April 19, 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-16-01, MISSOURI UNIVERSITY OF SCIENCE AND TECHNOLOGY

Dear Dr. Lee:

During the week of March 21, 2016, the U.S. Nuclear Regulatory Commission (NRC) administered operator licensing examinations 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, 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 (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 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 e-mail at John.Nguyen@nrc.gov.

Sincerely,

/RA/

Anthony 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-16-01
2. Written examination

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

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DISTRIBUTION w/ enclosures.:
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ADAMS ACCESSION #: ML16096A423 Package: ML16013A345 Template #:NRR-079

OFFICE	NRR/DPR/PROB/CE	NRR/DPR/PROB/OLA	NRR/DPR/PROB/BC
NAME	JNguyen	CRevelle	AMendiola
DATE	04/04/2016	04/05/2016	04/19/2016

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
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Jefferson City, MO 65102-0570

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Department of Natural Resources
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Jefferson City, MO 65101

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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
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Missouri University of Science
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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-16-01

FACILITY DOCKET NO.: 50-123

FACILITY LICENSE NO.: R-79

FACILITY: Missouri University of Science and Technology

SUBMITTED BY: /RA/ 04/04/2016
John T. Nguyen, Chief Examiner Date

SUMMARY:

During the week of March 21, 2016, the NRC administered operator licensing examinations to two reactor operator (RO) license candidates. Both license candidates failed the Section B, Normal/Emergency Procedures and Radiological Controls, of the written examination.

REPORT DETAILS

1. Examiner: John T. Nguyen, Chief Examiner

2. Results:

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

3. Exit Meeting:

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

The NRC examiners thanked the facility for their support in the administration of 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:	MSTR
DATE ADMINISTERED:	03/23/2016
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
20.00	33.3	___________	_____	A.	REACTOR THEORY, THERMODYNAMICS AND FACILITY OPERATING CHARACTERISTICS
20.00	33.3	___________	_____	B.	NORMAL AND EMERGENCY OPERATING PROCEDURES AND RADIOLOGICAL CONTROLS
20.00	33.3	___________	_____	C.	FACILITY AND RADIATION MONITORING SYSTEMS
60.00		___________ FINAL GRADE	_____	%	TOTALS

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

____
Candidate's Signature

ENCLOSURE 2

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 ___

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 ___

A17 a b c d ___

A18 a b c d ___

A19 a b c d ___

A20 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 ___

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 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 ___ (0.5 each)

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 ___ g ___

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 ___

(***** 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 <u>only</u> 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

X X

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

$Q = m\, \Delta h$

X

$Q = UA\, \Delta T$

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

$SUR = 26.06/\tau$

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

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

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

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

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

$\rho = \Delta Keff/Keff$

$\bar{\beta} = 0.007$

$DR_1D_1^2 = DR_2D_2^2$

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

$\lambda_{eff} = 0.1/sec$

$SCR = S/(1-Keff)$

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

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

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

$SDM = (1-Keff)/Keff$

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

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

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

$R = 6\ C\ E\ n$

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

$DR = DR_o e^{-\lambda t}$

$P = S\ /\ (1 - Keff)$

---

1 Curie = $3.7\text{x}10^{10}$ dps

1 hp = $2.54\text{x}10^{3}$ BTU/hr

1 BTU = 778 ft-lbf

931 Mev = 1 amu

1 kg = 2.21 lbm

1 Mw = $3.41\text{x}10^{6}$ BTU/hr

°F = 9/5°C + 32

°C = 5/9 (°F - 32)

QUESTION A.01 [1.0 point]
A process whereby a neutron collides with a ground state nucleus, imparts kinetic energy to the nucleus, and leaves the nucleus in ground state is called:

a. Fission Process.

b. Radiative Capture.

c. Inelastic Scattering.

d. Elastic Scattering.

QUESTION A.02 [1.0 point]
A reactor operator accidently inserted a sample worth 1.0 % ΔK/K into the reactor core, resulting an instantaneous change in power. Which ONE of the following best describes the values of K-effective (Keff) and ρ during the power increment?

a. $K_{eff} = 1$ and $0 < \rho < 1$

b. $K_{eff} > 1$ and $0 < \rho < \beta\text{-eff}$

c. $K_{eff} > 1$ and $\beta\text{-eff} < \rho < 1$

d. $K_{eff} > 1$ and $1 < \rho <$ infinity (∞)

QUESTION A.03 [1.0 point]
During a reactor startup, the reactor operator observes the current position of the control rods is LOWER than the last startup. Which ONE of the following reasons could be the cause?

a. Higher moderator temperature (assume negative temperature coefficient)

b. Insertion of a negative reactivity worth experiment

c. Burnout of xenon

d. Fuel depletion

QUESTION A.04 [1.0 point]
The product of number density and microscopic cross section of an element is defined as:

a. Macroscopic Cross Section.

b. Maximum Cross Section.

c. Thermal Cross Section.

d. Decay Constant.

QUESTION A.05 [1.0 point]
Reactor A with a K_{eff} of 0.1 and reactor B with a K_{eff} of 0.6, K_{eff} is increased by 0.1 for each reactor. The amount of reactivity added in reactor A is _______ in reactor B for the same increment.

a. less than

b. the same

c. six times more

d. twenty-one times more

QUESTION A.6 [1.0 point]
Which ONE of the following correctly describes the SIX- FACTOR FORMULA?

a. $K_\infty = K_{eff}$ * the utilization factor

b. $K_{eff} = K_\infty$ * the total leakage probability

c. $K_\infty = K_{eff}$ * the total non-leakage probability

d. $K_{eff} = K_\infty$ * the total non-leakage probability

QUESTION A.07 [1.0 point]
Which ONE of the following describes the term **PROMPT JUMP**?

a. A reactor is increasing power at a constant rate of 10 second period.

b. The instantaneous change in power when a reactor operator removes a fuel element.

c. The instantaneous change in power when a reactor operator inserts a negative worth, -0.3 %Δk/k, of experiment into the reactor core.

d. The instantaneous change in power level when a reactor operator withdraws a control rod.

QUESTION A.08 [1.0 point]
Which ONE of the following best describes the beta-plus decay (β_{+1}) of a nuclide?

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

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

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

d. The atomic mass number unchanged, and the number of neutrons increase by 1.

QUESTION A.09 [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 interactions with fast neutrons, while delayed neutrons are released during U-235 interactions with thermal neutrons.

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

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

QUESTION A.10 [1.0 point]
A reactor is subcritical with a K_{eff} of 0.927. If you add 7.875 %Δk/k of positive reactivity into the core, the reactor will be:

a. subcritical.

b. just critical.

c. supercritical.

d. prompt critical.

QUESTION A.11 [1.0 point]
The reactor is on a **CONSTANT** positive period. Which ONE of the following power changes will take the **longest time** to complete?

a. from 95 kW to 100 kW

b. from 80 kW to 90 kW

c. from 60 kW to 80 kW

d. from 20 kW to 40 kW

QUESTION A.12 [1.0 point]
Delayed neutrons are produced by:

a. decay of gamma.

b. Photoelectric Effect.

c. decay of fission fragments.

d. directly from the fission process.

QUESTION A.13 [1.0 points]
The MAIN reason for operating a reactor with thermal neutrons instead of fast neutrons is:

a. The fission cross section of the fuel is much higher for fast neutrons than thermal energy neutrons. Since fast neutrons are easier to cause fission, a reactor cannot control with fast neutrons.

b. The neutron lifetime of thermal neutrons is longer than fast neutrons, so the fuel has enough time to capture thermal neutrons.

c. The fission cross section of the fuel is much higher for thermal energy neutrons than fast neutrons, so thermal neutrons are easier to cause fission.

d. The atomic weight of thermal neutrons is larger than fast neutrons, so thermal neutrons are easily to slow down and be captured by the fuel.

QUESTION A.14 [1.0 point]
A reactor is subcritical with K_{eff} of 0.955. Which ONE of the following is the MINIMUM reactivity (ΔK/K) that must be added to produce a PROMPT criticality? Given βeff=0.0078

a. 0.0450

b. 0.0078

c. 0.0548

d. 0.1000

QUESTION A.15 [1.0 point]
Following a positive reactivity addition to a shutdown reactor, the neutron power will increase even though k-effective is less than 1. The MAIN reason is due to:

a. Production of fast neutrons

b. Neutron moderation in the fuel

c. Subcritical multiplication process

d. Void temperature coefficient in the moderator

Section A: Theory, Thermo & Facility Operating Characteristics

QUESTION A.16 [1.0 point, 0.33 each]
Match the term listed in Column A with its corresponding units listed in column B. Answer in Column B can be used once, more than once, or not at all.

Column A		Column B
a.	Microscopic Cross Section	1. 1/cm
b.	Macroscopic Cross Section	2. 10^{-24} cm^2
c.	Neutron Flux	3. Neutrons / cm^2/sec
.		4. Neutrons / cm^3/sec
		5. 10^{-24} cm^3

QUESTION A.17 [1.0 point]
Which ONE of the following is the stable reactor period which will result in a power rise from 1% to 100% power in 120 seconds?

a. 10 seconds

b. 13 seconds

c. 26 seconds

d. 80 seconds

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	1.50	1.30
Rod 2	1.20	1.00
Rod 3	1.40	0.50
Rod 4	2.30	1.10

Assume all control rods are scrammable. The SHUTDOWN margin defined by Tech Spec is ______ (%Δk/k):

a. 1.6

b. 2.5

c. 3.9

d. 6.4

QUESTION A.19 [1.0 point]
Two critical reactors at low power are identical, except that Reactor 1 has a beta fraction of 0.0065 and Reactor 2 has a beta fraction of 0.0072. Which ONE of the following best describes the response if an equal amount of positive reactivity is inserted into both reactors?

a. Period of the Reactor 1 will be longer than the period of the Reactor 2

b. The final power in the Reactor 1 will be lower than the final power in the Reactor 2

c. The trace (power vs. time) of the Reactor 1 will be higher than the trace of the Reactor 2

d. The trace (power vs. time) of the Reactor 1 will be identical to the trace of the Reactor 2

QUESTION A.20 [1.0 point]
An example of a **FISSIONABLE NUCLEI** is:

a. Pu-239

b. U-238

c. U-235

d. U-233

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

Section B: Normal/Emergency Procedures and Radiological Controls

QUESTION B.01 [1.0 points]
Per MSTR Emergency Plan, the outside walls of the reactor confinement building are defined as the _________, where the Emergency Director has direct authority over all activities during an emergency.

a. Site Boundary

b. Offsite Boundary

c. Operations Boundary

d. Containment Boundary

QUESTION B.02 [1.0 point]
Per MSTR Technical Specifications, the regulating rod shall be worth no more than _______ in reactivity.

a. 0.7 Δk/k

b. 0.7 % Δk/k

c. 1.5 Δk/k

d 1.5 % Δk/k

QUESTION B.03 [1.0 point]
A reactor is at full power with experiments in the Beam Port. Which ONE of the following is considered a Tech Spec violation?

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

b. You review the irradiation request form and find that the current experiment contains 20 mg of explosive material.

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

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

QUESTION B.04 [1.0 point, 0.25 each]
Match type of radiation listed in column A with their quality factor listed in column B. Items in column B can be used once, more than once or not at all.

	Column A		Column B
a.	X-ray	1.	1
b.	Gamma	2.	5
c.	Alpha particles	3.	10
d.	High-energy photons	4.	20

QUESTION B.05 [1.0 point]
A radioactive source reads 5 Rem/hr on contact. Five hours later, the same source reads 1.25 Rem/hr. How long is the time for the source to decay from a reading of 5 Rem/hr to 625 mRem/hr?

a. 5.5 hours

b. 7.5 hours

c. 9.5 hours

d. 11.5 hours

QUESTION B.06 [1.0 point]
Which ONE of the following changes must be submitted to NRC for approval prior to implementation?

a. Replace a primary cooling pump with identical pump.

b. Add new limitation to the Pre-Startup Checklist Procedure.

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

d. Delete a definition of Reactor Operator listed in the MSTR Technical Specifications.

Section B: Normal/Emergency Procedures and Radiological Controls

QUESTION B.07 [1.0 point]
The MINIMUM radiation level requiring a reactor operator to obtaining a Radiation Work Permit is ________ at 1 foot from the part involved.

a. 10 mrem/hr

b. 18 mrem/hr

c. 23 mrem/hr

d. 30 mrem/hr

QUESTION B.08 [1.0 point]
An annual test of the safety channel was performed. Which ONE of the following is the latest the test that must be performed again without violation of the Technical Specifications?

a. 13 months after

b. 14 months after

c. 15 months after

d. 16 months after

QUESTION B.09 [1.0 point]
A radioactive material is decaying at a rate of 30% per every two hours. Determine its half-life?

a. 2 hours

b. 3 hours

c. 4 hours

d. 5 hours

QUESTION B.10 [1.0 point]
During a reactor operation, the reactor operator observes that the core inlet temperature exceeds 140 °F. For this temperature, which ONE of the following is the best action?

a. The operator may increase power level to verify that at what temperature a Rod Run Down will be actuated.

b. The operator may continue an operation because the temperature is within TS limit.

c. The operator shall secure the reactor, and immediately report the result to the supervisor because the interlock system did not activate a Rod Run Down.

d. The operator shall secure the reactor, and immediately report the result to the supervisor because the interlock system did not activate a Rod Withdraw Prohibit.

QUESTION B.11 [1.0 point]
Which ONE of the following is the MINIMUM staffing requirement when the reactor is NOT SECURED?

a. 1 SRO in the control room

b. 1 RO in the control room + 1 designated person

c. 1 SRO onsite + 1 RO in the control room

d. 1 SRO on call +1 shift supervisor in the control room

QUESTION B.12 [1.0 point]
A two-curie source, emits 100% of a 2 Mev gamma, is to be stored in the reactor building. How far from the source should a HIGH RADIATION AREA sign be posted?

a. 7 feet

b. 8 feet

c. 11 feet

d. 16 feet

QUESTION B.13 [1.0 point]
The MAIN purpose to encapsulate a corrosive material irradiated in the reactor core is to prevent:

a. contamination in the pool water.

b. pressure build up in the sample holder.

c. release of corrosive gas to the reactor bay.

d. contamination to a reactor operator while handling it.

QUESTION B.14 [1.0 point]
Assume that there is no leak from outside of the demineralizer tank. You use a survey instrument with a window probe to measure the dose rate from the demineralizer tank. Compare to the reading with a window **CLOSED,** the reading with a window **OPEN** will:

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

b. remain the same, because the Quality Factors for gamma and beta radiation are the same.

c. increase, because the Quality Factor for beta and alpha is greater than for gamma.

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

QUESTION B.15 [1.0 point]
An alterate location of the MSTR Emergency Support Center shall be the:

a. Physics Building Main office.

b. Nuclear Engineering Department office.

c. Chair of Mining and Nuclear office.

d. MST Campus Police Chief office.

QUESTION B.16 [1.0 point]
The control rod drop time shall be measured at least:

a. monthly.

b. quarterly.

c. semi-annually.

d. annually.

QUESTION B.17 [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 core inlet temperature exceeds 150 °F.

b. An uncontrolled reactivity change in reactivity exceeds 0.1 %ΔK/K.

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

d. A reactor still maintains at full power when the Bridge RAM exceeds 25 mrem/hr.

QUESTION B.18 [1.0 point]
Fueled 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.19 [1.0 point]
The MINIMUM level of management who may authorize removing or installing reactor thermocouples is the:

a. Reactor Director.

b. Reactor Manager.

c. RO on duty.

d. SRO on duty.

QUESTION B.20 [1.0 point]
Per MST Technical Specifications, the MAXIMUM reactivity for a secured experiment shall be the absolute worth of :

a. 0.40 % $\Delta k/k$

b. 0.70 % $\Delta k/k$

c. 1.00 % $\Delta k/k$

d. 1.20 % $\Delta k/k$

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

Section C Facility and Radiation Monitoring Systems

QUESTION C.01 [1.0 point]
Which ONE of the following parameters can initiate a reactor scram, a rundown, and rod withdrawal prohibit?

a. Low Compensating Ion Chamber Voltage

b. Radiation Area Monitors

c. Reactor power

d. Reactor period

QUESTION C.02 [1.0 point]
Per MSTR Technical Specifications, the reactor operations shall require an operable ventilation fan with a rated capacity of at least _______ be turned on within _______ after the reactor reaches full power.

a. 100.7 m^3/min (3557 cfm) / 10 minutes

b. 110.7 m^3/min (3910 cfm) / 15 minutes

c. 117.4 m^3/min (4,147 cfm) / 15 minutes

d. 127.4 m^3/min (4,500 cfm) / 10 minutes

QUESTION C.03 [2.0 point, 0.5 each]
Match the following actions used in Column A with their respective definitions in Column B:

COLUMN A	COLUMN B
a. You compare readings of Safety Channel #1 with Safety Channel # 2 during reactor operations	1. Channel Check
b. During startup, you verify the reactor scram at 5 second period	2. Channel Test
c. You remove a neutron source to verify rod withdrawal prohibit	3. Channel Calibration
d. You adjust a safety channel reading after conducting a thermal power calibration	

QUESTION C.04 [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.05 [1.0 point]
During a loss of building electrical power, the power supplied to the reactor instrumentation will be:

a. lost and it will not return until building power returns and the linear power supply is manually reset.

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

c. automatically switched to the emergency power generator.

d. automatically switched to the UPS backup.

QUESTION C.06 [1.0 point]
During a reactor operation, the Demieralizer RAM exceeds the High Radiation Alarm setpoint. This event will cause:

a. reactor run down in conjunction with the audible alarm and visual annunciator.

b. reactor scram in conjunction with the audible alarm and visual annunciator.

c. Rod Withdraw Prohibit in conjunction with the audible alarm ONLY.

e. reactor scram in conjunction with the audible alarm ONLY.

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QUESTION C.07 [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. Rod Withdrawal Prohibit

b. Normal operation

c. Run down

d. Scram

QUESTION C.08 [1.0 point]
Which ONE of the following best describes the proper state of the ventilation system exhaust fans (F) and intake louvers (IL) during a significant airborne release?
Open = O, Close = C

a. F1 = O, F2 = O; F3 = C, IL = C

b. F1 = C, F2 = C; F3 = O, IL = O

c. F1 = C, F2 = C; F3 = C, IL = C

d. F1 = C, F2 = C; F3 = C, IL = O

QUESTION C.09 [1.0 point]
A signal of notification to the MST University Police is initiated by:

a. reactor pool water level low.

b. high radiation CAM alarm.

c. ventilation system off.

d. reactor recorder off.

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QUESTION C.10 [1.0 point]
Per SOP 810, a setpoint for the MSTR building evacuation alarm is between:

a. 10 mrem – 18 mrem

b. 15 mrem – 28 mrem

c. 35 mrem – 48 mrem

d. 45 mrem – 58 mrem

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 = 35 seconds	1.	Normal
b.	Linear Power Demand = 130% power	2.	Rod Withdrawal Prohibit
c.	Recorder turns off	3.	Rod Run Down
d.	CIC voltage = 65%	4.	Scram
e.	Startup count rate = 5 cps		
f.	Safety Channel 1 = 300 kW		
g.	Bridge motion activated		
h.	Regulating rod insert limit on automatic		

QUESTION C.12 [1.0 point]
Nitrogen gas is used in the pneumatic transfer system instead of compressed air because:

a. it is more compressible.

b. it does not retain moisture.

c. it minimizes Ar-41 production.

d. it minimizes N-16 production.

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]
A signal for Scram <5 sec period comes from the:

a. Startup channel.

b. Safety channel.

c. Linear channel.

d. Log and Linear channel.

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 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 coolant system.

c. Turn the exhaust fan ON, so N-16 will be exhausted through the stack

d. Turn the intake louvers ON, so N-16 will be diluted with air coming from the building outside.

QUESTION C.16 [1.0 point]
Two safety channels, a master and slave sensing circuit, are part of the reactor protection system which provides the mechanism for scramming the reactor. In order to have a reactor scram:

a. a scram signal must be present in both of the circuits.

b. a scram signal must be present in the master circuit; the slave circuit need not have a scram signal.

c. a scram signal must be present in the slave circuit; the master circuit need not have a scram signal.

d. a scram signal can be present in either circuit.

QUESTION C.17 [1.0 point]
Which ONE of the following is the method used to get rid of radioactive low-level solid waste? Radioactive low-level solid waste is:

a. burned, then dumped to the public trash system.

b. packed, then transferred to the Department of Energy.

c. packed, then transferred to the campus Materials License.

d. diluted with water to less than 10CFR20 limits, then pumped to the sanitary sewer system.

QUESTION C.18 [1.0 point]
Before unloading of fuel elements from the reactor core to fuel storage rack, which ONE of the following tasks needs to be performed FIRST?

a. Calculate the shutdown margin

b. Complete a startup checklist

c. Turn off the Constant Air Monitor (CAM)

d. Withdraw Shim rods 1,2 and 3 to Shim range

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

A.01
Answer d
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, Sec 2.4.5, page 2-29.

A.02
Answer: c
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Sec 4.2, page 4-1

A.03
Answer c
Reference: Standard NRC question.

A.04
Answer: a
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, Sec 2.5.2, page 2-43.

A.05
Answer: d
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1982, Sec 3.3.3, page 3-21.
$\Delta\rho$ reactor A = $(Keff_1-Keff_2)/(Keff_1*Keff_2)$. (0.2-0.1)/(0.2*0.1) = 5 Δk/k
$\Delta\rho$ reactor B = $(Keff_1-Keff_2)/(Keff_1*Keff_2)$. (0.7-0.6)/(0.7*0.6) = 0.2381 Δk/k
5/0.2381 = 21

A.06
Answer: d
Reference: Burn, R., Introduction of Nuclear Reactor Operations, © 1988, Sec 3.3

A.07
Answer: d
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, Section 4.7, Page 4-21.

A.08
Answer a
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, Section 2.8, Page 2-61.

A.09
Answer: d
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, Section 3.3.7, Page 3-27

A.10
Answer: b
Reference: SDM = (1- keff)/keff = (1-0.927)/0.927 = 0.07875 Δk/k. So if you add the same amount of SDM, the reactor is just critical.
Another method: you can find the new value of Keff when adding 0.07875 Δk/k to reactor.
Δp = (k2 –k1)/ k1*k2
0.07875 = (k2- 0.927)/(0.927* k2), solve for k2
K2 = 1, hence the reactor is just critical

A.11
Answer: d
Reference: Time is related to ratio of final power to initial power. 40/20 =2 is the largest ratio.

A.12
Answer: c
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1982, Sec 3.2.

A.13
Answer: c
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1982, Figure 2.6, page 2-39

A.14
Answer: c
Reference: from k=0.955 to criticality (k=1), Δρ = (k-1)/k = -0.047 Δk/k or Δρ = 0.047 Δk/k needed to reach criticality. From criticality to JUST prompt, Δk/k = βeff required, so minimum reactivity added to produce prompt criticality will be: 0.047+0.0078= 0.0548

A.15
Answer: c
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, subcritical Multiplication process.

A.16
Answer: a(2) b(1) c(3)
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, Sec 2.6

A.17
Answer: c
Reference: $P = P_0 e^{t/T}$ —> $T= t/Ln(P/ P_0)$
T= 120/Ln(100); T = 26 sec.

A.18
Answer: a
Reference: Total rod worth at critical – the highest control rod worth
3.9 – 2.3 =1.6 %Δk/k

A.19
Answer: c
Reference: Equation Sheet. $\tau = (\ell^*/\rho) + [(\beta-\rho)/\lambda_{eff}\rho]$. Since the period of the reactor 1 is shorter than the reactor 2, the trace (power vs. time) of the Reactor 1 will be higher than the trace of the Reactor 2

A.20
Answer: b
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* 1988 Section 3.2 page 3-2

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Section B Normal/Emergency Procedures and Radiological Controls

B.01
Answer: c
Reference: Emergency Plan 2.0

B.02
Answer: b
Reference: TS 3.1.5

B.03
Answer: c
Reference: TS 3.6 and 3.7

B.04
Answer: a(1) b(1) c(4) d(3)
Reference: 10 CFR 20

B.05
Answer: b
Reference: $DR = DR_{\circ} * e^{-\lambda t}$
1.25 rem/hr =5 rem/hr* $e^{-\lambda(5hr)}$
Ln(1.25/5) = -λ*5 --> λ=0.277; solve for t: Ln(.625/5)=-0.277 *t
t=7.5 hours

B.06
Answer: d
Reference: 10 CFR 50.59

B.07
Answer: c
Reference: SOP 615 will apply only when radiation level is greater than 5 mrem/hr at 2 feet from the part involved. $I_0 D_0^2 = I * D^2$
X* mrem/hr*(1 ft)^2 = 5 mRem/hr *4 ; X = 20 mrem/hr at 1 foot
X> 20 mrem/hr at 1 ft (or 5 mrem/hr at 2 feet) and X< 24 mrem (6 mrem/hr at 2 feet) , so X= 23 mrem/hr at 1 foot due to MINIMUM radiation level

B.08
Answer: c
Reference: TS 1.0, Definition

B.09
Answer: c
Reference: $DR = DR_{\circ} * e^{-\lambda t}$
30% is decayed, so 70% is still there 70% =100%* $e^{-\lambda(2hrs)}$
Ln(70/100) = -λ*2 -->λ=0.1783 t1/2=Ln(2)/ λ -->.693/.1783 t=3.89 hours

B.10
Answer: d
Reference: TS Table 3.1

Section B Normal/Emergency Procedures and Radiological Controls

B.11
Answer: c
Reference: TS 6.1.3

B.12
Answer: d
Reference: 6CEN = R/hr @ 1 ft. -> 6 x 2 x 2 x 1 = 24 R/hr at 1ft. $I_0 D_0^2 = I^* D^2$
24 R/hr*(1 ft)^2 = 0.1 R/hr *D ^{2}
D= sqrt(24/0.1) = 15.5 ft.

B.13
Answer: a
Reference: TS 3.3.3

B.14
Answer: d
Reference: Basic radiological concept (beta and alpha radiation don't make through the demineralizer tank)

B.15
Answer: b
Reference: EP 8.1

B.16
Answer: c
Reference: TS 4.2.1

B.17
Answer: b
Reference: TS 3.6.1

B.18
Answer: c
Reference: TS 3.7.2

B.19
Answer: d
Reference: SOP 806

B.20
Answer: d
Reference: TS 3.7.1

Section C Facility and Radiation Monitoring Systems

C.01
Answer: d
Reference: TS 3.1 and 3.2

C.02
Answer: d
Reference: TS 3.5 and SAR 9.1

C.03
Answer: a. = 1; b. = 2; c. = 2; d. = 3
Reference: TS 1.0

C.04
Answer: b
Reference: SAR 5.1

C.05
Answer: a
Reference: SOP 308

C.06
Answer: a
Reference: SOP 810 and TS 3.6.1

C.07
Answer: a
Reference: SAR 4.6 and Table 7.2 (RWP due to exceeding of operation limit of 135 °F)

C.08
Answer: c
Reference: SAR 9.1

C.09
Answer: a
Reference: Facility walkthrough

C.10
Answer: b
Reference: SOP 810

C.11
Answer: a(1) b(3) c(2) d(3) e(1) f(4) g(4) h(3)
Reference: TS 3.2.1 and SAR Table 7.2

C.12
Answer: c
Reference: SAR 10.2

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

C.14
Answer: d
Reference: SAR 7.1, Figure 7.1

C.15
Answer: b
Reference: Walkthrough information

C.16
Answer: d
Reference: SAR 7.1, Figure 7.1

C.17
Answer: c
Reference: SAR 11.1.1.3

C.18
Answer: b
Reference: SOP 207