UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

November 9, 2018

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-19-01, MISSOURI UNIVERSITY OF SCIENCE AND TECHNOLOGY

Dear Dr. Lee:

During the week of October 1, 2018, 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 e-mail 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:
1. Examination Report No. 50-123/OL-19-01
2. Written Examination

cc: Mr. Craig Reisner, Interim Manager,
Missouri University of Science and Technology

cc: w/o enclosure: See next page

SUBJECT: EXAMINATION REPORT NO. 50-123/OL-19-01, MISSOURI UNIVERSITY OF SCIENCE AND TECHNOLOGY NOVEMBER 9, 2018

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ADAMS Accession No. ML18312A393 **NRR-079**

OFFICE	NRR/DLP/PROB/CE	NRR/DLP/PROB/OLA	NRR/DLP/PROB/CE
NAME	MDeSouza	CJRandiki	AMendiola
DATE	10/12/2018	11/08/2018	11/09/2018

OFFICIAL RECORD COPY

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

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-19-01

FACILITY DOCKET NO.: 50-123

FACILITY LICENSE NO.: R-79

FACILITY: Missouri University of Science and Technology Reactor

EXAMINATION DATE: October 1, 2018

SUBMITTED BY: */RA/* 10/23/2018
Paulette Torres, Chief Examiner Date

SUMMARY:

During the week of October 1, 2018 the NRC administered a licensing examination to two Reactor Operator (RO) applicants and one Senior Reactor Operator Upgrade (SROU) applicant. Two of the applicants passed all portions of the examination. One applicant failed the written portion of the examination.

REPORT DETAILS

1. Examiner: Paulette Torres, Chief Examiner, NRC

2. Results:

	RO PASS/FAIL	SRO PASS/FAIL	TOTAL PASS/FAIL
Written	1/1	0/0	1/1
Operating Tests	3/0	1/0	3/0
Overall	2/1	1/0	2/1

3. Exit Meeting:
Paulette Torres, Chief Examiner, NRC
Craig Reisner, Interim Manager, MUST

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

FACILITY:	Missouri University of Science and Technology (Rolla)
REACTOR TYPE:	MTR
DATE ADMINISTERED:	10/01/2018
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		_____	_____ %	TOTALS
		FINAL GRADE		

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

_____
Candidate's Signature

ENCLOSURE 2

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 *****)

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 *****)

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 ___ e ___

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$A = A_0 e^{-\lambda t}$$

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

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

1 Curie = 3.7 x 10^{10} dis/sec
1 Horsepower = 2.54 x 10^3 BTU/hr
1 BTU = 778 ft-lbf
1 gal (H_2O) ≈ 8.34 lbm
1 ft = 30.48 cm
c_P = 1.0 BTU/hr/lbm/°F
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 - ROLLA

Operator Licensing Examination

Week of October 1, 2018

QUESTION A.01 [1.0 point]
Energy Yield (ΔQ) from a nuclear fission reaction is in the range of (or is approximately):

a. < 1 eV

b. 1.86 keV

c. 200 MeV

d. 1000 MeV

QUESTION A.02 [1.0 point]
A reactor is subcritical if:

a. $\rho = 1.0$

b. $K_{eff} < 1.0$ or $\rho < 0.0$

c. $K_{\infty} = 1.0$, $\rho = \beta$

d. $K_{eff} > 1.0$ or $\rho > 0.0$

QUESTION A.03 [1.0 point]
What is the meaning of any point on a differential rod worth curve? Represents

a. The amount of reactivity that one inch of rod motion would insert at that position in the core.

b. The zero reactivity when the rod is on the bottom and the positive reactivity being added as the rod is withdrawn.

c. The negative reactivity added as the rod is inserted.

d. The cumulative area under the differential curve starting from the bottom of the core.

QUESTION A.04 [1.0 point]
Which ONE of the following changes does not require a movement of control rods in order to maintain constant reactor power?

a. Pool water temperature decrease

b. U-235 burnup

c. Xe-135 buildup

d. N-16 formation

QUESTION A.05 [1.0 point]
The effective multiplication factor (K_{eff}) can be determined by dividing the number of neutrons produced from fission in the fourth generation by the number of neutrons produced from fission in the _____ generation.

a. First

b. Second

c. Third

d. Fifth

QUESTION A.06 [1.0 point]
Because the temperature of the fuel reacts immediately to changes in reactor power, the Fuel Temperature Coefficient is also called the:

a. Prompt Temperature Coefficient

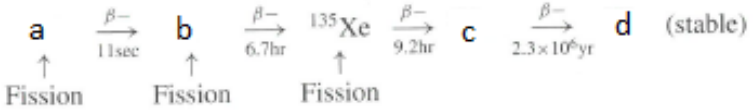
b. Moderator Temperature Coefficient

c. Nuclear Doppler Effect

d. Void Coefficient

QUESTION A.07 [1.0 point, 0.25 each]
Match the items in Column A with the isotopes in Column B.
The most important fission product poison is ^{135}Xe. The process that show how this isotope is formed and its decay is:

Column A



Column B

1. ^{135}Ba
2. ^{135}Cs
3. ^{135}I
4. ^{135}Te

QUESTION A.08 [1.0 point]
Delayed neutrons contribute more to reactor stability than prompt neutrons because they _____ the average neutron generation time and are born at a _____ kinetic energy.

a. Decrease, lower

b. Increase, lower

c. Decrease, higher

d. Increase, higher

QUESTION A.09 [1.0 point]
The neutron interaction in the reactor core that is MOST efficient in thermalizing fast neutrons occurs with the:

a. Hydrogen atoms in the water molecules.

b. Nitrogen-16 from Oxygen.

c. Boron atoms in the control rods.

d. Aluminum atoms in the fuel cladding.

QUESTION A.10 [1.0 point]
Which ONE of the following is the description of a thermal neutron?

a. A neutron possessing thermal rather than kinetic energy.

b. The primary source of thermal energy increase in the reactor coolant during reactor operation.

c. A neutron that experiences no net change in energy after several collisions with atoms of the diffusing media.

d. A neutron that has been produced in a significant time (on the order of seconds) after its initiating fission took place.

QUESTION A.11 [1.0 point]
Fuel is being loaded into the core. The operator is using a 1/M plot to monitor core loading. Which ONE of the following conditions would result in a non-conservative prediction of core critical mass, i.e., the reactor would reach criticality prior to the predicted critical mass?

a. The detector is too far away from the source and the fuel.

b. The detector is too close to the source and the fuel.

c. Excessive time is allowed between fuel elements being loaded.

d. A fuel element is placed between the source and the detector.

QUESTION A.12 [1.0 point]
What order process is the radioactive decay differential equation?

a. Zero

b. First

c. Second

d. Third

QUESTION A.13 [1.0 point]
Which ONE of the following is the major source of heat generation after an operating reactor has been shut down and cooled down for several days?

a. Resonance capture

b. Fission fragment decay

c. Delayed neutron reactions

d. Corrosion product activation

QUESTION A.14 [1.0 point]
Which ONE of the following is the primary mechanism for transferring heat through the cladding of a fuel rod?

a. Conduction

b. Convection

c. Radiation

d. Mass Transfer

QUESTION A.15 [1.0 point]
The reaction $_{54}Xe^{135} \rightarrow$ _____ + $_{55}Cs^{135}$ is an example of:

a. Alpha Decay

b. Beta Decay

c. Gamma Emission

d. Electron Capture

QUESTION A.16 [1.0 point]
What is the effect of delayed neutrons on the neutron flux decay following a scram from full power?

a. Adds negative reactivity creating a greater shutdown margin.

b. Adds positive reactivity due to the fuel temperature decrease following the scram.

c. Limits the final rate at which power decreases to a -80 second period.

d. Decreases the mean neutron lifetime.

QUESTION A.17 [1.0 point]
Several processes occur that may increase or decrease the available number of neutrons. Select from the following the six-factor formula term that describes an INCREASE in the number of neutrons during the cycle.

a. Thermal utilization factor

b. Resonance escape probability

c. Thermal non-leakage probability

d. Reproduction factor

QUESTION A.18 [1.0 point]
The Beryllium-9 in the facility installed neutron source undergoes a _____ reaction.

a. Fusion

b. Alpha-Neutron

c. Gamma-Neutron

d. Spontaneous Fission

QUESTION A.19 [1.0 point]
If Beta for U-235 is 0.0065 and Beta effective is approximately 0.007, how does this difference affect reactor period in the reactor period equation, T=(β-p)/λp? This difference produces a _____ for a given addition of reactivity with Beta effective.

a. Longer period

b. Shorter period

c. Stable period

d. Decay constant (λ) increase

QUESTION A.20 [1.0 point]
Which ONE of the following factors has the LEAST effect on Keff?

a. Fuel burnup

b. Increase in fuel temperature

c. Increase in moderator temperature

d. Xenon and samarium fission products

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

QUESTION B.01 [1.0 point]
What is the HALF LIFE of the isotope contained in a sample which produces the following count rates?

Time (Minutes)	Counts per Minute (cpm)
Initial count	840
30	740
60	615
90	512
180	270

a. 310 minutes

b. 210 minutes

c. 110 minutes

d. 60 minutes

QUESTION B.02 [1.0 point]
In an emergency in order to protect the public health and safety, 10 CFR 50.54 allows the operator to depart from a license condition or a technical specification. What is the minimum level of authorization needed to deviate from this action?

a. Reactor Director

b. Reactor Supervisor

c. Licensed Reactor Operator

d. Licensed Senior Reactor Operator

QUESTION B.03 [1.0 point]
The exposure rate for a point source is 100 mR/hr at a distance of 4 m. What is the exposure rate at a distance of 2 m?

a. 200 mR/hr

b. 400 mR/hr

c. 600 mR/hr

d. 800 mR/hr

QUESTION B.04 [1.0 point]
Given the following instruments, which ONE is the best to check your hands and clothing for beta-gamma contamination upon leaving a contamination zone?

a. GM Pancake

b. Ionization chamber survey instrument

c. Portable sodium Iodide (NaI) detector

d. Zinc Sulfide (ZnS) detector

QUESTION B.05 [1.0 point]
Reactor Operator works in a high radiation area for eight (8) hours a day. The dose rate in the area is 280 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. 1 days

b. 2 days

c. 3 days

d. 4 days

QUESTION B.06 [1.0 point]
Per Technical Specifications, the maximum cladding temperature associated with full-power (200 kilowatts (kW)) operations is _____.

a. 90°C

b. 140°C

c. 510°C

d. 527°C

QUESTION B.07 [1.0 point, 0.25 each]
Match the events listed in Column A with its emergency classification listed in Column B. Items in Column B can be used once, more than once or not at all.

Column A	Column B
a. Bomb threats	1. Unusual Event
b. Prolong fire in the reactor room	2. Alert
c. Significant releases of radioactive materials as a result of experiment failures.	3. Site Area Emergency
d. Major damage of fuel has occurred with actual failure of other physical barriers containing fission products in reactor fuel.	

QUESTION B.08 [1.0 point]
The isolation in a campus evacuation plan is provided by an immediate _____ "rope off" action around the Reactor facility.

a. 33 meter

b. 50 meter

c. 100 meter

d. 500 meter

QUESTION B.09 [1.0 point]
The actions taken in less urgent emergencies for a planned dose of hands and forearms shall not exceed:

a. 25 rem

b. 75 rem

c. 100 rem

d. 200 rem

QUESTION B.10 [1.0 point]
Which ONE of the following channels may be key bypassed at the reactor console by the Senior Operator on Duty as provided for in the Standard Operating Procedures?

a. Reg. Rod on Insert Limit in Auto

b. Reactor Power

c. Reactor Period 15 seconds

d. Radiation Area Monitors (RAMs)

QUESTION B.11 [1.0 point]
Per SOP, to provide for the thorough Reactor Staff review of all experiments to be irradiated by neutrons from the MSTR, the review evaluates potential all of the following EXCEPT:

a. Reactivity effects

b. Dose hazards to the experimenter

c. Hazards to the reactor

d. Fuel consumption

QUESTION B.12 [1.0 point]
As part on an emergency response, the official call list will be maintained by the:

a. Emergency Support Center Director

b. Senior Reactor Operator on Duty

c. Radiation Safety Officer

d. Missouri S&T Police

QUESTION B.13 [1.0 point]
_____ experiments that generate less than 1 W power may be irradiated anywhere in the facility.

a. Corrosion-resistant

b. Removable

c. Explosive

d. Fueled

QUESTION B.14 [1.0 point]
Gamma radiation area monitoring instrumentation required by Technical Specifications shall be channel _____ on a daily basis.

a. Calibrated

b. Cleansed

c. Checked

d. Tested

QUESTION B.15 [1.0 point]
Which ONE of the followings Pre-Startup checks requires the pool lights to be turn on?

a. Core Check

b. Period Trip Test

c. RAM System Check

d. Detector Response Check

QUESTION B.16 [1.0 point]
The OPERATIONS BOUNDARY is the area where the _____ has authority over all activities.

a. MSTR Director

b. Reactor Manager

c. Health Physics Technician

d. Senior Reactor Operator

QUESTION B.17 [1.0 point]
During a reactor building evacuation, which ONE of the following is a SRO on duty responsibility?

a. Vent Fans Off

b. Emergency Keys

c. All Personnel Evacuated

d. Proceed to Physics Building Basement Area

QUESTION B.18 [1.0 point]
The Standard Operating Procedures for Radiation Work Permit will apply only when radiation level is greater than _____ from the part involved.

a. 3 mrem/hr at 3 feet

b. 5 mrem/hr at 2 feet

c. 100 mrem/hr at 1 feet

d. 50 mrem/hr at 2 feet

QUESTION B.19 [1.0 point]
Which ONE of the following is done as part of the Annual Checklist?

a. Security System

b. Pool Conductivity

c. Low Pool Water Scram

d. Safety Amplifier System

QUESTION B.20 [1.0 point]
Which ONE of the following is an example of a record to be retained for the life of the facility?

a. Fuel inventories, receipts, and shipments.

b. Approved changes in operating procedures.

c. Radiation exposures for all personnel monitored.

d. Records of meeting minutes and audit reports of the committee.

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

QUESTION C.01 [1.0 point]
Students and trainees may operate the reactor under the direct supervision of a licensed Reactor Operator provided the excess reactivity is less than:

a. 0.4% Δ k/k

b. 0.7% Δ k/k

c. 1.2% Δ k/k

d. 1.5% Δ k/k

QUESTION C.02 [1.0 point, 0.20 each]
Match the detector in Column A with the corresponding detector location in Column B.

Column A

a. Fission Chamber

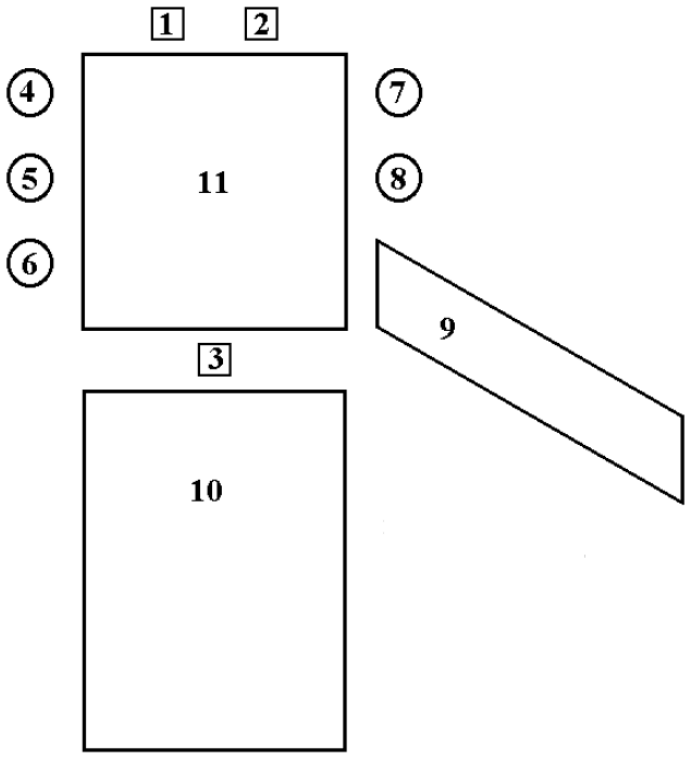
b. Log N (CIC)

c. Linear (CIC)

d. Safety Channel #1 (UIC)

e. Safety Channel #2 (UIC)

Column B



QUESTION C.03 [1.0 point]
Which ONE of the following "common" isotopes of plutonium the reactor facility is licensed to receive, possess and use?

a. Pu-238

b. Pu-239

c. Pu-240

d. Pu-241

QUESTION C.04 [1.0 point]
Which ONE of the following is the pool water flow rate circulated through the demineralizer system?

a. 30 gpm

b. 115 gpm

c. 250 gpm

d. 580 gpm

QUESTION C.05 [1.0 point]
Which ONE of the following isotopes could be monitored for internal exposure?

a. Hydrogen-3

b. Sodium-24

c. Aluminum-28

d. Cobalt-60

QUESTION C.06 [1.0 point]
Which ONE of the following Unit Initiating Actions corresponds to an Interlock Bypassed situation?

a. Micro-Switch

b. Key Switch

c. Float Switch

d. Motion Switch

QUESTION C.07 [1.0 point]
Which ONE of the following Radiation Monitoring Systems consists of a BF-3 detector?

a. Constant Air Monitor

b. Reactor Bridge Monitor

c. Demineralizer System Monitor

d. Basement Neutron Monitor

QUESTION C.08 [1.0 point]
A single tank with a minimum capacity of _____ provides sufficient holdup capacity for the liquid waste generated at the facility.

a. 100 gallons

b. 140 gallons

c. 325 gallons

d. 465 gallons

QUESTION C.09 [1.0 point]
Which ONE of the following mechanical arrangement of the shim/safety rod drive assembly is bolted to the reactor bridge?

a. Control Rod Fuel Element

b. Grid Plate

c. Magnet Guide Control Rod Fuel Element

d. Rod Drive Mount

QUESTION C.10 [1.0 point]
Which ONE of the following systems have an interlocks where the power level must be within about ± 2% of the set point before the system may be engaged?

a. Servo amplifier

b. Safety amplifiers

c. Reactor period

d. Start-up count rate

QUESTION C.11 [1.0 point]
An auxiliary cooling system containing a heat exchanger is located near the output of the:

a. Reactor Pool

b. Particulate Filter

c. Discharge Tank

d. Demineralizer Tank

QUESTION C.12 [1.0 point]
The active length of a fuel elements is approximately:

a. 3 inches

b. 6 inches

c. 24 inches

d. 36 inches

QUESTION C.13 [1.0 point]
This type of fuel element has six fuel plate positions left unoccupied.

a. Half

b. Standard

c. Irradiation

d. Control Rod

QUESTION C.14 [1.0 point]
Which ONE of the following is the original use of the Neutron Source in the reactor core?

a. Ensure the reactor change from subcritical to critical by using neutron source only.

b. Provide a reference point where all instruments undergo a check before the reactor is brought to a critical position.

c. Provide enough neutron to assure proper nuclear instrumentation response during initial reactor startup.

d. Prevent the reactor going up in power if the period exceeds 10 seconds.

QUESTION C.15 [1.0 point]
The fuel plate cladding material is _____ and the shim/safety rods is _____.

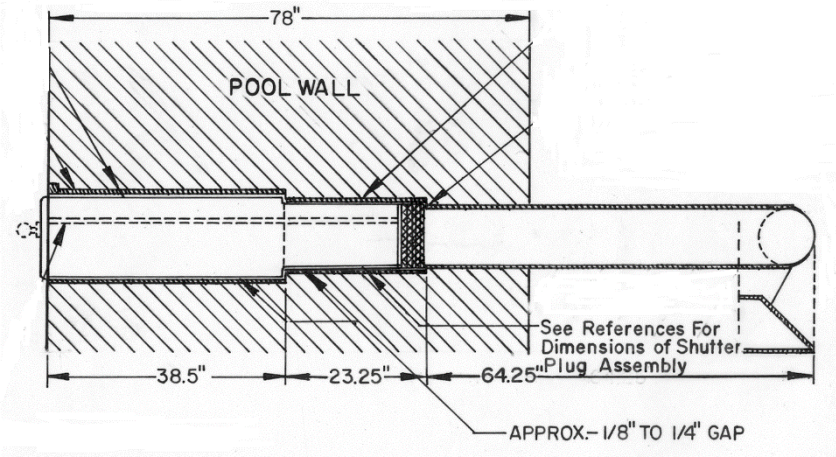
a. Aluminum / Boron Stainless Steel

b. Boral / Erbium

c. Cadmium / Zirconium Hydride

d. Graphite/ Stainless Steel

QUESTION C.16 [1.0 point]
The following figure represents the _____.



a. Thermal Column

b. Beam Port

c. Pneumatic Sample Transfer System

d. Isotope Production Element

QUESTION C.17 [1.0 point]
The detector of the _____ feds into a solid-state circuitry consisting of a preamplifier.

a. Start-Up Channel

b. Linear Channel

c. Log and Linear Channel

d. Safety Channel #1 and #2

QUESTION C.18 [1.0 point]
“Reactor thermal power shall be no greater than 300 kW, or 150% of full power” is an example of:

a. Safety Limit

b. Limiting Safety System Setting

c. Limiting Conditions for Operation

d. Surveillance Requirement

QUESTION C.19 [1.0 point]
On a loss of normal electrical power, the emergency electrical power system is required for:

a. The protection of the integrity of the fuel elements.

b. The reactor instrumentation and control systems.

c. The facility ventilation exhaust fans.

d. No emergency electrical power is required for the MSTR operation.

QUESTION C.20 [1.0 point]
Which ONE of the following Technical Specification applies to the capability of isolating the reactor facility from the unrestricted environment when necessary?

a. Confinement

b. Coolant System

c. Ventilation System

d. Radiation Monitoring System

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

A.01
Answer: c
REF: Lamarsh 3rd, Table 3.6, pg. 88

A.02
Answer: b
REF: Burns, Table 3.5, pg. 3-22

A.03
Answer: a
REF: Burns, Example 7.2 (b), pg. 7-4

A.04
Answer: d
REF: Burns, Problem 7.7.4, pg. 7-17

A.05
Answer: c
REF: Burns, Section 3.3.1, pg. 3-16

A.06
Answer: a
REF: Lamarsh 3rd ed., Section 7.4, pg. 367

A.07
Answer: a, 4 b, 3 c,2 d,1
REF: Lamarsh 3rd ed., Section 7.5, pg. 377
Burns, F1gure 8.1, pg. 8-6

A.08
Answer: b
REF: Burns, Section 3.2.4, pg. 3-12 and Section 3.4.4, pg. 3-33

A.09
Answer: a
REF: Burns, Section 6.4.1, pg. 6-5

A.10
Answer: c
REF: Glasstone, Sesonske, Nuclear Reactor Engineering, Section 1.32, pg. 11

A.11
Answer: a
REF: Burn, Section 5.5, pg. 5-18
A detector that is too far from the source and fuel will underestimate the effects of adding fuel, since the measured counts will not appreciably increase with each fuel element addition.

A.12
Answer: b
REF: Burns, 2.4.6, pg. 2-30
Mathematically, radioactive decay can be represented by the first order, linear differential equation $dA/dt = -\lambda A$ where A is the number density of radioactive atoms of a substance and λ is called the decay constant.

A.13
Answer: b
REF: DOE Handbook, NP-03, pg. 34

A.14
Answer: a
REF: Lamarsh 3rd, Section 8.3, pg. 417

A.15
Answer: b
REF: DOE Fundamentals Handbook, NP-01, pg. 24

A.16
Answer: c
REF: Burns, Section 4.10.12, pg. 4-32 to 4-33

A.17
Answer: d
REF: Burns, Section 3.2, pg. 3-13 to 3-18

A.18
Answer: b
REF: DOE Fundamentals Handbook, Volume 1, NP-02, pg. 3

A.19
Answer: a
REF: Burns, Example 3.4.3, pg. 3-32, 3-33
In the reactor period equation, $T=(\beta-p)/\lambda p$, if Beta effective is used instead of Beta for U-235, the term $(\beta_{eff}-p)$ is larger giving a longer period.

A.20
Answer: a
REF: Burns, Section 3.3.2, pg. 3-18

B.01
Answer: c
REF: $A = A_0 e^{-\lambda t}$
$270 = 840e^{-180\lambda}$, $180\lambda = -\ln(0.321)$, $\lambda = 0.00631\ min^{-1}$
$t_{1/2} = 0.693 / \lambda$, $= 0.693 / 0.00631\ min^{-1} = 109.8$ minutes

B.02
Answer: d
REF: 10 CFR 50.54(y)

B.03
Answer: b
REF: $I_2 = I_1 D_1^2 / d_2^2 = (100\ mR/hr)(4m)^2 / (2m)^2 = 400\ mR/hr$

B.04
Answer: a
REF: Glasstone, Sesonske, Nuclear Reactor Engineering, Section 9.88, pg. 537

B.05
Answer: b
REF: 10 CFR 20.1201(a)(1)
$\frac{5000\ mR \times 1\ hr \times day}{280\ mR * 8\ hr} = 2.23$ days

B.06
Answer: a
REF: TS 2.1 Bases, pg. 6

B.07
Answer: a,1 b,1 c,2 d,3
REF: EP 4.1 - 4.3, pg. 4-1 to 4-2

B.08
Answer: c
REF: EP 7.4.1, pg. 7-2, EP 7.4.5, pg. 7-4

B.09
Answer: c
REF: SOP 621, Section D.3., pg. 2 of 3

B.10
Answer: d
REF: TS Table 3.1, note 1, pg. 9

B.11
Answer: d
REF: SOP 702, Section A, pg. 1 of 7

B.12
Answer: d
REF: EP 7.1, pg. 7-1

B.13
Answer: d
REF: TS 3.7.2, pg. 16

B.14
Answer: c
REF: TS 4.6, pg. 21

B.15
Answer: a
REF: SOP 102, Section C.13., pg. 3 of 8 and item 13 pg. 7 of 8

B.16
Answer: a
REF: EP 2, pg. 2-1

B.17
Answer: c
REF: SOP 501, Section D.5., pg. 3 of 7
SOP 501, SRO Evacuation Checklist, pg. 6 of 7

B.18
Answer: b
REF: SOP 615, Section B.1., pg. 1 of 6

B.19
Answer: d
REF: SOP 800, Section 4, pg. 5 of 10
SOP 810, Section 2.B., pg. 1 of 11

B.20
Answer: c
REF: TS 6.8.3, pg. 34

C.01
Answer: b
REF: TS 6.1.4, pg. 27
SOP 101, pg. 1 of 3

C.02
Answer: a, 6 b, 5 c, 8 d, 7 e, 4
REF: SAR Figure 7.2, pg. 7-4

C.03
Answer: c
REF: SAR 9.5, pg. 9-3

C.04
Answer: a
REF: SAR 5.2, pg. 5-2
SOP 301, Section B.7., pg. 1 of 3

C.05
Answer: a
REF: SAR 11.1.2.3, pg. 11-9

C.06
Answer: b
REF: SAR Table 7.2, pg. 7-12

C.07
Answer: d
REF: SAR 7.4, pg. 7-10

C.08
Answer: a
REF: SAR 11.1.1.2, pg. 11-2

C.09
Answer: d
REF: SAR Figure 4.6, pg. 4-11

C.10
Answer: a
REF: SAR 7.2.2.6, pg. 7-9

C.11
Answer: d
REF: SAR 5.1, pg. 5-1
SAR Figure 5.1, pg. 5-2

C.12
Answer: c
REF: TS 5.3.2, pg. 23

C.13
Answer: c
REF: TS 5.3.2, pg. 23
SAR 4.2.1.4, pg. 4-6

C.14
Answer: c
REF: TS 5.3.5, pg. 24
SAR 4.2.4, pg. 4-10

C.15
Answer: a
REF: SAR Table 4.1, pg. 4-2

C.16
Answer: b
REF: SAR Figure 10.2, pg. 10-3

C.17
Answer: a
REF: SAR 7.2.2.1, pg. 7-5
SAR Figure 7.1, pg. 7-3

C.18
Answer: b
REF: TS 2.2, pg. 6

C.19
Answer: d
REF: SAR 78.2, pg. 8-1

C.20
Answer: a
REF: TS 3.4, pg. 12