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.

Sincerely,

Travis L. Tate
Digitally signed by Travis L. Tate
Date: 2021.12.13 14:42:11 -05'00'

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 10th Avenue, Suite 212 S
Topeka, KS 66612-1590

Kim Steves
Radiation Control Section
Kansas Department of Health and Environment
1000 SW Jackson, Suite 330
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

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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
William C Schuster IV, Chief Examiner 10/07/2021 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.

Kansas State University

Operator Licensing Examination

Week of September 27, 2021

ENCLOSURE 2

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.

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

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

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 ___

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

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 ___

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 <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.

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

EQUATION SHEET

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

1 Curie = 3.7 x 10^{10} dis/sec
1 Horsepower = 2.54 x 10^3 BTU/hr
1 BTU = 778 ft-lbf
1 gal (H_2O) ≈ 8 lbm
c_P = 1.0 BTU/lbm°F
1ft = 30.48 cm

1 kg = 2.21 lbm
1 Mw = 3.41 x 10^6 BTU/hr
°F = 9/5 °C + 32
°C = 5/9 (°F - 32)
c_p = 1 cal/g°C

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

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 $_{93}Np^{239} \rightarrow$ _____ + $_{94}Pu^{239}$ 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

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, ℓ*: Prompt neutron lifetime; ρ: reactivity insertion; β: beta fraction;
λ-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 $T = \left[\frac{\beta-\rho}{(\lambda_{eff})(\rho)}\right]$

c. The resultant period is a function of the prompt neutron lifetime (T=ℓ*/ρ)

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 (β) for U-235 is 0.0065 and beta effective (β_{eff}) for U-235 is approximately 0.0070, how does this difference affect reactor period in the reactor period equation, T=(β-p)/λp? This difference produces a _________ for a given addition of reactivity with beta effective (β_{eff}).

a. Longer period

b. Shorter period

c. Stable period

d. Decay constant (λ) increase

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 (ΔQ) 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. $K_{eff} < 1.0$ or $\rho < 0.0$

d. $K_{eff} > 1.0$ or $\rho > 0.0$

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_{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

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 ($_{92}U^{235}$)?

a. 92; 92; 143

b. 143; 92; 143

c. 92; 143; 92

d. 143; 143; 92

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}Xe. The process that shows how this isotope is formed and its decay is:

Column A

$$\underbrace{\mathbf{a}}_{fission} \xrightarrow[19s]{} {}^{0}_{-1}\beta + \underbrace{\mathbf{b}}_{fission} \xrightarrow[6.57h]{} {}^{0}_{-1}\beta + \underbrace{{}^{135}_{54}Xe}_{fission} \xrightarrow[9.1h]{} {}^{0}_{-1}\beta + \mathbf{c} \xrightarrow[2.3E6y]{} {}^{0}_{-1}\beta + \mathbf{d}\ (stable)$$

Column B

1. $_{56}Ba^{135}$
2. $_{52}Te^{135}$
3. $_{53}I^{135}$
4. $_{55}Cs^{135}$

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 approved 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

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 ºC

b. Pool water conductivity = 2 micromho/cm

c. Primary water temperature = 40 ºC

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 ________ ºC.

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

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. ¼ ALARA goal (annual)

b. ½ ALARA goal (annual)

c. ¼ 10CFR20 annual limit

d. ½ 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

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)

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

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

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

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_{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 *****)

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

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

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 exhanger 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

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	**Column B**
a. 1-kW Pulse Interlock	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.
b. Pulse Rod Interlock	2. Prevent pulses from being fired if the reactor power is above 1 kW in PULSE MODE
c. Control Rod (STANDARD) Position Interlock	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

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 ºF. 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 ºF

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

QUESTION   C.16   [1.0 point]
The __________ neutron startup source utilizes a _________ reaction.

a. Am-Be; (α,η)

b. Am-Be; (γ,η)

c. Am-Li; (α,η)

d. Am-Li; (γ,η)

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	Column B
a. Automatically insert the control rods into the reactor core when parameters deviate from limited safety system settings	1. Reactor Control System
b. Personnel protective measures and emergency assessment actions	2. Reactor Protection System
c. Provide the reactor operator with reactor status information	3. Radiation Monitoring Instruments
d. Govern the manner in which reactivity is varied in the reactor core	

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 ($UZrH_x$), 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 ($UZrH_x$), 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 ($UZrH_x$), 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 ($UZrH_x$), 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.

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) → 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 3rd, 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=(β-p)/λp, if Beta effective is used instead of Beta for U-235, the term (β_{eff}-p) is larger giving a longer period.

A.10
Answer: b
Reference: DOE Fundamentals Handbook, NP-03, pg. 6

A.11
Answer: b
Reference: Lamarsh 3rd, 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 3rd 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.

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

<u>Category C: Facility and Radiation Monitoring Systems</u>

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. Am-241 $\rightarrow$ Np-237 + α $\rightarrow$ Be-9 + α $\rightarrow$ (C-13)* $\rightarrow$ C-12 + η

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