October 30, 2015

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

SUBJECT: EXAMINIATION REPORT, NO. 50-123/OL-15-03, MISSOURI UNIVERISITY OF SCIENCE AND TECHNOLOGY

Dear Dr. Lee:

During the week of September 28, 2015, 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, published in June 2007. Examination questions and preliminary findings were discussed with Mr. Craig Resiner, Mr. William Bonzer, and Mr. Anthony Alchin of your staff 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 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 Mrs. Paulette Torres at (301) 415-5656, or via e-mail at Paulette.Torres@nrc.gov.

Sincerely,
/RA/

Kevin Hsueh, 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-15-03
2. Written Examination

cc: Mr. Craig Reisner, Training Coordinator

cc: w/o enclosures: See next page

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DISTRIBUTION w/ encls:
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ADAMS Accession No.: ML15293A233 **NRR 079**

OFFICE	NRR/DPR.PROB	NRR/DPR.PROB	NRR/DPR.PROB
NAME	PTorres	NParker	KHsueh
DATE	10/20/15	10/20/15	10/30/15

OFFICIAL RECORD COPY

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

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

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

REPORT NO.: 50-123/OL-15-03

FACILITY DOCKET NO.: 50-123

FACILITY LICENSE NO.: R-79

FACILITY: Missouri University of Science and Technology

EXAMINATION DATES: September 28-30, 2015

SUBMITTED BY: ***/RA/*** 10/20/15
Mrs. Paulette Torres, Chief Examiner Date

SUMMARY:

During the week of September 28, 2015, the NRC administered operator licensing examinations to three Reactor Operator license candidates. The candidates passed all applicable portions of the examinations.

REPORT DETAILS

1. Examiner: Mrs. Paulette Torres, Chief Examiner

2. Results:

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

3. Exit Meeting:

Mrs. Paulette Torres, Chief Examiner, NRC
Mr. Craig Reisner, Training Coordinator
Mr. William Bonzer, Reactor Manager
Mr. Anthony Alchin, Senior Reactor Operator

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

FACILITY: Missouri University of Science and Technology

REACTOR TYPE: MTR

DATE ADMINISTERED: 09/28/2015

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	100.00	_____	_____	%	TOTALS
		FINAL GRADE			

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

_____
Candidate's Signature

Section 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 d ___

A11 a b c d ___

A12 a b c d ___

A13 a b c d ___

A14 a b c d ___

A15 a b c d ___

A16 a b c d ___

A17 a b c d ___

A18 a b c d ___

A19 a b c d ___

A20 a b c d ___

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

Section 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 ___

B19 a b c d ___

B20 a b c d ___

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

Section 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 ___

C19 a b c d ___

C20 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.

EQUATION SHEET

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

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

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

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

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

$$\ell^* = 1 \times 10^{-4} \sec$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

DR – Rem, 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

MISSOURI UNIVERSITY OF SCIENCE AND TECHNOLOGY – ROLLA

Operator Licensing Examination

Week of September 28, 2015

QUESTION A.01 [1.0 point]
Shutdown Margin is defined as:

a. The negative reactivity inserted by an increase in moderator temperature within the core when the reactor is brought from zero to full power.

b. Provides a measure of excess reactivity available to overcome fission product buildup, fuel burnup, and power defect.

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

d. The amount of reactivity available above what is required to keep the reactor critical.

QUESTION A.02 [1.0 point]
A reactor scram has resulted in the instantaneous insertion of 0.005 ΔK/K of negative reactivity. Which ONE of the following is the stable negative reactor period resulting from the scram?

a. 25 seconds

b. 54 seconds

c. 80 seconds

d. 125 seconds

QUESTION A.03 [1.0 point]
The fuel temperature coefficient of reactivity is -1.25×10^{-4} Δk/k/°C. When a control rod with an average rod worth of 0.1 % Δk/k/inch is withdrawn 5 inches, reactor power increases and becomes stable at a higher level. At this point, the fuel temperature has:

a. increased by 40°C

b. decreased by 40°C

c. increased by 4°C

d. decreased by 4°C

QUESTION A.04 [1.0 point]
The count rate is 100 cps. An experimenter inserts an experiment into the core, and the count rate decreases to 60 cps. Given the initial K_{eff} of the reactor was 0.92, what is the worth of the experiment?

a. $\Delta\rho = - 0.07$

b. $\Delta\rho = + 0.07$

c. $\Delta\rho = - 0.02$

d. $\Delta\rho = + 0.02$

QUESTION A.05 [1.0 point]
Which ONE of the following is the MAJOR source of energy released during fission?

a. Kinetic energy of the fission neutrons.

b. Kinetic energy of the fission fragments.

c. Decay of the fission fragments.

d. Prompt gamma rays.

QUESTION A.06 [1.0 point]
Most text books list β for a U^{235} fueled reactor as 0.0065 ΔK/K and β_{eff} as being 0.0075 ΔK/K. Why is β_{eff} larger than β?

a. Delayed neutrons are born at higher energies than prompt neutrons resulting in a greater worth for these neutrons.

b. Delayed neutrons are born at lower energies than prompt neutrons resulting in a less loss due to leakage for these neutrons.

c. The fuel includes U^{238} which has a relatively large for fast fission.

d. Some U^{238} in the core becomes Pu^{239} (by neutron absorption) which has a larger for fission.

QUESTION A.07 [1.0 point]
As the moderator temperature increases, the resonance escape probability _____.

a. Increases, since the moderator becomes less dense.

b. Decreases, since the time required for a neutron to reach thermal energy increases.

c. Remains constant, since the effect of moderator temperature change is relatively small.

d. Increases, since the moderator-to-fuel ratio increases.

QUESTION A.08 [1.0 point]
What happens to the mass number and the atomic number of an element when it undergoes beta decay?

a. The mass number decreases by 4 and the atomic number decreases by 2.

b. The mass number does not change and the atomic number decreases by 2.

c. The mass number increases by 2 and the atomic number increases by 1.

d. The mass number does not change and the atomic number increases by 1.

QUESTION A.09 [1.0 point]
Which ONE of the following is the time period in which the maximum amount of Xenon-135 will be present in the core? Peak Xenon is reached _____.

a. 7 to 10 hours after a startup to 100% power.

b. 7 to 10 hours after shutdown.

c. 4 to 6 hours after a power increase from 50% to 100%.

d. 4 to 6 hours after a power decrease from 100% to 50%.

QUESTION A.10 [1.0 point]
Which ONE defines an integral rod worth curve?

a. Conforms to an axial flux shape.

b. Any point on the curve represents the amount of reactivity that one inch of rod motion would insert at that position in the core.

c. Represents the cumulative area under the differential curve starting from the bottom of the core.

d. Reactivity is highest at the top of the core and lowest at bottom of the core.

QUESTION A.11 [1.0 point]
During a fuel loading of the core, as the reactor approaches criticality, the value of 1/M:

a. Increases toward one.

b. Decreases toward one.

c. Increases toward infinity.

d. Decreases toward zero.

QUESTION A.12 [1.0 point]
INELASTIC scattering is the process by which a neutron collides with a nucleus and:

a. Recoils with the same kinetic energy it had prior to the collision.

b. Recoils with a lower kinetic energy than it had prior to the collision, with the nucleus emitting a gamma ray.

c. Is absorbed, with the nucleus emitting a gamma ray.

d. Recoils with a higher kinetic energy than it had prior to the collision, with the nucleus emitting a gamma ray.

QUESTION A.13 [1.0 point]
Two critical reactors at low power are identical except that Reactor 1 has a beta fraction of 0.0072 and Reactor 2 has a beta fraction of 0.0060. An equal amount of positive reactivity is inserted into both reactors. Which ONE of the following will be the response of Reactor 2 compared to Reactor 1?

a. The resulting power level will be lower.

b. The resulting power level will be higher.

c. The resulting period will be longer.

d. The resulting period will be shorter.

QUESTION A.14 [1.0 point]
Which one of the following has the highest thermal neutron cross section?

a. Cd-113

b. Xe-135

c. Gd-157

d. Sm-149

QUESTION A.15 [1.0 point]
The reactor is critical at 5 watts. Which ONE of the following correctly describes the reactor behavior when a reactivity worth of 0.50 % ΔK/K is IMMEDIATELY inserted to the reactor core?

a. Subcritical

b. Critical

c. Supercritical

d. Delayed critical

QUESTION A.16 [1.0 point]
The term _____ defines the condition where no delay neutrons are required.

a. Prompt Jump

b. Prompt Drop

c. Asymptotic Period

d. Prompt Critical

QUESTION A.17 [1.0 point]
Which ONE of the following is the correct reason that delayed neutrons enhance control of the reactor?

a. There are more delayed neutrons than prompt neutrons.

b. Delayed neutrons increase the average neutron generation time.

c. Delayed neutrons take longer to reach thermal equilibrium.

d. Delayed neutrons are born at higher energies than prompt neutrons and therefore have a greater effect.

QUESTION A.18 [1.0 point]
Which ONE of the following describes the production of fission neutrons resulting from thermal neutrons being absorbed in the fuel?

a. Fast Non-Leakage Probability (L_f)

b. Resonance Escape Probability (p)

c. Thermal Utilization Factor (f)

d. Reproduction Factor (η)

QUESTION A.19 [1.0 point]
A subcritical reactor is being started up. A control blade is raised in four equal steps. Which ONE of the following statement most accurately describes the expected reactor response?

a. Power increases by the same amount for each withdrawal.

b. Each withdrawal will add the same amount of reactivity.

c. The time for power to stabilize after each successive withdrawal increases.

d. A lower critical rod height is attained by decreasing the time intervals between withdrawals.

QUESTION A.20 [1.0 point]
Reactor period is defined as _____.

a. The time required for a reactor to change by a factor of *e.*

b. The time required for the reactor power to double.

c. The number of factors of ten that reactor power changes in one minute.

d. The fraction of all neutrons that are born as delayed neutrons.

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

QUESTION B.01 [1.0 point]
Per Technical Specifications, which ONE of the following Safety System Channels has a 4.88 m above the core set point that will automatically scram the rector?

a. Safety #1

b. Bridge Motion

c. Reactor Period

d. Loss of Coolant

QUESTION B.02 [1.0 point]
Per Technical Specifications, what is the basis for keeping the reactor pool temperature at a minimum of 60°F or greater when the reactor is operated?

a. To avoid damaging the regenerative mixed bed of ion exchanged resin in the demineralizer.

b. To not risk reaching a fuel temperature greater than the Safety Limit.

c. To ensure that the excess reactivity will not significantly increase and that the shutdown margin will not decrease.

d. To avoid damaging the heat exchanger plates.

QUESTION B.03 [1.0 point]
The statement “Unless the reactor is secured, the truck door is to be closed and the ventilation intake and exhaust duct louvers operable or secured in a closed position” corresponds to Technical Specification on:

a. Reactor Control and Safety Systems

b. Confinement

c. Ventilation System

d. Experiments

QUESTION B.04 [1.0 point]
Per Technical Specifications, a _____ of the reactor power range safety channel and period channel shall be performed annually.

a. Channel Calibration

b. Channel Check

c. Channel Replacement

d. Channel Test

QUESTION B.05 [1.0 point]
The dose rate 10 feet from a point gamma source is 25 mR/hr. A person working for 1.5 hours at 3 feet from the source will receive a dose of:

a. 417 mR

b. 278 mR

c. 125 mR

d. 83 mR

QUESTION B.06 [1.0 point]
MS&T reactor facility _____ requires each operator to be cognizant of all facility design, procedures and license changes.

a. Emergency Plan

b. Security Plan

c. Operator Requalification Program

d. Technical Specifications

QUESTION B.07 [1.0 point]
In accordance with 10 CFR Part 50.47(b)(11), under what conditions a radiation worker can have exposure in excess of 10CFR20 limits?

a. During any emergency.

b. In an emergency situation, a planned emergency exposure to the whole body could be allowed up to 75 rem to save a life.

c. As long as the radiation worker don't exceed 50 rem whole body to protect facilities.

d. In an emergency declared by the Emergency Support Center Director with concurrence of the Senior Reactor Operator on Duty.

QUESTION B.08 [1.0 point]
_____ are considered to be appropriate to initiate protective actions for members of the general public onsite.

a. Emergency Procedures

b. Emergency Action Levels

c. Emergency Planning Zones

d. Protective Action Guides

QUESTION B.09 [1.0 point]
Which ONE of the following is considered an Unusual Event?

a. Actual or projected radiological effluents at the site boundary calculated to produce a dose of 15 mrem whole body accumulated in 24 hours.

b. Actual or projected radiological effluents at the site boundary calculated to produce a dose of 75 mrem whole body accumulated in 24 hours.

c. Actual or projected radiological effluents at the site boundary calculated to produce a dose of 375 mrem whole body accumulated in 24 hours.

d. Actual or projected radiation levels at the site boundary of 20 mrem/hr for 1 hour whole body or 100 mrem thyroid dose.

QUESTION B.10 [1.0 point]
"The reactor thermal power shall be no greater than 300 kW." This is an example of a:

a. Safety Limit.

b. Limiting Safety System Setting.

c. Limiting Condition of Operation.

d. Surveillance Requirement.

QUESTION B.11 [1.0 point]
Per Emergency Procedures, the _____ has the administrative responsibility of establishing safety limits and an evacuation zone for emergency workers and the general public during a reactor related emergency.

a. Radiation Safety Officer

b. Emergency Support Center Director

c. Emergency Support Center Manager

d. Campus Health Physicist

QUESTION B.12 [1.0 point]
According to 10 CFR 20.152(a)(1), workers exceeding what percentage of the annual occupational dose limit shall be monitored (i.e., issued dosimetry) for radiation exposure?

a. 5%

b. 10%

c. 20%

d. 50%

QUESTION B.13 [1.0 point]
Radiation Safety Committee approval is required for experiments worth more than _____.

a. 0.05% Δk/k

b. 0.1% Δk/k

c. 0.4% Δk/k

d. 1.2% Δk/k

QUESTION B.14 [1.0 point]
No experiments are being moved or serviced that have, on movement, a reactivity worth that exceeds the maximum value allowed for a single experiment, or one dollar, whichever is smaller is a definition for _____.

a. Reactor Secured

b. Reactor Shutdown

c. Reference Core Condition

d. Reportable Occurrence

QUESTION B.15 [1.0 point]
A radioactive source generates a dose of 100 mR/hr at a distance of 10 feet. Using a two inch thick sheet of lead for shielding the reading drops to 50 mR/hr at a distance of 10 feet. What is the minimum number of sheets of the same lead shielding needed to drop the reading to less than 5 mR/hr at a distance of 10 feet?

a. 3

b. 4

c. 5

d. 6

QUESTION B.16 [1.0 point]
Reactor Operator works in a high radiation area for eight (8) hours a day. The dose rate in the area is 100 mR/hour. Which ONE of the following is the MAXIMUM number of days in which Reactor Operator may perform his duties WITHOUT exceeding 10 CFR 20 limits?

a. 5 days

b. 6 days

c. 7 days

d. 12 days

QUESTION B.17 [1.0 point]
10 CFR 20 defines the "Derived Air Concentration (DAC)" as:

a. The concentration of a given radionuclide in air which, if breathed by the reference man for a working year of 2,000 hours under conditions of light work (inhalation rate 1.2 cubic meters of air per hour), results in an intake of one ALI.

b. The derived limit for the amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in a year.

c. The dose equivalent to organs or tissues of reference (T) that will be received from an intake of radioactive material by an individual during the 50-year period following the intake.

d. The sum of the effective dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures).

QUESTION B.18 [1.0 point]
Which ONE of following types of radiation is the HIGHEST Quality Factor specified in 10CFR20?

a. Alpha

b. Beta

c. Gamma

d. Neutron (unknown energy)

QUESTION B.19 [1.0 point]
The MS&T reactor Radiation Work Permit (RWP) check list requires all of the following immediately prior to the work being done EXCEPT:

a. Contamination survey results.

b. Direct radiation survey results.

c. Airborne radioactivity levels (if applicable).

d. Personnel who were involved and their respective radiation exposures.

QUESTION B.20 [1.0 point]
You are currently the licensed operator at the control of the reactor. Which ONE of the following violates 10 CFR Part 55.53 “Conditions of licenses”?

a. Last license medical examination was 26 months ago.

b. Last requalification operating test was 11 months ago.

c. Last quarter you were the licensed operator for 6 hours.

d. Last requalification written examination was 13 months ago.

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

QUESTION C.01 [1.0 point]
Technical Specifications state that all of the following shall be visually checked for proper operation quarterly EXCEPT:

a. Ventilation Inlet

b. Radiation Area Monitors

c. Exhaust Duct Louvers

d. Personnel Security Door

QUESTION C.02 [1.0 point]
Which ONE of the following channels does not provide scram capability to the reactor safety system?

a. Safety #2

b. Reactor Period

c. Bridge Motion

d. Startup Count Rate

QUESTION C.03 [1.0 point]
The start-up source used in the MSTR is a _____ neutron source.

a. Am-Li

b. Am-Be

c. Sb-Be

d. Pu-Be

QUESTION C.04 [1.0 point]
Which ONE of the following prevents the accidental siphoning of reactor pool water?

a. A positive pressure difference inside the heat exchanger.

b. The capacity of the discharge tank.

c. A hole drilled in the in-pool piping.

d. The manual closure of the makeup water system hoses.

QUESTION C.05 [1.0 point]
Which ONE of the following experimental facilities is equipped with a seal and may be used as an air-filled assembly, water filled assembly, or a partial mix of air and water?

a. Pneumatic Sample Transfer System

b. Void Tube

c. Sample Rotor Assembly

d. Beam Port

QUESTION C.06 [1.0 point]
Possible causes for a leak in the coolant system are due to all of the following EXCEPT:

a. Rupture in the raw water supply system.

b. Crack in the pool wall.

c. Leak in the purification system.

d. Leak in the seal around the beam port or thermal column.

QUESTION C.07 [1.0 point]
The material of each shim/safety rods consists of _____.

a. Aluminum

b. Cadmium

c. Boron Carbide

d. Boron Stainless Steel

QUESTION C.08 [1.0 point]
Which ONE of the following radiation monitors uses a BF-3 detector?

a. Basement Neutron Monitor

b. Constant Air Monitor

c. Reactor Bridge Monitor

d. Experiment Room Monitor

QUESTION C.09 [1.0 point]
Per Technical Specifications, the water resistivity shall not exceed a prescribed value which corresponds to a water conductivity of _____.

a. 0.2 μmhos/cm

b. 1.25 μmhos/cm

c. 2.0 μmhos/cm

d. 5.0 μmho/cm

QUESTION C.10 [1.0 point]
Which ONE of the following systems is used at MSTR to reduce the N-16 radiation exposure levels on the bridge?

a. A diffuser system.

b. A pool cooling system.

c. A siphon break.

d. A continuous air monitoring system.

QUESTION C.11 [0.25 points each]
Match the type of automatic engineered protective actions listed in column A with its corresponding color alarm listed in column B.

Column A	Column B
a. Rod Withdrawal Prohibit (RWP) with audio/visual	1. WHITE alarms
b. Reactor Scram with audio/visual	2. YELLOW alarms
c. Informational with audio/visual	3. BLUE alarms
d. Reactor Rundown with audio/visual	4. RED alarms

QUESTION C.12 [1.0 point]
The MSTR standard fuel element shall be flat plate MTR type elements fueled with:

a. Low enrichment (<20% U-235) U_3Si_2, clad with aluminum.

b. Low enrichment (<30% U-235) U_3Si_2, clad with aluminum.

c. Low enrichment (<20% U-235) U_3Si_2, clad with stainless steel.

d. Low enrichment (<30% U-235) U_3Si_2, clad with stainless steel.

QUESTION C.13 [1.0 point]
At MSTR, the principal potential airborne radiation source is composed of all of the following EXCEPT:

a. ^{16}N

b. ^{41}Ar

c. neutron-activated dust particulates

d. ^{138}Cs

QUESTION C.14 [1.0 point]
What kind of detector feeds the Log and Linear Channel?

a. Fission Chamber

b. Compensated Ion Chamber

c. Geiger-Mueller

d. Uncompensated Ion Chamber

QUESTION C.15 [1.0 point]
The gas used as a transport medium for the Pneumatic Sample Transfer System is _____.

a. Compressed Air

b. CO_2

c. Helium

d. Nitrogen

QUESTION C.16 [1.0 point]
Inadvertent movement of the reactor bridge will result in:

a. Illumination of a status light in the reactor control console only.

b. A rod rundown.

c. An automatic scram.

d. An evacuation alarm.

QUESTION C.17 [1.0 point]
Which ONE of the following is true about the Regulating Rod?

a. Does not respond to a scram signal.

b. It is magnetically coupled to the drive mechanism.

c. Has a withdrawal rate of approximately 6 in. per minute.

d. The poison section of the rod contains approximately 1.5% natural boron.

QUESTION C.18 [1.0 point]
All of the following are Technical Specifications Reactor Building descriptions EXCEPT:

a. The reactor is housed in a steel-framed, double-walled building designed to restrict leakage.

b. Air and other gases may be exhausted through vents in the reactor bay ceiling 9.1 m (30 ft) above grade.

c. The reactor building's free volume is approximately 1700 m^3.

d. A system of three exhaust fans is mounted on the reactor building roof to provide ventilation for the reactor building.

QUESTION C.19 [1.0 point]
Per Technical Specifications, the building evacuation alarm is required to be set at or below _____.

a. 20 mR/h

b. 50 mR/h

c. 100 mR/h

d. There are no Technical Specifications requirements for building evacuation alarm.

QUESTION C.20 [1.0 point]
Which ONE of the following is true about the Continuous Air Monitoring (CAM)?

a. The reactor may be operated without the CAM if the period of operations does not exceed one day.

b. Has a local audible alarm setpoint of 20 mrem/hr or less.

c. Ensure that, in case of a failure of an experiment or a significant drop in the pool water level, the appropriate action can be automatically initiated.

d. Is a stand-alone unit and is not interfaced with the control console.

(***** END OF SECTION C *****)
(********** END OF EXAMINATION **********)

A.01
Answer: c
REF: Burns, example 6.2.3 (a), pg. 6-4

A.02
Answer: c
REF: Burn, example 4.5(a), pg. 4-13 and 4-16

A.03
Answer: a
REF: Lamarsh, Introduction to Nuclear Engineering, 3rd ed., pg. 365
Reactivity added by control rod = +(0.001 Δk/k/inch)(5 inches) = 0.005 Δk/k
Fuel temperature change = -Reactivity added by rod / fuel temperature coefficient
Fuel temperature change = (-0.005 Δk/k) / (-1.25×10^{-4} Δk/k/°C) = 40°C

A.04
Answer: a
REF: $CR_1 / CR_2 = (1 - K_{eff2}) / (1 - K_{eff1})$
$100 / 60 = (1 - K_{eff2}) / (1 - 0.92)$
Therefore $K_{eff2} = 0.867$
$\Delta\rho = K_{eff2} - K_{eff1} / K_{eff2} * K_{eff1}$
$\Delta\rho = (0.867 - 0.92) / (0.867 * 0.92)$
$\Delta\rho = - 0.0664$

A.05
Answer: b
REF: Burns, Section 3.2.1, and Table 3.2, pg. 3-4 and 3-5

A.06
Answer: b
REF: Burns, Section 3.2.4, pg. 3-12

A.07
Answer: b
REF: Lamarsh, Introduction to Nuclear Engineering, 3rd ed., pg. 372
Burns, Section 3.3.2, pg. 3-18

A.08
Answer: d
REF: DOE Handbook volume 1, NP-01, pg. 24, β decay = $ZX^A \rightarrow Z+1Y^A + e + v$,
A = atomic mass = proton + neutrons
Z = # protons

A.09
Answer: b
REF: Burns, Section 8.8.3 (d), pg. 8-24

A.10
Answer: c
REF: Burns, Section 7.3, pg. 7-5 to 7-7

A.11
Answer: d
REF: Burns, Table 5.5, pg. 5-15

A.12
Answer: b
REF: DOE Handbook volume1, NP-01, pg. 45

A.13
Answer: d
REF: $T = (\ell^*/\rho) + [(\beta - \rho)/ \lambda_{eff} \rho]$

A.14
Answer: b
REF: Allyn and Bacon, Basic Nuclear Engineering, 4th ed., Appendix A, pg. 577
^{113}Cd=2,450 b, ^{149}Sm=40,800 b, ^{157}Gd=240,000 b, $^{135}Xe=2.72 \times 10^6$ b

A.15
Answer: c
REF: Burn, Section 4.2
0.5 % $\Delta K/K$ =0.005 $\Delta K/K$ <0.007, therefore reactor is supercritical

A.16
Answer: d
REF: Ronald Allen Knief, Nuclear Engineering, 2nd ed., pg. 142

A.17
Answer: b
REF: Burns, Section 3.3.7, pg. 3-31 and Problem 3.4.4, pg. 3-33

A.18
Answer: d
REF: DOE Handbook volume 2, NP-03, pg. 13

A.19
Answer: c
REF: Burns, Section 5.3, pg. 5-7

A.20
Answer: a
REF: DOE Handbook volume 2, NP-4, pg. 21

B.01
Answer: d
REF: TS 3.2.2, Table 3.2, pg. 10

B.02
Answer: c
REF: TS 3.3.3) bases, pg. 12

B.03
Answer: b
REF: TS 3.4, pg. 12

B.04
Answer: a
REF: TS 4.2.2.2), pg. 19

B.05
Answer: a
REF: $DR_1d_1^2 = DR_2d_2^2$;
DR_1 = 25 mR/hr, d_1 = 10 ft, d_2 = 3 ft
$DR_2 = (25)(10)^2/(3)^2$
DR_2 = 278 mR/hr x 1.5 hr = 417 mR

B.06
Answer: c
REF: Operator Requalification Program, Section 2.0.b.(2), pg. 2

B.07
Answer: b
REF: EP section 7.4.6, pg. 18

B.08
Answer: b
REF: EP section 5.0, pg. 12

B.09
Answer: a
REF: EP Table I, pg. 11

B.10
Answer: b
REF: TS 2.2, pg. 6

B.11
Answer: d
REF: SOP 507 EP, section C.7.d, pg. 4 of 5

B.12
Answer: b
REF: 10 CFR 20.152(a)(1)

B.13
Answer: c
REF: SOP 702, section B.5.a, pg. 1 of 8

B.14
Answer: a
REF: TS 1.2, pg. 4

B.15
Answer: c
REF: Two inches = one-half thickness (T½). Using 5 half-thickness will drop the dose by a factor of (½)5 = 1/32. Then 100/32 = 3.125 mR/hr

B.16
Answer: b
REF: 10 CFR 20.1201(a)(1)

$$5000mR * \frac{1hr}{100mR} * \frac{1day}{8hr} = 6.25days$$

B.17
Answer: a
REF: 10 CFR 20.1003

B.18
Answer: a
REF: 10 CFR 20.1004

B.19
Answer: d
REF: SOP 615, RWP checklist step 10, pg. 6 of 6

B.20
Answer: a
REF: 10 CFR Part 55.53

- 55.53(i) – the licensee shall have a biennial medical examination.
- 55.53(h), 55.59(c) – annual operating tests
- 55.53(e) – the licensee shall actively perform the functions of a licensed operator for a minimum of 4 hours per calendar quarter.
- 55.53(h), 55.59(c)(1) – ”The requalification program must be conducted for a continuous period not to exceed 2 years”

C.01
Answer: b
REF: SAR 9.1, pg. 9-1
TS 4.4, pg. 20

C.02
Answer: d
REF: TS 3.2.2, pg. 10

C.03
Answer: d
REF: SAR 4.2.4, pg. 4-10

C.04
Answer: c
REF: SAR 4.3, pg. 4-12

C.05
Answer: b
REF: SAR 10.2.6, pg. 10-6

C.06
Answer: a
REF: SAR 5.2, pg. 5-2

C.07
Answer: d
REF: SAR 4.2.2, pg. 4-9

C.08
Answer: a
REF: SAR 7.4, pg. 7-10

C.09
Answer: d
REF: TS 3.3.2), pg. 11
Conductivity micromhos/cm = 1/Resistivity megohm-cm

C.10
Answer: a
REF: SAR 5.3, pg. 5-5
SAR 11.1.1.1, pg. 11-1

C.11
Answer: a,2 b,4 c,1 d,3
REF: SAR 7.2.2, pg. 7-1, 7-2

C.12
Answer: a
REF: TS 5.3.2.1), pg. 23
SAR 4.2.1.1, pg. 4-6

C.13
Answer: d
REF: SAR 11.1.1.1, pg. 11-1

C.14
Answer: b
REF: SAR Table 7.1, pg. 7-2

C.15
Answer: d
REF: SAR 10.2.3, pg. 10-4

C.16
Answer: c
REF: TS Table 3.2, pg. 10

C.17
Answer: a
REF: TS 5.3.3, pg. 23, TS 5.3.4, pg. 24
SAR 4.2.2, pg. 4-9

C.18
Answer: d
REF: TS 5.1.2, pg. 22

C.19
Answer: b
REF: TS Table 3.3, pg. 13
SAR 7.4, pg. 7-10

C.20
Answer: d
REF: SAR 7.4, pg. 7-10