

December 3, 2013

Dr. Tatjana Jevremovic, Director  
University of Utah  
Nuclear Research Reactor  
50 South Central Drive  
Salt Lake City, UT 84112

SUBJECT: EXAMINATION REPORT NO. 50-407/OL-14-01, UNIVERSITY OF UTAH

Dear Dr. Jevremovic:

During the week of November 4, 2013, the U.S. Nuclear Regulatory Commission (NRC) administered operator licensing examinations at your University of Utah TRIGA 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 at the conclusion of the examination with those members of your staff identified in the enclosed report.

In accordance with Title 10, Section 2.390 of the Code of Federal Regulations, 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 Public Electronic Reading Room). The NRC is forwarding the individual grades to you in a separate letter which will not be released publicly. If you have any questions concerning this examination, please contact Paulette Torres at (301) 415-5656 or via internet e-mail [Paulette.Torres@nrc.gov](mailto:Paulette.Torres@nrc.gov).

Sincerely,

**/RA/**

Gregory T. Bowman, Chief  
Research and Test Reactors Oversight Branch  
Division of Policy and Rulemaking  
Office of Nuclear Reactor Regulation

Docket No. 50-407

Enclosures:

1. Examination Report No. 50-407/OL-14-01
2. Facility Comments with NRC Resolution
3. Written Examination with Facility Comments Incorporated

cc w/o enclosures: See next page

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ADAMS Accession No: ML13336A274

OFFICE	NRR/DPR/PROB	NRR/DPR/PROB	NRR/DPR/PROB
NAME	Pisaac	CRevelle	GBowman
DATE	12/03/13	12/02/13	12/03/13

OFFICIAL RECORD COPY

University of Utah

Docket No. 50-407

cc:

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

REPORT NO.: 50-407/OL-14-01  
FACILITY DOCKET NO.: 50-407  
FACILITY LICENSE NO.: R-126  
FACILITY: University of Utah TRIGA Reactor  
EXAMINATION DATES: November 5 – November 7, 2013  
SUBMITTED BY: \_\_\_\_\_ Date \_\_\_\_\_  
Patrick Isaac, Chief Examiner

SUMMARY:

During the week of November 4, 2013, the NRC administered operator licensing examination to two Reactor Operator (RO) and three Senior Reactor Operator instant (SRO-I) license candidates. All the candidates passed their applicable portions of the examinations.

**REPORT DETAILS**

1. Examiners: Patrick Isaac, Chief Examiner, NRC  
Paulette Torres, Reactor Engineer, NRC

2. Results:

	<b>RO PASS/FAIL</b>	<b>SRO PASS/FAIL</b>	<b>TOTAL PASS/FAIL</b>
Written	2/0	3/0	5/0
Operating Tests	2/0	3/0	5/0
Overall	2/0	3/0	5/0

3. Exit Meeting:  
Patrick Isaac, Chief Examiner, NRC  
Paulette Torres, Reactor Engineer, NRC  
Greg Moffitt, Reactor Supervisor, Nuclear Engineering Program, University of Utah  
Jessica Engler, Nuclear Engineering Program, University of Utah

At the conclusion of the site visit, the examiner met with representative of the facility staff to discuss the comments the facility staff had on the written examination. The NRC examiners thanked the facility for their support in the administration of the examinations.

## FACILITY COMMENTS ON THE WRITTEN EXAM WITH NRC RESOLUTION

### **QUESTION: A.05d**

**COMMENT:** Question A.05 asks the candidate to explain the rod motion necessary to maintain reactor power. The answer key states that U-235 burn-up would not require rod motion, because it is insignificant in over short periods of time. However, nothing in the stem led the students to believe the question was meant to be over a short period of time, and all students selected withdraw ( 1 ), because they know that U-235 burn-up results in negative reactivity addition, that would require a positive reactivity addition from the control rods to maintain a constant power. Additionally, they had all been trained that this is U-235 burn-up is why expected critical rod position increases slowly over time.

**REFERENCE:** DOE-HDBK-1019/2-93, Page 30

**PROPOSED RESOLUTION:** We request that acceptable answer for A.05d to be both 1 (withdraw) & 3 (none) and the stem clarified to include a time frame if the question is used in the future.

**NRC RESOLUTION:** The NRC agrees with the facility comment and accepts both 1 and 3 as correct answers for A.05d.

### **QUESTION: A.09**

**COMMENT:** If this question is completed as written initially the candidate arrives at an answer of -8.6 seconds. Of which answer choice A was the correct response, and was the response to initially listed on the key. However, two students noted that this would make the reactor "prompt critical" and that a negative period would mean reactor power was decreasing, which would not align with the circumstances. Both of these candidates suggested that if the reactivity addition had been given in percent  $\Delta K/K$ , vice  $\Delta K/K$  that would yield a correct answer of 130.01 seconds, which, given the problem stem, is a feasible answer choice. The exam administrators told the candidates the "could" assume the reactivity addition was in percent  $\Delta K/K$  but to indicate this assumption on their answer sheet. All but one candidate did this, the candidate who did not, choose answer A, believing based on the Exam Administrator's Comments, that either the original answer key choice of A, or the modified choice of D would be acceptable.

**REFERENCE:** DOE-HDBK-1019/2-93, Page 15 & 16

**PROPOSED RESOLUTION:** We request that both answers A and D be allowed as correct answer choices.

**NRC RESOLUTION:** The NRC agrees with the facility comment and accepts both A and D as correct answers for A.09.

**QUESTION: B.12**

**COMMENT:** The key for B.12 was not in the proper order. This was obviously just an editorially error but is being included in the comments for completeness.

**REFERENCES:** 10CFR20

**PROPOSED RESOLUTION:** We request that key be modified to reflect the 10CFR20 dose limits.

**NRC RESOLUTION:** The staff agrees with the facility's comment. The answer key will be modified to correct the editorially error on B.12.

**QUESTION: C.07**

**COMMENT:** The question requested the candidate identify which ONE is a requirement for the UUTR experiments, but none of the answer choices were correct. The answer key stated that the correct answer was that "Experiments do not generate and Xe-135 or SM-149" this is not a restriction for our experiments, but rather a discussion of fact from the SAR. The only restrictions specifically listed in the Technical specifications pertain to corrosive material, explosive material, and reactivity worth of the experiment.

**REFERENCES:** SAR 4.5.3.8 / T.S 3.81 and 3.82

**PROPOSED RESOLUTION:** We request that question be removed from the exam as there is no correct answer.

**NRC RESOLUTION:** The staff agrees with the facility's comment. The answer key will be modified to remove question C.07 from the written examination.

**QUESTION: C.17**

**COMMENT:** The question requested the candidate identify which ONE is a special feature of the central irradiator facility. The key stated that it has a sealed interior that holds heavy water. This is not correct. The central irradiator is currently an empty hole in the center of the core filled with the coolant water. The SAR does discuss that a special apparatus with heavy water in the center could be utilized, but this would involve core alterations, and additional analysis before implementation.

**REFERENCES:** SAR 10.2.2.1

**PROPOSED RESOLUTION:** We request that question be removed from the exam as there is no correct answer.

**NRC RESOLUTION:** The staff agrees with the facility's comment. The answer key will be modified to remove the question C.17 from the written examination.

**QUESTION: C.19**

**COMMENT:** The question requested the candidate identify which ONE of the answer choices would result in a reactor scram. There are two correct answer choices to this question, C & D. The technical specification requires a scram when reactor water tank level is less than 15.5" and when power is lost to the console. Since 17" below the top of the core is a greater distance from the top of the core than 15.5" this would cause a scram.

**REFERENCES:** TS 3.2.3

**PROPOSED RESOLUTION:** We request that both answer choices C and D be counted as correct.

**NRC RESOLUTION:** The NRC agrees with the facility comment and accepts both C and D as correct answers for C.19.

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

FACILITY: University of Utah  
 REACTOR TYPE: TRIGA  
 DATE ADMINISTERED: 11/05/2013  
 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.

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

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

\_\_\_\_\_  
Candidate's Signature



A. RX THEORY, THERMO & FAC OP CHARS

- 2 -

**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 \_\_\_\_ (0.25 each)

A06 a \_\_\_\_ b \_\_\_\_ c \_\_\_\_ d \_\_\_\_ (0.25 each)

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 \*\*\*\*\*)

B. NORMAL/EMERG PROCEDURES & RAD CON

- 3 -

**A N S W E R   S H E E T**

Multiple Choice (Circle or X your choice)

If you change your Answer, write your selection in the blank.

B01 a b c d \_\_\_\_

B02 a b c d \_\_\_\_

B03 a b c d \_\_\_\_

B04 a b c d \_\_\_\_

B05 a b c d \_\_\_\_

B06 a b c d \_\_\_\_

B07 a \_\_\_\_ b \_\_\_\_ c \_\_\_\_ d \_\_\_\_ (0.5 each)

B08 a \_\_\_\_ b \_\_\_\_ c \_\_\_\_ d \_\_\_\_ (0.5 each)

B09 a b c d \_\_\_\_

B10 a b c d \_\_\_\_

B11 a b c d \_\_\_\_

B12 a \_\_\_\_ b \_\_\_\_ c \_\_\_\_ d \_\_\_\_ (0.25 each)

B13 a b c d \_\_\_\_

B14 a b c d \_\_\_\_

B15 a b c d \_\_\_\_

B16 a \_\_\_\_ b \_\_\_\_ c \_\_\_\_ d \_\_\_\_ (0.25 each)

B17 a b c d \_\_\_\_

B18 a b c d \_\_\_\_

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

C. PLANT AND RAD MONITORING SYSTEMS

- 4 -

**A N S W E R   S H E E T**

Multiple Choice (Circle or X your choice)

If you change your Answer, write your selection in the blank.

C01 a b c d \_\_\_\_

C02 a b c d \_\_\_\_

C03 a b c d \_\_\_\_

C04 a b c d \_\_\_\_

C05 a b c d \_\_\_\_

C06 a b c d \_\_\_\_

~~C07 a b c d \_\_\_\_~~ deleted per facility comment

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 \_\_\_\_~~ deleted per facility comment

C18 a b c d \_\_\_\_

C19 a b c d \_\_\_\_

C20 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

$\dot{Q} = \dot{m}c_p\Delta T = \dot{m}\Delta H = UA\Delta T$	$P_{\max} = \frac{(\beta - \rho)^2}{(2\alpha\ell)}$	$\lambda_{\text{eff}} = 0.1 \text{ sec}^{-1}$
$P = P_0 e^{t/\tau}$	$SCR = \frac{S}{-\rho} \cong \frac{S}{1 - K_{\text{eff}}}$	$\ell^* = 1 \times 10^{-4} \text{ sec}$
$SUR = 26.06 \left[ \frac{\lambda_{\text{eff}} \rho + \dot{\rho}}{\bar{\beta} - \rho} \right]$	$CR_1(1 - K_{\text{eff}_1}) = CR_2(1 - K_{\text{eff}_2})$	$CR_1(-\rho_1) = CR_2(-\rho_2)$
$P = \frac{\beta(1 - \rho)}{\beta - \rho} P_0$	$M = \frac{1}{1 - K_{\text{eff}}} = \frac{CR_2}{CR_1}$	$P = P_0 10^{SUR(t)}$
$M = \frac{1 - K_{\text{eff}_1}}{1 - K_{\text{eff}_2}}$	$SDM = \frac{1 - K_{\text{eff}}}{K_{\text{eff}}}$	$T = \frac{\ell^*}{\rho - \bar{\beta}}$
$T = \frac{\ell^*}{\rho} + \left[ \frac{\bar{\beta} - \rho}{\lambda_{\text{eff}} \rho + \dot{\rho}} \right]$	$T_{\frac{1}{2}} = \frac{0.693}{\lambda}$	$\Delta\rho = \frac{K_{\text{eff}_2} - K_{\text{eff}_1}}{K_{\text{eff}_1} K_{\text{eff}_2}}$
$\rho = \frac{K_{\text{eff}} - 1}{K_{\text{eff}}}$	$DR = DR_0 e^{-\lambda t}$	$DR_1 d_1^2 = DR_2 d_2^2$
$DR = \frac{6CiE(n)}{R^2}$	$\frac{(\rho_2 - \beta)^2}{Peak_2} = \frac{(\rho_1 - \beta)^2}{Peak_1}$	

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

**1 Curie = 3.7 x 10<sup>10</sup> dis/sec**

**1 kg = 2.21 lbm**

**1 Horsepower = 2.54 x 10<sup>3</sup> BTU/hr**

**1 Mw = 3.41 x 10<sup>6</sup> BTU/hr**

**1 BTU = 778 ft-lbf**

**°F = 9/5 °C + 32**

**1 gal (H<sub>2</sub>O) ≈ 8 lbm**

**°C = 5/9 (°F - 32)**

**c<sub>p</sub> = 1.0 BTU/hr/lbm/°F**

**c<sub>p</sub> = 1 cal/sec/gm/°C**



UNIVERSITY OF UTAH  
TRIGA REACTOR

Operator Licensing Examination

Week of November 4, 2013

**QUESTION A.01 [1.0 point]**

What will be the time necessary to shutdown a reactor if the average neutron flux goes from  $1.75 \times 10^{13}$  to  $10^3$  neutrons/cm<sup>2</sup>s? Assume a reactor period of 56 seconds.

- a. 589 sec
- b. 1321 sec
- c. 2643 sec
- d. 11642 sec

**QUESTION A.02 [1.0 point]**

Which ONE of the following is an example of alpha decay?

- a.  ${}_{35}\text{Br}^{87} - {}_{33}\text{As}^{83}$
- b.  ${}_{35}\text{Br}^{87} - {}_{35}\text{Br}^{87}$
- c.  ${}_{35}\text{Br}^{87} - {}_{34}\text{Se}^{86}$
- d.  ${}_{35}\text{Br}^{87} - {}_{36}\text{Kr}^{87}$

**QUESTION A.03 [1.0 point]**

One gram of Silicon-20 undergoes beta decay with a half-life of 6.0 hours. What amount of the original sample will remain after seven days?

- a.  $3.725\text{E}^{-09}$
- b.  $9.537\text{E}^{-07}$
- c.  $3.906\text{E}^{-03}$
- d.  $6.250\text{E}^{-02}$

**QUESTION A.04 [1.0 point]**

Which ONE is TRUE about subcritical multiplication? As the reactor approaches criticality, the parameter

- a.  $k_{\text{eff}}$  approaches zero



- b.  $\rho$  approaches infinity
- c.  $M$  approaches one
- d.  $1/M$  approaches zero

**QUESTION A.05 [1.0 point, 0.25 points each]**

As a result of the conditions below, select the appropriate rod motion to maintain reactor power constant.

- |   |             |
|---|-------------|
| a. _____Xe-135 buildup                  | a. withdraw |
| b. _____Pool water temperature increase | b. insert   |
| c. _____N-16 formation                  | c. none     |
| d. _____U-235 burnup                    |             |

**QUESTION A.06 [1.0 point, 0.25 points each]**

Match each of the terms in column A with the correct definition from column B.

- | <u>Column A</u>     | <u>Column B</u>                                      |
|---------------------|--|
| a. Fast neutrons    | 1. Neutrons released directly from fission.          |
| b. Prompt neutrons  | 2. High energy neutrons.                             |
| c. Slow neutrons    | 3. Neutrons releases from decay of fission products. |
| d. Delayed neutrons | 4. Low energy neutrons.                              |

**QUESTION A.07 [1.0 point]**

Control rods worth is affected by the following factors EXCEPT:

- a. Moderator temperature
- b. Core age
- c. Source position
- d. Adjacent rods

**QUESTION A.08 [1.0 point]**

Which ONE is true about "excess reactivity"?

- a. Ensures that the reactor can be shut down from any condition of operation
- b. Ensures that the fuel temperature safety limit will not be exceeded
- c. Is the change in reactivity caused by control rod motion
- d. Is the amount of reactivity in excess of the amount of reactivity needed to make the reactor critical

**QUESTION A.09 [1.0 point]**

The reactor is critical at 5 watts. Following a positive reactivity addition of  $0.05 \Delta K/K$ , what is the resultant reactor period?

- a. 8.6 sec
- b. 14.3 sec
- c. 90.8 sec
- d. 130.1 sec

**QUESTION A.10 [1.0 point]**

Which one of the following is the **MAJOR** source of energy released during fission?

- a. Kinetic energy of the fission neutrons.
- b. Kinetic energy of the fission fragments.
- c. Decay of the fission fragments.
- d. Prompt gamma rays.

**QUESTION A.11 [1.0 point]**

The **PRIMARY** reason that a neutron source is installed in the reactor is to:

- a. allow for testing and irradiation of experiments when the core is shutdown.
- b. supply the neutrons required to start the chain reaction for subsequent reactor startups.
- c. provide a neutron level high enough to be monitored for a controlled reactor startup.
- d. increase the excess reactivity of the reactor which reduces the frequency for refueling.

**QUESTION A.12 [1.0 point]**

When a reactor is prompt critical, the delayed neutron fraction ( $\beta_{\text{eff}}$ ) is:

- a. 0.9925
- b. 0.0075
- c. 0.0065
- d. 0

**QUESTION A.13 [1.0 point]**

For different changes to the core configuration, which one of the following increases the thermal utilization factor in the six factor formula?

- a. Increasing the moderator to fuel ratio
- b. Raising control rods
- c. Decreasing enrichment
- d. Fuel Burn up

**QUESTION A.14 [1.0 point]**

Reactor period is defined as:

- a. The time required for a reactor to change by a factor of  $e$
- b. The time required for the reactor power to double
- c. The number of factors of ten that reactor power changes in one minute
- d. The fraction of all neutrons that are born as delayed neutrons

**QUESTION A.15 [1.0 point]**

Which one of the following has the highest thermal neutron cross section?

- a. Cd-113
- b. Gd-157
- c. Xe-135
- d. Sm-149

**QUESTION A.16 [1.0 point]**

A reactor scram causes power to decrease on a -80 second period. Starting from an initial power of 100 watts, what would be the reactor power after 5 minutes?

- a.  $2 \times 10^{-5}$  watts
- b. 1.7 watts
- c. 2.35 watts
- d. 0.15 watts

**QUESTION A.17 [1.0 point]**

Which ONE of the following statements describes why the fuel element moderator contributes to a "prompt" negative Fuel Temperature Coefficient?

- a. Samarium build up causes the insertion of negative reactivity at higher fuel temperatures.
- b. As fuel temperatures increases, the thermal neutron energy distribution shifts to a higher level.
- c. As fuel temperatures increases, the thermal neutron energy distribution shifts to a lower level.
- d. As fuel temperature increases, Zirconium Hydride causes the escape probability to decrease

**QUESTION A.18 [1.0 point]**

The shutdown margin (SDM), upon full insertion of all control rods following a reactor scram from full power, is \_\_\_\_\_ the SDM immediately prior to the scram.

- a. Equal to
- b. Less than
- c. Greater than
- d. Independent of

**QUESTION A.19 [1.0 point]**

At shutdown, the only removal mechanism for Xenon-135 is by \_\_\_\_\_.

- a. Decay
- b. Fission
- c. Burnup
- d. Neutron capture

**QUESTION A.20 [1.0 point]**

In a subcritical reactor where  $k_{eff0} = 0.8$  what is the new value of  $k_{eff}$  if the count rate doubles?

- a. 0.1
- b. 0.5
- c. 0.9
- d. 1.1

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

Section B Normal, Emergency and Radiological Control Procedures  
Page 9

**QUESTION B.01 [1.0 point]**

Per T.S., which ONE of the following Reactor Control and Safety systems specifications has to be channel checked during operations?

- a. Linear Power level
- b. Manual console scram
- c. Console power supply
- d. Reactor tank water level

**QUESTION B.02 [1.0 point]**

Continuous stack monitor checks for all EXCEPT:

- a. Particulate
- b. Ar-41
- c. Iodine
- d. N-16

**QUESTION B.03 [1.0 point]**

The Excess Reactivity is calculated by:

- a. Adding the shutdown margin and worth of the shim rod and subtracting the worth of the regulating and safety rods
- b. Adding the worth of the safety rod and subtracting the shutdown margin and the worth of the shim and regulating rods
- c. Adding the worth of the shim and regulating rods and subtracting the shutdown margin
- d. Adding the shutdown margin and subtracting the worth of the shim and regulating rods

**QUESTION B.04 [1.0 point]**

At the UUTR, for stainless steel clad fuel rod located in the D-hexagonal ring, the Limiting Safety System Setting is \_\_\_\_\_.

- a. 340°C (613.15°K)
- b. 460°C (733.15°K)
- c. 680°C (953.15°K)
- d. 800°C (1073.15°K)

**QUESTION B.05 [1.0 point]**

According to the UUTR TS, the Core Excess Reactivity limit is \_\_\_\_\_.

- a. \$0.25
- b. \$1.20
- c. \$2.50
- d. \$4.00

**QUESTION B.06 [1.0 point]**

\_\_\_\_\_ are radiological dose rates; used as thresholds for initiating specific emergency measures.

- a. Emergency action levels
- b. Emergency planning zones
- c. Emergency procedures
- d. Protective action guides



**QUESTION B.07 [2.0 points, 0.5 point each]**

Identify each of the following actions as either a **CHANNEL CHECK**, **CHANNEL TEST** or a **CHANNEL CALIBRATION**.

- a. Verifying overlap between Nuclear Instrumentation channels.
- b. Replacing a Resistance Temperature Detector (RTD) with a precision resistance decade box, to verify proper channel output for a given resistance.
- c. Performing a calorimetric (heat balance) calculation on the primary system, then adjusting the Nuclear Instrumentation to agree.
- d. During reactor shutdown you verify the period meter reads -80 seconds.

**QUESTION B.08 [2.0 points, 0.5 point each]**

Match the 10CFR55 requirements for maintaining an active operator license in column A with the corresponding time period from column B.

<u>Column A</u>	<u>Column B</u>
a. Renew License	1 year
b. Medical Exam	2 years
c. Pass Requalification Written Examination	4 years
d. Pass Requalification Operating Test	6 years

**QUESTION B.09 [1.0 point]**

An ion chamber reads a radiation source as 200 R/hr. An aluminum shield is placed between the ion chamber and the radiation source. The new reading is 50 R/hr. What would be the gamma and beta doses prior the shielding?

- a. The gamma dose rate is 20 R/hr and the beta rate is 180 R/hr
- b. The gamma dose rate is 50 R/hr and the beta rate is 150 R/hr
- c. The dose rate from gammas is half of the betas
- d. Gamma and beta dose rates are the same

**QUESTION B.10 [1.0 point]**

Following an evacuation of the facility during an emergency, who by title, may authorize reentry into the reactor room (according to the Emergency Plan)?

- a. The CENTER Director
- b. The OEC, with advice from the RSO
- c. A Senior Operator, with advice from the PSR
- d. The Radiation Safety Officer

**QUESTION B.11 [1.0 point]**

The regulations that establish the procedures and criteria for the issuance of licenses to operators and senior operators of utilization facilities are found in \_\_\_\_\_.

- a. 10 CFR 50
- b. 10 CFR 52
- c. 10 CFR 54
- d. 10 CFR 55

**QUESTION B.12 [1.0 point, 0.25 each]**

Match the following Occupational Dose Limits in adults:

- |   |            |
|---|------------|
| a. Total Effective Dose Equivalent (TEDE) | 1. 0.5 rem |
| b. Extremity/skin                         | 2. 5 rem   |
| c. Eye lens                               | 3. 15 rem  |
| d. Declared Pregnant Workers              | 4. 50 rem  |

**QUESTION B.13 [1.0 point]**

In the event of a radioactive spill, which ONE of the following is the first action you are expected to take?

- a. Confine the source of contamination to keep it from spreading and contaminating people.
- b. Take the roll of polyethylene sheeting kept with the first aid supplies near the reactor room, and spread it on the floor of the control room in front of the door to the reactor room.
- c. Do not let anyone present during the emergency leave the site until they have been surveyed and found to be free of contamination.
- d. Classify the event as a Non-Reactor, Safety-Related Event.

**QUESTION B.14 [1.0 point]**

Per T.S., the absolute value of the reactivity worth of any single secured or unsecured experiment shall be less than \_\_\_\_\_, and, the sum of the absolute values of the reactivity worth of all experiments shall be less than \_\_\_\_\_.

- a. \$1.00 and \$2.00
- b. \$1.20 and \$1.80
- c. \$1.00 and \$1.20
- d. \$1.80 and \$2.00

**QUESTION B.15 [1.0 point]**

Per 10 CFR 55.53 "Conditions of Operator Licenses", which ONE of the following is a condition of your reactor operating license?

- a. Transferrable between facilities
- b. Subject to all NRC rules and regulations
- c. Subject to an annual medical examination
- d. Must be exercised for at least 8 hours per quarter

**QUESTION B.16 [1.0 point, 0.25 points each]**

Match the following safeguard events with its classification:

- | Column A   | Column B           |
|--|--------------------|
| a. Any threat made against the facility  | 1. Class I event   |
| b. Actual or attempted theft of Special Nuclear Materials  | 2. Class II event  |
| c. Safeguards system failures impacting the effectiveness of the system  | 3. Class III event |
| d. Actual or attempted acts of events which interrupt normal operations due to unauthorized use of or tampering with machinery, components or controls | 4. Class IV event  |

**QUESTION B.17 [1.0 point]**

Which one of the following describes a Radiation Area?

- a. Any area to which access is limited for any reason.
- b. Any area to which access is limited for the purpose of protecting individuals against undue risks from exposure to radiation.
- c. Any accessible area in which an individual could receive a dose equivalent exceeding 5 mrem in 1 hour at 30 cm from the source.
- d. Any accessible area in which an individual could receive a dose equivalent exceeding 100 mrem in hour at 30 cm from the source.

**QUESTION B.18 [1.0 point]**

If a gamma source measures 675 mR/hr at one foot, what will it measure at four feet?

- a. 0.024 mR/hr
- b. 42 mR/hr
- c. 2700 mR/hr
- d. 10800 mR/hr

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

**QUESTION C.01 [1.0 point]**

Which ONE of the following conditions will allow the operator to raise control rods?

- a. Scrams not reset
- b. High area radiation monitor alarm
- c. Source level below minimum count
- d. Two up switches depressed at the same time

**QUESTION C.02 [1.0 point]**

The UUTR core has a 5 Ci \_\_\_\_\_ neutron start-up source.

- a. Am-Li
- b. Am-Be
- c. Sb-Be
- d. Pu-Be

**QUESTION C.03 [1.0 point]**

Why do the UUTR maintain the reactor room at a negative pressure with respect to surroundings areas?

- a. To minimize the release of gaseous waste
- b. To prevent the generation of Argon-41
- c. To keep personnel exposures ALARA
- d. To expedite reactor cooling by natural convection

**QUESTION C.04 [1.0 point]**

Which ONE of the following channels is not linked to a safety function?

- a. Source count rate channel
- b. Linear power channel
- c. Log percent power channel

- d. Percent power channel

**QUESTION C.05 [1.0 point]**

Which ONE of the following neutron irradiation facilities has the highest neutron flux in the core?

- a. The Fast Neutron Irradiator
- b. The Pneumatic Irradiator
- c. The Thermal Irradiator
- d. The Central Irradiator

**QUESTION C.06 [1.0 point]**

Per T.S., the reactor tank water radioactivity shall be measured \_\_\_\_\_.

- a. Prior to each day's operation
- b. Monthly
- c. Semi-annually
- d. Annually

~~**QUESTION C.07 [1.0 point]**~~

~~Which ONE is a requirement for UUTR experiments?~~

- ~~a. Experiments do not generate any Xe-135 or SM-149~~
- ~~b. Experiments containing corrosive materials shall be single encapsulated~~
- ~~c. Explosive materials in quantities greater than 25 milligrams TNT equivalent may be irradiated provided the pressure produced upon detonation of the explosive has been calculated~~
- ~~d. Experiments not to exceed the fuel element temperature limit of 500 °C for a SS element and 1,000 °C for an aluminum element~~

Deleted per facility comment

**QUESTION C.08 [1.0 point]**

The purge gas for the Pneumatic Irradiator is \_\_\_\_\_.

- a. Argon
- b. CO<sub>2</sub>
- c. Helium
- d. Oxygen

**QUESTION C.09 [1.0 point]**

A conductivity alarm occurs when the conductivity of the demineralizer rises to \_\_\_\_\_.

- a. 0.1 μmhos/cm
- b. 1 μmhos/cm
- c. 4 μmhos/cm
- d. 5 μmhos/cm

**QUESTION C.10 [1.0 point]**

UUTR produces an automatic scram in response to high \_\_\_\_\_.

- a. Water conductivity
- b. ph
- c. Water temperature
- d. Fuel temperature

**QUESTION C.11 [1.0 point]**

UUTR fuel elements are located in all EXCEPT:

- a. A-ring
- b. C-ring
- c. E-ring
- d. G-ring

**QUESTION C.12 [1.0 point]**

Which ONE of the following control rod components is used to provide an indication of rod position?

- a. Steeping motor
- b. Magnet rod-coupler
- c. Rack and pinion gear system
- d. Ten-turn potentiometer

**QUESTION C.13 [1.0 point]**

Which ONE of the following is an ALARA principle for mitigating **internal** radiation hazards?

- a. Minimize time
- b. Maximize distance
- c. Use of proper shielding
- d. Control of contamination

**QUESTION C.14 [1.0 point]**

In UUTR, the Area Radiation Monitors (ARMs) display the radiation levels present at the:

- a. Reactor ceiling, reactor tank, the stack and the counting lab
- b. Reactor ceiling, reactor tank, control room and the counting lab
- c. Reactor ceiling, reactor tank, the stack and the radiochemistry lab
- d. Control room, reactor tank, the stack and the radiochemistry lab



**QUESTION C.15 [1.0 point]**

Fuel temperature must be limited in the aluminum clad, low hydride fuel elements in order to avoid fuel element failure due to which of the following mechanisms?

- a. Distortion of the fuel element due to a phase change of the zirconium hydride.
- b. Melting the aluminum cladding due to high temperature.
- c. Damage to fuel cladding due to excessive pressure from expansion of fission product gasses.
- d. Damage to fuel cladding due to excessive pressure from hydrogen produced by disassociation of the zirconium and hydrogen.

**QUESTION C.16 [1.0 point]**

Per T.S., the radiation shielding requirements of the primary coolant system are fulfilled by keeping at least \_\_\_\_\_ of water directly above the reactor core.

- a. 12 ft
- b. 15.5 ft
- c. 18 ft
- d. 20 ft

~~**QUESTION C.17 [1.0 point]**~~

~~Which ONE is a special feature associated with the Central Irradiation Facility?~~

- ~~a. Driven by the force of dry, compressed helium~~
- ~~b. Has a sealed interior that holds heavy water~~
- ~~c. Made of Grafoil, a graphite gasket material~~
- ~~d. Can be sealed to ensure no radiation hazards from Ar-41 or N-16~~

Deleted per facility comment

**QUESTION C.18 [1.0 point]**

Which ONE of the following systems is connected to a separate uninterrupted power supply (UPS) system?

- a. Continuous air monitor
- b. Primary coolant pump
- c. Control rods
- d. Pneumatic transfer system

**QUESTION C.19 [1.0 point]**

Which ONE of the following will result in a reactor scram?

- a. Reactor tank water temperature below 35 °C
- b. Fuel element temperature at 180 °C
- c. Reactor tank water level at 17 inches below the top of the UUTR tank
- d. Loss of electrical power to the reactor console

**QUESTION C.20 [1.0 point]**

On a signal requiring isolation of the reactor room the:

- a. Supply damper automatically closes, and automatically reopens when the signal clears.
- b. Supply damper automatically closes, and is opened by an operator, using a button on the control console.
- c. Supply damper automatically closes, and is manually opened using a pull cord at the damper.
- d. Supply damper is manually closed and opened at the damper.

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

**A.01**

Answer: b  
REF: Given:  $\Phi=10^3$  neutrons/cm<sup>2</sup>sec  
 $\Phi_0=1.75 \times 10^{13}$  neutrons/cm<sup>2</sup>sec  
 $T = 56$  sec  
Then:  $\Phi=\Phi_0 e^{t/T}$   
 $t=T \ln (\Phi/\Phi_0)$   
 $t=1321$  sec

**A.02**

Answer: a  
REF: Chart of the Nuclides

**A.03**

Answer: a  
REF:  $N/N_0 = e^{-\lambda t}$  where  $\lambda = \ln(2) / t_{1/2}$   
Given:  $t_{1/2} = 6.0$  hrs and  $t = 7$  days = 168 hrs  
Then  $N/N_0 = e^{-(0.693/6.0)168}$ ,  $N/N_0 = e^{-19.408}$ ,  $N/N_0 = 3.725290E^{-09}$

**A.04**

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

**A.05**

Answer: a, 1 b, 1 c, 3 d, 3 or 1 per facility comment  
REF: Burns, Chapter 7, problem 7.7.4

**A.06**

Answer: a, 2; b, 1; c, 4; d, 3  
REF: DOE Handbook part 1, module 2.

**A.07**

Answer: c  
REF: Burns, Chapter 7

**A.08**

Answer: d  
REF: TS Section 3.1.3, pg. 16 (Answer for a and b is shutdown margin)  
DOE Handbook part 2, module 3, p. 50 (Answer for c is control rod worth)

**A.09**

Answer: a or d per facility comment  
REF:  $T = (\beta - \rho) / \lambda \rho$   
 $T = (0.007 - 0.05) / (0.1)(0.05)$   
 $T = 8.6$  sec

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**A.10**

Answer: b  
REF: Burns, Chapter 3

**A.11**

Answer: c  
REF: T.S. 3.2.3, Basis

**A.12**

Answer: d  
REF: Burns, Chapter 4, Figure 4.1

**A.13**

Answer: b  
REF: Reed Training Manual, pg. 131

**A.14**

Answer: a  
REF: DOE Handbook part 2, module 4, pg. 21

**A.15**

Answer: c  
REF: Lamarsh 3<sup>rd</sup> ed., pg. 377, 387

**A.16**

Answer: c  
REF: Burns, pg.4-26  
Given  $P = P_0 e^{-t/T}$   
Then  $P = 1,00 e^{-300/80} = 2.3 \text{ MWt}$

**A.17**

Answer: b  
REF: Burn, R., *Introduction to Nuclear Reactor Operations*, © 1982, § 6.4.4

**A.18**

Answer: a  
REF: Burn, R., *Introduction to Nuclear Reactor Operations*, © 1982, § 6.2.3, p. 6-4.

**A.19**

Answer: a  
REF: DOE Handbook part 2, module 3, pg. 38

**A.20**

Answer: c

REF: DOE Handbook part 2, module 4, eq. 4-5, pg. 37

$$M = \frac{1 - \text{Keff}_0}{1 - \text{Keff}_1} = \frac{CR_1}{CR_0} \quad \text{Then} \quad \frac{1}{M} = \frac{CR_0}{2CR_0} = \frac{1 - \text{Keff}_1}{1 - \text{Keff}_0}$$

$$0.5 = \frac{1 - \text{Keff}_1}{1 - 0.8}, \text{ then } \text{Keff}_1 = 0.9$$

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**B.1**

Answer: a  
REF: TS 4.2, pg. 37-39

**B.2**

Answer: d  
REF: N-16 has too short a half-life to require environmental monitoring.  
SAR, 7.7.2, pg. 183, UNEP Procedure form CENTER-020R12 and DOO, Section 6.2.1, pg. 90

**B.3**

Answer: c  
REF: UNEP Procedure form 003R8, pg. 2, #13

**B.4**

Answer: c  
REF: TS 2.2, pg. 9

**B.5**

Answer: b  
REF: TS 3.1.3, pg. 13

**B.6**

Answer: a  
REF: EP 2.0, pg. 10-11

**B.7**

Answer: a, CHECK; b, TEST; c, CAL; d, CHECK  
REF: T.S. Definitions

**B.8**

Answer: a, 6; b, 2; c, 2; d, 1  
REF: 10 CFR 55.59

**B.9**

Answer: b  
REF: With the aluminum shield in place, with the shield in place, only gammas are measured, so the gamma dose rate is 50 R/hr. Without the shield, both gamma and beta are measured, so the beta dose rate must be  $200 \text{ R/hr} - 50 \text{ R/hr} = 150 \text{ R/hr}$ .

**B.10**

Answer: b  
REF: EP Section 3.4

**B.11**

Answer: d  
REF: 10 CFR 55

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**B.12**

Answer: a,2 b,4 c,3 d,1  
REF: 10 CFR 20.1201 and 10 CFR 20.1208

**B.13**

Answer: a  
REF: EP appendix 4, pg. 39

**B.14**

Answer: c  
REF: TS 3.8.1, pg. 30

**B.15**

Answer: b  
REF: 10 CFR 55.53

**B.16**

Answer: (a,3) (b,1) (c,4) (d,2)  
REF: UNEP Procedure form 031

**B.17**

Answer: c  
REF: Radiation Safety Policy Manual, pg. 20

**B.18**

Answer: b  
REF: Given  $DR_1(d_1)^2 = DR_2(d_2)^2$

$$\text{Then } DR_2 = \frac{DR_1}{(d_2/d_1)^2}$$

$$DR_2 = \frac{675 \text{ mR}}{(4/1)^2}$$

$$DR_2 = 42 \text{ mR/hr}$$

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**C.01**

Answer: b  
REF: SAR 3.1.2, Criterion 13, pg. 51

**C.02**

Answer: d  
REF: SAR 1.3.3 page 9

**C.03**

Answer: a  
REF: TS 3.5, pg. 26

**C.04**

Answer: c  
REF: SAR 3.1.3, Criterion 24, pg. 53

**C.05**

Answer: d  
REF: SAR 3.5, pg. 64

**C.06**

Answer: b  
REF: TS 4.3, pg. 40

~~**C.07**~~

~~Answer: a  
REF: TS 3.8 and SAR 4.5.3.8 deleted per facility comment~~

**C.08**

Answer: c  
REF: SAR 4.5.2.1, pg. 101

**C.09**

Answer: c  
REF: SAR 5.3, pg. 157

**C.10**

Answer: d  
REF: SAR 7.2.1 pg. 169

**C.11**

Answer: a  
REF: A-ring is empty and used as a central irradiator.  
SAR 4.5.1.1, pg. 99 and SAR Table 4.5-1, pg. 100



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**C.12**

Answer: d  
REF: SAR 7.3.1 pg. 175, 178

**C.13**

Answer: d  
REF: Radiation Safety Policy Manual, pg. 11 and SAR 11.1.3.2, pg. 261

**C.14**

Answer: a  
REF: SAR 7.7.1 pg. 182

**C.15**

Answer: a  
REF: TS 2.1

**C.16**

Answer: c  
REF: TS 5.2, pg. 49 and SAR 5.2, pg. 151

~~**C.17**~~

~~Answer: b  
REF: SAR 10.2.1.1, pg. 226 deleted per facility comment~~

**C.18**

Answer: a  
REF: DOO 6.3, pg. 92

**C.19**

Answer: d or c per facility comment  
REF: a, TS 5.2, pg.49  
b, c, and d, TS 3.2.3, Table 1, pg. 20

**C.20**

Answer: b  
REF: SAR 11.1.5.10, pg. 270