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

December 23, 2019

Mr. Ethan Taber, Reactor Manager
Missouri University of Science
and Technology
Nuclear Reactor Facility
250 West 13th Street
Rolla, MO 65409-0630

SUBJECT: EXAMINATION REPORT NO. 50-123/OL-20-01, MISSOURI UNIVERSITY OF SCIENCE AND TECHNOLOGY

Dear Mr. Taber:

During the week of November 19, 2019, 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,

Anthony J. Mendiola, Chief
Non-Power Production and Utilization Facility
Oversight Branch
Division of Advanced Reactors and Non-Power
Production and Utilization Facilities
Office of Nuclear Reactor Regulation

Docket No. 50-123

Enclosures:
1. Examination Report No. 50-123/
OL-20-01
2. Written Examination

cc: w/o enclosure: See next page

cc:

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

Planner, Dept of Health and Senior Services
Section for Environmental Public Health
930 Wildwood Drive
Jefferson City, MO 65102-0570

Deputy Director for Policy
Department of Natural Resources
1101 Riverside Drive
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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
Attention: Amber Johnson
Dept of Materials Science and Engineering
University of Maryland
4418 Stadium Drive
College Park, MD 20742-2115

Dr. Ayodeji Alajo, Interim Program Director
Missouri of Science and Technology
Nuclear Engineering
222 Fulton Hall
Rolla, MO 65409- 0630

Dr. Joseph Graham, Director
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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-20-01

FACILITY DOCKET NO.: 50-123

FACILITY LICENSE NO.: R-79

FACILITY: Missouri University of Science and Technology Reactor

EXAMINATION DATE: November 19, 2019

SUBMITTED BY: Paulette Torres, Chief Examiner — 11/21/19 Date

SUMMARY:

During the week of November 19, 2019 the NRC administered a licensing examination to one Senior Reactor Operator Instant (SROI) applicant. The applicant passed all portions of the examination..

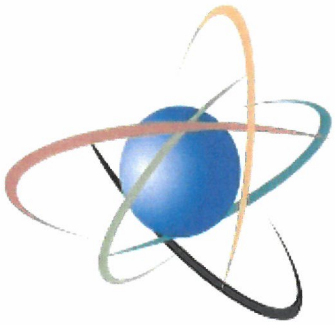
REPORT DETAILS

1. Examiner: Paulette Torres, Chief Examiner, NRC

2. Results:

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

3. Exit Meeting:
Paulette Torres, Chief Examiner, NRC
Ethan Taber, Reactor Manager, MUST



U.S.NRC

UNITED STATES NUCLEAR REGULATORY COMMISSION

Protecting People and the Environment

MISSOURI UNIVERSITY OF SCIENCE AND TECHNOLOGY - ROLLA

Operator Licensing Examination

Week of November 18, 2019

ENCLOSURE 2

U. S. NUCLEAR REGULATORY COMMISSION

NON-POWER REACTOR LICENSE EXAMINATION

FACILITY: Missouri University of Science and Technology (Rolla)

REACTOR TYPE: MTR

DATE ADMINISTERED: 11/19/2019

CANDIDATE: _____

INSTRUCTIONS TO CANDIDATE:

Answers are to be written on the Answer sheet provided. Attach all Answer sheets to the examination. Point values are indicated in parentheses for each question. A 70% in each category is required to pass the examination. Examinations will be picked up three (3) hours after the examination starts.

CATEGORY VALUE	% OF TOTAL	CANDIDATE'S SCORE	% OF CATEGORY VALUE	CATEGORY
20.00	33.3	_____	_____	A. REACTOR THEORY, THERMODYNAMICS AND FACILITY OPERATING CHARACTERISTICS
20.00	33.3	_____	_____	B. NORMAL AND EMERGENCY OPERATING PROCEDURES AND RADIOLOGICAL CONTROLS
20.00	33.3	_____	_____	C. FACILITY AND RADIATION MONITORING SYSTEMS
60.00		_____ FINAL GRADE	_____ %	TOTALS

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

_____

Candidate's Signature

A. Reactor Theory, Thermohydraulics & Facility Operating Characteristics _____

ANSWER SHEET

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 ___

B. Normal and Emergency Operating Procedures and Radiological Controls _____

ANSWER SHEET

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 _____

ANSWER SHEET

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

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

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

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

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

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

$$\ell^* = 1\times10^{-4}\,\text{sec}$$

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

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

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

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

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

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

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

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

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

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

$$T_{\frac{1}{2}} = \frac{0.693}{\lambda} \qquad \Delta\rho = \frac{K_{eff_2}-K_{eff_1}}{K_{eff_1}K_{eff_2}}$$

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

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

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

$$DR = \frac{6\,Ci\,E(n)}{R^2} \qquad A = A_0 e^{-\lambda t}$$

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

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

1 Curie = 3.7 x 10^{10} dis/sec

1 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

1 ft = 30.48 cm

QUESTION A.01 [1.0 point]

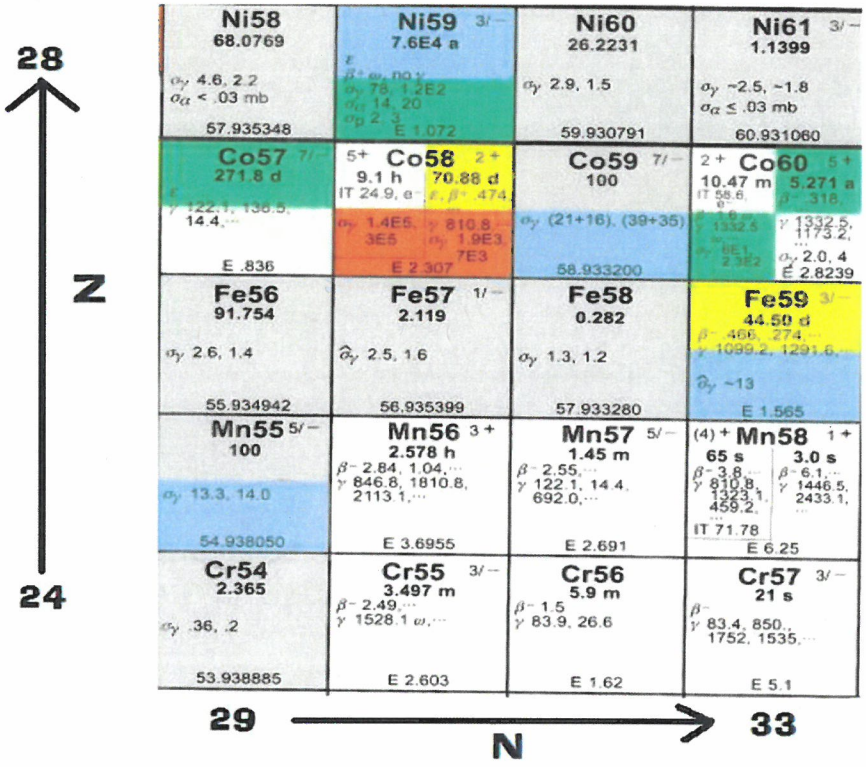
Using the applicable portion from the chart of the nuclides, what will Mn-56 decay into?

a. Mn-55

b. Fe-56

c. Fe-58

d. Co-60



QUESTION A.02 [1.0 point]

What effect does moderator temperature have on neutron population?

a. As the density of the moderator decreases, less moderation occurs and more neutrons leaks from the core.

b. As the density of the moderator increases, less moderation occurs and more neutrons leak from the core.

c. As the density of the moderator decreases, more moderation occurs and less neutrons leak from the core.

d. As the density of the moderator increases, less moderation occurs and less neutrons leak from the core.

QUESTION A.03 [1.0 point]
The product of number density and microscopic cross section of an element is defined as:

a. Macroscopic Cross Section.

b. Thermal Cross Section.

c. Mean Free Path.

d. Decay Constant.

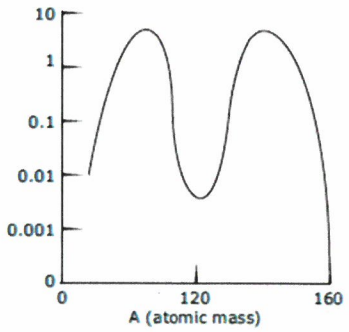
QUESTION A.04 [1.0 point]
The following graph for U-235 depicts.....

a. Axial flux distribution in the core.

b. Fission product yield distribution.

c. Radial flux distribution in the core.

d. Neutron energy distribution in the moderator.



QUESTION A.05 [1.0 point]
A 1/M curve is being generated as fuel is loaded into the core. After some fuel elements have been loaded, the count rate existing at that time is taken to be the new initial count rate, Co. Additional elements are then loaded, and the inverse count rate ratio continues to decrease. As a result of changing the initial count rate:

a. Predicted criticality will occur with the same number of elements loaded as if the initial count rate had not been changed.

b. Predicted criticality will occur earlier (i.e., with fewer elements loaded).

c. Predicted criticality will occur later (i.e., with more elements loaded).

d. Criticality will be completely unpredictable.

QUESTION A.06 [1.0 point]
Which ONE of the following is the definition for Differential Control Rod Worth? The reactivity:

a. Due to control rod position (ΔK/K).

b. Change per unit of rod motion (ΔK/K/in).

c. Due to the difference in rod speed (ΔK/K/in/min).

d. Still available for shutdown after control rod withdrawal.

QUESTION A.07 [1.0 point]
The longest-lived DNP group has a half-life of _____ seconds.

a. 0.026

b. 0.1

c. 55

d. 80

QUESTION A.08 [1.0 point]
The process in which a neutron strikes a nucleus leaving the nucleus in an excited state is referred to as:

a. Elastic scattering

b. Inelastic scattering

c. Radiative capture

d. Neutron annihilation

QUESTION A.09 [1.0 point]
Which ONE of the following best describes the source of Nitrogen-16 produced in the reactor primary coolant system?

a. Neutron decay of deuterium.

b. Neutron activation of a nitrogen atom.

c. Neutron scattering of the nucleus of a boron atom.

d. Neutron (n,p) particle ejection by the nucleus of an oxygen atom.

QUESTION A.10 [1.0 point]
The probability that a thermal neutron will be absorbed in the fuel is referred to as:

a. Reproduction probability

b. Thermal utilization probability

c. Resonance escape probability

d. Thermal non-leakage probability

QUESTION A.11 [1.0 point]
During Reg Rod calibration, doubling time was recorded to be 78 seconds. What was reactor period?

a. 39 seconds

b. 54 seconds

c. 113 seconds

d. 156 seconds

QUESTION A.12 [1.0 point]
In a comparison between a delayed neutron and a prompt neutron born from the same fission event, the delayed neutron is more likely to:

a. Leak out of the core.

b. Be absorbed in the moderator.

c. Cause fission of a u-238 nucleus.

d. Cause fission of a u-235 nucleus.

QUESTION A.13 [1.0 point]
Which ONE of the following describes the factors that have the greatest effect on the fast fission factor?

a. Arrangement and temperatures of the fuel and the moderator.

b. Arrangement and concentrations of the fuel and the moderator.

c. Enrichment of the fuel and temperature of the moderator.

d. Enrichment of the fuel and concentration of the moderator.

QUESTION A.14 [1.0 point]
A critical reactor is operating at a low power level below POAH (point of added heat) when the primary pump is turned off decreasing the rate of flow of the coolant through the reactor. What affect will the change in coolant flow rate have on reactivity?

a. Varying the coolant flow at low power levels does not result in measurable reactivity changes.

b. Varying the coolant flow at low power levels will cause the addition of negative reactivity due to the reduction in pressure, resulting in a prompt drop.

c. Varying the coolant flow at low power levels will cause the addition of positive reactivity due to the increase of reactor coolant density, resulting in a power level increase.

d. Varying the coolant flow at low power levels will cause the addition of negative reactivity due the increase in coolant temperature, resulting in the reactor becoming subcritical.

QUESTION A.15 [1.0 point]
Which ONE of the following best describes the relationship between reactor power and neutron flux?

a. Reactor power is two times greater than the fission rate of the fuel.

b. Reactor power increases exponentially as the fission rate increases.

c. The rate of energy produced by the reactor is linearly proportional to the fission rate in the core.

d. Thermal power can be calculated by multiplying the neutron flux by the total volume of the core.

QUESTION A.16 [1.0 point, 0.25 each]
Identify whether each of the following conditions will INCREASE or DECREASE the shutdown margin of a reactor.

a. Burnout of a burnable poison.

b. Insertion of boron graphite to the reactor core.

c. Moving one fuel element from reactor core to fuel storage.

d. Insertion of a fueled ICSA (in-core sample assembly).

QUESTION A.17 [1.0 point]
While a reactor is at 5 W, the reactor operator is withdrawing a control rod to insert a positive reactivity of 0.00156 ($\Delta K/K$). Which ONE of the following will be the stable reactor period as a result of this withdrawal? Given beta-effective = 0.0073 and λ_{eff}= 0.1.

a. 17 seconds

b. 27 seconds

c. 37 seconds

d. 47 seconds

QUESTION A.18 [1.0 point]
Which ONE of the following describes a property of a GOOD MODERATOR?

a. It slows down fast neutrons to thermal energy levels via a small number of collisions.

b. It reduces gamma radiation to thermal energy levels via a small number of collisions.

c. It slows down fast neutrons to thermal energy levels via a large number of collisions.

d. It reduces gamma radiation to thermal energy levels via a large number of collisions.

QUESTION A.19 [1.0 point]
Which ONE of the following is a number of neutrons in the Uranium-235 nucleus ($_{92}U^{235}$)?

a. 92

b. 143

c. 235

d. The U-235 doesn't have a constant number of neutrons, it fluctuates between 95 and 140.

QUESTION A.20 [1.0 point]
Which ONE of the following correctly describes the SIX- FACTOR FORMULA?

a. $K\infty$ = Keff * the reproduction factor

b. $K\infty$ = Keff * the total leakage probability

c. Keff = $K\infty$ * the total non-leakage probability

d. Keff = $K\infty$ * (the resonance escape probability * the reproduction factor)

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

QUESTION B.01 [1.0 point]
During reactor startup to low power, the "MILESTONE - VERIFY DOUBLING" step falls under the:

a. Withdraw rods to 18 inches.

b. Withdraw rods to shim range.

c. Withdraw rods to instrument turnaround.

d. Continue power increase and level at low power.

QUESTION B.02 [1.0 point, 0.25 points each]
Identify the emergency classification (UE, Alert, Site Area Emergency) for each of the following emergency action levels. Answers can be used once, more than once or not at all.

a. Actual or projected radiation levels at the site boundary calculated of 100 mrem/hr for 1 hour whole body or 500 mrem thyroid dose.

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. Report of observation of severe natural phenomenon.

d. Receipt of bomb threat or credible security threat.

QUESTION B.03 [1.0 point]
Which ONE of the following is TRUE regarding the reactor natural convection operating condition?

a. Technical specifications require for an auxiliary cooling system containing a heat exchanger near the output of the demineralizer tank to reduce pool water temperature at all times.

b. The coolant height is conservatively set at 6 feet above top of the pool walls to ensure an adequate coolant inventory.

c. The only parameter that can be used to limit the fuel cladding temperature is the reactor power.

d. The major mechanism for heat removal from the pool is through condensation.

QUESTION B.04 [1.0 point]
Which ONE of the following has the authority to initiate recovery and re-entry of affected areas offsite the MSTR facility?

a. Reactor Operator.

b. Senior Reactor Operator on duty.

c. The highest organizational level activated during the emergency.

d. Missouri Bureau of Radiological Health assisted by Missouri State Emergency Management Agency.

QUESTION B.05 [1.0 point]
All of the following Detector Response Checks, the operator "spike" as part of the pre-startup checklist procedure EXCEPT:

a. Log Channel

b. Linear Channel

c. Period Channel

d. Start-Up Channel

QUESTION B.06 [1.0 point]
The purpose of the _____ checklist is to ensure the proper operation of the control and safety-related instruments of the reactor and to functionally test the Physical Security Alarm System.

a. Annual

b. Pre-Startup

c. Secure

d. Weekly

QUESTION B.07 [1.0 point]
Which ONE of the following is the radiation dose limit for the public in an unrestricted area?

a. No limit

b. 2 rem in a year

c. 2 rem in any one hour

d. 2 mrem in any one hour

QUESTION B.08 [1.0 point, 0.25 points each]
Match the 10 CFR parts in Column A with the requirements in Column B.

Column A	Column B
a. 10 CFR 19	1. Technical information including the proposed maximum power level
b. 10 CFR 20	2. Medical examination by a physician every two years
c. 10 CFR 50	3. Individual radiation exposure data
d. 10 CFR 55	4. Postings of notices to workers

QUESTION B.09 [1.0 point]
Which ONE of the following Radiation Area Monitors initiates a Building Evacuation?

a. Neutron

b. Demineralizer

c. Reactor Bridge

d. Basement Experimental Area

QUESTION B.10 [1.0 point]
How long will it take an 80 Curie Cobalt-60 source, with a half-life of 5.27 years, to decay to 2 Curie?

a. 24 years

b. 26 years

c. 28 years

d. 30 years

QUESTION B.11 [1.0 point]
Which ONE of the following surveillances is required to be performed quarterly?

a. Resistivity of the Coolant Water

b. Conductivity

c. Ventilation Inlet

d. Thermal Power

QUESTION B.12 [1.0 point]
Which ONE of the following shall be 1 rem whole body or 5 rem thyroid?

a. Emergency Action Levels

b. Protective Action Guide

c. Emergency Exposure Limits

d. Emergency Planning Zone

QUESTION B.13 [1.0 point]
Which ONE of the following generates a pool demineralizer effluent conductivity high alarm?

a. Rod withdrawal prohibit alarm

b. White light annunciator alarm

c. Rundown alarm

d. Scram alarm

QUESTION B.14 [1.0 point]
_____ means the energy imparted by ionizing radiation per unit mass of irradiated material.

a. Absorbed dose

b. Ionization density

c. Deep dose equivalent

d. Radiation equivalent man

QUESTION B.15 [1.0 point]
Which ONE of the following isotopes is not part of the "fueled experiment" definition given in Technical Specifications?

a. Uranium-233

b. Uranium-235

c. Uranium-238

d. Plutonium-239

QUESTION B.16 [1.0 point]
The reactor has been shutdown following a suspected coolant system leak. In accordance with operating procedures, if the leak is due to the purification system close valve _____ and stop the purification pump.

a. #19 (pool suction)

b. #58 (water in)

c. #59 (water out)

d. #60 (heat exchanger bypass)

QUESTION B.17 [1.0 point]
How often are licensed reactor operators required to pass a comprehensive requalification operating test, in accordance with the 10 CFR 55.59?

a. Only for initial qualification

b. Every six years

c. Biennially

d. Annually

QUESTION B.18 [1.0 point]
"A committee shall review and audit reactor operations to ensure that the facility is operated in a manner consistent with public safety and within the terms of the facility license." This is an example of _____ section listed in the Technical Specifications.

a. Design Features

b. Administrative Controls

c. Surveillance Requirements

d. Limiting Conditions for Operation (LCO)

QUESTION B.19 [1.0 point]
Only the individual in charge of the Emergency Support Center may officially authorize voluntary radiation exposure up to the emergency dose limit of _____, when immediate action is essential.

a. 5 Rem

b. 10 Rem

c. 25 Rem

d. 75 Rem

QUESTION B.20 [1.0 point]
The metal enclosure which houses the reactor core, pool and irradiated fuel storage facilities defines the _____.

a. Site Boundary

b. Exclusion Area

c. Operations Boundary

d. Confinement Building

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

QUESTION C.01 [1.0 point]
Which ONE of the following channels has a detector that is attached to a motor driven positioning mechanism?

a. Start-Up Channel

b. Linear Channel

c. Log and Linear Channel

d. Safety Channel #1

QUESTION C.02 [1.0 point]
Which ONE of the following nuclides requires a semi-annual pool water analysis?

a. H-3

b. N-16

c. F-18

d. Na-24

QUESTION C.03 [1.0 point]
Which ONE of the following of functions may be key bypassed at the reactor console by the Senior Operator on Duty as provided for in the Standard Operating Procedures?

a. Reactor Power 120% Rundown

b. Linear Power Demand 120% Rundown

c. Radiation Area Monitors (RAMs) 20 mrem/hr Rundown

d. Low Compensating Ion Chamber Voltage 80% Rundown

QUESTION C.04 [1.0 point]
The water forced upwards around the _____ provides a hydraulic snubbing action which permits the safety rod to come to rest without damage.

a. Piston

b. Magnet

c. Actuator

d. Guide Tube

QUESTION C.05 [1.0 point]
All of the following are categorized as closure equipment that ensures the reactor bay is operable EXCEPT:

a. Ventilation fans

b. Ventilation inlet

c. Exhaust duct louvers

d. personnel security door

QUESTION C.06 [1.0 point]
Experiments worth more than 0.4% Δk/k shall be all of the following EXCEPT:

a. A secured experiment.

b. A movable experiment.

c. Inserted and removed with the reactor shut down.

d. Inserted and removed from the reactor with a procedure approved by the Radiation Safety Committee.

QUESTION C.07 [1.0 point]
Which ONE of the following represents the reactor being in a secured condition?

a. The reactor is in the Not Operate mode.

b. No work is in progress involving core fuel, core structure, installed control rods, or control rod drives, unless they are physically decoupled from the control rods.

c. There are no experiments in any reactor experiment facility.

d. All fuel elements and core components must be secured in position to prevent mechanical damage of the components.

QUESTION C.08 [1.0 point]
Which ONE of the following contains a Geiger-Muller detector for contamination control at MSTR?

a. Frisker meter

b. Pocket dosimeter

c. Portable air sampler

d. Portable neutron survey meter

QUESTION C.09 [1.0 point]
Which ONE of the following situations have a Motion Switch Initiating Action with a corresponding reactor scram Protective Action?

a. Bridge Motion

b. Basement Sump Level High

c. Beam Port or Thermal Column "Open"

d. Reg. Rod on Insert Limit in Auto-Control

QUESTION C.10 [1.0 point]
Which ONE of the following ensures a pathway for natural convection flow?

a. The core is submerged in the reactor pool.

b. The water temperature is no less than 15.5 °C.

c. The reactor pool serves as a heat sink and radiation shield.

d. The resistivity of the pool water is greater than 0.2 megaohms-cm.

QUESTION C.11 [1.0 point]
Technical Specifications require at least _____ of water above the top of the core for reactor operations.

a. 2 ft

b. 6 ft

c. 16 ft

d. 20 ft

QUESTION C.12 [1.0 point]
The design basis of the emergency electrical power system is to provide power to selected loads for a minimum of _____ following loss of off-site power.

a. 1 hour

b. 8 hours

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

d. Only the load required for reactor decay heat removal will receive emergency power in the event of a loss of off-site power.

QUESTION C.13 [1.0 point]
Which ONE of the following is located in the outlet piping of the demineralizer column?

a. Conductivity cell

b. Flow meter

c. Heat exchanger

d. Particulate filter

QUESTION C.14 [1.0 point]
The pressure shall be calculated or experimentally determined in _____ materials so that it will not cause the sample container to fail.

a. Corrosive

b. Explosive

c. Fueled

d. Radioactive

QUESTION C.15 [1.0 point]
Technical specifications establish safety limits on important process variables that are found to be necessary to reasonably protect the integrity of certain physical barriers that guard against the uncontrolled release of radioactivity. Which ONE of the following is the principal physical barrier?

a. The Reactor Building

b. The Experiment Container

c. The Fuel Cladding

d. The Pool

QUESTION C.16 [1.0 point]
"A strong enough neutron source is available to satisfy the requirements of a count rate greater than 2 counts per second during a cold reactor startup" is an example of a/an _____ feature.

a. Administrative

b. Design

c. Inherent Safety

d. Passive Safety

QUESTION C.17 [1.0 point, 0.25 points each]
Match the alarm in Column A with the four types of automatic engineered protective actions provided with the MSTR instrumentation listed in Column B.

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

QUESTION C.18 [1.0 point]
When the radiation area monitors required by Technical Specification 3.6 are inoperable, portable gamma radiation instruments maybe substituted for:

a. hourly

b. 1 week

c. A duration of a reactor run

d. Indefinitely until repairs can be made

QUESTION C.19 [1.0 point]
Per Technical Specifications, the regulating rod shall be worth no more than _____ in reactivity.

a. 0.7% Δk/k

b. 0.85% Δk/k

c. 2.5% Δk/k

d. 3.0% Δk/k

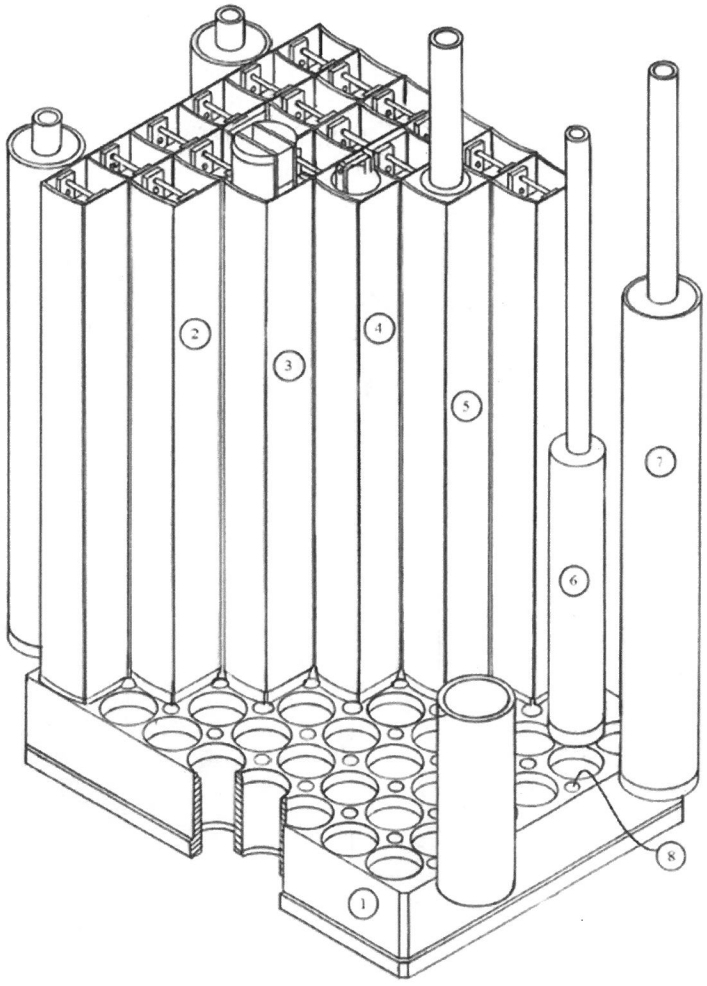
QUESTION C.20 [1 point, 0.25 points each]
Identify the best answer from the components labeled 1 through 8 on the figure of the Grid Plate provided. (Note: Only one answer per number.)

a. Control Rod Element _____

b. Core Access Element _____

c. Fission Chamber _____

d. Ionization Chamber _____



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

A.01
Answer: b
REF: Mn-56 is beta decay, which is the conversion of a neutron into a proton and electron.
Baum, E., Knox, H., and Miller, T. 2002. Nuclides and Isotopes 16th Ed.
pg. 28

A.02
Answer: a
REF: Burn, Section 6.5, pg. 6-14

A.03
Answer: a
REF: Burn, Section 2.5.2, pg. 2-43

A.04
Answer: b
REF: DOE Manual Vol. 1, pg. 57

A.05
Answer: a
REF: Burns, Section 5.5, pg. 5-18

A.06
Answer: b
REF: DOE Fundamentals of Reactor Theory, Volume 2, NP-03, pg. 52
The reactivity change per unit movement of a rod and is normally expressed as r/inch, $\Delta k/k$ per inch, or pcm/inch.

A.07
Answer: c
REF: Burn, Section 3.2.2

A.08
Answer: b
REF: Burn, Section 2.4, pg. 2-28

A.09
Answer: d
REF: Lamarsh 3rd ed., Table 10.7, pg. 599

A.10
Answer: b
REF: Burn, Section 3.3, pg. 3-16

A.11
Answer: c
REF: T = Doubling Time/ln(2) = 78 seconds/0.693 = 112.55 ≈113 seconds

A.12
Answer: d
REF: Burn, R., Introduction of Nuclear Reactor Operations, © 1988, Sec 3.2

A.13
Answer: b
REF: DOE Fundamentals of Reactor Theory, Volume 2, NP-03, pg. 3

A.14
Answer: a
REF: DOE Fundamentals of Reactor Theory, Volume 2, NP-04, pg. 30

A.15
Answer: c
REF: Burn, Section 2.8, pg. 2-64

A.16
Answer: (a) DECREASE; (b) INCREASE; (c) INCREASE; (d) DECREASE
REF: DOE Fundamentals of Reactor Theory, Volume 2, NP-04, pg.28

A.17
Answer: c
REF: Reactivity added = 156 pcm = 0.00156 Δk/k
$\tau = (\beta-\rho)/\lambda_{eff}\rho = (0.0073 - 0.00156)/ ((0.1)*(0.00156)) = 37$ seconds

A.18
Answer: a
REF: DOE Fundamentals of Reactor Theory, Volume 1, NP-02, pg. 23

A.19
Answer: b
REF: Nuclides and Isotopes
N = A – Z
235-92 = 143

A.20
Answer: c
REF: Burn, Section 3

B.01
Answer: b
REF: SOP 103, C.2.c, pg. 2 of 6

B.02
Answer: (a) Site Area Emergency; (b) Alert; (c) UE; (d) UE
REF: EP Table 4-1, pg. 4-3

B.03
Answer: c
REF: TS 2.2 Basis, pg. 6

B.04
Answer: d
REF: EP 9, pg. 9-1

B.05
Answer: d
REF SOP 102, C.28, pg. 6 of 8, #28, pg. 8 of 8

B.06
Answer: d
REF: SOP 810, A, pg. 1 of 11

B.07
Answer: d
REF: 10 CFR 20.1301(a)(2)

B.08
Answer: (a) 4; (b) 3; (c) 1; (d) 2
REF: 10 CFR 19.11, 10 CFR 20.1501(2)(i), 10 CFR 50.34(1)(ii)(A), 10 CFR 55.21

B.09
Answer: c
REF: TS Table 3.3, pg. 13
SOP 655, C.9, pg. 3 of 6

B.10
Answer: c
REF: $\lambda = \ln(2)/T_{1/2} = 0.693/5.27 = 0.1315$
$A=A_0e^{-\lambda t} \rightarrow 2 = 80e^{-0.1315(t)} \rightarrow \ln(2/80) = -0.315t \rightarrow t = 28$ years

B.11
Answer: c
REF: TS 4.4, pg. 20

B.12
Answer: b
REF: EP 5, pg. 5-4

B.13
Answer: b
REF: SOP 150, F.5, pg. 4 of 4

B.14
Answer: a
REF: 10 CFR 20.1003

B.15
Answer: c
REF: TS 1.2, pg. 2

B.16
Answer: a
REF: SOP 309, C.4, pg. 1 of 1

B.17
Answer: d
REF: 10 CFR 55.59(a)(2)

B.18
Answer: b
REF: TS 6.2, pg. 28

B.19
Answer: c
REF: EP 7.4.6, pg. 7-5

B.20
Answer: d
REF: EP 2, pg. 2-1

C.01
Answer: a
REF: SAR Table 7.1, pg. 7-2
SAR Figure 7.1, pg. 7-3

C.02
Answer: a
REF: SAR 11.1.2.3, pg. 11-8

C.03
Answer: c
REF: TS Table 3.1, pg. 9

C.04
Answer: a
REF: SAR 4.2.2, pg. 4-9

C.05
Answer: a
REF: TS 4.4, pg. 20
SOP 812, A), pg. 1 of 2

C.06
Answer: b
REF: TS 3.7.1, pg. 15

C.07
Answer: b
REF: TS 1.2, pg. 4

C.08
Answer: a
REF: SAR 11.1.6, pg. 11-12

C.09
Answer: a
REF: SAR Table 7.2, pg. 7-12

C.10
Answer: b
REF: TS 3.3, pg. 11
TS 5.2, pg. 23
SAR 5.1, pg. 5-1

C.11
Answer: c
REF: SAR 5.1, pg. 5-1

C.12
Answer: c
REF: SAR 8.2, pg. 8-1

C.13
Answer: a
REF: SAR Figure 5.1, pg. 5-2

C.14
Answer: b
REF: TS 3.7.2.2), pg. 16
SAR 10.3, pg. 10-7

C.15
Answer: c
REF: TS 1.2, pg. 4

C.16
Answer: b
REF: TS 5.3.5, pg. 24

C.17
Answer: a, 2 b, 4 c, 1 d, 3
REF: SAR 7.2.2, pg. 7-1 & 7-2

C.18
Answer: B
REF: TS 3.6.1, pg. 13

C.19
Answer: a
REF: TS 3.1.5), pg. 7

C.20
Answer: a,3 b, 5 c,6 d, 7
REF: SAR Figure 4.3, pg. 4-5

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