August 11, 2016

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-16-02, MISSOURI UNIVERSITY OF SCIENCE AND TECHNOLOGY

Dear Dr. Lee:

On July 18, 2016, Mr. Craig Reisner administered an U.S. Nuclear Regulatory Commission (NRC) prepared operator licensing examination at your Missouri University of Science and Technology reactor. The examinations were conducted according to NUREG-1478, "Operator Licensing Examiner Standards for Research and Test Reactors," Revision 2. Examination questions and preliminary findings were discussed at the conclusion of the examination with those members of your staff identified in the enclosed report.

In accordance with Title 10 of the *Code of Federal Regulations* Section 2.390, a copy of this letter and the enclosures will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records 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 T. Nguyen at (301) 415-4007 or via internet e-mail John.Nguyen@nrc.gov.

Sincerely,

/RA/

Anthony J. Mendiola, Chief
Research and Test Reactors Oversight Branch
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Docket No. 50-123

Enclosures:
1. Examination Report No. 50-123/OL-16-02
2. Written examination

cc: William E. Bonzer
cc: w/o enclosures: See next page

August 11, 2016

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-16-02, MISSOURI UNIVERSITY OF SCIENCE AND TECHNOLOGY

Dear Dr. Lee:

On July 18, 2016, Mr. Craig Reisner administered an U.S. Nuclear Regulatory Commission (NRC) prepared operator licensing examination at your Missouri University of Science and Technology reactor. The examinations were conducted according to NUREG-1478, "Operator Licensing Examiner Standards for Research and Test Reactors," Revision 2. Examination questions and preliminary findings were discussed at the conclusion of the examination with those members of your staff identified in the enclosed report.

In accordance with Title 10 of the *Code of Federal Regulations* Section 2.390, a copy of this letter and the enclosures will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records 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 T. Nguyen at (301) 415-4007 or via internet e-mail John.Nguyen@nrc.gov.

Sincerely,
/RA/
Anthony J. Mendiola, Chief
Research and Test Reactors Oversight Branch
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Docket No. 50-123

Enclosures:
1. Examination Report No. 50-123/OL-16-02
2. Written examination

cc: William E. Bonzer
cc: w/o enclosures: See next page

DISTRIBUTION:
PUBLIC AAdams STraiforos MMorlang

ADAMS ACCESSION NO.: ML16216A139

OFFICE	DPR/PROB/CE	DPR/IOLB/LA	DPR/PROB/BC
NAME	JNguyen	CRevelle	AMendiola
DATE	08/09/2016	08/10/2016	08/11/2016

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
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

Dr. Ralph Flori, Interim Chair
Mining and Nuclear Engineering
Missouri University of Science
and Technology
226 McNutt Hall
Rolla, MO 65409-0450

Mr. 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-16-02

FACILITY DOCKET NO.: 50-123

FACILITY LICENSE NO.: R-79

FACILITY: Missouri University of Science and Technology

SUBMITTED BY: **/RA/** 08/09/2016
John T. Nguyen, Chief Examiner Date

SUMMARY:

Mr. Craig Reisner administered an U.S. Nuclear Regulatory Commission (NRC) prepared operator licensing examination for two candidates who had failed Section B of the NRC written examination administered in March 2016. Both candidates passed the retake examination.

REPORT DETAILS

1. Examiner: John T. Nguyen, Chief Examiner

2. Results:

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

3. Exit Meeting:

Due to the nature of this examination there was no exit meeting.

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

FACILITY: Missouri University of Science and Technology

REACTOR TYPE: MSTR

DATE ADMINISTERED: 07/18/2016

CANDIDATE: _____

INSTRUCTIONS TO CANDIDATE:
Answers are to be written on the Answer sheet provided. Attach Answer sheet to the examination. Point values are indicated in parentheses for each question. A 70% in this category is required to pass the examination. Examinations will be picked up one (1) hour after the examination starts.

CATEGORY VALUE	% OF TOTAL	CANDIDATE'S SCORE	% OF CATEGORY VALUE	CATEGORY
N/A				A. REACTOR THEORY, THERMODYNAMICS AND FACILITY OPERATING CHARACTERISTICS
20.00	100.0			B. NORMAL AND EMERGENCY OPERATING PROCEDURES AND RADIOLOGICAL CONTROLS
N/A				C. FACILITY AND RADIATION MONITORING SYSTEMS
20.00				% TOTALS
		FINAL GRADE		

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

_____
Candidate's Signature

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 ___

e ___ f ___ g ___ h ___

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 ___

(********** 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 this category.

12. There is a time limit of one (1) hour for completion of the examination.

EQUATION SHEET

$Q = m\, c_p\, \Delta T$

$Q = m\, \Delta h$

$Q = UA\, \Delta T$

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

$SUR = 26.06/\tau$

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

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

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

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

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

$\rho = \Delta Keff/Keff$

$\bar{\beta} = 0.007$

$DR_1D_1^2 = DR_2D_2^2$

$Cp\ (H20) = 0.146\ \dfrac{kw}{gpm\ \cong EF}$

$\lambda_{eff} = 0.1/sec$

$SCR = S/(1-Keff)$

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

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

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

$SDM = (1-Keff)/Keff$

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

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 hp = 2.54×10^3 BTU/hr

1 BTU = 778 ft-lbf

931 Mev = 1 amu

1 kg = 2.21 lbm

1 Mw = 3.41×10^6 BTU/hr

°F = 9/5°C + 32

°C = 5/9 (°F - 32)

Section B: Normal/Emergency Procedures and Radiological Controls

QUESTION B.01 [1.0 points]
Per MSTR Technical Specifications, a ventilation fan with a rated capacity of at least 4,500 cubic feet per minute (cfm) shall be turned on within 10 minutes after _____.

a. the reactor is critical

b. the reactor is at full power

c. the reactor power level exceeds 100 kW

d. the radioactive gaseous effluents exceeds 127.4 µci/mL released to the stack

QUESTION B.02 [2.0 points, 0.25 each]
Per MSTR Technical Specifications, match the input Channel 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 = 30 seconds	1.	Normal
b.	Safety Channel #1 = 150%	2.	Rod Withdrawal Prohibit
c.	Recorder turns off	3.	Rod Run Down
d.	CIC voltage = 80%	4.	Scram
e.	Log count rate = 3 cps		
f.	Linear Power Demand = 110 % full power		
g.	Radiation monitor at reactor top = 20 mRem/hr		
h.	Regulating rod insert limit on automatic		

QUESTION B.03 [1.0 point]
Two point sources have the same Curie strength. Source B's gammas have an energy of 1 MeV, while Source A's gammas have an energy of 4 MeV. You obtain a reading from the same GM tube radiation monitor 10 feet from each source. Concerning the two readings, which ONE of the following statements is true?

a. The reading from Source A is four times that of Source B

b. The reading from Source A is twice that of Source B

c. The reading from Source A is the same as Source B

d. The reading from Source A is 1/4 that of Source B

Section B: Normal/Emergency Procedures and Radiological Controls

QUESTION B.04 [1.0 point]
Which ONE of the following changes must be submitted to NRC for approval prior to implementation?

a. Replace an old Linear Channel with identical Linear Channel

b. Delete Section 1 listed in the SOP 103, Reactor Startup to Lower Power

c. Add more responsibilities to the Radiation Protection Officer listed in the health physics procedure

d. Delete a definition of “Reactor Shutdown” listed in the MSTR Technical Specifications

QUESTION B.05 [1.0 point]
The MSTR reactor operator, who receives the total effective dose equivalent (TEDE) of 5 Rems, shall be _____.

a. placed under medical observation

b. restricted from any further radiation work

c. allowed to continue working until exceeding of 25 rems (TEDE)

d. restricted from any further radiation work and immediately transported to medical facility

QUESTION B.06 [1.0 point]
In the event of a suspected fuel leak, which ONE of the following nuclides would most likely be found in the Stack Particulate Monitor?

a. N-16

b. Na-24

c. Ar-41

d. I-135

Section B: Normal/Emergency Procedures and Radiological Controls

QUESTION B.07 [1.0 point, 0.25 each]
Match the license requirement listed in Column A for an actively licensed operator with the correct 10 CFR regulatory requirement listed in Colum B.

	Column A		Column B
a.	Facility Licenses	1.	10 CFR 20
b.	Notices, Instructions and Reports to Workers	2.	10 CFR 50
c.	Radiation Protection	3.	10 CFR 55
d.	Maintain an active operator or senior operator license	4.	10 CFR 19

QUESTION B.08 [1.0 point]
Per NRC regulation, the reactor operator must be actively performed for a minimum of _____ to maintain an active Reactor Operator/Senior reactor Operator license.

a. 4 hours per calendar quarter

b. 4 hours per calendar month

c. five 8-hour shifts per calendar quarter

d. 40 hours per calendar year

QUESTION B.09 [1.0 point]
An experimenter wishes to irradiate three specimens with reactivity worths 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 provide a justification?

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

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

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

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

Section B: Normal/Emergency Procedures and Radiological Controls

QUESTION B.10 [1.0 point]
The MINIMUM staffing requirement when the reactor is NOT shutdown shall be:

a. 1 SRO in the control room and 1 health physics on call

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

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

d. 1 SRO on call, 1 reactor manager in the control room, and 1 staff member

QUESTION B.11 [1.0 point]
_____ specifies the limiting conditions for operations of the facility.

a. Emergency Plan

b. Physical Security Plan

c. Technical Specifications

d. Operator Licensing Requalification Plan

QUESTION B.12 [1.0 point]
The Quality Factor is used to convert:

a. an absorbed dose in rads to dose equivalent in rems

b. an absorbed dose in rems to dose equivalent in rads

c. contamination in rads to contamination equivalent in rems

d. contamination in rems to contamination equivalent in rads

Section B: Normal/Emergency Procedures and Radiological Controls

QUESTION B.13 [1.0 point]
The shim/safety rod drop times shall be measured:

a. Monthly

b. Semi-annually

c. Annually

d. Biannually

QUESTION B.14 [1.0 point]
A radioactive material is decaying at a rate of 30% per every hours. Determine its half-life?

a. 2 hours

b. 3 hours

c. 4 hours

d. 5 hours

QUESTION B.15 [1.0 point]
Per MSTR Technical Specifications, which ONE of the following is the MAXIMUM reactivity worth of the regulating rod?

a. 0.30 % $\Delta k/k$

b. 0.50 % $\Delta k/k$

c. 0.70 % $\Delta k/k$

d. 1.50% $\Delta k/k$

QUESTION B.16 [1.0 point]
An alternate location of the MSTR Emergency Support Center shall be the:

a. Reactor Manager office

b. MST Campus Police Chief office

c. Physics Building Main office

d. Nuclear Engineering Department office

Section B: Normal/Emergency Procedures and Radiological Controls

QUESTION B.17 [1.0 points, 0.25 each]
Match the radiation reading from Column A with its corresponding radiation area classification (per 10 CFR 20) listed in Column B. Answer can be used more than once. Assume a Quality factor of 1.

	Column A	Column B
a.	10 mrem/hr at 30 cm	1. Public Area
b.	550 mrem/hr at 30 cm	2. Radiation Area
c.	2 mrem/hr at 1 m	3. High Radiation Area
d.	550 rem/hr at 1 m	4. Very High Radiation Area

QUESTION B.18 [1.0 point]
The MST Safety Limit is on:

a. the reactor power, which is 300 kW

b. the reactor inlet pool temperature, which is 135 °F

c. the temperature of fuel cladding, which is 950 °F

d. the temperature at the center fuel element, which is 950 °F

QUESTION B.19 [1.0 point]
The MSTR Technical Specifications define that a Special Report is the circumstances of the event that the licensee shall make a report by telephone to the NRC Headquarters Operations Center no later than the following working day, followed by a written report, submitted to the NRC Document Control Desk, within 14 days. The below items are listed as a Special Report, EXCEPT:

a. A fuel cladding temperature exceeds 950 °F

b. A reactor scram resulting from the Safety Channel #1 exceeding its set point

c. An uncontrolled reactivity change in reactivity exceeds 0.9 %ΔK/K

d. Fission products are detected in the reactor CAM during reactor operation

(***** END OF THE EXAMINATION *****)

ANSWER KEY

B.01
Answer: b
Reference: TS 3.5

B.02
Answer: a(2) b(4) c(2) d(3) e(1) f(1)
g(3) h(3)
Reference: TS 3.2.1 and SAR Table 7.2

B.03
Answer: c
Reference: Standard Health Physics definition
GM tubes cannot distinguish between energies

B.04
Answer: d
Reference: 10 CFR 50.59

B.05
Answer: b
Reference: Emergency Plan, Section 7.4.6

B.06
Answer: d
Reference: SAR 13.1

B.07
Answer: a (2); b(4); c(1); d(3)

B.08
Answer: a
Reference: 10 CFR 55.53(e)

B.09
Answer: d
Reference: TS 3.7.1

B.10
Answer: c
Reference: TS 6.1.3

B.11
Answer: c
Reference: 10 CFR 50.36

B.12
Answer: a
Reference: 10CFR20.1003 and 10CFR20.1004

B.13 Corrected typographical error. Accept either “b” or “d” as the correct answers. “Biannually” will be changed to “biennially” for the future exam.
Answer: b or d
Reference: TS 4.2.1

B.14
Answer: a
Reference: $DR = DR_{\circ} * e^{-\lambda t}$
30% is decayed, so 70% is still there $70\% = 100\% * e^{-\lambda(1\ hrs)}$
$\ln(70/100) = -\lambda * 1$ -->$\lambda = 0.3567$ $t_{1/2} = \ln(2)/\lambda$ -->.693/.3567 t=1.94 hours

B.15
Answer: c
Reference: TS 3.1.5

B.16
Answer: d
Reference: EP 8.1

B.17
Answer: a(2); b(3); c(2); d(4)
Reference: 10 CFR 20.1003 Definitions
Note:
Equivalent dose: 1 rem= 1 rad x Q (quality factor)
550 rads/hr x QF = 1→ 550 rem/hr,
2 mrem/hr at 1 m = 2 mR/hr at 100 cm = 22 mrem/hr at 30 cm,

B.18
Answer: c
Reference: TS 2.1

B.19
Answer: b
Reference: TS 6.7.2
Note: 0.9 $\%\Delta K/K$ > $1.00