November 9, 2016

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-17-01, TEXAS A&M UNIVERSITY

Dear Dr. McDeavitt:

During the week of October 03, 2016, the U.S. Nuclear Regulatory Commission (NRC) administered an operator licensing examination at your Texas A&M University research 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 Mr. John T. Nguyen at (301) 415-4007 or via e-mail John.Nguyen@nrc.gov.

Sincerely,

/RA/

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

Docket No. 50-128

Enclosures: 1. Examination Report No. 50-128/OL-17-01
2. Written examination

cc: Mr. Jerry Newhouse, Texas A&M University
cc: w/o enclosures: See next page

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

November 9, 2016

SUBJECT: EXAMINATION REPORT NO. 50-128/OL-17-01, TEXAS A&M UNIVERSITY

Dear Dr. McDeavitt:

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ADAMS ACCESSION #: ML16309A291 **TEMPLATE #:NRR-074**

OFFICE	NRR/DPR/PROB/CE	NRR/DPR/PROB/OLA	NRR/DPR/PROB/BC
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DATE	10/26/2016	11/04/2016	11/09/2016

OFFICIAL RECORD COPY

cc:

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Test, Research and Training
Reactor Newsletter
University of Florida
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U. S. NUCLEAR REGULATORY COMMISSION
OPERATOR LICENSING INITIAL EXAMINATION REPORT

REPORT NO.: 50-128/OL-17-01

FACILITY DOCKET NO.: 50-128

FACILITY LICENSE NO.: R-83

FACILITY: TRIGA

EXAMINATION DATES: October 04-06, 2016

SUBNSCTED BY: **/RA/** **10/20/2016**
John T. Nguyen, Chief Examiner Date

SUMMARY:
During the week of October 03, 2016, the NRC administered operator licensing examinations to four license candidates (two Reactor Operator-Instant, one Reactor Operator-Retake, and one Senior Reactor Operator–Retake). The Reactor Operator-Retake candidate failed the Section A and Section B of the written examination.

REPORT DETAILS

1. Examiners: John T. Nguyen, Chief Examiner, NRC

2. Results:

	RO PASS/FAIL	SRO PASS/FAIL	TOTAL PASS/FAIL
Written	2/1	1/0	3/1
Operating Tests	3/0	1/0	4/0
Overall	2/1	1/0	3/1

3. Exit Meeting:
John T. Nguyen, Chief Examiner, NRC
Jerry Newhouse, Associate Director, Texas A&M University
Scott Miller, Reactor Operations Manager, Texas A&M University
Cameron MacDonnell, Training Supervisor, Texas A&M University

At the conclusion of the meeting, the NRC Examiner thanked the facility for their support in the administration of the examinations. The facility licensee had no comments on the written examination. The examiner also discussed the weaknesses observed during the examination. The candidates have shown the weaknesses in a basic understanding of 10 CFR 50.59, a lack of knowledge in the operations of nuclear instrumentation channels, and were unfamiliar with radiation sources and hazards. The facility licensee promised to take actions to improve program performance in the training programs.

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

FACILITY: Pool

REACTOR TYPE: TRIGA

DATE ADMINISTERED: 10/05/2016

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

A. RX THEORY, THERMO & FAC OP CHARS

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 ___ (0.25 each)

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 *****)

B. NORMAL/EMERG PROCEDURES & RAD CON

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 ___ (0.25 each)

B03 a ___ b ___ c ___ d ___ (0.25 each)

B04 a b c d ___

B05 a b c d ___

B06 a ___ b ___ c ___ d ___ (0.25 each)

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 ___ (0.25 each)

B16 a b c d ___

B17 a b c d ___

B18 a ___ b ___ c ___ d ___ (0.25 each)

B19 a b c d ___

B20 a b c d ___

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

C. PLANT AND RAD MONITORING SYSTEMS

A N S W E R   S H E E T

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

C01 a b c d ___

C02 a b c d ___

C03 a b c d ___

C04 a b c d ___

C05 a ___ b ___ c ___ d ___ (0.5 each)

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 ___ (0.25 each)

(***** 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 NSC 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 <u>only</u> 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

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

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

$$\lambda^* = 1 \times 10^{-4} \text{ seconds}$$

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

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

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

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

$$M = \frac{1 - K_{eff_0}}{1 - K_{eff_1}}$$

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

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

$$P = P_0 e^{\frac{t}{\tau}}$$

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

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

$$\tau = \frac{\lambda^*}{\rho - \bar{\beta}}$$

$$\tau = \frac{\lambda^*}{\rho} + \left[\frac{\bar{\beta} - \rho}{\lambda_{eff} \rho} \right]$$

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

$$T_{‰} = \frac{0.693}{\lambda}$$

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

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

$$DR = \frac{6CiE(n)}{R^2}$$

$$DR_1 d_1^2 = DR_2 d_2^2$$

$\lambda_{eff} = 0.1/sec$

---

1 Curie = 3.7×10^{10} dps	1 kg = 2.21 lbm
1 hp = 2.54×10^{3} BTU/hr	1 Mw = 3.41×10^{6} BTU/hr
1 BTU = 778 ft-lbf	°F = 9/5°C + 32
931 Mev = 1 amu	°C = 5/9 (°F - 32)

Section A L Theory, Thermo & Fac. Operating Characteristics

QUESTION A.01 [1.0 point]
Which ONE of the following statements describes a NEGATIVE moderator temperature coefficient?

a. When moderator temperature increases, negative reactivity is added

b. When moderator temperature decreases, negative reactivity is added

c. When moderator temperature increases, positive reactivity is added

d. When moderator temperature increases, no change in reactivity

QUESTION A.02 [1.0 point]
You're increasing reactor power on a steady +13 second period. How long will it take to increase power by a factor of 10?

a. 10 seconds

b. 20 seconds

c. 30 seconds

d. 40 seconds

QUESTION A.03 [1.0 point]
During the time following a reactor scram, reactor power decreases on an 80 second period, which corresponds to the half-life of the longest-lived delayed neutron precursors of:

a. 80 seconds

b. 55 seconds

c. 40 seconds

d. 20 seconds

QUESTION A.04 [1.0 point]
Reactor operator performs a $1.50 pulse. Which ONE of the following best describes the values of K_{eff} and ρ during the power increment?

a. $K_{eff} = 1$ and $\rho = 1$

b. $K_{eff} > 1$ and $\rho = 1$

c. $K_{eff} > 1$ and $\beta\text{-eff} < \rho < 1$

d. $K_{eff} > 1$ and $0 < \rho < \beta\text{-eff}$

QUESTION A.05 [1.0 point]
If the multiplication factor, k, is increased from 0.800 to 0.950, the amount of reactivity added is:

a. 0.157

b. 0.167

c. 0.187

d. 0.197

QUESTION A.06 [1.0 point]
Which ONE of the following correctly describes the SIX- FACTOR FORMULA at the NSC reactor? The multiplication factor between generation, K-effective, is the product of k-infinitive and the:

a. Thermal utilization factor

b. Total non-leakage probability

c. Resonance escape probability

d. Reproduction factor

QUESTION A.07 [1.0 point]
Which ONE of the following is a number of protons in the tritium nucleus ($_1T^3$ or $_1H^3$)?

a. 1

b. 2

c. 3

d. 4

QUESTION A.08 [1.0 point]
Which ONE of the following is the MAIN reason for operating reactor with thermal neutrons instead of fast neutrons?

a. The atomic weight of thermal neutrons is larger than fast neutrons, so thermal neutrons are easily to slow down and be captured by the fuel

b. The neutron lifetime of thermal neutrons is longer than fast neutrons, so the fuel has enough time to capture thermal neutrons

c. Fast neutrons give off higher radiation than thermal neutrons. Reactor needs to reduce radiation limit by using thermal neutrons

d. The fission cross section of the fuel is much higher for thermal energy neutrons than fast neutrons

QUESTION A.09 [1.0 point]
Which ONE of the following is the MINIMUM amount of reactivity that makes the NSC (**finite)** critical reactor to be a prompt critical reactor? This MINIMUM amount is equal to:

a. the shutdown margin

b. the k-effective value

c. 1.0 % ΔK/K

d. the β-effective value

QUESTION A.10 [1.0 point]
A few minutes following a reactor scram at full power, the reactor period has stabilized and the power level is decreasing at a CONSTANT rate. What is a reactor power level five minutes later from 4 kW?

a. 1500 W

b. 940 W

c. 94 W

d. 15 W

QUESTION A.11 [1.0 point]
Reactor A increases power from 10% to 20% with a period of 25 seconds. Reactor B increases power from 80% to 100% with a period of also 25 seconds. Compared to Reactor A, the time required for the power increase of Reactor B is:

a. longer than A

b. exactly the same as A

c. twice that of A

d. shorter than A

QUESTION A.12 [1.0 point, 0.25 each]
Match the following Neutron Interactions in Column A with the appropriate definition in Column B (each used only once)

Column A	Column B
a. Fission	1. Neutron enters nucleus, forms a compound nucleus, then decays by gamma emission
b. Radiative capture	2. Particle enters nucleus, forms a compound nucleus and is excited enough to eject a new particle with incident neutron remaining in nucleus
c. Scattering	3. Nucleus absorbs neutron and splits into two similarly sized parts
d. Particle ejection	4. Nucleus is struck by a neutron and emits a single neutron

QUESTION A.13 [1.0 point]
In a just critical reactor, adding $0.50 worth of reactivity in the STEADY STATE MODE will cause:

a. The reactor period to be equal to 50 seconds

b. The reactor period to be equal to $(\beta-\rho)/\lambda\rho$

c. A number of prompt neutrons equals to a number of delayed neutrons

d. The resultant period to be a function of the prompt neutron lifetime ($T=\ell^*/\rho$)

QUESTION A.14 [1.0 point]
The following shows part of a decay chain for the radioactive element Pa-234:
${}_{91}Pa^{234} \rightarrow {}_{92}U^{234}$
This decay chain is an example of _______ decay.

a. Alpha

b. Beta

c. Gamma

d. Neutron

QUESTION A.15 [1.0 point]
Which one of the following statements describes the difference between differential rod worth (DRW) and integral rod worth (IRW) curves?

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 rod 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.16 [1.0 point]
Which ONE of the following isotopes has the **LEAST** thermal neutron cross section?

a. Cd-112

b. Sm-149

c. Xe-135

d. U-235

QUESTION A.17 [1.0 point]
Which ONE of the following is a correct statement describing prompt and delayed neutrons? Prompt neutrons:

a. are released during U-238 interacts with fast neutrons, while delayed neutrons are released during 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.18 [1.0 point]
What is the condition of the reactor when $k = \frac{1}{1-\beta}$?

a. Subcritical

b. Critical

c. Super critical

d. Prompt critical

QUESTION A.19 [1.0 point]
Which **ONE** of the following conditions will **INCREASE** the shutdown margin of a 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 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 (e.g., 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

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

Section B Normal/Emergency Procedures and Radiological Controls

QUESTION B.01 [1.0 point]
Per NSC Emergency Plan, the individual who is responsible for the termination of an emergency is the:

a. NSC Police Chief

b. Public Relations Coordinator

c. NSC Radiation Protection Officer

d. NSC Emergency Director

QUESTION B.02 [1.0 points, 0.25 each]
Match the radiation reading from Column A with its corresponding radiation area classification (per 10 CFR 20) listed in Column B. Answer in Column B can be used more than once, or not at all.

	Column A	Column B
a.	5 mrem/hr at 30 cm	1. Public Area
b.	50 mrem/hr at 30 cm	2. Radiation Area
c.	20 mrem/hr at 1 m	3. High Radiation Area
d.	5.5 grays/hr at 1 m	4. Very High Radiation Area

QUESTION B.03 [1.0 point, 0.25 each]
Identify each of the following surveillances as a channel check (**CHECK)**, a channel test (**TEST)**, or a channel calibration (**CAL)**.

a. During reactor operation, you compare readings of a pool water temperature

b. During the startup, you verify the reactor interlock system by performing simultaneous manual withdrawal of two control rods

c. During the startup, you verify a reactor high voltage scram

d. Adjust the Wide Range Linear Power Channel in accordance with recent data collected on the reactor thermal power calibration

QUESTION B.04 [1.0 point]
The radiation from an unshielded source is 100 mrem/hr. You insert a lead sheet with 20 mm thickness; the radiation level reduces to 25 mrem/hr. What is the half-value-layer (HVL) of lead? (HVL: thickness of lead required so that the original intensity will be reduced by half)?

a. 10 mm

b. 20 mm

c. 30 mm

d. 40 mm

QUESTION B.05 [1.0 point]
A biennial test of the reactor shutdown margin was performed. Which ONE of the following is the latest the test that must be performed again?

a. 7.5 months after

b. 15 months after

c. 27 months after

d. 29 months after

QUESTION B.06 [1.0 point, 0.25 each]
Match each of the Technical Specification Limits in column A with its corresponding value in column B. (Each limit has only one answer, values in Column B may be used once, more than once or not at all.)

	Column A		Column B
a.	Worth of 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

QUESTION B.07 [1.0 point]
Per NSC Tec Spec, which ONE of the following will violate the Limiting Safety System Settings?

a. An unanticipated change in reactivity of two dollar

b. Instrumented fuel temperature = 550 °C

c. Steady State power exceed 1.25 MW

d. Pool water temperature = 80 °C

QUESTION B.08 [1.0 point]
Which ONE of the following changes must be submitted to NRC for approval prior to implementation?

a. Replace a primary cooling pump with an identical pump

b. Add new limitation to the Pre-Startup Checklist Procedure

c. Add more responsibilities to the Radiation Protection Officer listed in the health physics procedure

d. Delete a definition of Channel Test listed in the NSC Technical Specifications

QUESTION B.09 [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	900
30	740
60	615
90	512
180	294

a. 321 minutes

b. 211 minutes

c. 111 minutes

d. 91 minutes

<u>Section C Facility and Radiation Monitoring Systems</u>

QUESTION B.10 [1.0 point]
Per Reactor Core Manipulation procedure, the MINIMUM crew required to load fuel elements into the reactor core consists of the following personnel:

a. NSC Director, SRO, RO, Fuel Handler

b. RSB Chairman, SRO, RO, Fuel Handler

c. SRO, RO, Fuel Handler, Health Physicist

d. SRO, Fuel Handler, Health Physicist

QUESTION B.11 [1.0 point]
An example of Byproduct Material would be:

a. Pu-239

b. U-238

c. U-235

d. Co-60

QUESTION B.12 [1.0 point]
A five-curie source, emitted 100% of 1 Mev gamma, is to be stored in the reactor building. How far from the source should a <u>HIGH RADIATION AREA</u> sign be posted?

a. 7 feet

b. 17 feet

c. 27 feet

d. 54 feet

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 power

QUESTION B.14 [1.0 point]
Assume that there is no leak from outside of the demineralizer tank. You use a survey instrument with a window probe to measure the dose rate from the demineralizer tank. Compare to the reading with a window **CLOSED,** the reading with a window **OPEN** will:

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

b. remain the same, because the Quality Factors for gamma and beta radiation are the same

c. increase, because the Quality Factor 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.15 [1.0 point, 0.25 each]
Match type of radiation listed in column A with their quality factor listed in column B. Items in column B can be used once, more than once or not at all.

	Column A		Column B
a.	X-ray	1.	1
b.	Gamma	2.	5
c.	Alpha particles	3.	10
d.	High-energy photons	4.	20

<u>Section C Facility and Radiation Monitoring Systems</u>

QUESTION B.16 [1.0 point]
Which ONE of the following is the definition of Total Effective Dose Equivalent (TEDE)?

a. The sum of 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.17 [1.0 point]
According to 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.18 [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.

<u>Column A</u>		<u>Column B</u>
a.	Reactor operator falls from stair	1. Operational Event
b.	Loss of pool water causing an alarm (Capable filling with the water make up system)	2. Unusual Event
c.	Earthquake causing damage to the control rods during full power. Operator could not scram the reactor	3. Alert
d.	Severe failure of fuel cladding, causing significant releases of radioactive material	

Section C Facility and Radiation Monitoring Systems

QUESTION B.19 [1.0 point]
Which ONE of the following materials shall NOT be irradiated in the reactor core?

a. Any explosive material

b. Any corrosive material

c. Any fissionable material

d. Any movable experiment

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

a. 5 days

b. 6 days

c. 7 days

d. 12 days

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

Section C Facility and Radiation Monitoring Systems

QUESTION C.01 [1.0 point]
On a long-term basis, more than 95% of the facility's Ar-41 is produced in the:

a. Dry tube

b. Reactor pool

c. Open beam port tubes

d. Pneumatic irradiation systems

QUESTION C.02 [1.0 point]
Use the following diagram of an instrumented fuel element. Which ONE of the following is the correct match for the position locator (Column A) to the correct component (Column B)?

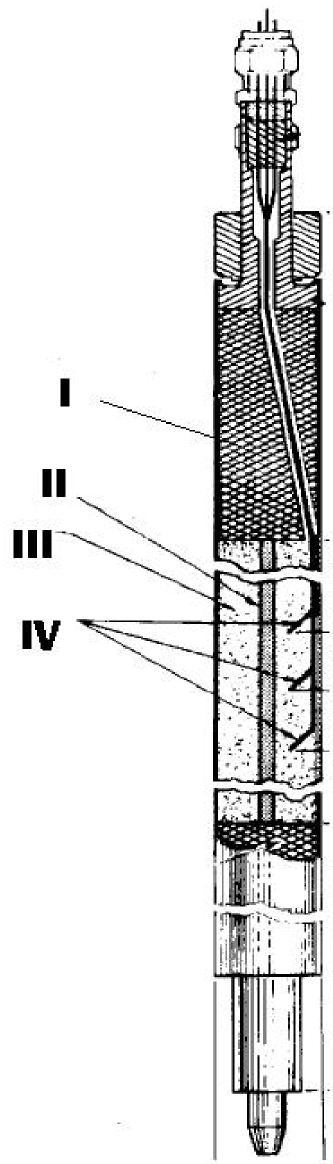
Column A	Column B
I	A. Zirconium Hydride-Uranium
II	B. Stainless steel
III	C. Samarium Burnable Poison
IV	D. Graphite Reflector
	E. Zirconium Rod
	F. Spacer
	G. Thermocouples

a. I-C, II-F, III-A, IV-C

b. I-D, II-A, III-E, IV-C

c. I-D, II-E, III-A, IV-G

d. I-C, II-B, III-E, IV-G


I
II
III
IV

QUESTION C.03 [1.0 point]
For an emergency pool fills using the demineralizer system, a reason for not exceeding a flow rate of 70 gpm is to:

a. Blow out the demineralizer resin into the pool

b. Destroy the recirculation pump control switch

c. Destroy the conductivity probe in the demineralizer

d. Cause channeling through the demineralizer resin column

QUESTION C.04 [1.0 point]
During reactor operation, which ONE of the following is the MAIN reason for not operating the coolant pumps in dry (no prime) for no longer than two minutes?

a. Increasing the amount of Ar-41 released to the reactor bay

b. Increasing the amount of N-16 in the reactor pool

c. Damaging the pump motor

d. Damaging the coolant pipes

QUESTION C.05 [2.0 points, 0.5 each]
Match the input signals listed in column A with their AUTOMATICAL Control Systems responses (reactor will automatically response when exceeding the conditions) in column B. (Items in column B may be used once, more than once or not at all). Assume that the reactor is in operation.

	Column A		Column B
a.	HV Wide Range Linear channel = 140 V	1.	Indication ONLY
b.	Servo Fault	2.	Rod withdraw prohibit
c.	Power Channel = 1.25 MW	3.	Scram
d.	Withdrawal of shim rod during a pulse mode	4.	Rod run-in

QUESTION C.06 [1.0 point]
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. This technique is called:

a. Rod Drop Method

b. Positive Period Method

c. Thermal Power Calibration Method

d. Positive Period-Differential Worth Method

QUESTION C.07 [1 point]
Which ONE of the following elements is MAINLY used as the neutron absorber on the NSC control rods?

a. boron

b. zirconium-hydride

c. borated graphite

d. gold-indium-cadmium

QUESTION C.08 [1.0 point]
Which ONE of the following best describes on how the Uncompensated Ion Chamber (UIC) and Compensated Ion Chamber (CIC) operate?

a. The CIC has two chambers, both can sense gamma rays but only one is coated with boron-10 for (n,α) reaction; whereas the UIC has only one chamber coated with boron-10 for (n,α) reaction.

b. The CIC has two chambers, one is coated with U-235 for fission reaction and the other is coated with boron-10 for (n,α) reaction; whereas the UIC has only one chamber coated with U-235 for fission reaction.

c. The CIC has only one chamber coated with boron-10 for (n,α) reaction; whereas the UIC has two chambers, one is coated with U-235 for fission reaction and the other is coated with boron-10 for (n,α) reaction.

d. The CIC has only one chamber coated with U-235 for fission reaction, whereas the UIC has two chambers, both can sense gamma rays but only one is coated with boron-10 for (n,α) reaction.

Section C Facility and Radiation Monitoring Systems

QUESTION C.09 [1.0 point]
Nominal Hydrogen- Zirconium atom ratio in the TRIGA LEU fuel elements is:

a. 1.6 H atom to 1.0 Zr atoms

b. 1.0 H atom to 1.6 Zr atoms

c. 30 H atom to 20 Zr atoms

d. 20 atom to 30 Zr atoms

QUESTION C.10 [1.0 point]
Which ONE of the following describes the yellow light associated with the beam port water shutters?

a. An illuminated yellow light indicates that the shutter tube is evacuated and the beam is active

b. An illuminated yellow light indicates that a shutter flood permissive has been selected by the reactor operator

c. The yellow light warns the experimenter of the commencement of a reactor startup

d. The yellow light tells the experimenter that the beam has been cut off

QUESTION C.11 [1.0 point]
The Main purpose for setting a conductivity limit of the pool water is to:

a. Maintain the departure of nucleate boiling ratio (DNBR) greater than the unity

b. Minimize the possibility of corrosion of the cladding on the fuel elements

c. Extend integrity of resin bed on the demineralizer

d. Minimize Ar-41 released to the public

QUESTION C.12 [1.0 point]
After firing a pulse, the Pulse Channel provides the indications of:

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.13 [1.0 point]
A 1-3/4 inch diameter hole through the grid plate is located at the southwest corner of the four rod fuel assemblies. The purpose of these holes is to:

a. Accommodate a fuel followed control rod

b. Provide a mounting location for in-core experiments

c. Provide a coolant flow path through the grid plate

d. Accommodate a void follower in the transient rod

QUESTION C.14 [1.0 point]
In an event of a loss of normal electrical power, an emergency power will distribute its power to:

a. Radiation monitoring systems

b. Coolant pumps

c. Emergency lights

d. Reactor console

Section C Facility and Radiation Monitoring Systems

QUESTION C.15 [1.0 point]
You conducted a control drop test at fully out position of the Shim rod. Which ONE of the following is an acceptable value?

a. 1500 msec

b. 1300 msec

c. 1000 msec

d. 100 msec

QUESTION C.16 [1.0 point]
Which ONE of the following best describes the information in the system tags number, 06-12-03?

a. 06: Calendar year – 12: Sequential number for year – 03: Sequential number in tag group

b. 06: Calendar year – 12: Sequential number in tag group – 03: Sequential number for year

c. 06: Sequential number in tag group – 12: Sequential number for year – 03: Calendar year

d. 06: Sequential number in tag group – 12: Calendar year – 03: Sequential number for year

QUESTION C.17 [1.0 point]
Which ONE of the following statements is NOT TRUE regarding the Servo Flux Control system?

a. The regulating rod control is automatically shift back to manual if the level drifts out of ±.5% range

b. The regulating rod moves in response to the signal from the Linear Power Channel

c. The regulating rod moves in response to the signal from the Log Power Channel

d. Alarm if the REG rod is inserted less than 20% fully withdrawn

QUESTION C.18 [1.0 point]
Which ONE of the following provides a reactor scram in any mode of operation?

a. High fuel temperature

b. Low pool level

c. High power level

d. High pool conductivity

QUESTION C.19 [1.0 point]
Use the following diagram of the control rod armature; match the components listed in Column A to the appropriate position locator listed in the diagram.

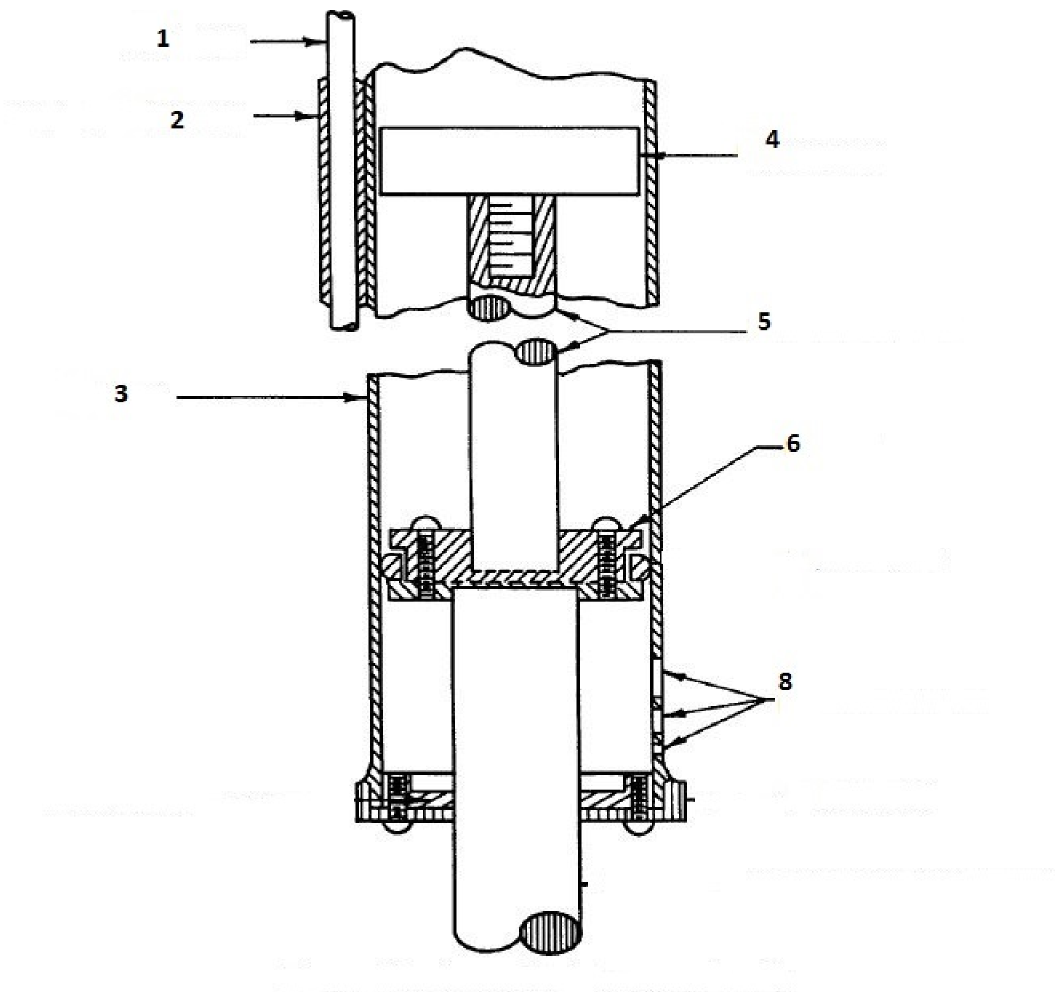
Column A

a. Armature

b. Barrel

c. Piston

d. Dashpot Port



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

Section A L Theory, Thermo & Fac. Operating Characteristics

A.01
Answer a
Reference: Introduction to Nuclear Operation, Reed Burn, 1982, Sec 6.4

A.02
Answer: c
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988
ln (P/P_0) × period = time, ln(10) × 13 = 2.30 × 13 = 29.9

A.03
Answer: b
Reference: Group 1 is the longest-lived delayed neutron precursor for thermal fission in U-235, with a half-life of 55.72 sec.
Lamarsh, J. "Introduction to Nuclear Engineering" p. 88

A.04
Answer: c
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Sec 4.2

A.05
Answer: d
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1982, Sec 3.3.3, page 3-21.
In order to solve the question A.05, the applicant can use one of the following methods:
At k=0.8; ρ = ΔKeff/Keff or ρ = Keff-1/Keff = -0.2/0.8 =-0.25. At k=0.95, ρ =-0.05/0.95
ρ = -0.053. The difference between ρ is the answer ,i.e. -0.053-(-0.25)=0.197
Δ ρ = ρ1 – ρ2 where ρ1 = Keff1-1/Keff1 and ρ2 = Keff2-1/Keff2. Substitute ρ1 and ρ2 with Keff1 and Keff2 into the equation above, the result is Δρ = keff1-keff2/(keff1 x keff2) = 0.95-0.8 /(0.8*0.95)=0.197

A.06
Answer: b
Reference: Burn, R., Introduction of Nuclear Reactor Operations, © 1988, Sec 3.3

A.07
Answer: a
Reference: Nuclides and Isotopes
Z=1, A=3 , N=2

A.08
Answer: d
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1982, Figure 2.6, page 2-39

A.09
Answer: d
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Sec 4.6

A.10
Answer: c
Reference: $P = P0\ e^{-t/T}$ = 4 kW * e(300sec/-80sec) = 4 kW * exp(-3.75) = 0.0235 * 4 kW = 0.094 kW = 94 W

A.11
Answer: d
Reference: The power of reactor A increases by a factor of 2, while the power of reactor B increases by a factor of 1.25. Since the periods are the same (rate of change is the same), power increase B takes a shorter time.

A.12
Answer: a (3) b (1) c (4) d (2)
Reference: DOE Fundamentals Handbook *Nuclear Physics and Reactor Theory*, Volume 1, Module 1, Page 43-46

A.13
Answer b
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, Sec 4.6 page 417

A.14
Answer: b
Reference: Chart of the Nuclides

A.15
Answer: d
Reference: NRC Standard Question

A.16
Answer: d
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, Table2.5, page 2-59.

A.17
Answer: c
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1988

A.18
Answer: c
Reference: LaMarsh, Introduction to Nuclear Engineering, Page 340-341
$(1-\beta)k=1$ manipulated reads $k=1/(1-\beta)$

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

A.20
Answer: d
Reference: TRIGA Fuel Design

Section B Normal/Emergency Procedures and Radiological Controls

B.01
Answer: d
Reference: EP 3.3

B.02
Answer: a(2); b(2); c(3); d(4)
Reference: 10 CFR 20.1003 Definitions
For part c, 20 mrem/hr at 1m will be equal to 222 mrem/hr at 30 cm :=> high radiation area
5.5 grays→ 550 rad/hr at 1 m ➔ very high radiation area
Definition
High Radiation Area: 100 mrem/hr at 30 cm
Radiation Area : 5 mrem/hr at 30 cm
Very High Radiation Area: 500 rads/hr at 1 m

B.03
Answer: a = CHECK; b = TEST; c = TEST; d = CAL
Reference: NSC Technical specification, Definitions

B.04
Answer: a
Reference: $DR = DR_{\circ} * e^{-\mu X}$
Find μ : $25 = 100 * e^{-\mu * 20}$; μ = 0.0693
If insertion of an HVL (thickness of lead), the original intensity will be reduced by half.
Find X: $1 = 2 * e^{-0.0693 * X}$; X= 10 mm
Find HVL by shortcut:
100mR- 50 mR is the 1st HVL
50 mR – 25 mR is the 2nd HVL
So HVL=20mm/2 = 10 mm

B.05
Answer: d
Reference: TS 4.1

B.06
Answer: a, 3 b,2 c,5 d,4
Reference: TS 3.1.6 and TS 3.6.1

B.07
Answer: b
Reference: TS 2.2

B.08
Answer: d
Reference: 10 CFR 50.59

B.09
Answer: c
Reference: $A = A_o e^{-\lambda t}$
$294 = 900e^{-180\lambda}$, 180λ = -ln 0.327, λ = 0.00623 min^{-1}
$t_{1/2} = 0.693 / \lambda$, $= 0.693 / 0.00623\ min^{-1} = 111$ minutes

Section B Normal/Emergency Procedures and Radiological Controls

B.10
Answer: c
Reference: SOP II. I.2.a

B.11
Answer: d
Reference: Byproduct material is any radioactive material (except special nuclear material) made radioactive by the process of producing or using special nuclear material. 10 CFR Part 20.1003

B.12
Answer: b
Reference: 6CEN = R/hr @ 1 ft. -> 6 x 5 x 1 x 1 = 30 R/hr at 1ft. $I_0D_0^2 = I*D^2$
30 R/hr*(1 ft)^2 = 0.1 R/hr *D^2
D= sqrt(30/0.1) = 17.3 ft.

B.13
Answer: c
Reference: TS Section 6.1.3

B.14
Answer: d
Reference: Basic radiological concept (beta and alpha radiation don't make through the demineralizer tank)

B.15
Answer: a(1) b(1) c(4) d(3)
Reference: 10 CFR 20

B.16
Answer: c
Reference: 10 CFR 20.1003

B.17
Answer: b
Reference: TS 1.30

B.18
Answer: a(1) b(2) c(2) d(3)
Reference: EP 4.1, EP 4.2, and EP 4.3

B.19
Answer: c
Reference: TS 3.6

B.20
Answer: b
Reference: 10CFR20.1201(a)(1) [5000 mr x $\frac{1\ hr}{100\ mr}$ x $\frac{day}{8\ hr}$ = 6.25 days

Section C Facility and Radiation Monitoring Systems

C.01
Answer: b
Reference: SAR 11.1.1

C.02
Answer: c
Reference: NRC Standard Question

C.03
Answer: d
Reference: SOP V-A

C.04
Answer: c
Reference: NRC Standard Question

C.05
Answer: a(1) b(1) c(3) d(2)
Reference: TS 3.3 and SAR 7.0, Instrumentation and Control

C.06
Answer: a
Reference: SOP II, Procedure K

C.07
Answer: c
Reference: SAR 4.2.2

C.08
Answer: a
Reference: NRC Standard Question

C.09
Answer: a
Reference: TS 5.2

C.10
Answer: a
Reference: SOP IVI.D.b.10

C.11
Answer: b
Reference: TS 3.8.1

C.12
Answer d
Reference: SAR 7.2.3.2

Section C Facility and Radiation Monitoring Systems

C.13
Answer: a
Reference: SAR 4.2.5

C.14
Answer: c
Reference: SAR 8.2

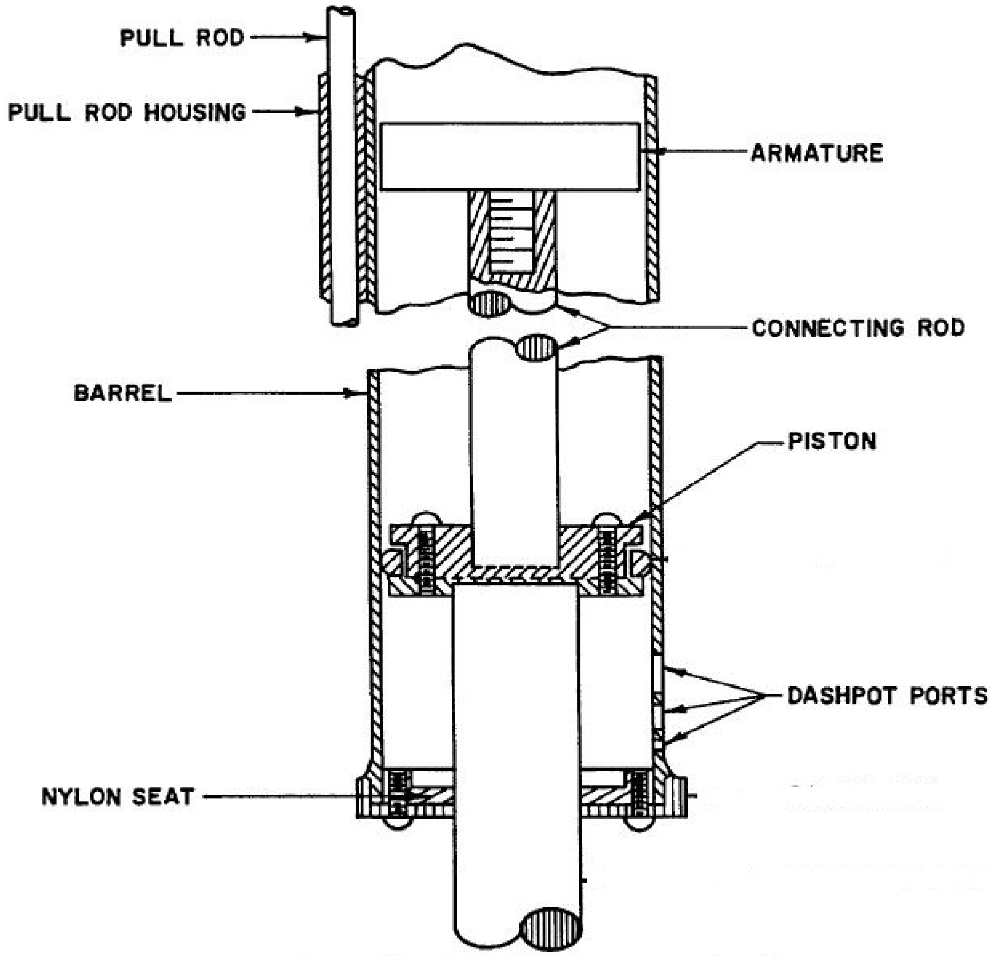
C.15
Answer: c
Reference: TS 3.2.3 (d is within a TS but it is too short)

C.16
Answer: a
Reference: SOP VI.D.3

C.17
Answer c
Reference: SAR 7.1 Summary Descriptions, Figure 7-1 and SOP III-C

C.18
Answer: a
Reference: TS 3.2.2

C.19
Answer: a(4) b(3) c(6) d(8)
Reference: SAR 7.3.1


PULL ROD
PULL ROD HOUSING
ARMATURE
CONNECTING ROD
BARREL
PISTON
DASHPOT PORTS
NYLON SEAT