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

November 19, 2019

Dr. Sean McDeavitt, Director
Nuclear Science Center
Texas A&M University
Texas Engineering Experiment Station
1095 Nuclear Science Road, MS 3575
College Station, Texas 77843

SUBJECT: EXAMINATION REPORT NO. 50-128/OL-20-01, TEXAS A&M UNIVERSITY

Dear Dr. McDeavitt:

During the week of October 7, 2019, the U.S. Nuclear Regulatory Commission (NRC) administered an operator licensing examination at your Texas A&M University Nuclear Science Center (NSC) reactor. The examinations were conducted according to NUREG-1478, "Operator Licensing Examiner Standards for Research and Test Reactors," Revision 2. Examination questions and preliminary findings were discussed with 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 enclosures will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records (PARS) component of NRC's Agencywide Documents Access and Management System (ADAMS). ADAMS is accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html. The 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 Ms. Michele DeSouza at (301) 415-0747 or via internet e-mail Michele.DeSouza@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. 50-128

Enclosures:
1. Examination Report No. 50-128/OL-20-01
2. Written Examination

cc: w/o enclosures: See next page

cc:

Mayor, City of College Station
P.O. Box Drawer 9960
College Station, TX 77840-3575

Governor's Budget and
Policy Office
PO Box 12428
Austin, Texas 78711-2428

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Radiation Program Officer
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Technical Advisor
Office of Permitting, Remediation & Registration
Texas Commission on Environmental Quality
P.O. Box 13087, MS 122
Austin, TX 78711-3087

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

Mr. Scott Miller, Manager
Reactor Operations
Texas A&M University
Texas Engineering Experiment Station
1095 Nuclear Science Road, MS 3575
College Station, Texas 77843

State Energy Conservation Office
Comptroller of Public Accounts
P.O. Box 13528
Austin, TX 78711-3528

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

REPORT NO.: 50-128/OL-20-01

FACILITY DOCKET NO.: 50-128

FACILITY LICENSE NO.: R-83

FACILITY: TXA&M NSC

EXAMINATION DATES: October 7-10, 2017

SUBMITTED BY: Michele DeSouza
Michele DeSouza, Chief Examiner

10/18/2019
Date

SUMMARY:
During the week of October 7, 2019, the NRC administered an operator licensing examination to one Senior Reactor Operator Upgrade (SRO-U) retake candidate, three SRO-U candidates, one Senior Reactor Operator Instant (SRO-I) candidate, and two Reactor Operator (RO) candidates. The candidates passed all applicable portions of the examinations.

REPORT DETAILS

1. Examiner: Michele DeSouza, Chief Examiner, NRC

2. Results:

	RO PASS/FAIL	SRO PASS/FAIL	TOTAL PASS/FAIL
Written	2/0	1/0	3/0
Operating Tests	2/0	5/0	7/0
Overall	2/0	5/0	7/0

3. Exit Meeting:
Michele C. DeSouza, Chief Examiner, NRC
Jerry Newhouse, Associate Director, TXA&M NSC
Scott Miller, Manager, Reactor Operations, TXA&M NSC
Cameron MacDonald, Reactor Supervisor, TXA&M NSC

Per discussion with the facility, prior to administration of the examination, adjustments were accepted. Upon completion of the examination, the NRC Examiner met with facility staff representatives to discuss the results. A facility training flaw was identified and corrected prior to the NRC Examiner departing; the facility referred to their personal monitoring devices as 'film badges' when in fact they are either thermoluminescent dosimeters or optically stimulated dosimeters. The facility agreed this was a terminology usage and will adjust to reflect correctly. At the conclusion of the meeting, the NRC examiner thanked the facility for their support in the administration of the examination.

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

FACILITY: TX A&M NSC

REACTOR TYPE: TRIGA

DATE ADMINISTERED: 10/09/2019

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

ENCLOSURE 2

Category A – Reactor Theory, Thermodynamics, & 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___ (0.25 each)

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 CATEGORY A *****)

Category B – Normal/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 CATEGORY B *****)

Category 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_____ (0.25 each)

C02 a b c d ___

C03 a b c d ___

C04 a b c d ___

C05 a b c d ___

C06 a b c d ___

C07 a b c d ___

C08 a b c d ___

C09 a b c d ___

C10 a b c d ___

C11 a b c d ___

C12 a b c d ___

C13 a b c d ___

C14 a b c d ___

C15 a b c d ___

C16 a b c d ___

C17 a b c d ___

C18 a___ b___ c___ d ___

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

NRC RULES AND GUIDELINES FOR LICENSE EXAMINATIONS

During the administration of this examination the following rules apply:

1. Cheating on the examination means an automatic denial of your application and could result in more severe penalties.

2. After the examination has been completed, you must sign the statement on the cover sheet indicating that the work is your own and you have neither received nor given assistance in completing the examination. This must be done after you complete the examination.

3. Restroom trips are to be limited and only one candidate at a time may leave. You must avoid all contacts with anyone outside the examination room to avoid even the appearance or possibility of cheating.

4. Use black ink or dark pencil 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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

1 Horsepower = 2.54 x 10^3 BTU/hr

1 BTU = 778 ft-lb

1 gal (H_2O) ≈ 8 lb

c_P = 1.0 BTU/hr/lb/°F

1 kg = 2.21 lb

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

Category A – Reactor Theory, Thermodynamics, & Facility Operating Characteristics

Question A.01 [1.0 point]
Which ONE of the following physical characteristics of the TRIGA fuel is the main contributor for the prompt negative temperature coefficient?

a. As the fuel heats up the resonance absorption peaks broaden and increases the likelihood of neutron absorption in U-238.

b. As the fuel heats up a rapid increase in moderator temperature occurs through conduction and convection heat transfer mechanisms which adds negative reactivity.

c. As the fuel heats up fission product poisons (eg., Xe) increase in concentration within the fuel matrix and add negative reactivity via neutron absorption.

d. As the fuel heats up the oscillating hydrogen in the ZrH lattice imparts energy to a thermal neutron, thereby increasing its mean free path and probability of escape.

Question A.02 [1.0 point]
A reactor is slightly supercritical with the following values for each of the factors in the six-factor formula:

Fast Fission Factor = 1.03
Resonance Escape Probability = 0.96
Thermal Utilization Factor = 0.70
Fast non-leakage probability = 0.84
Thermal non-leakage probability = 0.88
Reproduction Factor = 1.96

A control rod is inserted to bring the reactor back to critical. Assuming all other factors remain unchanged, the new value for the Thermal Utilization Factor is:

a. 0.698

b. 0.702

c. 0.704

d. 0.708

Question A.03 [1.0 point]
Which ONE of the following conditions will require the control rod withdrawal to maintain constant power level after the following change?

a. Adding of a fuel experiment such as U-235 into the core

b. Removal of an experiment containing borated graphite

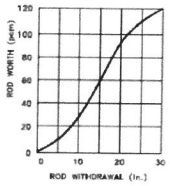
c. Increase of pool water temperature

d. Burnout of Xenon in the core

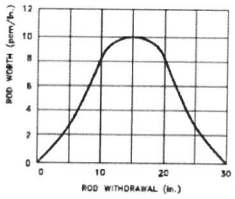
Question A.04 [1.0 point, 0.25 points each]
Identify if the descriptions or graphs in Column A describe or depict integral control rod worth or differential rod worth?

Column A	Column B
a. total reactivity worth of the control rod at that height	1. Differential Rod Worth
b. reactivity change per unit movement of a control rod	2. Integral Rod Worth

c.



d.



Question A.05 [1.0 point]
What is the condition of the reactor when $k = (1/1-\beta)$?

a. Subcritical

b. Critical

c. Super Critical

d. Prompt Critical

Question A.06 [1.0 point]
The reactor is critical at 100 watts. A control rod is withdrawn to insert a positive reactivity of 0.126% $\Delta k/k$. Which ONE of the following will be the stable reactor period as a result of the reactivity insertion? Given Beta effective = 0.0078

a. 13 seconds

b. 46 seconds

c. 52 seconds

d. 80 seconds

Question A.07 [1.0 point]
Which ONE of the following is a correct statement describing prompt and delayed neutrons?

a. Are released when U-238 interacts with fast neutrons, while delayed neutrons are released when U-235 interacts with thermal neutrons

b. Account for less than 1% of the neutron population, while delayed neutrons account for the rest

c. Are released during the fission process, while delayed neutrons are released during the decayed process

d. Are the dominating factor in determining reactor period, while delayed neutrons have no effect on reactor period

Question A.08 [1.0 point]
Which ONE of the following isotopes has the LEAST thermal neutron cross section?

a. Cadium-112

b. Samarium-149

c. Xenon-135

d. Uranium-235

Question A.09 [1.0 point]

FAST FISSION FACTOR is defined as a ratio of which ONE of the following?

a. The number of neutrons that reach thermal energy over the number of fast neutrons that start to slow down.

b. The number of fast neutrons produced from fission in a generation over the number of fast neutrons produced from fission in the previous generation.

c. The number of fast neutrons produced from U-238 over the number of thermal neutrons produced from U-235.

d. The number of fast neutrons produced from all fission over the number of fast neutrons produced from thermal fission.

Question A.10 [1.0 point]
Reactor power is rising on a 10 second period. Approximately how long will it take for power to quadruple?

a. 14 seconds

b. 29 seconds

c. 55 seconds

d. 72 seconds

Question A.11 [1.0 point]
Which ONE of the following describes the difference between differential rod worth (DRW) and integral rod worth (IRW)?

a. DRW relates the time rate of reactivity change to rod position. IRW relates the total reactivity in the core to the time rate of reactivity change

b. IRW relates the worth of the rod per increment of movement to rod position. DRW relates the total reactivity added by the rod to the rod position

c. IRW is the slope of the DRW at a given position

d. DRW relates the worth of the rod per increment of movement to rod position. IRW relates the total reactivity added by the rod to the rod position

Question A.12 [1.0 point]
The following shows part of a decay chain for the radioactive element Pa-234: ${}_{91}Pa^{234} \rightarrow {}_{92}U^{234}$?

a. Alpha

b. Beta

c. Gamma

d. Neutron

Question A.13 [1.0 point]
What is the amount of reactivity added if, the multiplication factor, k, is increased from 0.800 to 0.950?

a. 0.157

b. 0.167

c. 0.187

d. 0.197

Question A.14 [1.0 point]
In a subcritical reactor, K_{eff} is increased from 0.885 to 0.943. Which one of the following is the amount of reactivity that was added to the core?

a. 4.68 %Δk/k

b. 5.58 %Δk/k

c. 6.94 %Δk/k

d. 7.45 %Δk/k

Question A.15 [1.0 point]
The first pulse has a reactivity worth of **$1.10** which results in a peak power of **500 MW**. If the second pulse has a peak power of **5000 MW**, the corresponding reactivity worth is:
Given: β_{eff}=0.0075

a. $1.32

b. $1.40

c. $1.62

d. $2.02

Question A.16 [1.0 point]
Which ONE of the following atoms will cause a neutron to lose the most energy in an elastic collision?

a. U-238

b. Ar-40

c. O-16

d. H-1

Question A.17 [1.0 point]
Which ONE of the following is the stable reactor period which will result in a power rise from 10% to 100% power in 10 seconds?

a. 4 seconds

b. 10 seconds

c. 24 seconds

d. 43 seconds

Question A.18 [1.0 point]
A mechanism by which a nucleus can gain stability by converting a neutron to proton or vice versa is called:

a. Gamma decay

b. Beta decay

c. Alpha decay

d. Photoelectric effect

Question A.19 [1.0 point]
Which ONE of the following conditions will INCREASE the shutdown margin of the reactor?

a. Lowering moderator temperature, assume negative temperature coefficient

b. Insertion of a positive reactivity worth experiment

c. Burnout of a burnable poison

d. Fuel depletion

Question A.20 [1.0 point]
Which ONE of the reactions below describes a method of production and removal of Xenon?

a. $_{52}Te^{134} \rightarrow \gamma + {}_{53}I^{134} \rightarrow p + {}_{54}Xe^{135} \rightarrow \beta^- + {}_{55}Cs^{135} \rightarrow \beta^- + {}_{56}Ba^{135}$

b. $_{52}Te^{135} \rightarrow \gamma + {}_{53}I^{135} \rightarrow \beta^- + {}_{54}Xe^{135} \rightarrow {}_{0}n^{1} + {}_{54}Xe^{136} \rightarrow \beta^- + {}_{56}Ba^{135}$

c. $_{52}Te^{135} \rightarrow \beta^- + {}_{53}I^{135} \rightarrow \beta^- + {}_{54}Xe^{135} \rightarrow \beta^- + {}_{55}Cs^{135} \rightarrow \beta^- + {}_{56}Ba^{135}$

d. $_{52}Te^{134} \rightarrow \beta^- + {}_{53}I^{135} \rightarrow \beta^- + {}_{54}Xe^{135} \rightarrow \gamma + {}_{55}Cs^{135} \rightarrow \beta^+ + {}_{56}Ba^{135}$

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

Category B – Normal/Emergency Procedures and Radiological Controls

Question B.01 [1.0 point]
Which ONE of the following materials shall NOT be irradiated in the reactor core?

a. Explosive material

b. Corrosive material

c. Fissionable material

d. Movable experiment

Question B.02 [1.0 point]
How long will it take a 1 Curie source, with a half-life of 1 year, to decay to 0.01 Curie?

a. 4.6 years

b. 6.6 years

c. 10.6 years

d. 16.6 years

Question B.03 [1.0 point]
A Reactor Operator (RO) works in a High Radiation Area (HRA), with a dose rate of 100 mR/hr, for eight hours a day. Which ONE of the following is the MAXIMUM number of days in which the RO may perform his duties WITHOUT exceeding 10CFR20 limits?

a. 5 days

b. 6 days

c. 7 days

d. 12 days

Question B.04 [1.0 point]
An irradiated sample provides a dose rate of 0.5 rem/hr at 2 feet. Approximately how far from the sample reads 5 mrem/hr?

a. 6 feet

b. 9 feet

c. 14 feet

d. 20 feet

Question B.05 [1.0 point]
In accordance with TXA&M SOP, what is the MINIMUM level of authority to approve temporary changes to the operating procedures that do not change the effectiveness or the original intent of the procedures?

a. Reactor Safety Board

b. NSC Director or his designated alternate

c. Reactor Supervisor

d. Senior Reactor Operator

Question B.06 [1.0 point]
In accordance with TXA&M NSC procedures and Technical Specifications, which ONE of the following is NOT considered an UNSCHEDULED SHUTDOWN?

a. Loss of power to the building removed the high voltage supply to the reactor console and caused all the safety rods to scram

b. During the annual surveillance check, a reactor operator inputs a channel test signal of 1250 kW, causing all the safety rods to scram

c. The operator was not watching reactor period when it reached 4 seconds and caused all the safety rods to scram

d. The operator inadvertently leaned on the scram bar with their elbow and caused all the safety rods to scram

Question B.07 [1.0 point]
Assuming there is no leak from outside of the demineralizer tank, you use a survey instrument to measure the dose rate from it. Compare the reading of the window probe with the window CLOSED and the reading with the window OPEN will:

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

b. remain the same, because the Quality Factors for Gamma and Beta radiation are the same

c. increase, because the Quality Factors for Beta and Alpha is greater than for Gamma

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

Question B.08 [1.0 point]
According to the TXA&M NSC Emergency Classification guide, the pool leakage which indicated abnormal loss at a rate exceeding makeup capacity is defined as:

a. Operational Event

b. Notification of Unusual Event

c. Alert

d. Site Area Emergency

Question B.09 [1.0 point]
Which ONE of the following statements correctly describes the relationship between the Safety Limit (SL) and the Limiting Safety System Setting (LSSS)?

a. The SL is a maximum operationally limiting value that prevents exceeding the LSSS during normal operations.

b. The SL is a parameter that assures the integrity of the fuel cladding. The LSSS initiates protective actions to preclude reaching the SL.

c. The SL is a maximum setpoint for instrumentation response. The LSSS is the minimum number of channels required to be operable.

d. The LSSS is a parameter that assures the integrity of the fuel cladding. The SL initiates protective action to preclude reaching the LSSS.

Question B.10 [1.0 point]
Which ONE of the following is the definition of the Total Effective Dose Equivalent (TEDE)?

a. The sum of the thyroid dose and external dose

b. The sum of the external deep dose and the organ dose

c. The sum of the deep dose equivalent and the committed effective dose equivalent

d. The dose that your whole body is received from the source, but excluded from the deep dose

Question B.11 [1.0 point]
Which ONE of the following is the correct definition of a CHANNEL CHECK?

a. The combination of sensor, line, amplifier, and output device which are connected for the purpose of measuring the value of a parameter.

b. The introduction of a signal into the channel for verification that it is operable.

c. A qualitative verification of acceptable performance by observation of channel behavior.

d. An adjustment of the channel such that its output corresponds with acceptable accuracy to known values of the parameter which the channel measures.

Question B.12 [1.0 point]
Which ONE of the following is the definition for "Annual Limit on Intake (ALI)"?

a. Projected dose commitment values to individuals that warrant protective action following a release of radioactive material.

b. The concentration of a radio-nuclide in air which, if inhaled by an adult worker for a year, results in a total effective dose equivalent of 100 millirem.

c. The effluent concentration of a radio-nuclide in air which, if inhaled continuously over a year, would result in a total effective dose equivalent of 50 millirem for noble gases.

d. 10CFR20 derived limit, based on a Committed Effective Dose Equivalent of 5 Rems whole body or 50 Rems to any individual organ, for the amount of radioactive material inhaled or ingested in a year by an adult worker.

Question B.13 [1.0 point]
Which ONE of the following events does NOT require the presence of a Licensed Senior Reactor Operator at the scene?

a. Fuel relocations within the core region

b. Removal of safety control rod for inspection

c. Insertion of experiment worth of $0.70

d. Reactor startup and approach to power

Category B – Normal/Emergency Procedures and Radiological Controls

Question B.14 [1.0 point]
Which ONE of the following is an example of a Byproduct Material?

a. Pu-239

b. U-238

c. U-235

d. Co-60

Question B.15 [1.0 point]
Per TXA&M Emergency Classification, which ONE of the following is a "failure of an in-core experiment with a minor release of radioactive material"?

a. Alert

b. Unusual Event – (reactor related)

c. Operational Event – (non-reactor related)

d. Normal Operation

Question B.16 [1.0 point]
Which ONE of the following parts in 10CFR requires all applicants for an RO and SRO license to submit NRC Form 396 and NRC Form 398 to the US NRC before taking a licensing examination?

a. Part 19

b. Part 20

c. Part 50

d. Part 55

Category B – Normal/Emergency Procedures and Radiological Controls

Question B.17 [1.0 point]
When measuring the scram time measurement, using the Oscilloscope method for the SHIM rod, the SHIM rod should be withdrawn to how much before pressing the fuel temperature scram test button?

a. 25%

b. 50%

c. 75%

d. 100%

Question B.18 [1.0 point]
10 CFR 50.59 would require TXA&M submit a request to the NRC for which ONE of the following modifications?

a. Utilize a new Xenon poisoning method of measurement

b. Change of primary coolant pressure gauge with a like model

c. Use new Resistance Temperature Detectors (RTD) to perform reactor power calibration

d. Replace the Wide Range Log with an uncompensated ion chamber

Question B.19 [1.0 point]
You are currently the licensed operator at TXA&M NSC reactor. Which ONE of the following will violate 10CFR55.53 (Conditions of Licenses)?

a. Last licensed renewal was 60 months ago

b. Last requalification operating test was 18 months ago

c. Last quarter you were the licensed operator for 5 hours

d. Last requalification written examination was 18 months ago

Category B – Normal/Emergency Procedures and Radiological Controls

Question B.20 [1.0 point, 0.25 each]
Match each of the Technical Specification limits in Column A with its corresponding value in Column B. (Answers in Column B may be used once, more than once, or not at all)

Column A	Column B
a. Worth of a single secured experiment	1. $0.50
b. Non-secured experiment	2. $1.00
c. Excess Reactivity	3. $2.00
d. Sum of the absolute value of reactivity of all experiments	4. $5.00
	5. $7.85
	6. $11.50

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

Category C – Facility and Radiation Monitoring Systems

Question C.01 [2.0 points, 0.50 each]
Identify whether each of the following Reactor Safety Channels shall be effective in the Steady State (SS) mode, the Pulse mode (P), or both modes (Both)

a. Console Scram Button

b. High Power Level

c. Preset Timer

d. Fuel Element Temperature

Question C.02 [1.0 point]
What is the reason for not exceeding a flow rate of 70 gpm for an emergency pool fill using the demineralizer system?

a. Prevent blow out of the demineralizer resin into the pool

b. Destroy the recirculation pump control switch

c. Destroy the conductivity prove in the demineralizer

d. Prevent channeling through the demineralizer resin column

Question C.03 [1.0 point]
What is the MAIN purpose of the fuel followers installed in the reactor control rods?

a. Decrease the fast neutron flux in the core

b. Enhance their control characteristics

c. Increase the core excess reactivity in the reactor core

d. Increase the effectiveness for reactor pulsing

Question C.04 [1.0 point]
Which ONE of the following is NOT true regarding the configuration of TAMU TRIGA-LEU fuel elements?

a. Uranium content: maximum of 30 wt% enriched to maximum 19.95% Uranium-235 with nominal enrichment of 19.75% Uranium-235

b. Hydrogen to Zirconium atom ratio (in the ZrHx): nominal 1.0 Hydrogen atoms to 1.6 Zirconium atoms with a maximum Hydrogen to Zirconium ratio of 1.05

c. Natural Erbium content (homogeneously distributed): nominal 0.90 wt%

d. Cladding: 304 Stainless Steel

Category C – Facility and Radiation Monitoring Systems

Question C.05 [1.0 point]
In the event of a loss of normal electrical power, where will emergency power be distributed to?

a. Radiation monitoring systems

b. Coolant pumps

c. Emergency lights

d. Reactor console

Question C.06 [1.0 point]
What will occur if, while the reactor power is 10 watts, a reactor staff member accidentally opens the Dry Cell Door (Core is in the Cell Position)?

a. An annunciator light in the control room will illuminate

b. Normal operation, no indication

c. A reactor scram

d. A reactor interlock

Question C.07 [1.0 point]
When the pool levels falls to approximately 90% of normal operating level, it will initiate visual and audible alarms in certain locations. Which ONE of the following locations gets an indication of VISUAL and AUDIBLE alarms?

a. Reception Room

b. University Communications Room

c. Director Office

d. Reactor Bay

Question C.08 [1.0 point]
What will occur with the conductivity of the pool water if there is any SIGNIFICANT buildup of radioactivity from the reactor pool?

a. Increase

b. Decrease

c. Stay the same

d. No relationship between radioactivity and conductivity in the pool water

Category C – Facility and Radiation Monitoring Systems

Question C.09 [1.0 point]
Which ONE of the following is an ACCEPTABLE value when conducting a control rod drop test at a fully out position of the Shim rod?

a. 1500 msec

b. 1300 msec

c. 1000 msec

d. 100 msec

Question C.10 [1.0 point]
What is the technique for calibration of the control rod: the operator determines the rod reactivity by measuring the rate of decrease in power level by scram of the calibrated rod from the desired height?

a. Rod Drop Method

b. Positive Period Method

c. Thermal Power Calibration Method

d. Positive Period-Differential Worth Method

Question C.11 [1.0 point]
Which ONE of the following Control Rod Drive Mechanisms (CRDM) for the Shim Safety Control Rods holds the control rods in position during reactor operation?

a. Motor

b. Armature

c. Electromagnet

d. Piston

Question C.12 [1.0 point]
In the event a Fuel-Followed Control Rod becomes detached from its mounting, what prevents it from falling out of the core?

a. Tapered section above absorber prevents passage through reactor frame

b. Safety plate assembly beneath the reactor grid plate

c. Notch in control rod pole connected to reactor frame

d. Bottom of pool is within two inches of grid plate

Category C – Facility and Radiation Monitoring Systems

Question C.13 [1.0 point]
What indication does the Pulse Channel provide after firing a pulse?

a. Energy and Fuel Temperature

b. Peak Power and 1 kW Interlock

c. Peak Power and Reactor Period

d. Percent Power and Energy

Question C.14 [1.0 point]
Which ONE of the following elements is MAINLY used as the neutron absorber on the TXA&M NSC Control Rods?

a. Boron

b. Zirconium-Hydride

c. Borated Graphite

d. Gold-Indium-Camium

Question C.15 [1.0 point]
Which ONE of the following is the MAIN purpose of the thermal column?

a. To enhance natural convection flow

b. Provide a thermal neutron flux on the Safety Channels

c. Provide a fast (high energy) neutron flux for a film irradiation facility

d. To shield a radiation dose from reactor core to the experiment area

Question C.16 [1.0 point]
The Facility Air Monitor (FAM) air flow configuration is color coded in accordance with the location of where its' air sample is coming from. What is the color code if the air sample is coming from the reactor bridge?

a. Blue

b. Red

c. Green

d. Yellow

Category C – Facility and Radiation Monitoring Systems

Question C.17 [1.0 point]
On a long-term basis, where is more than 95% of the facility's Argon-41 produced?

a. Dry tube

b. Reactor pool

c. Open beam port tubes

d. Pneumatic irradiation systems

Question C.18 [2.0 points, 0.50 each]
Match the input signal listed in Column A with the AUTOMATIC Control System response in Column B. Assume the reactor is in operation. Items in Column B may be used more than once or not at all.

Column A

a. Servo Fault

b. Power Channel = 1.25 MW

c. Pulse mode shim rod withdrawal

d. HV Wide Range Linear Channel = 140V

Column B

1. SCRAM
2. Rod run in
3. Rod Withdraw Prohibit
4. Indication ONLY

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

Category A – Theory, Thermodynamics & Facility Operating Characteristics

A.01
Answer: d
Reference: TRIGA Fuel Design

A.02
Answer: a
Reference: 1.03 x 0.96 x 0.84 x 0.88 x 1.96 x 0.70 = 1.00
1 / (1.03 x 0.96 x 0.84 x 0.88 x 1.96) = 0.698

A.03
Answer: c
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, Sec 3.3.1

A.04
Answer: a. 2; b. 1; c. 2; d. 1
Reference: DOE Fundamentals Handbook, NPRT, Vol. 2, Module 3, EO 5.4, EO 5.5, EO 5.6, pp 51-53

A.05
Answer: c
Reference: LaMarsh, Introduction to Nuclear Engineering, Page 340-341; $(1-\beta)k=1$ manipulated reads $k=1/(1-\beta)$

A.06
Answer: c
Reference: Reactivity added = $0.126\%\Delta k/k=0.00126\Delta k/k$; $T=\beta-\rho/\lambda_{eff}\rho$;
$(0.0078-0.00126)/(0.1)(0.00126) = 51.9$ seconds

A.07
Answer: c
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1988

A.08
Answer: d
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, Table 2.5, page 2-59

A.09
Answer: d
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, Sec 3.3.1, page 3-16

A.10
Answer: a
Reference: $P=P_oe^{t/T}$ ln(4)=time / 10 seconds Time = ln(4)x10 seconds 1.386 x10 = 13.8 seconds

A.11
Answer: d
Reference: NRC Standard Question

A.12
Answer b
Reference: Chart of the Nuclides, KAPL. Seventeenth Edition

A.13
Answer: d
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1988
$k=0.8$; $\rho=\Delta k_{eff}/k_{eff}$; -0.2/0.8 at $k=0.95$, ρ=-0.5/0.95; ρ= -0.053; the difference between ρ is the answer; -0.053-(-0.25) = 0.197
(0.95-0.80)/(0.8*0.95) = 0.197

A.14
Answer: c
Reference: Burn, R., Introduction to Nuclear Reactor Operations, Section 3.3.4
$\Delta\rho$ = (Keff1-Keff2)/(Keff1*Keff2) = (0.943-0.885)/((0.943*0.885)
$0.0694\Delta k/k = 6.94\%\Delta k/k$

A.15
Answer: a
$\rho1=(\rho\$1)(\beta_{eff})=(\$1.10)(.0075)=(.00825)$
$[(\rho2-\beta_{eff})^2]/Peak2 = [(\rho1-\beta_{eff})^2]/Peak1$
$Peak2/Peak1*[(\rho1-\beta_{eff})^2]=[(\rho2-\beta_{eff})^2]$
$(5000/500)*[(.00825-.0075)^2]= [(\rho2-\beta_{eff})^2]$
$[(.000005625)^{1/2}]+\beta_{eff} =\rho2=.009872$
$\rho\$2=(\rho2/\beta_{eff})=(.009872/.0075)= \$1.316 \approx \$1.32$
Reference: Burn, R., Introduction to Nuclear Reactor Operations, 1988. § 4.6, p. 4-16

A.16
Answer: d
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, sec 2.5.3

A.17
Answer: a
Reference:

A.18
Answer: b
Reference: NRC Standard Question

A.19
Answer: d
Reference: Decreasing the reactivity worth in the core will increase the shutdown margin

A.20
Answer: c
Reference: Chart of Nuclides; Production and decay of radionuclides

Category B – Normal/Emergency Procedures and Radiological Characteristics

B.01
Answer: c
Reference: TXA&M Technical Specification 3.6

B.02
Answer: b
Reference: $A=A_o e^{-\lambda t}$ $0.01Ci=1Ci^{e-\lambda t}$; $\ln(0.01/1) = -0.693(t)$ -4.60/-0.693; 6.6 years

B.03
Answer: b
Reference: 10CFR20.1201(a)(1) [5000 mR x (1 hr/100mR) x (day/8 hr)] = 6.25 days

B.04
Answer: d
Reference: $500mrem(2)^2=5mrem(d)^2$ D=20 feet

B.05
Answer: b
Reference: TXA&M Procedure F, Section I

B.06
Answer: b
Reference: TXA&M Technical Specification 1.30

B.07
Answer: d
Reference: Basic radiological techniques; Beta and Alpha radiation don't make it through the demineralizer tank

B.08
Answer: c
Reference: TXA&M Emergency Plan, Section 4, Emergency Classification System Table I

B.09
Answer: b
Reference: TXA&M 2.1.2 and 2.2.1, Objective

B.10
Answer: c
Reference: 10CFR20.1003

B.11
Answer: c
Reference: TXA&M Technical Specifications, Definitions

B.12
Answer: d
Reference: 10CFR20.1003

Category B – Normal/Emergency Procedures and Radiological Characteristics

B.13
Answer: c
Reference: TXA&M Technical Specification 6.1.3

B.14
Answer: d
Reference: 10CFR20.1003; byproduct material is any radioactive material, except special nuclear material, made radioactive by the process of producing or using special nuclear material

B.15
Answer: b
Reference: TXA&M Emergency Plan 4.2

B.16
Answer: d
Reference: 10CFR55

B.17
Answer: d
Reference: TXA&M SOP Procedure I, Section III

B.18
Answer: d
Reference: 10CFR50.59

B.19
Answer: b
Reference: 10CFR55.53; 55.53(i)- licensee shall have a biennual medical exam, 55.53(h) 55.59(c) – annual operating tests; 55.53(e) 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) requalification program must be conducted for a continuous period not to exceed 2 years; License renewal – 6 years

B.20
Answer: a. 3, b. 2, c. 5, d. 4
Reference: TXA&M Technical Specifications 3.1.6, 3.6.1

Category C: Facility and Radiation Monitoring Systems

C.01
Answer: a. Both b. SS c. Pulse d. Both
Reference: TXA&M Technical Specification 3.2

C.02
Answer: d
Reference: TXA&M SOP V-A

C.03
Answer: c
Reference: TXA&M SAR 1.8

C.04
Answer: b
Reference: TXA&M Technical Specification 5.2

C.05
Answer: c
Reference: TXA&M SAR 8.2

C.06
Answer: c
Reference: TXA&M SOP, Procedure D, Section IV

C.07
Answer: b
Reference: TXA&M SOP, Procedure O, Section III, Reactor Pool Surveillance

C.08
Answer: a
Reference: NRC Standard Question

C.09
Answer: c
Reference: TXA&M Technical Specification 3.2.3

C.10
Answer: a
Reference: TXA&M SOP II, Procedure K

C.11
Answer: c
Reference: TXA&M SAR 7.2.3.6 and 7.3.1

C.12
Answer: b
Reference: TXA&M SAR 4.2.5

C.13
Answer: d
Reference: TXA&M SAR 7.2.3.2

Category C: Facility and Radiation Monitoring Systems

C.14
Answer: c
Reference: TXA&M SAR 4.2.2

C.15
Answer: d
Reference: TXA&M Training Manuals

C.16
Answer: b
Reference: TXA&M Procedure VII-F1, Section VII

C.17
Answer: b
Reference: TXA&M SAR 11.1.1

C.18
Answer: a. 4 b. 1 c. 3 d. 4
Reference: TXA&M Technical Specification 3.3 and TXA&M SAR 7.0

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