May 15, 2018

Dr. Joseph Graham, Director
Missouri University of Science and Technology
Mining and Nuclear Engineering
228 Fulton Hall
Rolla, MO 65409-0170

SUBJECT: EXAMINATION REPORT NO. 50-123/OL-18-01, MISSOURI UNIVERSITY OF SCIENCE AND TECHNOLOGY

Dear Dr. Graham:

During the week of November 13, 2017, the U.S. Nuclear Regulatory Commission (NRC) administered an operator licensing examination at your Missouri University of Science and Technology reactor. The examination was conducted according to NUREG-1478, "Operator Licensing Examiner Standards for Research and Test Reactors," Revision 2. Examination questions and preliminary findings were discussed with you and those members of your staff identified in the enclosed report at the conclusion of the examination.

In accordance with Title 10 of the *Code of Federal Regulations* Section 2.390, a copy of this letter and the enclosure will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records (PARS) component of NRC's Agencywide Documents Access and Management System (ADAMS). ADAMS is accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html. The NRC is forwarding the individual grades to you in a separate letter which will not be released publicly. Should you have any questions concerning this examination, please contact Mrs. Paulette Torres at (301) 415-5656 or via electronic mail at Paulette.Torres@nrc.gov.

Sincerely,

/RA/

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

Docket No. 50-123

Enclosures:
As stated

cc: Mr. Craig Reisner, Interim Manager
Missouri University of Science
and Technology
226 McNutt Hall
Rolla, MO 65409-0450

cc: w/o enclosure: See next page

SUBJECT: EXAMINATION REPORT NO. 50-123/OL-18-01, MISSOURI UNIVERSITY OF SCIENCE AND TECHNOLOGY DATED: MAY 15, 2018

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OFFICE	NRR/DLP/PROB	NRR/DLP/PROB	NRR/DLP/PROB/BC
NAME	PTorres	AFerguson	AMendiola
DATE	03/07/2018	03/14/2018	05/15/2018

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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
Commissioner's Office
Office of Administration
P.O. Box 809
State Capitol Building, Room 125
Jefferson City, MO 65101

Test, Research and Training Reactor Newsletter
P.O. Box 118300
University of Florida
Gainesville, FL 32611

Dr. Braden T. Lusk, Chair
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Missouri University of Science and Technology
226 McNutt Hall
Rolla, MO 65409-0450

Planning Coordinator
Missouri Department of Natural Resources
1101 Riverside Drive
Jefferson City, MO 65101

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

REPORT NO.: 50-123/OL-18-01

FACILITY DOCKET NO.: 50-123

FACILITY LICENSE NO.: R-79

FACILITY: Missouri University of Science and Technology Reactor

EXAMINATION DATE: November 13, 2017

SUBMITTED BY: ***/RA/*** **03/07/2018**
Paulette Torres, Chief Examiner Date

SUMMARY:

During the week of November 13, 2017 the NRC administered a licensing examination to three Reactor Operator (RO) applicants. Two of the applicants passed all portions of the examination. One applicant failed all portions of the examination.

REPORT DETAILS

1. Examiner: Paulette Torres, Chief Examiner, NRC

2. Results:

	RO PASS/FAIL	SRO PASS/FAIL	TOTAL PASS/FAIL
Written	2/1	0/0	2/1
Operating Tests	2/1	0/0	2/1
Overall	2/1	0/0	2/1

3. Exit Meeting:
Paulette Torres, Chief Examiner, NRC
Osvaldo Font, Examiner in training, NRC
Craig Reisner, Training Coordinator, MUST
William Bonzer, Reactor Manager, MUST

At the exit meeting, the NRC examiner thanked the facility for their support in the administration of the examination

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

FACILITY:	Missouri University of Science and Technology
REACTOR TYPE:	Pool
DATE ADMINISTERED:	November 13, 2017
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. Reactor Theory, Thermohydraulics & Facility Operating Characteristics

A N S W E R S H E E T

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

A01 a b c d ___

A02 a b c d ___

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 ___

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 SECTION A *****)

B. Normal/Emergency Procedures and Radiological Controls

A N S W E R S H E E T

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

B01 a b c d ___

B02 a b c d ___

B03 a b c d ___

B04 a b c d ___

B05 a b c d ___

B06 a b c d ___

B07 a b c d ___

B08 a b c d ___

B09 a b c d ___

B10 a b c d ___

B11 a b c d ___

B12 a b c d ___

B13 a b c d ___

B14 a b c d ___

B15 a b c d ___

B16 a b c d ___

B17 a b c d ___

B18 a ___ b ___ c ___ d ___

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

C. Facility and Radiation Monitoring Systems

A N S W E R S H E E T

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

C01 a b c d ___

C02 a b c d ___

C03 a b c d ___

C04 a b c d ___

C05 a b c d ___

C06 a b c d ___

C07 a b c d ___

C08 a b c d ___

C09 a b c d ___

C10 a b c d ___

C11 a b c d ___

C12 a b c d ___

C13 a b c d ___

C14 a b c d ___

C15 a b c d ___

C16 a b c d ___

C17 a b c d ___

C18 a b c d ___

(***** 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.

1. EQUATION SHEET

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

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

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

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

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

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

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

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

$$N = N_0 e^{(t/T)}$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$R = N\sigma\phi$$

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

1 Curie = 3.7 x 10^{10} dis/sec
1 Horsepower = 2.54 x 10^3 BTU/hr
1 BTU = 778 ft-lbf
1 gal (H_2O) ≈ 8 lbm
c_P = 1.0 BTU/hr/lbm/°F
1 barn = 10^{-24} cm^2

1 kg = 2.21 lbm
1 Mw = 3.41 x 10^6 BTU/hr
°F = 9/5 °C + 32
°C = 5/9 (°F - 32)
c_p = 1 cal/sec/gm/°C

MISSOURI UNIVERSITY OF SCIENCE AND TECHNOLOGY
Operator Licensing Examination

Week of November 13, 2017

Question A.1 [1.0 point]
What is the result of the Doppler Effect in the fuel temperature coefficient?

a. Stationary nuclei absorb more neutrons

b. Vibrating nuclei absorb less neutrons

c. An unbroadening of the energy range of neutrons that may be resonantly absorbed.

d. An apparent broadening of the nuclei's resonances due to a temperature increase.

Question A.2 [1.0 point]
What is the difference between prompt and delayed neutrons?

a. Prompt neutrons are released virtually instantaneously and are responsible for the ability to control the rate at which power can rise the reactor; and delayed neutrons are a very small fraction of the total number of neutrons and do not have an important role in the control of the reactor.

b. Prompt neutrons are released during fast fission while delayed neutrons are released during thermal fissions.

c. Prompt neutrons are released within 10^{-13} seconds of the fission event, whereas delayed neutrons are emitted following the first beta decay of a fission fragment.

d. Prompt neutron generation time is approximately 12.5 seconds and the delayed neutron generation time is approximately 5×10^{-5} seconds.

Question A.3 [1.0 point]
What is the energy range of a thermal neutron?

a. 0 – 1eV

b. 1ev – 100 keV

c. 100 keV – 10 MeV

d. > 10 MeV

Question A.4 [1.0 point]

The number density of Xenon-135 in a reactor core is $1x10^{16}$ at cm^3 and its cross section is $2.7x10^6$ barns. Average core flux is $2x10^{13}$ $n/cm^2/sec$. What is the absorption reaction rate for Xenon-135 in units of absorptions/sec/cm^3?

a. $5.4x10^{59}$

b. $5.4x10^{35}$

c. $5.4x10^{11}$

d. $5.4x10^{-1}$

Question A.5 [1.0 point]
How many half-lives does it take for a radioactive isotope to decay to less than 1% of its original activity?

a. 4

b. 5

c. 6

d. 7

Question A.6 [1.0 point]
What is the effect on neutron flux when positive reactivity is added making the reactor supercritical? A _____ increase, followed by a stable period determined by _____.

a. Steady, the amount of reactivity inserted only.

b. Rapid, the delayed neutron generation time only.

c. Steady, the amount of reactivity inserted and the delayed neutron generation time.

d. Rapid, the amount of reactivity inserted and the delayed neutron generation time.

Question A.7 [1 point]
What fission product affects reactor operations the MOST?

a. Cd-113

b. Xe-135

c. Sm-151

d. Gd-155

Question A.8 [1.0 point]
What is excess reactivity?

a. A measure of extra fuel loaded above the amount needed to be critical in order to compensate for fuel burnup and fission product poisons.

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

c. An increase in power output due to a positive reactivity insertion producing negative reactivity feedback.

d. The amount of positive reactivity in a reactor core corresponding to the excess multiplication factor.

Question A.9 [1.0 point]
What is NOT a consideration in the rate of reactivity change (positive or negative) by the control rods?

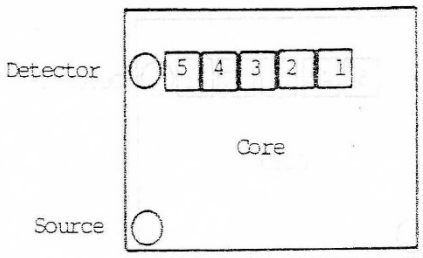
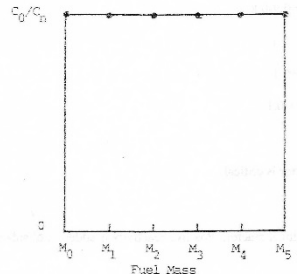
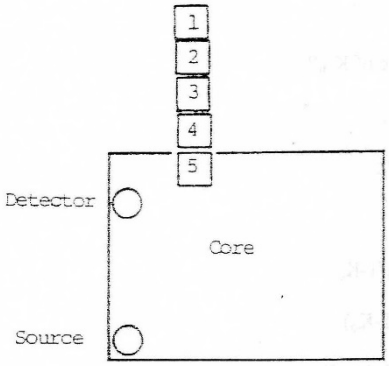
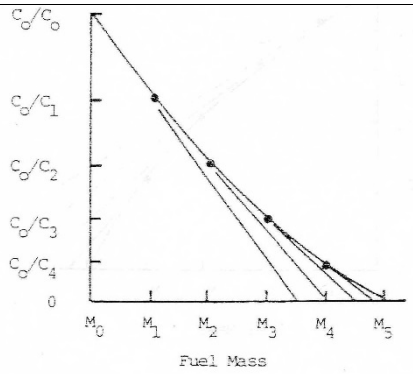
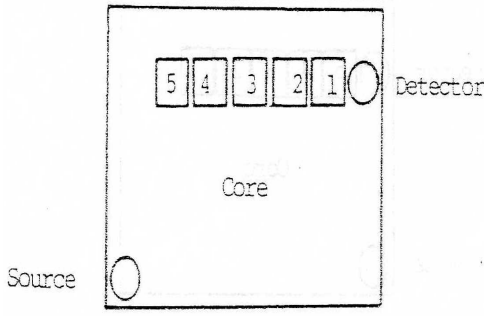
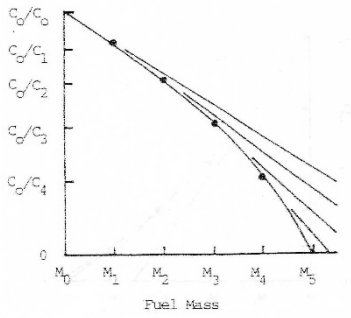
a. Supercriticality on a short period.

b. Overheating and core damage.

c. Xenon reactivity transients.

d. Provide adequate shutdown margin.

Question A.10 [1.0 point, 0.33 points each]
Match the fuel loading sequence in Column A with the corresponding 1/M plot shown in Column B.

Column A	Column B
a.  Loading starts too far away from the detector (right to left)	1. 
b.  Loading begins away from the core (top to bottom)	2. 
c.  Loading starts too close to the detector (right to left)	3. 

Question A.11 [1 point]
Reactor core analysis does NOT include:

a. Neutron dose rate.

b. Core neutron flux profiles.

c. Fuel burn up and fission product poisons.

d. Core temperature profiles.

Question A.12 [1.0 point]
The reactor is subcritical with a K_{eff} of 0.96 and 30 counts per second indicated. After a fuel element is removed the count rate drops to 10 counts per second. No other changes have occurred. What is the K_{eff} of the core with the fuel element removed?

a. 0.9733

b. 0.8800

c. 0.8400

d. 0.8000

Question A.13 [1.0 point]
The reactor is at a power of 1 watt, with a 30 second stable period. How long will it take for power to reach 500 watts?

a. 186 seconds

b. 140 seconds

c. 124 seconds

d. 81 seconds

Question A.14 [1.0 point]
What is the result in a potential elastic scattering reaction between a neutron and a target nucleus?

a. Energy is transferred into nuclear excitation, and then emitted via a gamma emissions.

b. The target nucleus gains the amount of kinetic energy that the neutron loses.

c. The neutron is absorbed by the target nucleus and then emitted with lower kinetic energy.

d. The neutron conserves its initial kinetic energy if the target nucleus is large.

Question A.15 [1.0 point]
What is the effect of neutrons on the neutron flux decay following a scram from full power? Neutron level in the core is sustained by the:

a. Prompt and delayed neutrons.

b. Decay of fission product precursors, following the prompt drop.

c. Shortest lived precursors as they limit the power decrease to a -80 second period.

d. Longest lived precursor as power decreases fairly rapidly as they decay.

Question A.16 [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 supercritical.

b. The reactor is critical.

c. The reactor is subcritical.

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

Question A.17 [1.0 point]
An example of a FISSIONABLE NUCLEI is:

a. Pu-239

b. U-238

c. U-235

d. U-233

Question A.18 [1.0 point]
Which ONE of the following multiplication factors is least affected during very short intervals of reactor operation?

a. Fast non leakage probability

b. Thermal non leakage probability

c. Fast fission factor

d. Thermal utilization factor

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

Question B.1 [1 point]
What type of Uranium and Silicon stoichiometric compound is the fuel MSTR is licensed to receive, posses, and use?

a. USi_2

b. USi

c. U_3Si_2

d. U_3Si

Question B.2 [1 point]
Minor modifications to the facility procedures that do not change their original intent can be made by the _____.

a. Facility Manager or higher

b. NRC

c. Radiation Safety Committee

d. SRO on duty

Question B.3 [1 point]
What is the limiting safety system setting for the MSTR?

a. 510 °C

b. 300 kW

c. 400 kW

d. 105 °C

Question B.4 [1 point]

Per Technical Specifications, MSTR can be operated:

a. With the demineralizer out of service for up to 3 weeks.

b. With free-drop time for the shim rods at greater than one second.

c. With the truck door open while the reactor is secured.

d. With one RAM channel inoperable for 10 days.

Question B.5 [1 point]
Why would you turn off the water pump after a high power run?

a. The core is cooled by natural convection and would no longer be needed.

b. To reduce radiological activity in the demineralizer.

c. N-16 is no longer being generated.

d. To measure the resistivity of the pool water.

Question B.6 [1 point]
As a licensed operator, when are you allowed to disregard certain SOPs provided that no safety requirements are violated?

a. Never; technical specification require that written procedures always be followed.

b. At the request of the Health Physicist.

c. Under the instruction of the SRO on Duty.

d. If a Limiting Safety System Setting will be exceeded.

Question B.7 [1 point]
The “Irradiation Request Form” evaluates all of the following EXCEPT:

a. Dose hazards to members of the public.

b. Dose hazards to the experimenter.

c. Hazards to the reactor.

d. Reactivity effects.

Question B.8 [1 point]
The purpose corresponding to the Receipt of bomb threat Action Level of an Unusual Event is:

a. To assure that the first step in a response has been carried out.

b. To bring the operating staff to a state of readiness.

c. To provide for handling information and decision making.

d. To notify offsite organizations.

Question B.9 [1 point]
Which ONE of the following is an example of an Alert action level?

a. An intruder in the facility.

b. Effluent release of 75 mrem over 24 hours at the site boundary.

c. Local news reports a tornado in the area.

d. Radiation levels of 100 mrem/hr at the site boundary.

Question B.10 [1 point]

A radioactive source is to be stored in the reactor bay with no shielding. The source reads 2 R/hr at 1 foot. How far from the source does a barrier need to be placed for it to be considered a “Radiation Area”?

a. 372 cm

b. 610 cm

c. 110 cm

d. 30 cm

Question B.11 [1 point]
As a research reactor licensed operator, you were unable to perform the functions of an operator for the minimum number of hours during the previous calendar quarter. What are the minimum number of hours you must complete before resumption of functions authorized by your license?

a. 4

b. 6

c. 8

d. 12

Question B.12 [1.0 point]
Per Technical Specifications, the neutron multiplication factor of the fully loaded storage pit shall not exceed:

a. 0.6

b. 0.7

c. 0.8

d. 0.9

Question B.13 [1.0 point]

Which Part of Title 10 of the Code of Federal Regulations licenses an individual to operate a reactor?

a. 20

b. 50

c. 55

d. 73

Question B.14 [1.0 point]
Per Technical Specifications, in the irradiation fuel element, which fuel plate position (s) are left unoccupied?

a. 1 – 9

b. 10 and 17

c. 11 – 16

d. 18

Question B.15 [1.0 point]
Which ONE of the following is NOT part of the procedure for "Entry Into A High Radiation Area"?

a. The SRO on Duty or Health Physicist shall be responsible for determining when a High Radiation Area exists.

b. An announcement will be made to ensure that no one is present in the area to become a High Radiation Area over the building public address system.

c. The doors leading to the High Radiation Area shall be locked.

d. The RO entering a High Radiation Area is responsible for entering their name and time in and out of the area.

Question B.16 [1.0 point]
_____ is the area enclosed by the walls of the reactor facility.

a. Emergency Planning Zone

b. Operations Boundary

c. Exclusion Area

d. Low Population Zone

Question B.17 [1.0 point]
The “Insertion and Removal of Experiments” procedure details the insertion and removal of the following types of experiments EXCEPT:

a. Rabbit facility

b. Wire and foil stringer

c. Vial stringer

d. Void tube

Question B.18 [1.0 point, 0.25 points each]
Match type of radiation in Column A with the proper penetrating power in Column B.

Column A	Column B
a. Alpha	1. Best shielded by light material
b. Beta	2. Best shielded by dense material
c. Gamma	3. Stopped by thin sheet of paper
d. Neutron	4. Stopped by thin sheet of metal

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

Question C.1 [1.0 point]
Which ONE of the following is TRUE about the reactor building?

a. The vents connected with the ventilation system are manually closed when the system is shut down.

b. Is constructed of insulated steel curtain walls.

c. Is constructed of reinforced concrete.

d. Has an air volume of about $1.4E^3$ m^3.

Question C.2 [1.0 point]
The regulating rod has a drive speed of _____ per minute.

a. 2 inches

b. 6 inches

c. 24 inches

d. 40 inches

Question C.3 [1.0 point]
MSTR's start-up source is:

a. Plutonium-Beryllium

b. Americium-Beryllium

c. Polonium-Beryllium

d. Radium-Beryllium

Question C.4 [1.0 point]

How many fuel plates does a standard fuel element have and how many grams of U-235 does each plate contain?

a. 9; 12.5

b. 18; 12.5

c. 9; 19.75

d. 18; 19.75

Question C.5 [1.0 point]
Which ONE of the following channels will scram on Power > 150%?

a. Channel #1: Startup

b. Channel #2: Log and Linear

c. Channel #3: Linear

d. Channel #4: Safety

Question C.6 [1.0 point]
Which ONE of the following is a characteristics of the Shim/Safety Rods?

a. Aluminum Rod

b. Tubular

c. Grooved Rod

d. Auto Control

Question C.7 [1.0 point]
Who owns the reactor fuel, and is responsible for its disposal?

a. The State of Missouri

b. Missouri University Science and Technology

c. Department of Energy

d. Nuclear Regulatory Commission

Question C.8 [1.0 point, 0.25 points each]
Choose the correct flow path for the Pool Water Cleanup and Makeup System. Water flowing to the demineralizer system must first flow through:

Flow Path Order	Components
a. _____	1. particulate filter
b. _____	2. mixed bed demineralizer column
c. _____	3. conductivity cell with alarm
d. _____	4. conductivity cell for performance assessment

Question C.9 [1.0 point]
The two diffusers are used to reduce exposure to which isotope?

a. O-16

b. N-16

c. Ar-41

d. Co-60

Question C.10 [1.0 point]
Which one of these actions results in a rundown?

a. High Neutron Flux in Beam Room

b. Period < 30 seconds

c. Regulating Rod on Insert Limit in Auto-Control

d. Safety Rods Below Shim Range

Question C.11 [1.0 point]
Which ONEW of the following detectors is sensitive enough to monitor reactor neutrons from shutdown to a power of about 1 W?

a. Safety Channel 1 (UIC)

b. Log N (CIC)

c. Linear (CIC)

d. Fission Chamber

Question C.12 [1.0 point]
The reactor power range safety channel and period channel shall be _____ annually.

a. Channel-Checked

b. Channel-Calibrated

c. Channel-Replaced

d. Channel-Tested

Question C.13 [1.0 point]
Aside from limitations on excess reactivity and shutdown margin, what is another constraint on core configuration?

a. Criticality with an open internal lattice

b. Experiments and experimental facilities

c. Type of fuel elements and location

d. Peak cladding temperature at full power

Question C.14 [1.0 point]
When the reactor is started up at the usual operating pool water temperature of about 20°C (68°F), what will the bulk temperature in the pool be after about 24 hours at full power?

a. 57°C (135°F)

b. 90°C (194°F)

c. 100°C (212°F)

d. 103°C (217.4°F)

Question C.15 [1.0 point]
What is the MSTR maximum hypothetical accident?

a. Failure of a Moveable Experiment

b. Flooding of an Irradiation Facility

c. Failure of a Fueled Experiment

d. Malfunction of Fuel

Question C.16 [1.0 point]
Why is nitrogen gas used as the transport system in the pneumatic tube “rabbit” system?

a. Availability at the facility.

b. The gases “chocking” properties.

c. To reduce Ar-41 activation.

d. To prevent fire.

Question C.17 [1.0 point]
In the case of any abnormal situation involving a significant airborne release, exhaust fans automatically:

a. Turn off.

b. Close louvers.

c. Turn off and close louvers.

d. Turn normal fans off and starts the exhaust fan.

Question C.18 [1 point]
The neutron-absorbing material in the MUST control rods is:

a. Beryllium

b. Boron

c. Aluminum Oxide

d. Zirconium Hydride

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

A.01
Answer: A.1 d.
Reference: DOE Fundamentals Handbook, NPRT, Vol. 2, Module 3, EO 2.7,p. 26

A.02
Answer: A.2 c.
Reference: DOE Fundamentals Handbook, NPRT, Vol. 1, Module 2, EO 3.1, p. 29

A.03
Answer: A.3 a.
Reference: Burns Section 2.5, pg. 2-36

A.04
Answer: A.4 c.
Reference: Burns Example 2.6.2 (b), pg. 2-51
$R = N_{135}\sigma_a\phi = (1x10^{16}\ at/cm^3)(2.7x10^6\ barns)(10^{-24}\ cm^2)(2x10^{13}\ n/cm^2/sec)$
$R = 5.4x10^{11}$ absorptions/sec/cm^3

A.05
Answer: A.5 d.
Reference: Burns Section 2.6, Figure 2.8 on pg. 2-52 and Example 2.6.3 on pg. 2-56
Given $A = A_o e^{-.693t/T2} = 0.01A_o$
$0.01 = e^{-.693t/T2}$
$\ln(0.01) = \ln(e^{-.693t/T2}) = -4.61 = -.693t/T_2$
$t = 6.65T_2 \approx 7T_2$

A.06
Answer: A.6 d.
Reference: Reference: Burns Example 4.10.12 (c), pg. 4-33

A.07
Answer: A.7 b.
Reference: Burns Section 8.1, pg. 8-1 and Table 8.1 on pg. 8-2

A.08
Answer: A.8 d.
Reference: Burns Section 6.2, pg. 6-2

A.09
Answer: A.9 d.
Reference: Burns Section 7.4, pg. 7-10

A.10
Answer: A.11 a. 2, b. 1, c. 3
Reference: Burns Section 5.5, Figures 5.4 – 5.6, pg. 5-20 – 5-22

A.11
Answer: A.10 a.

Reference: Burns Section 9.1, pg. 9.1

A.12
Answer: A.12 b.
Reference: CR1/CR2 = [1 - Keff2]/[1 - Keff1] 30/10 = [1 - Keff]/[1 - 0.96] 1 - Keff = 3 x 0.04 = 0.12 Keff = 0.88

A.13
Answer: A.13 a.
Reference: $N/N0 = e^{t/T}$; $500 = e^{t/T}$; ln 500 = t/30; t = 6.21 x 30 = 186 seconds

A.14
Answer: A.14 b.
Reference: DOE Fundamentals Handbook, NPRT, Vol. 1, Module 1, EO 3.1, p.43

A.15
Answer: A.15 b.
Reference: Burns Example 4.10.12 (c), pg. 4-33

A.16
Answer: A.16 a.
Reference: Burns Section 3.3.7, pg. 330: During a positive reactivity addition (supercritical), the shortest lived delayed neutron precursors are formed more rapidly than the longer lived precursors.

A.17
Answer: A.17 b.
Reference: Burn, R., Introduction to Nuclear Reactor Operations, 1988 Section 3.2 page 3-2

A.18
Answer: A.18 c.
Reference: Burns Section 3.3.1, pg. 3-17; Example 3.3.1 (c), pg. 3-18

B.01
Answer: B.1 c.
Reference: License, SAR Table 4.1 pg. 2, and TS 5.3.2

B.02
Answer: B.2 a.
REF: TS 6.4, pg. 30

B.03
Answer: B.3 b.
Reference: TS 2.2, pg. 6

B.04
Answer: B.4 a.
Reference: TS Section 3.3 bases (2), pg. 11-12

B.05
Answer: B.5 b.
Reference: SOP 101, "General Operational Procedures" Section B.5, pg. 1 of 3

B.06
Answer: B.6 c.
Reference: SOP 101, "General Operational Procedures"

B.07
Answer: B.7 a.
Reference: SOP 702, "Irradiation Request Forms" Section A, pg. 1 of 8

B.08
Answer: B.8 c.
Reference: SOP 502, "Emergency Procedures for an Unusual Event" Table I, pg. 2 of 2

B.09
Answer: B.9 b.
Reference: SOP 503, "Emergency Procedures for an Unusual Event" Table I, pg. 2 of 2

B.10
Answer: B.03 b.
Reference: $\frac{DR_1}{x_2^2} = \frac{DR_2}{x_1^2}$; $x_2^2 = \frac{2000\ mrem}{5\ mrem} 1\ ft^2 \left(\frac{(30.48\ cm)^2}{1\ ft^2}\right) = x = 609.6\ cm$

B.11
Answer: B.11 b.
Reference: 10 CFR 55.53 (f)

B.12

Answer: B.12 d.
Reference: TS 5.4, pg. 24

B.13
Answer: B.13 c.
Reference: 10 CFR Part 55

B.14
Answer: B.14 c.
Reference: TS 5.3.2(4), pg. 23

B.15
Answer: B.15 d.
Reference: SOP 602, “Entry Into A High Radiation Area”

B.16
Answer: B.16 a.
Reference: EP 6.0, pg. 12

B.17
Answer: B.17 d.
Reference: SOP 710, “Insertion and Removal of Experiments” Section B.1, pg. 1 of 7

B.18
Answer: B.18 a., 3, b., 4, c., 2, d., 1
Reference: DOE Handbook volume 1, module 1, pg. 64-66

C.01
Answer: C.1 b.
Reference: SAR 1.3.1, pg. 1-3

C.02
Answer: C.2 c.
Reference: SAR Table 4.1, pg. 4-2 and TS 5.3.4 2), pg. 24

C.03
Answer: C.3 a.
Reference: SAR Section 4.2.4, pg. 4-10

C.04
Answer: C.4 b.
Reference: SAR Section 4.2.1.1, pg. 4-6

C.05
Answer: C.5 d.
Reference: SAR Table 7.1, pg. 7-2

C.06
Answer: C.6 c.
Reference: SAR Section 4.2.2, pg. 4-9

C.07
Answer: C.7 c.
Reference: SAR 1.7, pg. 1-6

C.08
Answer: C.8 a.1; b.4; c.2; d.3
Reference: SAR Section 5.2; pg. 5.2

C.09
Answer: C.9 b.
Reference: SAR Section 5.3, pg. 5-5

C.10
Answer: C.10 c.
Reference: SAR Table 7.2, pg. 7-12

C.11
Answer: C.11 d.
Reference: SAR 7.2.2.1, pg. 7-5

C.12
Answer: C.12 b.

Reference: TS 4.2.2 2), pg.19

C.13
Answer: C.13 a.
Reference: SAR Section 4.5.1, pg. 4-13

C.14
Answer: C.14 a.
Reference: SAR Section 4.6, pg.4-17

C.15
Answer: C.15 c.
Reference: SAR Section 13.1, pg. 13-1

C.16
Answer: C.16 c.
Reference: SAR Section 10.2.3, pg. 10-4

C.17
Answer: C.2 b.
Reference: SAR Section 9.1, pg. 9-1

C.18
Answer: C.18 b.
Reference: SAR 4.2.2, pg. 4-9 and TS 5.3.3, pg. 23