March 6, 2018

Dr. Melinda Krahenbuhl, Director
Reed Reactor Facility
3203 SE Woodstock Blvd.
Portland, OR 97202

SUBJECT: EXAMINATION REPORT NO. 50-288/OL-18-01, REED COLLEGE

Dear Dr. Krahenbuhl:

During the week of October 16, 2017 and October 23, 2017, the U.S. Nuclear Regulatory Commission (NRC) administered operator licensing examinations at your Reed College TRIGA Reactor. The examinations were conducted according to NUREG-1478, "Operator Licensing Examiner Standards for Research and Test Reactors," Revision 2. Examination questions and preliminary findings were discussed at the conclusion of the examination with those members of your staff identified in the enclosed report.

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

Sincerely,

/RA/

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

Docket No. 50-288

Enclosures:
1. Examination Report No. 50-288/OL-18-01
2. Written examination

cc: w/o enclosures: See next page

SUBJECT: EXAMINATION REPORT NO. 50-288/OL-18-01, REED COLLEGE
DATED: MARCH 6, 2018

DISTRIBUTION:
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OFFICE	NRR/DLP/PROB	NRR/DLP/PROB	NRR/DLP/PROB
NAME	PTorres	AFerguson	AMendiola
DATE	12/20/2017	3/5/2018	3/6/2018

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

REPORT NO.: 50-288/OL-18-01

FACILITY DOCKET NO.: 50-288

FACILITY LICENSE NO.: R-112

FACILITY: Reed College TRIGA Reactor

EXAMINATION DATES: October 16, 2017 - October 23, 2017

SUBMITTED BY: ***/RA/*** **12/20/2017**
Paulette Torres, Chief Examiner Date

SUMMARY:

During the week of October 16, 2017 and October 23, 2017, the NRC administered operator licensing examination to fourteen (14) Reactor Operators (RO) license candidates and four Senior Reactor Operator (SRO) license candidates. Two RO candidates failed the written exam.

REPORT DETAILS

1. Examiner: Paulette Torres, Examiner, NRC

2. Results:

	RO PASS/FAIL	SRO PASS/FAIL	TOTAL PASS/FAIL
Written	12/2	1/0	13/2
Operating Tests	14/0	4/0	18/0
Overall	12/2	1/0	13/2

3. Exit Meeting:
Paulette Torres, Chief Examiner, NRC
Melinda, Krahenbuhl, Director Reed Reactor Facility

Per discussion with the facility, prior to administration of the examination, adjustments to the written exam were accepted. At the exit meeting, the NRC examiner thanked the facility for their support in the administration of the examination.

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

FACILITY: Reed College

REACTOR TYPE: TRIGA

DATE ADMINISTERED: 10/20/2017

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

A. RX THEORY, THERMO & FAC OP CHARS

A N S W E R S H E E T

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

A01 a b c d ___

A02 a b c d ___

A03 a b c d ___

A04 a b c d ___

A05 a b c d ___

A06 a b c d ___

A07 a b c d ___

A08 a b c d ___

A09 a b c d ___

A10 a b c d ___

A11 a b c d ___

A12 a b c d ___

A13 a b c d ___

A14 a b c d ___

A15 a b c d ___

A16 a b c d ___

A17 a b c d ___

A18 a b c d ___

A19 a b c d ___

A20 a b c d ___

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

B. NORMAL/EMERG PROCEDURES & RAD CON

A N S W E R S H E E T

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

B01 a b c d ___

B02 a b c d ___

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 *****)

C. PLANT AND RAD MONITORING SYSTEMS

A N S W E R S H E E T

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

C01 a b c d ___

C02 a b c d ___

C03 a b c d ___

C04 a b c d ___

C05 a b c d ___

C06 a b c d ___

C07 a b c d ___

C08 a ___ b ___ c ___

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 ___

(***** 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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$\frac{A_T}{A_0} = \frac{1}{2^n}$$

DR – Rem, 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/hr/lbm/°F

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/sec/gm/°C

REED COLLEGE

Operator Licensing Examination

Week of October 16, 2017 and October 23, 2017

QUESTION A.01 [1.0 point]
All unique combinations of protons and neutrons are referred to as _____.

a. Isobars

b. Isotones

c. Isotopes

d. Nuclides

QUESTION A.02 [1.0 point]
The energy equivalence of one electron is:

a. 511 keV

b. 931 keV

c. 1022 keV

d. 1.6 E^{-19} keV

QUESTION A.03 [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. Critical

b. Subcritical

c. Supercritical

d. Delayed critical

QUESTION A.04 [1.0 point]
Which type of neutron interaction (light nuclei) is most important in moderating fast neutrons to thermal energies?

a. Radiative capture

b. Elastic scattering

c. Inelastic scattering

d. Charged particle reactions

QUESTION A.05 [1.0 point]
Crystal scintillators are not suitable for detecting the _____ particles produced by tritium.

a. Low Energy Beta

b. Low Energy Gamma

c. High Energy Beta and High Energy Gamma

d. Low Energy Beta and High Energy Gamma

QUESTION A.06 [1.0 point]
Which ONE of the following types of neutrons has a mean neutron generation lifetime of about 12 seconds?

a. Prompt

b. Delayed

c. Fast

d. Thermal

QUESTION A.07 [1.0 point]
During the neutron cycle from one generation to the next, several processes occur that may increase or decrease the available number of neutrons. Which ONE of the following factors describes an increase in the number of neutrons during the cycle?

a. Thermal Utilization Factor

b. Resonance Escape Probability

c. Thermal Non-Leakage Probability

d. Fast Fission Factor

QUESTION A.08 [1.0 point]
Which ONE of the following correctly describes the relationship between differential rod worth (DRW) and integral rod worth (IRW)?

a. DRW is the slope of the IRW curve at a given location.

b. DRW is the area under the IRW curve at a given location.

c. DRW is the square root of the IRW curve at a given location.

d. There is no relationship between DRW and IRW.

QUESTION A.09 [1.0 point]
Which ONE of the following describes the response of the reactor to equal amounts of reactivity insertion as the reactor approaches critical (K_{eff} = 1.0)? The change in neutron population per reactivity insertion is:

a. Larger, and it requires a longer time to reach a new equilibrium count rate.

b. Larger, and it takes an equal amount of time to reach a new equilibrium count rate.

c. Smaller, and it requires a shorter time to reach a new equilibrium count rate.

d. Smaller, and it requires a longer time to reach a new equilibrium count rate.

QUESTION A.10 [1.0 point]
Which ONE of the following factors has a long term effect on K_{eff} but is of no consequence during short term and transient operation?

a. Fuel burnup

b. Increase in fuel temperature

c. Increase in moderator temperature

d. Xenon and Samarium fission products

QUESTION A.11 [1.0 point]
Fuel is being loaded into the core. The operator is using a 1/M plot to monitor core loading. Which ONE of the following conditions would result in a non-conservative prediction of core critical mass, i.e., the reactor would reach criticality prior to the predicted critical mass?

a. The detector is too close to the source and the fuel.

b. The detector is too far away from the source and the fuel.

c. A fuel element is placed between the source and the detector.

d. Excessive time is allowed between fuel elements being loaded.

QUESTION A.12 [1.0 point]
Which ONE of the following statements is the predominant factor for the change in Xenon concentration following a reactor scram?

a. The concentration of ^{135}Xe will decrease by natural decay into ^{135}I.

b. The concentration of ^{135}Xe will increase due to reduced nuclear flux.

c. The concentration of ^{135}Xe will increase due to the decay of the ^{135}I inventory.

d. The concentration of ^{135}Xe will remain constant until it is removed via neutron burnout during the subsequent reactor startup.

QUESTION A.13 [1.0 point]
Following a scram, the shortest stable negative period is limited to -80 seconds as determined by the rate of decay of _____.

a. Mean Neutron Lifetime

b. Shortest Lived Delayed Neutron

c. Longest Lived Delayed Neutron

d. Fast Neutrons

QUESTION A.14 [1.0 point]
An initial count rate of 100 is doubled five times during startup. Assuming an initial K_{eff} = 0.950, what is the new K_{eff}?

a. 0.957

b. 0.979

c. 0.988

d. 0.995

QUESTION A.15 [1.0 point]
Which ONE of the following increases both the Fast Non-Leakage Probability (P_f) and the Thermal Non-Leakage Probability (P_{th}) in the six factor formula?

a. Adding Reflector

b. Raising Control Rods

c. Decreasing Enrichment

d. Increasing Moderator/Fuel Ratio

QUESTION A.16 [1.0 point]
During a Subcritical Multiplication "1/M" plot, data is required to be taken. What does the 1/M represent?

a. The inverse of fuel elements presented in the core.

b. The inverse of the moderator coefficient of reactivity.

c. The inverse migration length of neutrons of varying energies.

d. The inverse multiplication of the count rate between generations.

QUESTION A.17 [1.0 point]
INELASTIC scattering is the process by which a neutron collides with a nucleus and:

a. Is absorbed, with the nucleus emitting a gamma ray.

b. Recoils with the same kinetic energy it had prior to the collision.

c. Recoils with a lower kinetic energy than it had prior to the collision, with the nucleus emitting a gamma ray.

d. Recoils with a higher kinetic energy than it had prior to the collision, with the nucleus emitting a gamma ray.

QUESTION A.18 [1.0 point]
Which ONE is true about "core excess reactivity"?

a. Ensures that the reactor can be shut down from any operating condition.

b. Ensures that the fuel temperature safety limit will not be exceeded.

c. It is the change in reactivity caused by control rod motion.

d. It is the amount of reactivity in excess of the amount of reactivity needed to make the reactor critical.

QUESTION A.19 [1.0 point]
Reactor Power increases from 15 watts to 65 watts in 31 seconds. The period of the reactor is:

a. 7 seconds

b. 14 seconds

c. 21 seconds

d. 28 seconds

QUESTION A.20 [1.0 point]
What happens to the neutron flux, to keep power constant, as fuel depletion occurs?

a. Decreases, due to the increase in fission product poisons.

b. Increases, in order to compensate for fuel depletion.

c. Decreases, because fuel is being depleted.

d. Remains the same.

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

QUESTION B.01 [1.0 point]
Based on 10 CFR 55, which ONE of the following is the MINIMUM requirement that must be met to retain an active Reactor Operator license? Must perform license duties:

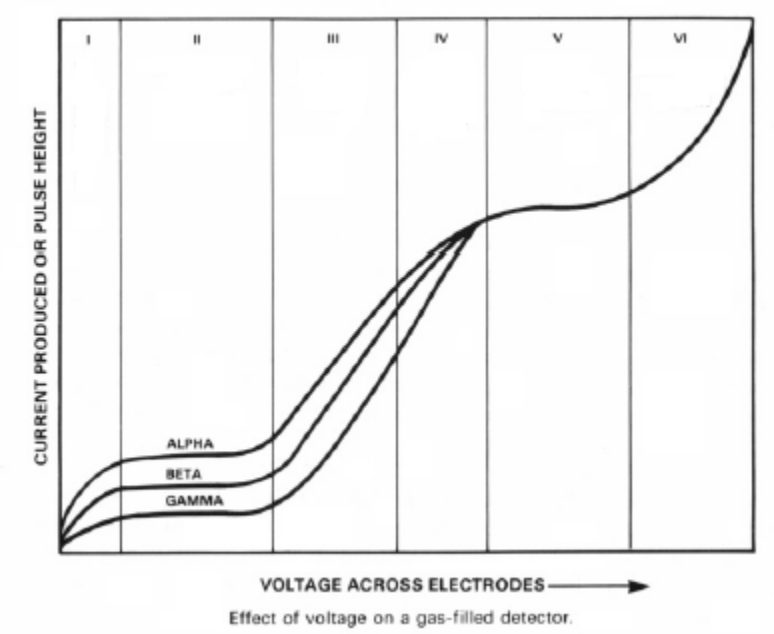
a. A minimum of 8 hours per month.

b. At least 40 hours per calendar year.

c. A minimum of 4 hours per calendar quarter.

d. A minimum of 5 eight-hour shifts per calendar quarter.

QUESTION B.02 [1.0 point]
The figure below is an example of the gas ionization curve for gas-filled detectors. Which ONE of the following Regions corresponds to the GEIGER-MUELLER Region?



Effect of voltage on a gas-filled detector.

a. Region II

b. Region III

c. Region IV

d. Region V

QUESTION B.03 [1.0 point]
The intensity of radiation from a point source is 100 mR/hr at a distance of 12 meters. What is the intensity at 4 meters?

a. 1,800 mR/hr

b. 900 mR/hr

c. 33 mR/hr

d. 11.1 mR/hr

QUESTION B.04 [1.0 point]
10 CFR 20 requires that dose equivalent to the embryo/fetus during the entire pregnancy, due to the occupational exposure of a declared pregnant woman, does not exceed _____.

a. 0.5 rem

b. 5.0 rem

c. 0.1 rem

d. 1.0 rem

QUESTION B.05 [1.0 point]
An individual is accidentally exposed to a mixed gamma and neutron radiation field for 20 minutes. The radiation field from gamma is 30 R/hr, and the radiation field from neutrons of unknown energy is 9 R/hr. What is the individual's total absorbed dose? Refer to the table below.

Radiation	Q
Alpha; heavy recoil nuclei	20
Neutron (fast)	11
Neutron (unknown energy)	10
Neutron (slow)	2
Beta	1
X-ray; gamma	1

a. 10 rem

b. 13 rem

c. 40 rem

d. 39 rem/hr

QUESTION B.06 [1.0 point]
Fuel temperature must be limited in the TRIGA fuel in order to avoid fuel element failure due to which ONE of the following mechanisms?

a. Distortion of the fuel element due to a phase change of the erbium (burnable poison).

b. Fission product built up.

c. Excessive pressure from expansion of Argon-41.

d. Excessive pressure caused by air, fission product gases, and zirconium hydride hydrogen dissociation.

QUESTION B.07 [1.0 point]
The following statement, “The steady-state reactor power level shall not exceed 250 kW.” provided in the Reed Technical Specifications is an example of a (an)….

a. Safety Limit

b. Limiting Safety System Setting (LSS)

c. Limiting Condition For Operation (LCO)

d. Administrative Power Limit

QUESTION B.08 [1.0 point]
While performing a fuel element inspection, you noticed that the sagitta (transverse bend) of one fuel element is 0.0472 inches over the length of the cladding. Which ONE of the following is the correct action to take?

a. Continue the fuel inspection because this bend is within Technical Specifications limit.

b. Continue the fuel inspection because Technical Specifications requires the elongation measurement of the fuel element only.

c. Stop the fuel inspection; immediately report the result to the supervisor because it is considered a damaged fuel element.

d. Stop the fuel inspection, immediately report the result to the U.S. NRC since it is a reportable occurrence.

QUESTION B.09 [1.0 point]
Which ONE of the following conditions meets the Technical Specification definition for “Reactor Secured” at Reed?

a. A single experiment with a reactivity of 0.2% ΔK/K is being installed in the reactor with all control rod fully inserted, the console key switch is in the off position, and the key is removed from the console.

b. The three control rods are fully inserted, the console key switch is in the off position, console key is not removed and no experiments or irradiation facilities in the core are being moved or serviced.

c. The three control rods are fully inserted, the reactor is shutdown, the console key switch is in the off position, the key is removed from the console, no experiments or irradiation facilities in the core are being moved or serviced, and no work is in progress involving core fuel, core structure, installed control rods, or control rod drives.

d. Work in one control rod drive mechanism is in progress with the drive coupled to the control rod and the remaining operable control rods are fully inserted with the console key switch is in the off position, and the console key is removed from the console.

QUESTION B.10 [1.0 point]
One way to calculate Shutdown Margin defined by Technical Specifications is by:

a. Adding the core excess reactivity, adding the worth of the highest-worth rod and worth of the shim rod and subtracting the sum of the control rods worths.

b. Adding the sum of the control rods worths and subtracting the core excess reactivity and adding the worth of the highest-worth rod.

c. Adding the sum of the control rods worths, subtracting the worth of the highest-worth rod and subtracting the core excess reactivity.

d. Adding the core excess reactivity and subtracting the worth of the control rods.

QUESTION B.11 [1.0 point]
_____ are specific instrument readings, or observations; radiation dose or dose rates; or specific contamination levels of airborne, waterborne, or surface-deposited radioactive materials that may be used as thresholds for establishing emergency classes and initiating appropriate emergency methods.

a. Emergency Action Levels

b. Emergency Planning Zones

c. Emergency Implementation Procedures

d. Protective Action Guides

QUESTION B.12 [1.0 point]
The _____ensures that in the event of an emergency RRR personnel on the Emergency Notification Call List (ENCL) will be notified.

a. Community Safety Officer

b. Director

c. Radiation Safety Officer

d. Reactor Operations Manager

QUESTION B.13 [1.0 point]
According to the RRR Emergency Implementation Procedures, which ONE of the following would be classified as an ALERT?

a. A credible bomb threat.

b. A release of fission products with an air particulate monitor (APM) display of ≥ 7.0×10^{-3} $\mu Ci/cm^3$.

c. A fire in the reactor console and the fire department was needed to put out the fire.

d. A security event with a measured or projected cumulative dose at the site boundary ≥ 15 mrem during a 24-period.

QUESTION B.14 [1.0 point]
In accordance with 10 CFR 50.47(b)(11), under what conditions a radiation worker can have exposure in excess of 10 CFR 20 limits?

a. During any emergency.

b. In an emergency, when the exposure is authorized for non-pregnant adults on a once in a lifetime basis.

c. As long as the radiation worker don't exceed 50 rem Total Effective Dose equivalent (TEDE).

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

QUESTION B.15 [1.0 point]
Which ONE of the following monitors corresponds to a 1) Red strobe lights and audible alarm in Control Room, and 2) Red light at the detector and audible beep?

a. Effluent Release

b. Evacuation Alarm

c. Isolation Cycle Indicator

d. Pool temperature Alarm

QUESTION B.16 [1.0 point]
Substantive changes to approved experiments shall be made only after review and approval by the _____.

a. Nuclear Regulatory Commission

b. Reactor Operations Committee

c. Reactor Operations Manager

d. Reactor Director

QUESTION B.17 [1.0 point]
The Senior Reactor Operator must be present in the facility during the following EXCEPT:

a. The first core excess of the day.

b. A return to power following an inadvertent scram.

c. All fuel element or control rod relocation.

d. Fuel temperature calibration.

QUESTION B.18 [1.0 point]
Which ONE of the following is classified as a Notification of Unusual Event?

a. Facility evacuation.

b. Change in pool water level greater than 1 ft.

c. Significant personnel injury.

d. Major contamination of the facility.

QUESTION B.19 [1.0 point]
“Clean Skimmer” is part of the _____ checklist form.

a. Quarterly

b. Bimonthly

c. Semiannual

d. Annual

QUESTION B.20 [1.0 point]
The areas composed of the Control Room, Reactor Bay and Mechanical Room are referred to as the:

a. Vital Area

b. Escorted Area

c. Control Room Area

d. Controlled Access Area

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

QUESTION C.01 [1.0 point]
Which ONE of the following is the control rod guide tube position for the Regulating Rod?

a. C5

b. C9

c. E1

d. F9

QUESTION C.02 [1.0 point]
Which ONE of the following Limit Switch combinations corresponds to an after SCRAM condition?

a. Rod Down: closed, Motor Down: open, Motor Up: closed

b. Rod Down: closed, Motor Down: open, Motor Up: open

c. Rod Down: closed, Motor Down: closed, Motor Up: open

d. Rod Down: open, Motor Down: open, Motor Up: closed

QUESTION C.03 [1.0 point]
Which ONE of the following conditions will cause improper reactor operation?

a. A required reactor power detectors is 95% of nominal voltage.

b. The reactor operator simultaneously withdrawal two control rods.

c. During reactor startup, neutron source count is 1.4 cps.

d. The demineralizer inlet temperature is 40°C.

QUESTION C.04 [1.0 point]
If high airborne radiation readings are shown on the CAM or GSM, the ventilation system:

a. Automatically switch into recirculation mode and goes up the exhaust stack.

b. Switches to the isolation mode.

c. Is in normal operation.

d. Shuts down.

QUESTION C.05 [1.0 point]
Experiments containing _____ shall be doubly encapsulated.

a. Corrosive materials

b. Erosive materials

c. Explosive materials

d. A short half-life material

QUESTION C.06 [1.0 point]
In support of the ALARA program, the Reed Research Reactor goal is to assure that actual exposures are not greater than _____ of the occupational limits.

a. 0.1 %

b. 5 %

c. 10 %

d. 50 %

QUESTION C.07 [1.0 point]
Which ONE of the following is a major contributor to radiation exposure attributed to the Rotary Specimen Rack adjacent to the core?

a. Argon-41

b. Hydrogen-3

c. Nitrogen-16

d. Xenon-131

QUESTION C.08 [1.0 point, 0.33 each]
Match each type of radiation monitor in Column A with its specific function in Column B.

Column A	**Column B**
a. Continuous Air Monitor	1. Monitor air leaving the facility but does not utilize a filter.
b. Gaseous Stack Monitor	2. Measure gamma-ray exposure rates in the reactor bay.
c. Area Radiation Monitors	3. Measure particulates in room air in the reactor bay.

QUESTION C.09 [1.0 point]
The start-up source used in the Reed Research Reactor is a _____ neutron source.

a. Am-Li

b. Am-Be

c. Sb-Be

d. Pu-Be

QUESTION C.10 [1.0 point]
Which ONE of the following conditions when the reactor console is powered ON corresponds to a BLUE console indicator light?

a. When the motor is fully UP.

b. When the motor is fully DOWN.

c. When the magnet is energized, i.e., no scrams.

d. When the motor down and rod down limit switches agree (both close or both open).

QUESTION C.11 [1.0 point]
During reactor operation, the control rods are held in place by the _____.

a. Electromagnets

b. Potentiometer

c. Armature

d. Piston

QUESTION C.12 [1.0 point]
Each fuel element contains a top and bottom reflector plugs which are made of _____.

a. Graphite

b. Zirconium

c. Stainless Steel

d. Zirconium Hydride

QUESTION C.13 [1.0 point]
Which ONE of the following design features prevents the accidental siphoning of reactor pool water?

a. Reaching water capacity in one of the two demineralizer tanks.

b. The turbulence of the primary coolant deflector nozzle.

c. An increase in differential pressure difference between the pressure gauges on either side of the heat exchanger.

d. A hole located in the discharge pipe, 40 inches below the surface of the water.

QUESTION C.14 [1.0 point]
Which ONE of the following experimental facilities provides access to the point of maximum flux in the core?

a. The Gamma Irradiation Facility

b. Central Thimble

c. Pneumatic Transfer System

d. Rotary Specimen Rack

QUESTION C.15 [1.0 point]
What kind of detector feeds the Log Channel?

a. Fission Chamber

b. Compensated Ion Chamber

c. Uncompensated Ion Chamber

d. Scintillation

QUESTION C.16 [1 point]
Which ONE of the following temperature measuring devices operates on the principle that when two dissimilar metals are joined in two places, and there is a temperature difference between the junctions, the metals will respond to the temperature difference differently?

a. Resistance Temperature Detector

b. Bimetallic Thermometer

c. Thermocouple

d. Thermistor

QUESTION C.17 [1.0 point]
There are small holes (0.314 inches (0.798 cm) in diameter) drilled at various positions in the top and bottom grid plates. These holes are provided in order to:

a. Ensure unimpeded coolant flow through the core.

b. Ensure proper alignment of the top and bottom grid plates.

c. Permit insertion of wires or foils into the core to obtain flux data.

d. Allow thermocouple leads from instrumented fuel elements to pass out of the core.

QUESTION C.18 [1.0 point]
The pool water serves all of the following functions EXCEPT:

a. Allows for cooling of the reactor core through natural convection.

b. Shields the reactor bay from radiation generated in the core.

c. Minimize corrosion of all reactor components.

d. Moderates neutrons in the core.

QUESTION C.19 [1.0 point]
The fuel-moderator elements are:

a. 20% enriched uranium clad with zirconium.

b. Heterogeneous elements clad with stainless steel, consisting of 8.5% enriched uranium.

c. Heterogeneous elements clad with stainless steel, consisting of 20% enriched uranium.

d. 8.5% enriched uranium clad with zirconium.

QUESTION C.20 [1.0 point]
To establish proper flow through the water-purification loop, a stainless steel orifice assembly is installed in the piping from the heat exchanger. Which ONE of the following is the amount of water that DOES NOT flow through the orifice and passes through the purification loop instead?

a. 10 gpm

b. 20 gpm

c. 100 gpm

d. 120 gpm

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

A.01
Answer: d
REF: Reed Training Manual, Section 2.2, pg. 13

A.02
Answer: a
REF: Reed Training Manual, Section 3.1, pg. 33

A.03
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.04
Answer: b
REF: Lamarsh 3rd ed., Section 3.6, pg. 68-71
Basic Nuclear Engineering 4th ed., Slowing Down of Neutrons, pg. 226-227

A.05
Answer: a
REF: Reed Training Manual, Section 5.3, pg. 88
Chart of the nuclides. Tritium is the lowest energy beta emitter known with a total transition, or endpoint, energy of 18.6 keV.

A.06
Answer: b
REF: Reed Training Manual, Section 9.6, pg. 142
DOE Handbook, Volume 1, NP-02, pg. 31

A.07
Answer: d
REF: Reed Training Manual, Section 8.2, pg. 126
DOE Handbook, Volume 2, NP-03, pg. 3

A.08
Answer: a
REF: DOE Handbook, Volume 2, NP-03, “Integral and Differential Control Rod Worth”, pg. 52

A.09
Answer: a
REF: Burns, Section 5.3, pg. 5-7

A.10
Answer: a
REF: Reed Training Manual, Section 8.3, pg. 130
Burns, Session 3.3.2, pg. 3-18

A.11
Answer: b
REF: Burns, Section 5.5, pg. 5-18

A.12
Answer: c
REF: Reed Training Manual, Section 10.4, pg. 168
DOE Handbook, Volume 2, NP-03, pg. 38

A.13
Answer: c
REF: Reed Training Manual, Section 9.7, pg. 144-145
Burns, Section 4.5, pg. 4-12 to 4-16

A.14
Answer: d
REF: $CR_1/CR_2 = (1 - K_{eff2})/(1 - K_{eff1})$; $CR_1=100$, $CR_2= 100 \times 2 \times 5 = 1000$, $K_{eff1} = 0.950$
$100/1000 = (1 - K_{eff2})/(1 - 0.95)$, $0.1 = (1 - K_{eff2}) / 0.05$, $0.005 = (1 - K_{eff2})$, $K_{eff2} = 0.995$

A.15
Answer: a
REF: Reed Training Manual, Review of Chapter 8, pg. 135

A.16
Answer: d
REF: Reed Training Manual, Section 8.4, pg. 130-134
DOE Handbook, Volume 2, NP-04, “Subcritical Multiplication”, pg. 1-9

A.17
Answer: c
REF: Reed Training Manual, section 3.3, pg. 40
DOE Handbook, Volume1, Module 1, “Inelastic Scattering”, pg. 45

A.18
Answer: d
REF: Reed Training Manual, Section 10.1, pg. 151
TS Section 3.1.3, pg. 8 (Answer for a and b is shutdown margin)
DOE Handbook, Volume 2, Module 3, p. 50 (Answer for c is control rod worth)

A.19
Answer: c
REF: $P = P_0 e^{t/T}$, $\ln(65/15) = 31 \text{ sec}/T$
$T = (31 \text{ sec})/(\ln 4.3333) = 21.14$

A.20
Answer: b
REF: Burns, Problem 3.4.8, pg. 3-35

B.01
Answer: c
REF: 10 CFR 55.53(e)

B.02
Answer: d
REF: Reed Training Manual, Figure 5.2, pg. 78

B.03
Answer: b
REF: $DR_1d_1^2 = DR_2d_2^2$
$100\ mR/hr \times (12\ m)^2 = DR_2 \times (4\ m)^2$
$DR_2 = 900\ mR/hr$

B.04
Answer: a
REF: Reed Training Manual, Section 4.6, pg. 70
10 CFR 20.1208 (a)

B.05
Answer: c
REF: Reed Training Manual, Section 4.2, pg. 53-54
10 CFR 20.1004

Radiation	Absorbed dose (D)	Exposure time	Quality factor (Q)	Effective Dose equivalent (exposure time x D x Q)
Gamma	30 R/hr	20 min	1	30 R/hr x 1hr/60 min x 20 min x 1 = 10 rem
Neutrons of unknown energy	9 R/hr	20 min	10	9 R/hr x 1hr/60 min x 20 min x 10 = 30 rem
			Total absorbed exposure:	10 rem + 30 rem = 40 rem

B.06
Answer: d
REF: TS 2.1 Basis, pg. 4

B.07
Answer: c
REF: TS 3.1.1, pg. 6

B.08
Answer: a
REF: TS 3.1.4 (c), pg. 9

B.09
Answer: c
REF: TS 1, pg. 2

B.10
Answer: c
REF: TS 3.1.2 Basis, pg. 7

B.11
Answer: a
REF: EP 2, pg. 2

B.12
Answer: a
REF: EP 7.1, pg. 13

B.13
Answer: d
REF: Emergency Implementation Procedures, pg. 38

B.14
Answer: b
REF: EP 3.5, pg. 8

B.15
Answer: a
REF: EP Appendix C, Table 3, pg. 22

B.16
Answer: b
REF: Administrative Procedures, Section 2.2.3, pg. 5

B.17
Answer: d
REF: Administrative Procedures, Section 3.1.2, pg. 6

B.18
Answer: b
REF: Emergency Implementation Procedures, pg. 3 of 65

B.19
Answer: d
REF: SOP 26A, Annual Checklist Form, pg. 1 of 1

B.20
Answer: d
REF: SOP 65.5.1, pg. 3 of 8

C.01
Answer: c
REF: Reed Training Manual. Section 11.3, pg. 182

C.02
Answer: b
REF: Reed Training Manual. Section 11.3, Table 11.1, pg. 185

C.03
Answer: b
REF: SAR 7.3, pg. 7-7
TS 3.4.3, Table 2, pg. 13

C.04
Answer: b
REF: Reed Training Manual, Section 11.9, pg. 194

C.05
Answer: a
REF: TS 3.6.2 b., pg. 19

C.06
Answer: c
REF: SAR 11.1.3.1, pg. 11-14

C.07
Answer: a
REF: SAR 1.2.2, pg. 1-3

C.08
Answer: a. 3, b. 1, c. 2
REF: SAR, Table 11.10, pg. 11-15
Reed Facility Reference Manual, Section 3.6, pg. 34-35

C.09
Answer: b
REF: Reed Training Manual, Section 7.7, pg. 121
SAR 9.5, pg. 9-6

C.10
Answer: d
REF: Reed Training Manual, Section 11.3, pg. 183 and Table 11.1, pg. 185

C.11
Answer: a
REF: SAR 3.6, pg. 3-3

C.12
Answer: a
REF: SAR 4.2.4, pg. 4-7

C.13
Answer: d
REF: Reed Training Manual, Section 11.6, pg. 191

C.14
Answer: b
REF: SAR 10.2.1, pg. 10-1

C.15
Answer: a
REF: Reed Training Manual, Section 11.8, pg. 193

C.16
Answer: c
REF: Reed Training Manual, Section 11.6, pg. 191

C.17
Answer: c
REF: SAR 4.2.3, pg. 4-5

C.18
Answer: c
REF: Reed Training Manual, Section 11.6, pg. 188-189

C.19
Answer: c
REF: SAR 1.3.3, pg. 1-5, SAR Table 1.1, pg. 1-12

C.20
Answer: b
REF: Reed Training Manual, Section 11.6, pg. 189
Reed Facility Reference Manual, Section 2.2.5, pg. 24