to a predetermined “source gamma level” is fed into the pre-amplifier electronically removing source gammas from the signal. Fission gammas are proportional to reactor power and therefore not compensated for.

Section C Facility and Radiation Monitoring Systems

Question C.13 [1.0 point]
Which ONE of the following has a battery backup so that even on a loss of power it will cause an alarm at the campus police station?

a. Pool Low Level

b. All three Radiation Area Monitors

c. Continuous Air Monitor

d. Fire Alarm System

Question C.14 [1.0 point]
Which ONE of the following correctly describes how indicated power will compare to actual power for a loss of compensating voltage to the Linear Channel detector? Power level is at 150 watts, when the compensating voltage is lost.

a. Indicated power will peg high.

b. Indicated power is slightly higher than actual power.

c. Indicated power is slightly lower than actual power.

d. Indication will read zero.

QUESTION C.15 [1.0 point]
Input to the servo system is provided by the:

a. Log and Linear Power Channel.

b. Linear Power Channel.

c. Safety Channel #1.

d. Safety Channel #2.

QUESTION C.16 [1.0 point]
Per MUSTR Technical Specifications, the minimum resistivity of the MUST pool water shall be greater than ______ megohm-cm when the fuel elements are in the reactor pool.

a. 0.2

b. 0.5

c. 2.0

d. 5.0

***** END OF EXAMINATION *****

Section A Facility and Radiation Monitoring Systems

A.1 a
REF: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, §

A.2 c
REF: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, §

A.3 d
REF: Glasstone, S. and Sesonske, A, *Nuclear Reactor Engineering,* Kreiger Publishing, Malabar, Florida, 1991, § 5.20, p. 236.

A.4 c
REF: MUST Technical Specifications 3.1

A.5 b
REF: MUST Technical Specifications 3.1

A.6 d
REF: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, §

A.7 b
REF: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, §

A.8 c
REF: Glasstone, S. and Sesonske, A, *Nuclear Reactor Engineering,* Kreiger Publishing, Malabar, Florida, 1991, § 5.47, p. 246.

A.9 d
REF: Glasstone, S. and Sesonske, A, *Nuclear Reactor Engineering,* Kreiger Publishing, Malabar, Florida, 1991, § 5.18, p. 234.

A.10 b
REF: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, §

A.11 b
REF: Glasstone, S. and Sesonske, A, *Nuclear Reactor Engineering,* Kreiger Publishing, Malabar, Florida, 1991, §§ 5.224 — 5.229, pp. 306 — 307.

A.12 c
REF: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, §

A.13 a
REF: Since period is always positive, reactor power is increasing, but at different rates.

Section A Facility and Radiation Monitoring Systems

A.14 c
REF: Glasstone, S. and Sesonske, 1991, § 5.18, p. 234.
$T = (\beta-\rho)/\lambda\rho$ $T = (.0070 - .00175)/.1 \times .00175$ T = 30 seconds

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

A.16 c
$P = P_0 e^{t/\tau}$ 1st find τ. τ = time/(ln(2)) = 42/0.693 = 60.6 sec. Time = $\tau \times$ ln(10) = 60.6 $\times$ 139.5 sec
REF: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, §

Section B Normal and Emergency Operating Procedures and Radiological Controls

B.1 b
REF: SOP 103 Startup to Low Power, § B.2.

B.2 d
REF: Technical Specifications 3.7.1

B.3 a
REF: SOP 501 Emergency Procedures for Reactor Building Evacuation § C.I.6

B.4 c
REF: 10CFR55.55(a)

B.5 d
REF: A rem is a rem.

B.6 a = 1; b = 2; c = 3; d = 1
REF: Technical Specification 1.3 Definitions, p. 2.

B.7 d
REF: University of Missouri-Rolla Emergency Plan, Page 4.

B.8 a
REF: SOP 601, Handling of Radioactive Samples.

B.9 b
REF: SAR, Section 7.6.1.

B.10 b
REF: SOP 104, Reactor Power Changes and Stable Operations.

B.11 d
REF: SOP 104, § B.3.

B.12 a
REF: Technical Specifications § 1, Definitions

B.13 a = 4; b = 1; c = 3; d = 2
REF: Technical Specification Table 3.1

B.14 b
REF: Emergency Plan, § 2.0 Definitions, p. 2-1.

Section C Facility and Radiation Monitoring Systems

C.1 d
REF: SAR § 3.2.3, p. 3-13

C.2 a. = 3; b. = 1; c. = 4; d. = 4
REF: SAR page 3-41, Table IX

C.3 c
REF: Technical Specifications Table 3.3 and SAR § 3.6.2, pp. 3-46 – 3-48.

C.4 d
REF: SAR § 3.2.3, p. 3-11.

C.5 a
REF: SAR § 3.6.2, 7th ¶.
(Designed to detect particulate NOT gaseous radioactivity.)

C.6 c
REF: SAR, Table IX, page 3-41.

C.7 a
REF: SAR § 3.2.3 6th ¶

C.8 c
REF: SAR § 5.2

C.9 c
REF: SAR § 4.3, p. 4-5.

C.10 a
REF: SAR, page 3-47.

C.11 a
REF: SAR, page 9-19.

C.12 a
REF: Standard NRC Question

C.13 d
REF: SAR § 5.5

C.14 b
REF: Standard NRC Question

C.15 b
REF: SAR § 3.5.2

Section C Facility and Radiation Monitoring Systems

C.16 a
REF: TS 3.3