June 1, 2016

Dr. Jeffrey Geuther, Manager
KSU Nuclear Reactor Facility
Department of Mechanical and
Nuclear Engineering
112 Ward Hall
Kansas State University
Manhattan, KS 66506-5204

SUBJECT: EXAMINATION REPORT, NO. 50-188/OL-16-02, KANSAS STATE UNIVERSITY

Dear Dr. Geuther:

During the week of April 25, 2016, the U.S. Nuclear Regulatory Commission (NRC) administered an operator licensing examination at your Kansas State University reactor. The examination was 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 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 enclosure will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records (PARS) component of NRC's Agencywide Documents Access and Management System (ADAMS). ADAMS is accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html. The NRC is forwarding the individual grades to you in a separate letter which will not be released publicly. Should you have any questions concerning this examination, please contact Mrs. Paulette Torres at (301) 415-5656 or via e-mail Paulette.Torres@nrc.gov.

Sincerely,

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

Docket No. 50-188

Enclosures: 1. Examination Report No. 50-188/OL-16-02
2. Facility Comments with NRC Resolution
3. Written Examination

cc: w/o enclosure: See next page

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In accordance with Title 10 of the Code of Federal Regulations Section 2.390, a copy of this letter and the enclosure will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records (PARS) component of NRC's Agencywide Documents Access and Management System (ADAMS). ADAMS is accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html. The NRC is forwarding the individual grades to you in a separate letter which will not be released publicly. Should you have any questions concerning this examination, please contact Mrs. Paulette Torres at (301) 415-5656 or via e-mail Paulette.Torres@nrc.gov.

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DISTRIBUTION w/ encl.
Public Anthony Mendiola Gary Morlang
Alexander Adams Spyros Traiforos

ADAMS Accession No. ML16153A020 **NRR-074**

OFFICE	NRR/DPR/PROB/CE	NRR/DPR/PROB/OLA	NRR/DPR/PROB/BC
NAME	PTorres	CRevelle	AMendiola
DATE	5/24/2016	6/01/2016	6/01/2016

OFFICIAL RECORD COPY

Kansas State University
cc:

Docket NO: 50-188

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Test, Research, and Training
Reactor Newsletter
University of Florida
202 Nuclear Sciences Center
Gainesville, FL 32611

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

REPORT NO.: 50-188/OL-16-02

FACILITY DOCKET NO.: 50-188

FACILITY LICENSE NO.: R-88

FACILITY: Kansas State University Reactor

EXAMINATION DATE: April 25, 2016

SUBMITTED BY: **/RA/** **05/24/2016**
Paulette Torres, Chief Examiner Date

SUMMARY:

During the week of April 25, 2016 the NRC administered a licensing examination to four Reactor Operator (RO) candidates. Two candidates failed the written portion of the examination. The remainder candidates passed all applicable portions of the examinations.

REPORT DETAILS

1. Examiner: Paulette Torres, Chief Examiner, NRC

2. Results:

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

3. Exit Meeting:

Paulette Torres, Chief Examiner, NRC
Jeffrey Geuther, Manager, KSU

The facility licensee agreed to email their comments on the written examination which were incorporated into the examination report (see Enclosure 2).

FACILITY COMMENTS ON THE WRITTEN EXAM WITH NRC RESOLUTION

QUESTION A.01 [1.0 point, 0.25 each]
Match the following neutron interactions with its net result. Answers can be used more than once.

Column A	Column B
a. Elastic Scattering	1. γ – Rays
b. Inelastic Scattering	2. Positive Ions
c. Nuclear Reactions	3. Protons
d. Capture	

Answer: a,3 b,1 c,2 d,1
REF: Denaro and Jayson, Fundamentals of Radiation Chemistry, pg. 51

Facility Comments & Recommendations: Nuclear reactions can produce a broad range of "net results," including gamma rays and protons. For example, two very important nuclear reactions at the KSU TRIGA reactor are the control rod neutron absorption reaction $^{10}B(n,\alpha)^{7}Li$, which has a 94% chance of emitting a gamma ray, and the reaction which produces ^{16}N in the moderator, which produces a proton: $^{16}O(n,p)^{16}N$. Therefore the Facility recommends that all answers be accepted for A.01c.

NRC Resolution: The NRC agrees with the facility comment and accepts all answers (1, 2 and 3) to be correct for question A.01c.

QUESTION A.06 [1.0 point]
During a fuel loading of the reactor core, as the reactor approaches criticality, the multiplication factor:

a. Increases toward unity.

b. Decreases toward unity.

c. Increases toward infinity.

d. Decreases toward zero.

Answer: c
REF: KSU Reactor Training Manual, pg. 166 of 212

Facility Comments &
Recommendations: This question does not specify whether "multiplication factor" refers to the subcritical multiplication factor M or the neutron multiplication factor k. Both are commonly used by reactor operators. Therefore the Facility recommends that both A and C be accepted as correct answers for A6.

NRC Resolution: The NRC examiner noted this during the exam and corrected the question to read "During a fuel loading of the reactor core, as the reactor approaches criticality, the neutron multiplication factor, M:" for the benefit of all candidates. Therefore the NRC will keep answer c as the correct answer.

QUESTION A.08 [1.0 point]
Which ONE of the following statements correctly describes the term neutron lifetime?

a. The mean time required for fission neutrons to slow down to thermal energies.

b. The average time that thermal neutrons diffuse before being lost in some way.

c. The time between succeeding neutron generations and is the sum of fission time, slowing down time, and diffusion time.

d. The average time between the release of a neutron in a fission reaction and its loss from the system by absorption or escape.

Answer: d
REF: Burns, section 3.3.5, pg. 3-23

Facility Comments &
Recommendations: Both C and D are good descriptions of neutron lifetime. The time to slow down and diffuse is the same as the time for a neutron to be absorbed or escape. It seems that "D" just lumps the slowing down and diffusion time together, while "C" considers them separately. The Facility recommends that both answers C and D be accepted. (Note that both answers refer specifically to neutrons born in fission, thereby excluding consideration of delayed neutrons).

NRC Resolution: The NRC will accept both "c" and "d" as correct answers for question A.08.

QUESTION A.18 [1.0 point, 0.25 each]
The six factor formula is stated as $k_{eff} = \epsilon L_f p L_t f \eta$.
Match with the correct answer:

Column A	Column B
a. Thermal utilization factor (f)	1. Change as fertile material is converted to fissile material.
b. f and p factors	2. Can be changed, by inserting movable control rods in and out.
c. f, p, Reproduction (η) factors	3. Changes reactor power.
d. Resonance escape probability (p)	4. Change as fuel is burned.

Answer: a,2 b,4 c,1 d,3
REF: DOE Handbook part 2, module 3, pg. 10, 15

Facility Comments & Recommendations: There are several problems with this question. First of all, the conversion of fertile material to fissile material, insertion of control rods, and fuel burnup all affect most of the factors in the six factor formula, although some are affected more than others. Also, it seems that the intent was to say that resonance escape probability is changed by reactor power, but the answer is "changes reactor power." The facility recommends either that this question be withdrawn.

NRC Resolution: The NRC agrees with the facility comment and question A.18 will be deleted from the examination.

QUESTION B.05 [1.0 point]
Which ONE of the following IS NOT a Reportable Occurrence per Technical Specifications?

a. The Limiting Safety System Setting (LSSS) for reactor power level is set at 1250 kW.

b. An unanticipated change in reactivity of $1.00.

c. Airborne contamination levels in the reactor bay lower than 10 CFR 20 limits.

d. The period scram and the linear high power scrams are disabled by the Senior Reactor Operator while in pulse mode.

Answer: d
REF: TS 6.9, pg. TS-48
SAR 7.4, pg. 7-19

Facility Comments &
Recommendations: It is not a reportable occurrence to have the LSSS set correctly (Answer A) or to have airborne contamination levels within limits (Answer C). The Facility recommends that A, C, and D be accepted as correct answers to this question.

NRC Resolution: All answers are correct. Therefore question B.05 will be deleted from the examination.

QUESTION B.17 [1.0 point]
The Emergency Operations Center (EOC) shall be located in the _____.

a. Emergency Planning Zone

b. Hot Zone

c. Warm Zone

d. Cold Zone

Answer: d
REF: KSU Reactor Training Manual, Emergency Plan section 1.5.1, pg. 124 of 212
Emergency Plan & Emergency Plan Procedures, Section 1.5.2, pg. 9

Facility Comments &
Recommendations: It is correct that the Emergency Operation Center must be in the Cold Zone, per EPP 10. However, EP 10.1 also states that "During an Unusual Event or an Alert, the Emergency Operations Center (EOC) should be the Reactor Control Room, located in Room 109 or Ward Hall." The Reactor Control Room is one of two rooms included in the Emergency Planning Zone (see EP 1.5.2). Therefore the Facility recommends accepting both A and D as correct answers to this question.

NRC Resolution: The NRC will accept both "a" and "d" as correct answers for question B.17.

QUESTION B.20 [1.0 point]
An Airborne Radioactivity Area is an area in which the airborne radioactivity concentration exceeds (DAC is the Derived Air Concentration):

a. 0.1 DAC

b. 0.5 DAC

c. 5 DAC- hours in a week

d. 1 DAC or 12 DAC-hours in a week

Answer: a
REF: 10 CFR 20.1003

Facility Comments & Recommendations: The definition of "Airborne Radioactivity Area" used as a reference to this question, 10CFR20.1003, states that: "Airborne Radioactivity Area means a room, enclosure, or area in which airborne radioactive materials, composed wholly or partly of licensed materials, exist in concentrations – (1) In excess of the derived air concentrations (DACs) specified in Appendix B, to 20.1001 – 20.2401, or (2) To such a degree that an individual present in the area without respiratory protective equipment could exceed, during the hours the individual is present in a week, an intake of 0.6 of the annual limit on intake (ALI) or 12 DAC-hours." Based on this definition, the correct answer should be changed from A to D.

NRC Resolution: The NRC agrees with the facility comment that the correct answer is "d" for question B.20.

QUESTION C.08 [1.0 point]
The remote area monitors utilize G-M detectors located throughout the reactor bay. A movable detector can be located:

a. At the thermal column.

b. Above the bulk shield tank.

c. At the top of the reactor tank.

d. Near the ion exchanger in the primary coolant system.

Answer: a
REF: SAR 7.7, pg. 7-21

Facility Comments &
Recommendations: This question statement does not reference any section of the SAR or Procedure. It only asks where "a movable detector can be located." Moveable detectors can be located anywhere in the reactor bay. Even when specifically discussing RMS units, it is possible and common to mount RMS units at the locations listed as answers B, C, and D. Therefore the Facility recommends that all possible answers be accepted for this question.

NRC Resolution: The NRC will delete question C.08 from the examination.

QUESTION C.17 [1.0 point]
The Primary Water Conductivity meter is located at the:

a. Cleanup Loop Inlet and Outlet

b. Heat Exchanger Inlet and Outlet

c. Water Box

d. Pools Surface

Answer: a
REF: SAR Table 5.1, pg. 5-3

Facility Comments &
Recommendations: The water box at the outlet of the cleanup loop houses one of the two primary water conductivity meters. Many past exams have asked questions regarding the fact that there is a conductivity meter in the water box. The question statement does not specify whether it is asking about the inlet conductivity monitor, outlet conductivity monitor, or both. Therefore the Facility recommends that both A and C be accepted.

NRC Resolution: The NRC will accept both "a" and "c" as correct answers for question C.17.

QUESTION C.18 [1.0 point]
Which ONE of the following can also be used for temporary fuel storage?

a. Reactor Tank

b. Surge Tank

c. Bulk Shield Tank

d. Sump Tank

Answer: c
REF: SAR 1.3.6 c, pg. 1-12
SAR 5.1, pg. 5-2
SAR 9.2, pg. 9-1

Facility Comments & Recommendations: The reactor tank contains many fuel racks, and is the usual location where the fuel is temporarily stored during fuel inspections, core reconfiguration, initial core loading, etc. Therefore the Facility recommends that both A and C be accepted as correct answers.

NRC Resolution: The NRC will accept both "a" and "c" as correct answers for question C.18.

QUESTION C.20 [1.0 point]
The thermocouples in the instrumented fuel element are located:

a. At the interior surface of the cladding.

b. At the center of the zirconium rod.

c. In the outer surface of the fuel.

d. Below the fuel surface.

Answer: d
REF: SAR 4.2.1a, pg. 4-4
SAR 7.3.2, pg. 7-11

Facility Comments & Recommendations: The section of the SAR referenced on the answer key states that the thermocouples in instrumented fuel elements are located "0.76 cm (0.3 in) below the fuel surface." The problem statement just states that they are "below the fuel surface," which seems to imply that they are immediately beneath the surface, i.e., at the interior of the cladding. Due to the vagueness of the problem statement, the Facility recommends that this problem be withdrawn.

NRC Resolution: The NRC will delete question C.20 from the examination.

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

FACILITY: Kansas State University

REACTOR TYPE: TRIGA

DATE ADMINISTERED: 04/25/2016

CANDIDATE: _____

INSTRUCTIONS TO CANDIDATE:
Answers are to be written on the Answer sheet provided. Attach all Answer sheets to the examination. Point values are indicated in parentheses for each question. A 70% in each category is required to pass the examination. Examinations will be picked up three (3) hours after the examination starts.

CATEGORY VALUE	% OF TOTAL	CANDIDATE'S SCORE	% OF CATEGORY VALUE	CATEGORY
19.00 ~~20.00~~	33.3	_____	_____	**A. REACTOR THEORY, THERMODYNAMICS AND FACILITY OPERATING CHARACTERISTICS**
19.00 ~~20.00~~	33.3	_____	_____	**B. NORMAL AND EMERGENCY OPERATING PROCEDURES AND RADIOLOGICAL CONTROLS**
18.00 ~~20.00~~	33.3	_____	_____	**C. FACILITY AND RADIATION MONITORING SYSTEMS**
56.00 ~~60.00~~		_____ **FINAL GRADE**	_____ %	**TOTALS**

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

_____
Candidate's Signature

ENCLOSURE 3

A. Reactor Theory, Thermohydraulics & 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 ___~~ (deleted per facility comment)

A19 a b c d ___

A20 a b c d ___

(***** END OF SECTION A *****)

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 ___~~ (deleted per facility comment)

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 SECTION B *****)

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 ___~~ (deleted per facility comment)

C09 a b c d ___

C10 a b c d ___

C11 a b c d ___

C12 a b c d ___

C13 a b c d ___

C14 a b c d ___

C15 a b c d ___

C16 a b c d ___

C17 a b c d ___

C18 a b c d ___

C19 a b c d ___

~~C20 a b c d ___~~ (deleted per facility comment)

(***** END OF SECTION 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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$T_{\frac{1}{2}} = \frac{0.693}{\lambda} \quad \Delta\rho = \frac{K_{eff_2} - K_{eff_1}}{K_{eff_1} K_{eff_2}}$$

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

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

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

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

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

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

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

1 kg = 2.21 lbm

1 Horsepower = 2.54 x 10^3 BTU/hr

1 Mw = 3.41 x 10^6 BTU/hr

1 BTU = 778 ft-lbf

°F = 9/5 °C + 32

1 gal (H_2O) ≈ 8 lbm

°C = 5/9 (°F - 32)

c_P = 1.0 BTU/hr/lbm/°F

c_p = 1 cal/sec/gm/°C

KANSAS STATE UNIVERSITY

Operator Licensing Examination

Week of April 25, 2016

QUESTION A.01 [1.0 point, 0.25 each]
Match the following neutron interactions with its net result. Answers can be used more than once.

Column A	Column B
a. Elastic Scattering	1. γ – Rays
b. Inelastic Scattering	2. Positive Ions
c. Nuclear Reactions	3. Protons
d. Capture	

QUESTION A.02 [1.0 point]
A _____ is an adjustment of the channel to that its output responds, with acceptable range and accuracy, to known values of the parameter that the channel measures.

a. Channel Calibration

b. Channel Check

c. Channel Test

d. Measuring Channel

QUESTION A.03 [1.0 point]
Shutdown Margin is defined as:

a. The negative reactivity inserted by an increase in moderator temperature within the core when the reactor is brought from zero to full power.

b. Provides a measure of excess reactivity available to overcome fission product buildup, fuel burnup, and power defect.

c. The amount of negative reactivity that would be added to a core if the rods in a critical, cold, clean reactor were fully inserted.

d. The amount of reactivity available above what is required to keep the reactor critical.

QUESTION A.04 [1.0 point]
The count rate is 100 cps. An experimenter inserts an experiment into the core, and the count rate decreases to 60 cps. Given the initial K_{eff} of the reactor was 0.92, what is the worth of the experiment?

a. $\Delta\rho = - 0.07$

b. $\Delta\rho = + 0.07$

c. $\Delta\rho = - 0.02$

d. $\Delta\rho = + 0.02$

QUESTION A.05 [1.0 point]
Emission of a highly energetic helium nucleus from the nucleus of a radioactive atom is called:

a. Alpha Decay

b. Beta Decay

c. Positron Emission

d. Bremsstrahlung

QUESTION A.06 [1.0 point]
During a fuel loading of the reactor core, as the reactor approaches criticality, the neutron multiplication factor, M:

a. Increases toward unity.

b. Decreases toward unity.

c. Increases toward infinity.

d. Decreases toward zero.

QUESTION A.07 [1.0 point]
The reactor is critical at 5 watts. Which ONE of the following correctly describes the reactor behavior when a reactivity worth of 0.50 % ΔK/K is IMMEDIATELY inserted to the reactor core?

a. Subcritical

b. Critical

c. Supercritical

d. Delayed critical

QUESTION A.08 [1.0 point]
Which ONE of the following statements correctly describes the term neutron lifetime?

a. The mean time required for fission neutrons to slow down to thermal energies.

b. The average time that thermal neutrons diffuse before being lost in some way.

c. The time between succeeding neutron generations and is the sum of fission time, slowing down time, and diffusion time.

d. The average time between the release of a neutron in a fission reaction and its loss from the system by absorption or escape.

QUESTION A.09 [1.0 point]
Most text books list β for a U^{235} fueled reactor as 0.0065 ΔK/K and β_{eff} as being 0.0075 ΔK/K. Why is β_{eff} larger than β?

a. Delayed neutrons are born at lower energies than prompt neutrons resulting in a less loss due to leakage for these neutrons.

b. Delayed neutrons are born at higher energies than prompt neutrons resulting in a greater worth for these neutrons.

c. The fuel includes U^{238} which has a relatively large for fast fission.

d. Some U^{238} in the core becomes Pu^{239} (by neutron absorption) which has a larger for fission.

QUESTION A.10 [1.0 point]
The neutron microscopic cross-section for absorption σ_a generally:

a. Increases as neutron energy increases.

b. Decreases as neutron energy increases.

c. Increases as the mass of the target nucleus increases.

d. Decreases as the mass of the target nucleus increases.

QUESTION A.11 [1.0 point]
Which ONE of the following statements best describes on how moderator temperature affects the core operating characteristics?

a. Increase in moderator temperature will decrease the neutron multiplication factor due to the resonance escape probability decrease.

b. Increase in moderator temperature will decrease the neutron multiplication factor due to the reproduction factor increase.

c. Increase in moderator temperature will increase the neutron multiplication factor due to the resonance escape probability increase.

d. Increase in moderator temperature will increase the neutron multiplication factor due to the fast non leakage probability decrease.

QUESTION A.12 [1.0 point]
Which ONE of the following is the correct reason for an installed neutron source within the core? A startup without an installed neutron source:

a. Is impossible because there would be no neutrons available to start up the reactor.

b. Would be very slow because it would take a long time to build up neutron population from so low a level.

c. Can be compensated for by adjusting the compensating voltage on the source range detector.

d. Could result in a very short period due to the reactor going critical before neutron population built up high enough to be read on nuclear instrumentation.

QUESTION A.13 [1.0 point]
Which ONE of the following is the correct reason for the 80 second negative period following a reactor scram?

a. The fuel temperature coefficient adding positive reactivity due to the fuel temperature decrease following a scram.

b. The ability of U-235 to fission with source neutrons.

c. The decay constant for the longest lived precursor.

d. The amount of negative reactivity added on a cram being greater that the shutdown margin.

QUESTION A.14 [1.0 point]
A reactor is operating at a power of 10 W. If there is a reactivity insertion of $\rho = 0.00065$, how long is it before the reactor power reaches 10 kW? (Assume $\beta_{eff} = 0.0065$, $\lambda = 0.07\ sec^{-1}$ and T = 129 sec)

a. 2 min

b. 10 min

c. 15 min

d. 20 min

QUESTION A.15 [1.0 point]
Which ONE of the following is the time period in which the maximum amount of Xe135 will be present in the core? Approximately:

a. 6 to 11 hours after a reactor startup to full power.

b. 3 to 6 hours after a power increase from 50% to 100%.

c. 3 to 6 hours after a power decrease from 100% to 50%.

d. 6 to 11 hours after a reactor shutdown from full power.

QUESTION A.16 [1.0 point]
A subcritical reactor is being started up. A control blade is raised in four equal steps. Which ONE of the following statement most accurately describes the expected reactor response?

a. Power increases by the same amount for each withdrawal.

b. Each withdrawal will add the same amount of reactivity.

c. The time for power to stabilize after each successive withdrawal increases.

d. A lower critical rod height is attained by decreasing the time intervals between withdrawals.

QUESTION A.17 [1.0 point]
Which ONE of the following is true concerning the differences between prompt and delayed neutrons?

a. Prompt neutrons account for less than 1% of the neutron population while delayed neutrons account for approximately 99% of the neutron population.

b. Prompt neutrons are released during fast fissions while delayed neutrons are released during thermal fissions.

c. Prompt neutrons are released during the fission process while delayed neutrons are released during the decay process.

d. Prompt neutrons are the dominating factor in determining the reactor period while delayed neutrons have little effect on the reactor period.

~~**QUESTION A.18 [1.0 point, 0.25 each]**~~ (deleted per facility comment)
~~The six factor formula is stated as $k_{eff} = \epsilon L_f p L_t f \eta$. Match with the correct answer:~~

~~Column A~~	~~Column B~~
~~a. Thermal utilization factor (f)~~	~~1. Change as fertile material is converted to fissile material.~~
~~b. f and p factors~~	~~2. Can be changed, by inserting movable control rods in and out.~~
~~c. f, p, Reproduction (η) factors~~	~~3. Changes reactor power.~~
~~d. Resonance escape probability (p)~~	~~4. Change as fuel is burned.~~

QUESTION A.19 [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.20 [1.0 point]
Which ONE of the following is the best approximation of the amount of energy released by the fission of one atom of U-235?

a. 5 - 10 MeV

b. 50 - 70 MeV

c. 100 - 120 MeV

d. 180 - 210 MeV

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

QUESTION B.01 [1.0 point]
If a fuel element is found to have corrosion, mechanical damage, elongation of more than _____ over manufactured length, or lateral bending of more than _____, the fuel element SHALL NOT be reinserted in the Reactor core grid plate.

a. 1/10 in.

b. 1/8 in.

c. 1/4 in.

d. 1/2 in.

QUESTION B.02 [1.0 point]
All of the following sources are major gamma emitters EXCEPT:

a. Co-60

b. Sr-90

c. Cs-137

d. Ra-226

QUESTION B.03 [1.0 point]
“Steady state fuel temperature shall not exceed 750°C.” This is an example of a:

a. Safety Limit

b. Limiting Safety System Setting

c. Limiting Conditions for Operation

d. Surveillance Requirement

QUESTION B.04 [1.0 point]
Technical Specifications defines Reactor Shutdown as:

a. All rods are fully inserted and the reactor console is secured.

b. The reactor is subcritical by at least $1.00 in the reference core condition with the reactivity worth of all experiments included.

c. The reactor console is secured and no work is in progress involving core fuel, core structure, installed controlled rods or control rod drives.

d. The reactor is subcritical by at least $1.00 of reactivity and the reactor console is secure.

~~**QUESTION B.05 [1.0 point]**~~ (deleted per facility comment)
~~Which ONE of the following IS NOT a Reportable Occurrence per Technical Specifications?~~

~~a. The Limiting Safety System Setting (LSSS) for reactor power level is set at 1250 kW.~~

~~b. An unanticipated change in reactivity of $1.00.~~

~~c. Airborne contamination levels in the reactor bay lower than 10 CFR 20 limits.~~

~~d. The period scram and the linear high power scrams are disabled by the Senior Reactor Operator while in pulse mode.~~

QUESTION B.06 [1.0 point]
In accordance with 10 CFR Part 50.47(b)(11), under what conditions an Emergency Team Worker can have exposure in excess of 10 CFR 20 limits?

a. During any emergency.

b. In an emergency situation, on a voluntary basis, whole body exposure > 25 rem dose equivalent per individual for life-saving efforts.

c. As long as the Emergency Team Worker don't exceed 50 rem whole body to save vital reactor equipment.

d. In an emergency declared by the Emergency Director with concurrence of the Senior Reactor Operator.

QUESTION B.07 [1.0 point]
Reactor Operator works in a high radiation area for eight (8) hours a day. The dose rate in the area is 100 mR/hour. Which ONE of the following is the MAXIMUM number of days in which Reactor Operator may perform his duties WITHOUT exceeding 10 CFR 20 limits?

a. 5 days

b. 6 days

c. 7 days

d. 12 days

QUESTION B.08 [1.0 point]
Which ONE of the following measuring channels has a minimum number operable of two in Steady State Mode?

a. Fuel Temperature

b. Reactor Power Level

c. Primary Pool Water Temperature

d. Reactor Bay Differential Pressure

QUESTION B.09 [1.0 point, 0.25 each]
Match the 10 CFR 55 requirements for maintaining an active operator license in column A with the corresponding time period from column B (answers can be used more than once).

Column A	Column B
a. Medical Exam	1 year
b. Pass Requalification Operating Test	2 years
c. Renewal Application of Existing License	4 years
d. Pass Requalification Written Examination	6 years

QUESTION B.10 [1.0 point]
_____ are thresholds for establishing emergency classes and initiating appropriate emergency measures.

a. Emergency Plan Procedures

b. Emergency Action Levels

c. Emergency Planning Zone

d. Protective Action Guides

QUESTION B.11 [1.0 point]
During an emergency, the _____ is responsible of ensuring that proper dosimetry is worn and recorded, that security procedures are followed, and shall record an approximate timeline as events occur.

a. Emergency Director

b. Emergency Radiation Safety Officer

c. Emergency Organization Officer

d. Senior Reactor Operator

QUESTION B.12 [1.0 point]
Which ONE of the following emergency situations may lead to an UNUSUAL EVENT?

a. Fire within the Reactor Facility causing damage to safety-related Reactor components or loss of security or surveillance capabilities for longer than 15 minutes.

b. Any Medical Incident requiring transportation of a contaminated accident victim to an off-site hospital.

c. Loss of radioactive material control leading to a deep dose equivalent of 75 mrem

d. Confirmed breach of cladding of multiple fuel elements.

QUESTION B.13 [1.0 point]
Which ONE of the following is the 10 CFR 20 definition of Total Effective Dose Equivalent (TEDE)?

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

b. The dose that your whole body receives from sources outside the body.

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

d. The dose to a specific organ or tissue resulting from an intake of radioactive material.

QUESTION B.14 [1.0 point]
If a gamma source measures 425 mR/hr at one foot, what will it measure at three feet?

a. 0.021 mR/hr

b. 47 mR/hr

c. 142 mR/hr

d. 207 mR/hr

QUESTION B.15 [1.0 point]
For at least 36 hours prior to commencing the _____ procedure, the secondary cooling system must not be operated. In addition, significant reactor heat (greater than 1 kWh) must not be produced.

a. Annual Remote Area Monitor Calibration

b. Annual Power Level Calibration

c. Temperature Channel Calibration

d. Differential Pressure Channel Calibration

QUESTION B.16 [1.0 point]
What is the KSU ALARA goal limit for members of the public?

a. KSU does not have ALARA goal limits.

b. ALARA goal limits applicable only for radiation workers.

c. Same as the average annual dose for radiation workers not to exceed 100 mrem.

d. ≤ 50 mrem annual TEDE.

QUESTION B.17 [1.0 point]
The Emergency Operations Center (EOC) shall be located in the _____.

a. Emergency Planning Zone

b. Hot Zone

c. Warm Zone

d. Cold Zone

QUESTION B.18 [1.0 point]
In order to comply with the Semimanual $1.00 Comparison Pulse procedure you must previously perform the _____ procedure.

a. Control Rod Inspection

b. Pulse Rod Drive Cylinder And Air Supply Inspection

c. Fuel Element Inspection

d. No Inspection Procedure Required

QUESTION B.19 [1.0 point]
After calibrating a Portable Radiation Survey Meter, the new calibration sticker on the instrument should indicate all of the following information EXCEPT:

a. Any ranges not calibrated

b. The individual performing the calibration

c. The calibration source used

d. Corrections for any ranges not indicating within ± 10 percent

QUESTION B.20 [1.0 point]
An Airborne Radioactivity Area is an area in which the airborne radioactivity concentration exceeds (DAC is the Derived Air Concentration):

a. 0.1 DAC

b. 0.5 DAC

c. 5 DAC- hours in a week

d. 1 DAC or 12 DAC-hours in a week

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

QUESTION C.01 [1.0 point]
Which ONE is the major source of radiation dose to the area above the reactor pool?

a. H-3

b. N-16

c. Ar-41

d. Cs-135

QUESTION C.02 [1.0 point]
Which ONE of the following lattice geometry rings has a maximum number elements of 18?

a. B ring

b. C ring

c. D ring

d. E ring

QUESTION C.03 [1.0 point]
The KSU reactor has a _____ neutron startup source.

a. Am-Li

b. Am-Be

c. Sb-Be

d. Pu-Be

QUESTION C.04 [1.0 point]
The purpose of the surface skimmer is to:

a. Maintain pool water purity.

b. Provide a filtering mechanism for makeup water.

c. Collect foreign particles that float on the pool surface.

d. Provide a path for makeup water for filling the pool during both normal an emergency pool fills.

QUESTION C.05 [1.0 point]
Per Technical Specifications for Pulse Mode, the transient rod drive is positioned for reactivity insertion (upon withdrawal) less than or equal to:

a. $1.00

b. $2.00

c. $3.00

d. $4.00

QUESTION C.06 [1.0 point]
Which ONE of the following safety system channel or interlock is required in both Steady State Mode and Pulse Mode of operation?

a. Reactor Power Level

b. Manual Scram Bar

c. Control Rod (Standard) Position Interlock

d. Pulse Rod Interlock

QUESTION C.07 [1.0 point]
The limiting design parameter for TRIGA fuel is related to:

a. The distortion of the fuel element due to a phase change of the 304 stainless steel.

b. Fission product built up.

c. Excessive pressure from expansion of Argon-41.

d. Buildup of pressure through dissociation of hydrogen in the matrix.

~~**QUESTION C.08 [1.0 point]**~~ (deleted per facility comment)
~~The remote area monitors utilize G-M detectors located throughout the reactor bay. A movable detector can be located:~~

~~a. At the thermal column.~~

~~b. Above the bulk shield tank.~~

~~c. At the top of the reactor tank.~~

~~d. Near the ion exchanger in the primary coolant system.~~

QUESTION C.09 [1.0 point]
During operations, the pulse rod is held in place by:

a. Electromagnets

b. Air pressure

c. Gravity

d. Micro-switches

QUESTION C.10 [1.0 point]
Backup battery systems are provided for all of the following EXCEPT:

a. Emergency Lighting

b. The Security System

c. The 22-Foot Level Evacuation Alarm

d. The Continuous Air Radiation Monitor

QUESTION C.11 [1.0 point]
Per Technical Specifications, which ONE of the following correctly describes the characteristic of the KSU TRIGA fuel elements used in the reactor core?

a. It shall contain a maximum of 8.5 weight percent uranium which has a maximum enrichment of 19%. There shall be 1.50 to 1.60 hydrogen atoms to 1.0 zirconium atom.

b. It shall contain a maximum of 9.0 weight percent uranium which has a maximum enrichment of 20%. There shall be 1.50 to 1.60 hydrogen atoms to 1.0 zirconium atom.

c. It shall contain a maximum of 8.5 weight percent uranium which has a maximum enrichment of 19%. There shall be 1.55 to 1.80 hydrogen atoms to 1.0 zirconium atom.

d. It shall contain a maximum of 9.0 weight percent uranium which has a maximum enrichment of 20%. There shall be 1.55 to 1.80 hydrogen atoms to 1.0 zirconium atom.

QUESTION C.12 [1.0 point]
Technical Specifications require the water temperature at the exit of the reactor pool not to exceed 130°C to:

a. Prevent corrosion of reactor components.

b. Avoid damaging the heat exchanger plates.

c. Prevent slow leakage of fission products from degraded cladding.

d. Maintain the mechanical and chemical integrity of the deionizer resin mixed bed.

QUESTION C.13 [1.0 point]
Which ONE of the following interlocks prevents applying power to pulse rod unless rod inserted/prevent inadvertent pulse?

a. Source Interlock

b. Pulse Rod Interlock

c. Pulse Mode Interlock

d. Pulse Power Interlock

QUESTION C.14 [1.0 point]
The reactor operator can determine the reactivity insertion rate for a given interval of rod motion using all of the following EXCEPT:

a. Rod Speed

b. Rod Weight

c. Rod Worth Curves

d. Rod Position Indication

QUESTION C.15 [1.0 point]
Which ONE of the following is an In Reflector Experimental Facility?

a. Central Thimble

b. Pneumatic Transfer System

c. Rotary Specimen Rack

d. Beam Ports

QUESTION C.16 [1.0 point]
Which ONE of the following is a basic control function of the Secondary Coolant Automatic Control System?

a. To prevent cooling water freeze-up during cold weather operations.

b. To minimize corrosion of reactor components.

c. To minimize production of radioactive materials.

d. To maintain optical clarity of the primary water.

QUESTION C.17 [1.0 point]
The Primary Water Conductivity meter is located at the:

a. Cleanup Loop Inlet and Outlet

b. Heat Exchanger Inlet and Outlet

c. Water Box

d. Pools Surface

QUESTION C.18 [1.0 point]
Which ONE of the following can also be used for temporary fuel storage?

a. Reactor Tank

b. Surge Tank

c. Bulk Shield Tank

d. Sump Tank

QUESTION C.19 [1.0 point]
Which ONE of the following is the channel that provides multi-range linear power indication?

a. PA-1000

b. NPP-1000

c. NLW-1000

d. NMP-1000

~~**QUESTION C.20 [1.0 point]**~~ (deleted per facility comment)
~~The thermocouples in the instrumented fuel element are located:~~

~~a. At the interior surface of the cladding.~~

~~b. At the center of the zirconium rod.~~

~~c. In the outer surface of the fuel.~~

~~d. Below the fuel surface.~~

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

A.01
Answer: a,3 b,1 c,1,2,3 (per facility comment) d,1
REF: Denaro and Jayson, Fundamentals of Radiation Chemistry, pg. 51

A.02
Answer: a
REF: TS Definitions, pg. TS-4

A.03
Answer: c
REF: Burns, example 6.2.3 (a), pg. 6-4

A.04
Answer: a
REF: $CR_1 / CR_2 = (1 – K_{eff2}) / (1 – K_{eff1})$
$100 / 60 = (1 – K_{eff2}) / (1 – 0.92)$
Therefore $K_{eff2} = 0.867$
$\Delta\rho = (K_{eff2} – K_{eff1}) / (K_{eff2} * K_{eff1})$
$\Delta\rho = (0.867 – 0.92) / (0.867 * 0.92)$
$\Delta\rho = - 0.0664$

A.05
Answer: a
REF: DOE Handbook volume 1, module 1, pg. 24

A.06
Answer: c
REF: KSU Reactor Training Manual, pg. 166 of 212

A.07
Answer: c
REF: Burn, Section 4.2, Figure 4-1, pg. 4-2
0.5 % $\Delta K/K = 0.005$ $\Delta K/K = \rho$, $\rho > 0$
$\rho = (k_{eff} -1) / k_{eff}$, then $k_{eff} = 1.005$
When $k > 1$, $\rho > 0$ and reactor is supercritical

A.08
Answer: c and d (per facility comment)
REF: Burns, section 3.3.5, pg. 3-23

A.09
Answer: a
REF: Burns, Section 3.2.4, pg. 3-12

A.10
Answer: b
REF: Foster & Wright, "Basic Nuclear Engineering" 4th ed., Figure 8.3, pg. 202

A.11
Answer: a
REF: Burns, Section 3.2.2, pg. 3-18 to 3-20

A.12
Answer: d
REF: DOE Handbook volume 1, module 2, pg. 3

A.13
Answer: c
REF: Lamarsh, 3rd ed., pg. 345
KSU Reactor Training Manual, pg. 168 of 212

A.14
Answer: c
REF: Reactor power: $P(t) = P(0) \exp(t/T)$
Solving for t, we find $t = T \ln [P(t)/P(0)] = 129 \ln (10{,}000/10) = 891$ s = 14.9 min
Also,
$\rho = 0.00065$, then
$T = (\beta_{eff} - \rho)/(\rho \lambda) = (0.0065 - 0.00065)/(0.07)(0.00065) =$ 129 seconds

A.15
Answer: d
REF: KSU Reactor Training Manual, Figure 30, pg. 190 of 212
Lamarsh, 3rd ed., Figure 7.14, pg. 381

A.16
Answer: c
REF: Burns, Section 5.3, pg. 5-7

A.17
Answer: c
REF: Lamarsh, 3rd ed., pg. 73 - 75

~~**A.18**~~ (deleted per facility comment)
~~Answer: a,2 b,4 c,1 d,3~~
~~REF: DOE Handbook part 2, module 3, pg. 10, 15~~

A.19
Answer: c
REF: Burns 7.7.12 (b), pg. 7-19

A.20
Answer: d
REF: Lamarsh, Table 3.6, pg. 88
Foster and Wright, Basic Nuclear Engineering, 4th ed., table 4.2, pg. 76, "The energy release per fission is approximately 200 MeV."

B.01
Answer: b
REF: KSU TRIGA Mark II Operation, Test & Maintenance Procedures, Procedure #10, pg. 2 of 5

B.02
Answer: b
REF: KSU TRIGA Mark II Operation, Test & Maintenance Procedures, Procedure #13, pg. 1 of 3
KSU TRIGA Mark II Operation, Test & Maintenance Procedures, Procedure #14, pg. 1 of 4

B.03
Answer: a
REF: TS 2.1.3 (2), pg. TS-8

B.04
Answer: b
REF: TS Definitions, pg. TS-6

~~**B.05**~~ (deleted per facility comment)
~~Answer: d~~
~~REF: TS 6.9, pg. TS-48~~
~~SAR 7.4, pg. 7-19~~

B.06
Answer: b
REF: KSU Reactor Training Manual, Emergency Plan Table EP-1, pg. 151 of 212
Emergency Plan & Emergency Plan Procedures, Table 9.1, pg. 34

B.07
Answer: b
REF: 10 CFR 20.1201(a)(1)

$$5000mR * \frac{1hr}{100mR} * \frac{1day}{8hr} = 6.25days$$

B.08
Answer: b
REF: TS 3.3 Table 1, pg. TS-14

B.09

Answer: a, 2 years (10 CFR 55.53)
b, 1 years (10 CFR 55.59)
c, 6 years (10 CFR 55.55)
d, 2 years (10 CFR 55.59)

REF: 10 CFR 55.53 “Conditions of Operator Licenses”
10 CFR 55.55 “Expiration”
10 CFR 55.59 “Requalification”

B.10

Answer: b
REF: KSU Reactor Training Manual, Emergency Plan section 2.1, pg. 126 of 212
Emergency Plan & Emergency Plan Procedures, Section 2.1, pg. 10

B.11

Answer: c
REF: KSU Reactor Training Manual, Emergency Plan Section 3.3, pg. 130 of 212
Emergency Plan & Emergency Plan Procedures, Section 3.4, pg. 14

B.12

Answer: b
REF: KSU Reactor Training Manual, Emergency Plan Section 6.1.3, pg. 142 of 212 and Section 7.2, pg. 145 of 212
Emergency Plan & Emergency Plan Procedures, Section 6.1.3, pg. 25 and Section 7.2, pg. 28

B.13

Answer: a
REF: 10 CFR 20.1003, Definitions
KSU Reactor Training Manual, section 2.1, pg. 100 of 212

B.14

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

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

$$DR_2 = \frac{425\ mR}{(3/1)^2}$$

$DR_2 = 47.2$ mR/hr

B.15

Answer: b
REF: KSU TRIGA Mark II Operation, Test & Maintenance Procedures, Procedure #2, pg. 1 of 4

B.16

Answer: d
REF: KSU Reactor Training Manual, Section 6, pg. 112 of 212
SAR 11.1.3 a, pg. 11-6

B.17

Answer: a and d (per facility comment)
REF: KSU Reactor Training Manual, Emergency Plan section 1.5.1, pg. 124 of 212
Emergency Plan & Emergency Plan Procedures, Section 1.5.2, pg. 9

B.18

Answer: b
REF: KSU TRIGA Mark II Operation, Test & Maintenance Procedures, Procedure #7, pg. 1 of 4

B.19

Answer: c
REF: KSU TRIGA Mark II Operation, Test & Maintenance Procedures, Procedure #13, pg. 2 of 3

B.20

Answer: d
REF: 10 CFR 20.1003

C.01
Answer: b
REF: SAR 11.1.1, pg. 11-1

C.02
Answer: c
REF: KSU Reactor Training Manual, Lattice Geometry, pg. 7 of 212

C.03
Answer: b
REF: KSU Reactor Training Manual, Startup source, pg. 7 of 212
SAR 4.2.4, pg. 4-13

C.04
Answer: c
REF: KSU Reactor Training Manual, Primary Loop, pg. 13 of 212
SAR 5.2, pg. 5-3

C.05
Answer: c
REF: TS 3.2.3, pg. TS-13

C.06
Answer: b
REF: TS 3.4.3 Table: 2, pg. TS-18

C.07
Answer: d
REF: SAR 3.5.1 d, pg. 3-16

~~**C.08**~~ (deleted per facility comment)
~~Answer: a~~
~~REF: SAR 7.7, pg. 7-21~~

C.09
Answer: b
REF: SAR 3.5.3, pg. 3-17
SAR 4.2.2 a, pg. 4-11

C.10
Answer: d
REF: SAR 8, pg. 8-1

C.11
Answer: d
REF: TS 5.1.3 (1), pg. TS-38

C.12
Answer: d
REF: TS 3.8.5 bases, pg. TS-26

C.13
Answer: b
REF: SAR table 4.2, pg. 4-11
TS 3.4 Table 2, pg. TS-18

C.14
Answer: b
REF: SAR 7.3.4 a, pg. 7-13

C.15
Answer: c
REF: SAR 10.2.3 c, pg. 10-5

C.16
Answer: a
REF: SAR 5.3.2, pg. 5-6

C.17
Answer: a and c (per facility comment)
REF: SAR Table 5.1, pg. 5-3

C.18
Answer: a and c (per facility comment)
REF: SAR 1.3.6 c, pg. 1-12
SAR 5.1, pg. 5-2
SAR 9.2, pg. 9-1

C.19
Answer: d
REF: SAR 7.3.1, pg. 7-9

~~**C.20**~~ (deleted per facility comment)
~~Answer: d~~
~~REF: SAR 4.2.1a, pg. 4-4~~
~~SAR 7.3.2, pg. 7-11~~