



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

December 13, 2021

Dr. Alan Cebula  
Nuclear Reactor Facility Manager  
Kansas State University  
112 Ward Hall  
Manhattan, KS 66506-5204

SUBJECT: EXAMINATION REPORT NO. 50-188/OL-21-01, KANSAS STATE UNIVERSITY

Dear Dr. Cebula:

During the week of September 27, 2021, the U.S. Nuclear Regulatory Commission (NRC) administered operator licensing examinations at the Kansas State University 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 you and 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. If you have any questions regarding the examination, please contact William Schuster at (301) 415-1590 or [William.Schuster@nrc.gov](mailto:William.Schuster@nrc.gov).

Sincerely,

Travis L. Tate, 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. 50-188

Enclosures:

1. Examination Report No. 50-188  
/OL-21-01
2. Written Examination

cc (w/o enclosures): See next page

cc:

Office of the Governor  
State of Kansas  
300 SW 10<sup>th</sup> Avenue, Suite 212 S  
Topeka, KS 66612-1590

Kim Steves  
Radiation Control Section  
Kansas Department of Health and Environment  
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Topeka, KS 66612-1365

Mayor of Manhattan  
City Hall  
1101 Poyntz Avenue  
Manhattan, KS 66502

Robert Seymour, Reactor Supervisor  
Kansas State University  
117 Ward Hall  
Manhattan, KS 66506

Test, Research and Training  
Reactor Newsletter  
Attention: Ms. Amber Johnson  
Department of Materials Science and Engineering  
University of Maryland  
4418 Stadium Drive  
College Park, MD 20742-2115

SUBJECT: EXAMINATION REPORT NO. 50-188/OL-21-01, KANSAS STATE UNIVERSITY  
DATED: DECEMBER 13, 2021

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**ADAMS ACCESSION No.: ML21347A833****NRR-079**

Office	NRR/DANU/UNPO/CE	NRR/DANU/UNPO/OLA	NRR/DANU/UNPO/BC
Name	WSchuster	ZTaru	TTate
Date	10/08/2021	12/09/2021	12/13/2021

**OFFICIAL RECORD COPY**

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

REPORT NO.: 50-188/OL-21-01

FACILITY DOCKET NO.: 50-188

FACILITY LICENSE NO.: R-88

FACILITY: Kansas State University

EXAMINATION DATES: September 27-30, 2021

SUBMITTED BY: William C Schuster IV 10/07/2021  
William C Schuster IV, Chief Examiner Date

**SUMMARY:**

During the week of September 27, 2021, the NRC administered operator licensing examinations to one Senior Reactor Operator (SRO) and three Reactor Operators (RO). One SRO and two RO candidates passed all applicable portions of the examinations. One RO candidate failed the written examination.

**REPORT DETAILS**

1. Examiners: William C Schuster IV, 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:  
William C Schuster IV, Chief Examiner, NRC  
Tuan Le, Reactor Engineer, NRC  
Alan Cebula, Nuclear Reactor Manager, KSU  
Robert Seymour, Nuclear Reactor Supervisor, KSU

Prior to administration of the written examination, based on facility comments, adjustments were accepted. Comments provided corrections and additional clarity to questions/answers and identified where changes were appropriate based on current facility conditions and documents. Upon completion of all operator licensing examinations, the NRC examiners met with facility staff representatives to discuss the results. At the conclusion of the meeting, the NRC examiners thanked the facility for their support in the administration of the examination.

ENCLOSURE 1



Kansas State University

Operator Licensing Examination

Week of September 27, 2021

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

FACILITY: Kansas State University

REACTOR TYPE: TRIGA

DATE ADMINISTERED: 09/28/2021

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>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

Category A: Reactor Theory, Thermodynamics, and Facility Operating Characteristics

**ANSWER SHEET**

Multiple Choice (Circle or X your choice)

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

A01 a b c d \_\_\_\_

A02 a b c d \_\_\_\_

A03 a b c d \_\_\_\_

A04 a b c d \_\_\_\_

A05 a b c d \_\_\_\_

A06 a b c d \_\_\_\_

A07 a b c d \_\_\_\_

A08 a b c d \_\_\_\_

A09 a b c d \_\_\_\_

A10 a b c d \_\_\_\_

A11 a b c d \_\_\_\_

A12 a b c d \_\_\_\_

A13 a b c d \_\_\_\_

A14 a b c d \_\_\_\_

A15 a b c d \_\_\_\_

A16 a b c d \_\_\_\_

A17 a b c d \_\_\_\_

A18 a b c d \_\_\_\_

A19 a \_\_\_\_ b \_\_\_\_ c \_\_\_\_ d \_\_\_\_

A20 a b c d \_\_\_\_

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

Category B: Normal/Emergency Procedures and Radiological Controls

**A N S W E R   S H E E T**

Multiple Choice (Circle or X your choice)

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

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

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

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

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

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

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

B07 a b c d \_\_\_\_

B08 a b c d \_\_\_\_

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

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

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

B12 a \_\_\_\_ b \_\_\_\_ c \_\_\_\_ d \_\_\_\_

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

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

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

B16 a b c d \_\_\_\_

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

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

B19 a b c d \_\_\_\_

B20 a b c d \_\_\_\_

(\*\*\*\*\* END OF 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 \_\_\_\_

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 \_\_\_\_

C12 a b c d \_\_\_\_

C13 a b c d \_\_\_\_

C14 a b c d \_\_\_\_

C15 a b c d \_\_\_\_

C16 a b c d \_\_\_\_

C17 a \_\_\_\_ b \_\_\_\_ c \_\_\_\_ d \_\_\_\_

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

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

C20 a b c d \_\_\_\_

(\*\*\*\*\* END OF 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

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

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

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

$$P = P_0 e^{\ell/\tau}$$

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

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

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

$$CR_1(1 - K_{\text{eff}_1}) = CR_2(1 - K_{\text{eff}_2}) \quad CR_1(-\rho_1) = CR_2(-\rho_2)$$

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

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

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

$$M = \frac{1 - K_{\text{eff}_1}}{1 - K_{\text{eff}_2}}$$

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

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

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

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

$$\Delta\rho = \frac{K_{\text{eff}_2} - K_{\text{eff}_1}}{K_{\text{eff}_1} K_{\text{eff}_2}}$$

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

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

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

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

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

$$DR_0 e^{-\mu x}$$

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

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

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

**1 BTU = 778 ft-lbf**

**1 gal (H<sub>2</sub>O) ≈ 8 lbm**

**c<sub>p</sub> = 1.0 BTU/lbm°F**

**1ft = 30.48 cm**

**1 kg = 2.21 lbm**

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

**°F = 9/5 °C + 32**

**°C = 5/9 (°F - 32)**

**c<sub>p</sub> = 1 cal/g°C**

Category A: Reactor Theory, Thermodynamics, and Facility Operating Characteristics

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

Of all the energy released per fission event, the largest amount appears in the form of:

- a. Kinetic energy of prompt and delayed neutrons
- b. Kinetic energy of fission fragments
- c. Alpha and beta radiation
- d. Gamma radiation

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

If a source strength is 10,000 neutrons per second (N/sec) and it produces the stable neutron count rate of 50,000 N/sec. What is the neutron multiplication factor?

- a. 0.70
- b. 0.75
- c. 0.80
- d. 0.85

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

Which ONE of the following is the major source of heat generation after an operating reactor has been shut down and cooled down for several days?

- a. Corrosion product activation
- b. Delayed neutron reactions
- c. Fission fragment decay
- d. Resonance capture

Category A: Reactor Theory, Thermodynamics, and Facility Operating Characteristics

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

Which ONE of the following is the primary mechanism for transferring heat through the cladding of a fuel rod?

- a. Conduction
- b. Convection
- c. Radiation
- d. Mass Transfer

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

The reaction  ${}_{93}\text{Np}^{239} \rightarrow \text{_____} + {}_{94}\text{Pu}^{239}$  is an example of:

- a. Gamma Emission
- b. Electron Capture
- c. Alpha Decay
- d. Beta Decay

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

What is the effect of delayed neutrons on the neutron flux decay following a scram from full power?

- a. Adds positive reactivity due to the fuel temperature decrease following the scram
- b. Limits the final rate at which power decreases to a -80 second period
- c. Adds negative reactivity creating a greater shutdown margin
- d. Decreases the mean neutron lifetime

Category A: Reactor Theory, Thermodynamics, and Facility Operating Characteristics

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

Reactor is at 100 W. The reactor operator inserts an experiment of \$0.50 reactivity worth into the core. This insertion will cause:

Given:

T: reactor period,  $\ell^*$ : Prompt neutron lifetime;  $\rho$ : reactivity insertion;  $\beta$ : beta fraction;

$\lambda_{\text{eff}}$ : delayed neutron precursor constant

- a. A number of prompt neutrons is twice as much as a number of delayed neutrons
- b. The resultant period is a function of the delayed neutron precursors  $T = \left[ \frac{\beta - \rho}{(\lambda_{\text{eff}})(\rho)} \right]$
- c. The resultant period is a function of the prompt neutron lifetime ( $T = \ell^* / \rho$ )
- d. A sudden drop in delayed neutrons

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

Which ONE of the following most accurately describes the reason that fission products such as Xenon-135 and Samarium-149 have the most substantial impact in reactor design and operation?

- a. Xenon-135 and Samarium-149 cause excess positive reactivity in the core
- b. Xenon-135 and Samarium-149 burn up causes an increase in the thermal flux
- c. Xenon-135 and Samarium-149 have large absorption cross sections resulting in a large removal of neutrons from the reactor
- d. Xenon-135 and Samarium-149 produce fast fission neutrons, resulting in the net increase in the fast neutron population of the reactor core

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

If beta ( $\beta$ ) for U-235 is 0.0065 and beta effective ( $\beta_{\text{eff}}$ ) for U-235 is approximately 0.0070, how does this difference affect reactor period in the reactor period equation,  $T = (\beta - \rho) / \lambda \rho$ ? This difference produces a \_\_\_\_\_ for a given addition of reactivity with beta effective ( $\beta_{\text{eff}}$ ).

- a. Longer period
- b. Shorter period
- c. Stable period
- d. Decay constant ( $\lambda$ ) increase

Category A: Reactor Theory, Thermodynamics, and Facility Operating Characteristics

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

Which ONE of the following is defined as the balance between the rate of production of fast neutrons from thermal fission and rate of absorption of thermal neutrons by the fuel?

- a. Utilization Factor
- b. Reproduction Factor
- c. Infinite Multiplication Factor
- d. Effective Multiplication Factor

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

Energy Yield ( $\Delta Q$ ) from a nuclear fission reaction is in the range of (or is approximately):

- a. 1000 MeV
- b. 200 MeV
- c. 1.86 keV
- d. < 1 eV

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

A reactor is subcritical if:

- a.  $\rho = 1.0$
- b.  $K_{\infty} = 1.0$ ,  $\rho = \beta$
- c.  $K_{\text{eff}} < 1.0$  or  $\rho < 0.0$
- d.  $K_{\text{eff}} > 1.0$  or  $\rho > 0.0$

Category A: Reactor Theory, Thermodynamics, and Facility Operating Characteristics

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

What is the meaning of any point on a differential rod worth curve?

- a. The negative reactivity added as the rod is inserted
- b. The cumulative area under the differential curve starting from the bottom of the core
- c. The zero reactivity when the rod is on the bottom and the positive reactivity being added as the rod is withdrawn
- d. The amount of reactivity that one unit (e.g. one inch, one percent) of rod motion would insert at that position in the core

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

Which ONE of the following changes does not require a movement of control rods in order to maintain constant reactor power?

- a. Pool water temperature decrease
- b. U-235 burnup
- c. Xe-135 buildup
- d. N-16 formation

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

The effective multiplication factor ( $K_{\text{eff}}$ ) can be determined by dividing the number of neutrons produced from fission in the third generation by the number of neutrons produced from fission in the \_\_\_\_\_ generation.

- a. First
- b. Second
- c. Third
- d. Fourth



Category A: Reactor Theory, Thermodynamics, and Facility Operating Characteristics

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

A reactor is subcritical with the following values for each of the factors in the six-factor formula:

Fast Fission Factor = 1.03

Fast non-leakage probability = 0.84

Resonance Escape Probability = 0.96

Thermal non-leakage probability = 0.88

Thermal Utilization Factor = 0.68

Reproduction Factor = 1.96

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

- a. 0.695
- b. 0.698
- c. 0.702
- d. 0.704

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

Delayed neutrons contribute more to reactor stability than prompt neutrons because they \_\_\_\_\_ the average neutron generation time and are born at a \_\_\_\_\_ kinetic energy.

- a. Decrease, lower
- b. Increase, lower
- c. Decrease, higher
- d. Increase, higher

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

Which ONE of the following answers provides the number of protons, the number of neutrons, and the number of electrons in the Uranium-235 atom ( ${}_{92}\text{U}^{235}$ )?

- a. 92; 92; 143
- b. 143; 92; 143
- c. 92; 143; 92
- d. 143; 143; 92

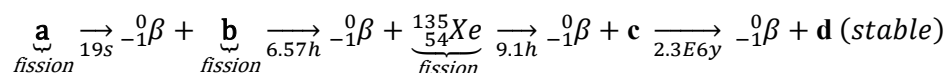
Category A: Reactor Theory, Thermodynamics, and Facility Operating Characteristics

**QUESTION A.19 [1.0 point, 0.25 each]**

Match the items in Column A with the isotopes in Column B.

The most important fission product poison is  $^{135}\text{Xe}$ . The process that shows how this isotope is formed and its decay is:

**Column A**



**Column B**

1.  ${}^{135}_{56}\text{Ba}$

2.  ${}^{135}_{52}\text{Te}$

3.  ${}^{135}_{53}\text{I}$

4.  ${}^{135}_{55}\text{Cs}$

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

Reactivity is defined as the:

- a. Fractional change in neutron population per generation
- b. Number of neutrons by which neutron population changes per generation
- c. Rate of change of reactor power measured in neutron per second
- d. Change in the number of neutrons per second that causes a fission event

(\*\*\*\*\* End of Category A \*\*\*\*\*)

Category B: Normal and Emergency Operating Procedures and Radiological Controls

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

According to the Technical Specifications, which ONE of the following statements describes a limiting condition for operation imposed on experiments?

- a. The reactivity effects associated with the moderator temperature is to be considered.
- b. The absolute reactivity worth of all experiments in the reactor shall not exceed \$2.00.
- c. No experiment shall be inserted or removed unless all control blades are fully inserted.
- d. An experiment which will not cause a 20-second period can be inserted in the core when the reactor is at power.

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

In an emergency, 10 CFR 50.54 allows reasonable action that departs from a license condition or a technical specification when this action is immediately needed to protect the public health and safety. In this case, what is the minimum level of authorization or approval needed to depart from a license condition or technical specification?

- a. Senior Reactor Operator
- b. Reactor Supervisor
- c. Manager, KSU Nuclear Reactor Facility
- d. President, KSU

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

The radiation dose limits for an individual member of the public, received as a result of facility operations, are provided in \_\_\_\_\_.

- a. 10 CFR 20
- b. 10 CFR 50
- c. 10 CFR 55
- d. 10 CFR 70

Category B: Normal and Emergency Operating Procedures and Radiological Controls

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

According to the Technical Specifications, which ONE condition below is NOT permissible when the reactor is operating?

- a. Fuel temperature = 200 °C
- b. Pool water conductivity = 2 micromho/cm
- c. Primary water temperature = 40 °C
- d. Maximum available reactivity (excess reactivity) above cold, clean condition = \$4.50

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

According to the Technical Specifications, KSU Nuclear Reactor Safety Limit for steady state fuel temperature is \_\_\_\_\_ °C.

- a. 600
- b. 650
- c. 700
- d. 750

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

According to the emergency plan, which ONE of following events is NOT an event that would be considered an unusual event or alert?

- a. Fire within the reactor facility that causes loss of surveillance capabilities lasting longer than 15 minutes
- b. Tornado that causes structural damage to the KSU Reactor Facility
- c. Fire that causes damage to safety-related reactor components lasting longer than 15 minutes
- d. Medical incident occurs from a laboratory accident involving radioactive contamination accompanied by bodily injury with no other associated facility event

Category B: Normal and Emergency Operating Procedures and Radiological Controls

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

According to the radiation protection program, the Reactor Supervisor reviews personnel doses monthly. If the KSU personnel doses exceed \_\_\_\_\_, causes and circumstances shall be investigated and reported to the Nuclear Reactor Facility Manager.

- a.  $\frac{1}{4}$  ALARA goal (annual)
- b.  $\frac{1}{2}$  ALARA goal (annual)
- c.  $\frac{1}{4}$  10CFR20 annual limit
- d.  $\frac{1}{2}$  10CFR20 annual limit

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

According to the emergency plan, which ONE of the following actual or projected radiological effluent releases (as calculated or measured at the site boundary) results in a committed effective dose equivalent of 75 mrem (based on a 24-hour exposure) and requires the declaration of an ALERT?

- a. 50 times the Effluent Concentrations for radionuclides other than noble gases
- b. 100 times the Effluent Concentrations for noble gases (argon, xenon, krypton)
- c. 100 times the Effluent Concentrations for radionuclides other than noble gases
- d. 250 times the Effluent Concentrations for noble gases (argon, xenon, krypton)

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

According to the radiation protection program, which ONE of the following periodic surveillance activities is NOT performed annually?

- a. Special Nuclear Material inventory reporting
- b. Calibration of the AMS II air monitor
- c. Calibration of the pool surface monitor
- d. Wipe test reactor bay and control room

Category B: Normal and Emergency Operating Procedures and Radiological Controls

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

There has been a confirmed breach of cladding for multiple fuel elements. According to the KSU Emergency Plan, this event would be classified as a(n):

- a. Non-Classified Event
- b. Medical Incident
- c. Unusual Event
- d. Alert

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

According to Procedure No. 24, "Sump Water Discharge System," the PRINCIPAL radionuclide typically discharged to sewerage from the K-State reactor to sanitary sewerage is \_\_\_\_\_.

- a. Argon-41
- b. Nitrogen-16
- c. Carbon-14
- d. Hydrogen-3

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

Match the channel in Column A with the number in Column B.

What are the MINIMUM number of measuring channels required to be OPERATING during reactor STEADY STATE MODE operations?

(Answers may be used once, more than once, or not at all)

<u>Column A</u>	<u>Column B</u>
a. Reactor Power Level	1. 1
b. Primary Pool Water Temperature	2. 2
c. Fuel Temperature	3. 3
d. Continuous Air Radiation Monitor	

Category B: Normal and Emergency Operating Procedures and Radiological Controls

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

The KSU requalification program must be conducted for a continuous period not to exceed 24 months in duration, in accordance with \_\_\_\_\_.

- a. 10 CFR 19
- b. 10 CFR 20
- c. 10 CFR 50
- d. 10 CFR 55

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

The reactor is shutdown with the pulse rod stuck all the way out. Calculate the amount of reactivity by which the reactor is shutdown with a stuck pulse rod.

Assume the following values: Shim Rod Worth = \$2.95; Regulating Rod Worth = \$2.75; Pulse Rod Worth = \$2.25; Excess reactivity = \$2.00.

- a. \$0.25
- b. \$2.00
- c. \$3.70
- d. \$5.70

**QUESTION B.15 [1.0 point, 0.25 each]**

Match the item in Column A with the value in Column B.

According to the NRC regulations, what are the annual occupational dose limits?  
(Answers may be used once, more than once, or not at all)

- |   |             |
|---|-------------|
| a. Total Effective Dose Equivalent (Whole Body)                                     | 1. 50.0 rem |
| b. Sum of Deep Dose Equivalent and Committed Dose Equivalent to any organ or tissue | 2. 15.0 rem |
| c. Lens Dose Equivalent to the lens of the eye                                      | 3. 5.0 rem  |
| d. Shallow Dose Equivalent to the skin  | 4. 0.5 rem  |

Category B: Normal and Emergency Operating Procedures and Radiological Controls

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

An alpha particle assay of the primary coolant is to be performed. According to Procedure No. 21, "Alpha Particle Assay of Reactor," the purpose of this assay is to \_\_\_\_\_ to assure compliance with limits for alpha-particle activity in effluents to the sanitary sewer.

- a. detect the level of nitrogen-16
- b. detect the level of sodium-24
- c. detect the levels of cobalt-60
- d. detect the levels of americium-241 and plutonium-239

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

According to Procedure No. 15, "Steady State Operation," which ONE of the following conditions is NOT allowed when switching to automatic (AUTO) mode?

- a. Reactor period is 20 seconds
- b. Regulating rod at 500 units
- c. Primary water temperature is 42 °C.
- d. Licensed Reactor Operator at the controls and Licensed Senior Reactor Operator on call

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

According to the emergency plan, which ONE of the following is defined as the OPERATIONS BOUNDARY?

- a. Room 110 (Reactor Bay)
- b. Room 109 (Control Room) and Room 110 (Reactor Bay)
- c. Ward Hall and adjacent fenced area
- d. KSU Manhattan Campus



Category B: Normal and Emergency Operating Procedures and Radiological Controls

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

According to the Technical Specifications, the fuel elements or fueled devices in storage are maintained in an array with a  $k_{\text{eff}}$  of less than:

- a. 0.75
- b. 0.8
- c. 0.85
- d. 0.9

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

According to the Technical Specifications, which ONE of the following is the MINIMUM staffing required during the fuel movement?

- a. Reactor Operator at reactor control console, Senior Reactor Operator on call
- b. Reactor Operator at reactor control console, Reactor Operator in the reactor bay, Reactor Supervisor on call
- c. Reactor Operator at reactor control console, Reactor Supervisor in the reactor bay
- d. Reactor Operator at reactor control console, Senior Reactor Operator in the reactor bay, Reactor Supervisor on call

(\*\*\*\*\* End of Category B \*\*\*\*\*)

## Category C: Facility and Radiation Monitoring Systems

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

According to the Technical Specifications, which ONE of the following safety system functions is required to be operable during both steady state mode and pulse mode operations?

- a. Manual scram bar
- b. Pulse rod interlock
- c. Reactor power level scram
- d. Control rod (standard) position interlock

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

According to Procedure No. 12, "Instrument Checkout," which ONE of the following criteria are not considered to be one of the acceptance criteria or exit conditions for the procedure?

- a. The primary coolant system is operable
- b. A reactor operator must review and approve the checks performed in the procedure by verifying that all Technical Specification requirements have been met
- c. A senior reactor operator must review and approve the checks performed in the procedure by verifying that all Technical Specification requirements have been met
- d. A control rod drive not capable of being driven through its full range of travel, without experiencing drifting or dropping, SHALL remain fully inserted

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

The transient rod is located in \_\_\_\_\_ of the reactor core.

- a. B ring
- b. C ring
- c. D ring
- d. E ring

Category C: Facility and Radiation Monitoring Systems

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

The Geiger-Mueller detector in the primary coolant cleanup loop is primarily intended to detect the presence of \_\_\_\_\_ in the primary water.

- a. Sodium-24
- b. Nitrogen-16
- c. Hydrogen-3
- d. Fission products

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

In the event of a loss of power, which ONE of the following systems WILL NOT be powered from the emergency battery backup?

- a. Security system
- b. Reactor instruments and control system
- c. University fire alarm system
- d. Evacuation alarm

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

According to the KSU safety analysis report, the rod withdraw interlock PREVENTS rod withdrawal when indicated neutron flux is \_\_\_\_\_.

- a. < 5 cps
- b. < 3 cps
- c. < 2 cps
- d. < 1 cps

## Category C: Facility and Radiation Monitoring Systems

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

According to KSU Procedure No. 11, "Reactor Start-Up with Period SCRAM Bypassed," the reactor shall not be operated in STEADY-STATE MODE with a predicted period of less than \_\_\_\_\_. According to the safety analysis report, the reactor period scram has a normal setpoint of \_\_\_\_\_.

- a. 3 seconds; 9 seconds
- b. 3 seconds; 5 seconds
- c. 1 seconds; 7 seconds
- d. 1 seconds; 3 seconds

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

The primary coolant clean up system contains a filter assembly with two replaceable cartridges. Pressure gauges are supplied on either side of the filter assembly. The MAIN purpose of these pressure gauges are to measure the pressure drop across the filter to provide indication of:

- a. potential for damage to the ion exchanger resin bed
- b. potential for channeling of the ion exchanger resin bed
- c. potential indication that the filters are clogged
- d. potential indication that the filters are leaking

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

Which ONE of the following systems is used at KSU to minimize the loss of water in the primary tank in the event of a rupture in the primary piping?

- a. Skimmer
- b. Primary Makeup Water system
- c. Siphon break
- d. Diffuser system

Category C: Facility and Radiation Monitoring Systems

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

The regulating rod is used to make smaller changes to reactor power. The primary neutron absorbing material in the regulating rod is \_\_\_\_\_.

- a. Aluminum
- b. Boron-Carbide or Borated Graphite
- c. Cadmium
- d. Hafnium

**QUESTION C.11 [1.0 point, 0.33 points each]**

Match the interlock in Column A with the description in Column B.

**Column A**

- a. 1-kW Pulse Interlock
- b. Pulse Rod Interlock
- c. Control Rod (STANDARD)  
Position Interlock

**Column B**

- 1. Prevent air from being applied to the pulse rod if the pulse rod shock absorber is above the full down position in STEADY STATE MODE.
- 2. Prevent pulses from being fired if the reactor power is above 1 kW in PULSE MODE
- 3. Prevent standard control rods being withdrawn, with the exception of the pulse rod, in PULSE MODE

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

According to Technical Specifications, CONTROL ROD (STANDARD) drop times SHALL be measured to have a drop time from fully withdrawn position of less than \_\_\_\_\_ and are measured \_\_\_\_\_.

- a. 0.5 second; Semiannually
- b. 0.5 second; Annually
- c. 1 second; Semiannually
- d. 1 second; Annually

Category C: Facility and Radiation Monitoring Systems

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

According to the safety analysis report, what is the alarm set point for the radiation monitor stationed at the control room door in the reactor bay?

- a. 100 mR/hr
- b. 10 mR/hr
- c. 5.0 mR/hr
- d. 2.5 mR/hr

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

The reactor operating is at 200 kW and the water temperature at the exit of the reactor pool is reading 135 °F. According to the technical specifications, which ONE of the following actions are NOT one of the required actions to be performed IMMEDIATELY?

- a. Ensure the reactor is SHUTDOWN
- b. Secure flow through the demineralizer
- c. Monitor water conductivity to ensure it has not exceeded 5 µmho/cm
- d. Reduce water temperature to less than 130 °F

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

According to technical specifications, the reactor must be capable of being made subcritical by a SHUTDOWN MARGIN of at least \_\_\_\_\_ under REFERENCE CORE CONDITIONS and is determined \_\_\_\_\_.

- a. \$0.25; Semiannually
- b. \$0.25; Biennially
- c. \$0.50; Semiannually
- d. \$0.50; Biennially

Category C: Facility and Radiation Monitoring Systems

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

The \_\_\_\_\_ neutron startup source utilizes a \_\_\_\_\_ reaction.

- a. Am-Be; ( $\alpha, \eta$ )
- b. Am-Be; ( $\gamma, \eta$ )
- c. Am-Li; ( $\alpha, \eta$ )
- d. Am-Li; ( $\gamma, \eta$ )

**QUESTION C.17 [1.0 point, 0.25 points each]**

Match the design function in Column A with the instrumentation and control system in Column B. (Answers may be used once, more than once, or not at all)

**Column A**

- a. Automatically insert the control rods into the reactor core when parameters deviate from limited safety system settings
- b. Personnel protective measures and emergency assessment actions
- c. Provide the reactor operator with reactor status information
- d. Govern the manner in which reactivity is varied in the reactor core

**Column B**

- 1. Reactor Control System
- 2. Reactor Protection System
- 3. Radiation Monitoring Instruments

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

According to the Technical Specifications, the standard fuel element shall be a TRIGA fuel element. The standard fuel element shall contain:

- a. Uranium-Zirconium Hydride ( $\text{UZrH}_x$ ), with a maximum of 9.0 weight percent uranium enriched to less than 20% U-235. There shall be 1.55 to 1.80 hydrogen atoms to 1.0 zirconium atoms.
- b. Uranium-Zirconium Hydride ( $\text{UZrH}_x$ ), with a maximum of 9.0 weight percent uranium enriched to less than 20% U-235. There shall be 1.65 to 1.85 hydrogen atoms to 1.0 zirconium atoms.
- c. Uranium-Zirconium Hydride ( $\text{UZrH}_x$ ), with a maximum of 8.5 weight percent uranium enriched to less than 20% U-235. There shall be 1.55 to 1.80 hydrogen atoms to 1.0 zirconium atoms.
- d. Uranium-Zirconium Hydride ( $\text{UZrH}_x$ ), with a maximum of 8.5 weight percent uranium enriched to less than 20% U-235. There shall be 1.65 to 1.85 hydrogen atoms to 1.0 zirconium atoms.

Category C: Facility and Radiation Monitoring Systems

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

Which ONE of the following best describes how the Uncompensated Ion Chamber (UCIC) is constructed?

- a. The UCIC has two chambers, one is coated with U-235 for fission reaction and the other is coated with Boron-10 for (n,a) reaction
- b. The UCIC has only one chamber coated with U-235 for fission reaction
- c. The UCIC has two chambers, both can sense gamma rays but only one is coated with Boron-10 for (n,a) reaction
- d. The UCIC has only one chamber coated with Boron-10 for (n,a) reaction

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

The water of cooling systems return line to the reactor pool enters the pool through a diffuser that induces a helical flow pattern in the reactor tank. Which ONE of the following statements is the PRIMARY purpose for this design?

- a. To decrease the activation rate of oxygen-16 to nitrogen-16 due to a decrease in time within the core
- b. To break up oxygen-16 bubbles in the pool thereby decreasing the production of nitrogen-16
- c. To increase the transport time for nitrogen-16 to reach the surface of the pool.
- d. To increase the heat transfer rate due to increased convective flow

(\*\*\*\*\* End of Category C \*\*\*\*\*)  
(\*\*\*\*\* End of the Exam \*\*\*\*\*)



## Category A: Reactor Theory, Thermodynamics, and Facility Operating Characteristics

### **A.01**

Answer: b

Reference: Glasstone, Nuclear Reactor Engineering, Section 1.47

### **A.02**

Answer: c

Reference:  $CR = S/(1-K) \rightarrow 50000 = 10000/(1 - K) = 1 - X = 10000/50000$   
 $K = 0.8$

### **A.03**

Answer: c

Reference: DOE Fundamentals Handbook, NP-03, pg. 34

### **A.04**

Answer: a

Reference: Lamarsh 3<sup>rd</sup>, Section 8.3, pg. 417

### **A.05**

Answer: d

Reference: DOE Fundamentals Handbook, NP-01, pg. 24

### **A.06**

Answer: b

Reference: Burns, Section 4.10.12, pg. 4-32 to 4-33

### **A.07**

Answer: b

Reference: Burn, Section 4.6, pg. 4-17

### **A.08**

Answer: c

Reference: DOE Fundamentals Handbook, NP-03, pg. 34

### **A.09**

Answer: a

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

### **A.10**

Answer: b

Reference: DOE Fundamentals Handbook, NP-03, pg. 6

## Category A: Reactor Theory, Thermodynamics, and Facility Operating Characteristics

### **A.11**

Answer: b

Reference: Lamarsh 3<sup>rd</sup>, Table 3.6, pg. 88

### **A.12**

Answer: c

Reference: Burns, Table 3.5, pg. 3-22

### **A.13**

Answer: d

Reference: Burns, Example 7.2 (b), pg. 7-4

### **A.14**

Answer: d

Reference: Burns, Problem 7.7.4, pg. 7-17

### **A.15**

Answer: b

Reference: Burns, Section 3.3.1, pg. 3-16

### **A.16**

Answer: b

Reference: Burns, Section 3.3.1, pg. 3-16

### **A.17**

Answer: b

Reference: Burns, Section 3.2.4, pg. 3-12 and Section 3.4.4, pg. 3-33

### **A.18**

Answer: c

Reference: Nuclides and Isotopes  
92 protons, 143 neutrons, 92 electrons

### **A.19**

Answer: a. 2; b. 3; c. 4; d. 1

Reference: Lamarsh 3<sup>rd</sup> ed., Section 7.5, pg. 377  
Burns, Figure 8.1, pg. 8-6

### **A.20**

Answer: a

Reference: Burns, Section 1.3.1, pg. 1-5

## Category B: Normal and Emergency Operating Procedures and Radiological Controls

### **B.01**

Answer: b

Reference: KSU Technical Specifications, Section 3.6, page TS-22.

### **B.02**

Answer: a

Reference: 10 CFR 50.54(y)

### **B.03**

Answer: a

Reference: 10 CFR 20

### **B.04**

Answer: d

Reference: KSU Technical Specifications, Section 3.1, page TS-11.

### **B.05**

Answer: d

Reference: KSU Technical Specifications, Section 2.1, page TS-8.

### **B.06**

Answer: d

Reference: KSU Emergency Plan and Procedures, Sections 4-8, pages 21-32.

### **B.07**

Answer: b

Reference: KSU Radiation Protection Program, Section 8.1, page 17.

### **B.08**

Answer: d

Reference: KSU Emergency Plans and Procedures, Section 8.2, page 31.

### **B.09**

Answer: d

Reference: KSU Radiation Protection Program, Section 4, page 5.

### **B.10**

Answer: d

Reference: KSU Emergency Plans and Procedures, Section 7.2.

Category B: Normal and Emergency Operating Procedures and Radiological Controls

**B.11**

Answer: d

Reference: KSU Procedure No. 24, Sump Water Discharge System, page 2

**B.12**

Answer: a. 2; b. 1; c. 1; d. 1

Reference: KSU Technical Specification, Section 3.3, Table 1, page TS-14  
KSU Procedure No. 15 – Steady State Operation, Table 1

**B.13**

Answer: d

Reference: 10 CFR 55.59(a)(1)

**B.14**

Answer: c

Reference: Shim rod + Reg rod = \$5.70. Excess reactivity - \$5.70 = -\$3.70

**B.15**

Answer: a. 3; b. 1; c. 2; d. 1

Reference: 10 CFR 20.1201

**B.16**

Answer: d

Reference: KSU Procedure No. 21 – Alpha Particle Assay of Reactor Liquids, page 2

**B.17**

Answer: a

Reference: KSU Procedure No. 15 – Steady State Operation, pages 1-2

**B.18**

Answer: b

Reference: KSU Emergency Plan, Section 1.5.2, page 9

**B.19**

Answer: b

Reference: KSU Technical Specifications, Section 5.2.3(2), page TS-39

**B.20**

Answer: d

Reference: KSU Technical Specifications, Section 6.1(c), page TS-44

## Category C: Facility and Radiation Monitoring Systems

### **C.01**

Answer: a

Reference: KSU Technical Specifications, Section 3.4.3, Table 2

### **C.02**

Answer: b

Reference: KSU Procedure No. 12 – Instrument Checkout, page 10

### **C.03**

Answer: b

Reference: KSU SAR 4.2.1.c, Figure 4.4, pg. 4-7

### **C.04**

Answer: d

Reference: KSU SAR Section 5.4; KSU Reactor Training Manual, page 13

### **C.05**

Answer: b

Reference: KSU SAR, Chapters 8.1 and 8.2, page 8-2

### **C.06**

Answer: c

Reference: KSU SAR 7.3.1, page 7-9

### **C.07**

Answer: d

Reference: KSU Procedure No. 11 – Reactor Start-Up with Period SCRAM Bypassed, page 1; KSU SAR, Chapter 7.3.1, page 7-9

### **C.08**

Answer: c

Reference: KSU SAR 5.4 , pages 5-8 and 5-9

### **C.09**

Answer: c

Reference: KSU SAR 5.2, page 5-3

### **C.10**

Answer: b

Reference: KSU SAR 1.3.3, page 1-6

## Category C: Facility and Radiation Monitoring Systems

### **C.11**

Answer: a. 2; b. 1; c. 3

Reference: KSU SAR 7.3.4.c, page 7-17

### **C.12**

Answer: d

Reference: KSU Technical Specifications, TS 4.4.2, page TS-31

### **C.13**

Answer: d

Reference: KSU SAR, 1.3.5.d, page 1-9

### **C.14**

Answer: c

Reference: KSU Technical Specifications, TS 3.8.4, page TS-25

### **C.15**

Answer: c

Reference: KSU Technical Specifications, TS 3.1.3 and 4.1.2, pages TS-11 and TS-28

### **C.16**

Answer: a

REF: Facility License Condition 2.B.3

DOE Fundamentals Handbook, NP-02, pg. 3-4, Beryllium-9 undergoes an alpha-neutron reaction (alpha decay from Am-241) and becomes carbon-12.  $\text{Am-241} \rightarrow \text{Np-237} + \alpha \rightarrow \text{Be-9} + \alpha \rightarrow (\text{C-13})^* \rightarrow \text{C-12} + \eta$

### **C.17**

Answer: a. 2; b. 3; c. 1; d. 1

Reference: KSU SAR 7.2.2, pages. 7-3 and 7-4

### **C.18**

Answer: a

Reference: KSU Technical Specifications, TS 5.1.3, page TS-38

### **C.19**

Answer: d

Reference: KSU SAR 7.3.1, page 7-10  
Standard NRC Question

### **C.20**

Answer: c

Reference: KSU SAR 5.6, page 5-10