August 12, 2015

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

SUBJECT: EXAMINATION REPORT NO. 50-288/OL-15-02, REED COLLEGE

Dear Dr. Krahenbuhl:

During the weeks of May 4 and May 11, 2015, the U.S. Nuclear Regulatory Commission (NRC) administered operator licensing examinations at your Reed College 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 Ms. Christina Barrett, Operations Supervisor, at the conclusion of the examinations.

In accordance with Title 10 of the *Code of Federal Regulations,* Section 2.390, a copy of this letter and 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 publicly released. Should you have any questions concerning these examinations, please contact Ms. Michele DeSouza at (301) 415-1169 or via e-mail Michele.DeSouza@nrc.gov.

Sincerely,

/RA/

Kevin Hsueh, Chief
Research and Test Reactors Oversight Branch
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Docket No. 50-288

Enclosures: 1. Examination Report No. 50-288/OL-15-02
2. Written Examination

cc: w/o enclosures: See next page

Dr. Melinda Krahenbuhl, Director
Reed Reactor Facility
3203 SE Woodstock Blvd.
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Facility File (CRevelle) O-07 F-08

ADAMS ACCESSION #: ML15180A071 **TEMPLATE #:NRR-079**

OFFICE	NRR/DPR/PROB:CE		NRR/DPR/PROB/OLA		NRR/DPRPROB:BC	
NAME	MDeSouza		CRevelle		KHsueh	
DATE	06/24/2015		07/30//2015		08/12/2015	

OFFICIAL RECORD COPY

cc:

Mayor of the City of Portland
1220 Southwest 5th Avenue
Portland, OR 97204

Dr. Nigel Nicholson, Dean of Faculty
Reed College
3203 SE Woodstock Boulevard
Portland, OR 97202-8199

Mr. John Kroger, President
Reed College
3203 SE Woodstock Boulevard
Portland, OR 97202-8199

Division Administrator
Nuclear Safety Division
Oregon Department of Energy
625 Marion Street NE
Salem, OR 97304-3737

Program Director
Radiation Protection Services
Public Health Division
Oregon Health Authority
800 NE Oregon Street, Suite 640
Portland, OR 97232-2162

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.: 50-288/OL-15-02

FACILITY DOCKET NO.: 50-288

FACILITY LICENSE NO.: R-112

FACILITY: Reed College

EXAMINATION DATES: May 4-12, 2015

SUBMITTED BY: **/RA/** **06/24/2015**
Michele DeSouza, Chief Examiner Date

SUMMARY:

During the weeks of May 4 and May 11, 2015, the NRC administered operator licensing examinations to fifteen Reactor Operator and seven Senior Reactor Operator candidates. The Reactor Operator and Senior Reactor Operator candidates passed all applicable portions of the examinations.

REPORT DETAILS

1. Examiners: Michele DeSouza, NRC
Patrick Isaac, NRC
John Nguyen, NRC

2. Results:

	RO PASS/FAIL	SRO PASS/FAIL	TOTAL PASS/FAIL
Written	15/0	0/0	15/0
Operating Tests	15/0	7/0	22/0
Overall	15/0	7/0	22/0

3. Exit Meeting:

Michele DeSouza, Chief Examiner, NRC
Melinda Krahenbuhl, Director
Christina Barrett, Operations Supervisor

Upon completion of the examinations, the NRC examiner met with facility staff representatives to discuss the results. At the conclusion of the meeting, the NRC examiner thanked the facility for their support in the administration of the examinations.

ENCLOSURE 1

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

FACILITY: Reed College

REACTOR TYPE: Reed TRIGA

DATE ADMINISTERED: 5/04/2015

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	33.3	_____	_____	A. REACTOR THEORY, THERMODYNAMICS AND FACILITY OPERATING CHARACTERISTICS
19.00	33.3	_____	_____	B. NORMAL AND EMERGENCY OPERATING PROCEDURES AND RADIOLOGICAL CONTROLS
20.00	33.3	_____	_____	C. FACILITY AND RADIATION MONITORING SYSTEMS
58.00		_____ FINAL GRADE	_____ %	TOTALS

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

_____
Candidate's Signature

ENCLOSURE 2

Category A: Reactor Theory, Thermodynamics, & 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 ___ (0.25 each)

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 Operating 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 ___ (0.33 each)

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 ___ (0.33 each)

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 ___ (0.25 each)

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 ___ (0.25 each)

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

1 kg = 2.21 lb

1 Horsepower = 2.54 x 10^3 BTU/hr

1 Mw = 3.41 x 10^6 BTU/hr

1 BTU = 778 ft-lb

°F = 9/5 °C + 32

1 gal (H_2O) ≈ 8 lb

°C = 5/9 (°F - 32)

c_P = 1.0 BTU/hr/lb/°F

c_p = 1 cal/sec/gm/°C

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

QUESTION A.01 [1.0 point]
The reactor is shutdown after a 10 hour run at full power. What is the approximate time it will take Xenon to reach its peak?

a. 8 hours

b. 16 hours

c. 24 hours

d. 32 hours

QUESTION A.02 [1.0 point]
Reactor is critical. What would be the corresponding k_{eff} when removing 0.05 $\Delta k/k$ from its criticality?

a. 0.9951

b. 0.9524

c. 0.9750

d. 1.0526

QUESTION A.03 [1.0 point, 0.25 each]
Match the following Neutron Interactions (each used only once)

a. Fission	1. Neutron enters nucleus, forms a compound nucleus, then decays by gamma emission
b. Radiative capture	2. Particle enters nucleus, forms a compound nucleus and is excited enough to eject a new particle with incident neutron remaining in nucleus
c. Scattering	3. Nucleus absorbs neutron and splits into two similarly sized parts
d. Particle ejection	4. Nucleus is struck by a neutron and emits a single neutron

QUESTION A.04 [1.0 point]
Which ONE of the following is a correct statement of how delayed neutrons enhance the ability to control reactor power?

a. Prompt neutrons can cause fissions in both U-235 and U-238 and delayed neutrons can only cause fissions in U-235

b. Delayed neutrons are born at higher energy levels than prompt neutrons

c. The average number of delayed neutrons produced per fission is higher than the average number of prompt neutrons

d. Delayed neutrons increase the average neutron lifetime that allows a reactor to be controlled

QUESTION A.05 [1.0 point]
The following shows part of a decay chain for the radioactive element Pa-234:
$_{91}Pa^{234} \rightarrow {}_{92}U^{234}$
This decay chain is an example of _____ decay.

a. Alpha

b. Beta

c. Gamma

d. Neutron

QUESTION A.06 [1.0 point]
Assume that the worths of the Shim rod is $3.70, Safety rod is $4.45, and Reg rod is $2.10. The reactor is critical at 15 W after WITHDRAWING the following control rod worths: Shim $2.10, Safety $3.50, and Reg $1.50. What is the CORE EXCESS?

a. $2.85

b. $3.15

c. $5.50

d. $7.10

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

QUESTION A.07 [1.0 point]
An ideal moderator for thermalizing neutrons is light water. Which ONE of the following correctly describes the nuclear properties of an ideal moderator?

a. Small energy loss per collision

b. Small Doppler Broadening effect

c. Large scattering cross section

d. Large absorption cross section

QUESTION A.08 [1.0 point]
Two common FISSION PRODUCTS that have especially large neutron cross sections and play a significant role in reactor physics are Xe-135 and _____.

a. Nitrogen-16

b. Argon-41

c. Iodine-131

d. Samarium-149

Question deleted prior to administration of the examination based on facility comment
~~**QUESTION A.09 [1.0 point]**~~
~~Which ONE of the following best describes the effects moderator temperature increase has on neutron multiplication?~~

~~a. Resonance escape probability increase, thermal non-leakage decrease, and rod worth increase~~

~~b. Resonance escape probability increase, thermal non-leakage increase, and rod worth decrease~~

~~c. Resonance escape probability decrease, thermal non-leakage decrease, and rod worth increase~~

~~d. Resonance escape probability decrease, thermal non-leakage decrease, and rod worth decrease~~

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

QUESTION A.10 [1.0 point]
Which ONE of the following best represents a characteristic of subcritical multiplication?

a. The number of neutrons gained per generation increases by a factor of 2 for each succeeding generation

b. For equal reactivity additions, it takes less time for the equilibrium subcritical neutron population level to be reached as k_{eff} approaches one

c. A constant neutron population is achieved when the total number of neutrons produced in one generation is equal to the number of source neutrons in the next generation

d. Doubling the indicated power will reduce the margin to criticality by approximately one half

QUESTION A.11 [1.0 point]
A subcritical reactor, k_{eff} is increased from 0.914 to 0.96. Which ONE of the following is the amount of reactivity that was added to the core?

a. 3.64%Δk/k

b. 4.38%Δk/k

c. 5.78%Δk/k

d. 6.57%Δk/k

QUESTION A.12 [1.0 point]
Which ONE of the following isotopes will absorb neutrons quickly when it interacts with neutrons?

a. Hydrogen-1

b. Oxygen-16

c. Boron-10

d. Uranium-235

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

QUESTION A.13 [1.0 point]
Core excess reactivity changes with _____.

a. Fuel element burnup

b. Control rod height

c. Neutron energy level

d. Reactor power level

QUESTION A.14 [1.0 point]
Which ONE of the following is the reason for the 80 second period following a reactor scram?

a. Amount of negative reactivity added on a scram exceeds the shutdown margin

b. Longest lived delayed neutron precursors decay constant

c. Fuel temperature coefficient adding positive reactivity

d. Uranium-235 affinity for source neutrons

QUESTION A.15 [1.0 point]
The reactor is on a CONSTANT positive period. Which ONE of the following power changes will take the SHORTEST time to complete?

a. From 100 kW to 150 kW

b. From 10 kW to 20 kW

c. From 10 W to 30 W

d. From 1 W to 5 W

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

QUESTION A.16 [1.0 point]
Which ONE of the following is the reason for an installed neutron source within the reactor core? A startup without an installed neutron source _____.

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

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

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

d. Would be very slow due to the long time to build up the neutron population from such a low level

QUESTION A.17 [1.0 point]
Which ONE of the following combinations of characteristics makes a good reflector?

	Scattering Cross Section	Absorption Cross Section
a.	Low	Low
b.	Low	High
c.	High	Low
d.	High	High

QUESTION A.18 [1.0 point]
Which ONE of the following parameters is MOST significant in determining the differential rod worth of a control rod?

a. Fuel temperature

b. Flux shape

c. Reactor power

d. Rod speed

QUESTION A.19 [1.0 point]
Given a source strength of 150 neutrons per second (N/sec) and a multiplication factor of 0.7, which ONE of the following is the expected stable neutron count rate?

a. 150 N/sec

b. 250 N/sec

c. 400 N/sec

d. 500 N/sec

QUESTION A.20 [1.0 point]
Which ONE of the following is the **MAJOR** source of energy released during fission?

a. Fission fragments

b. Fission product decay

c. Prompt gamma rays

d. Fission neutrons (kinetic energy)

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

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.01 [1.0 point]
Which ONE of the following conditions is a violation of Technical Specifications, reactor primary pool water?

a. Conductivity of the pool water is 4 uSiemens/cm averaged over one month

b. Bulk temperature of the coolant is 45^{o}C during reactor operation

c. Radioactivity in the pool water is 0.2 µCi/ml

d. Pool water pH is 5.7

QUESTION B.02 [1.0 point]
Per Reed Emergency Plan, OFFSITE is defined as the geographical area that is _____.

a. 200 feet beyond the Reed College campus

b. 200 feet beyond the operations boundary

c. Beyond the Reed College campus

d. Beyond the site boundary

QUESTION B.03 [1.0 point]
Which ONE of the following is the definition for "Annual Limit on Intake"?

a. The concentration of a radionuclide in air which, if inhaled by an adult worker for a year, results in a total effective dose equivalent of 100 mrem

b. The effluent concentration of a radionuclide in air which, if inhaled continuously over a year, would result in a total effective dose equivalent of 50 mrem for noble gases

c. 10CFR20 derived limit, based on a Committed Effective Dose Equivalent of 5 rem whole body or 50 rems to any individual organ, for the amount of radioactive material inhaled or ingested in a year by an adult worker

d. Projected dose commitment to individuals that warrant protective action following a release of radioactive material

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.04 [1.0 point]
Which ONE of the following is **NOT** a responsibility of the SRO and RO?

a. Review of fuel movement or core configuration changes

b. Insertion and removal of experiments

c. Participation in requalification program

d. Preparation of logs and records of reactor operations

QUESTION B.05 [1.0 point]
Per Reed Technical Specifications, what is the MINIMUM level of management who may direct relocation of any in-core experiment with reactivity worth greater than one dollar?

a. Reactor Director

b. Operations Supervisor

c. SRO at the facility

d. SRO on call

Question deleted prior to administration of the examination based on facility comment
~~**QUESTION B.06 [1.0 point]**~~
~~Which medical facility is preferred to provide care for contaminated injured individuals?~~

~~a. Legacy Good Samaritan~~

~~b. Mount Sinai~~

~~c. Providence~~

~~d. Kaiser Permanente~~

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.07 [1.0 point]
How long will it take a 50 Curie source, with a half-life of 5.26 years, to decay to 2 Curie?

a. 10.5 Years

b. 15.5 Years

c. 24.5 Years

d. 35.5 Years

QUESTION B.08 [1.0 point]
Which ONE of the following logbook entries would be made in **BLACK WITH GREEN UNDERLINE**?

a. Removal of fuel element from core

b. Failure of primary water pump

c. Removal of neutron source from core

d. Reactor scram due to electrical transient

QUESTION B.09 [1.0 point, 0.33 each]
Per Reed Emergency Classification match the emergency class with the emergency action level (Use each only once):

Column A

a. Calculated radiological effluent, DDE of 20 mrem/hr for 1 hour

b. A fire in the control room

c. Significant personnel injury

Column B

1. Not classified
2. Notification of Unusual Event
3. Alert

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.10 [1.0 point]
10 CFR 20 limits the annual occupational exposure to the WHOLE BODY of an individual to:

a. 50 rem

b. 15 rem

c. 100 rem

d. 5 rem

QUESTION B.11 [1.0 point]
"The steady state reactor power level shall not exceed 250 kW." This is an example of:

a. Safety Limit

b. Limiting Safety System Setting

c. Limiting Conditions for Operation

d. Safety Operational Limit

QUESTION B.12 [1.0 point]
Calculate an individual's total whole body dose given the individual received the following doses: 5 mrad of alpha, 10 mrad of gamma, and 10mrad of neutron (unknown energy)

a. 190 mrem

b. 200 mrem

c. 210 mrem

d. 220 mrem

QUESTION B.13 [1.0 point]
You are standing three feet from a radiation field of 250 mR/hr. What is your dose rate at 9 feet away from the source?

a. 24 mR/hr

b. 28 mR/hr

c. 32 mR/hr

d. 36 mR/hr

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.14 [1.0 point]
Based on the Reed Requalification Plan, each operator must perform the functions of a licensed operator to maintain an "active" operator's license a MINIMUM of _____.

a. 24 hours per year

b. 8 hours per quarter

c. 4 hours per month

d. 4 hours per quarter

QUESTION B. 15 [1.0 point]
Which ONE of the following must be performed on a daily basis prior to reactor operations?

a. Test the low/hi water level alarm

b. Test the evacuation alarm

c. Inventory licensed radioactive material

d. Radiation area monitor check

QUESTION B.16 [1.0 point]
After an emergency building evacuation, who has the authority to allow reentry to the reactor building?

a. Reed College Police Chief

b. Reed College Dean

c. Emergency Coordinator

d. U.S. NRC

QUESTION B.17 [1.0 point]
How far back is the reactor operator required to review the main log prior to performing a reactor startup checklist?

a. 45 days or the last time that operator operated the reactor

b. 30 days or the last time that operator operated the reactor

c. 48 hours or the previous time that operator operated the reactor

d. 24 hours or the previous time that operator operated the reactor

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.18 [1.0 point, 0.33 each]
Match the appropriate item in Column A with its definition in Column B.

Column A	Column B
a. Channel Calibration	1. The introduction of a signal into the channel for verification that it is operable
b. Channel Test	2. An adjustment of the channel such that its output corresponds with acceptable accuracy to known values of the parameter that the channel measures
c. Channel Check	3. Qualitative verification of acceptable performance by observation of channel behavior

QUESTION B.19 [1.0 point]
Which ONE of the following is the radiation dose limit for the public in an unrestricted area?

a. No limit

b. 2 rem in a year

c. 2 rem in any one hour

d. 2 mrem in any one hour

QUESTION B.20 [1.0 point]
A two curie source emits a 2MeV gamma 100% of the time. The source will be placed in the reactor storage building. How far from the source should a high radiation area sign be posted?

a. Not required

b. 10.5 feet

c. 12.5 feet

d. 15.5 feet

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

Category C: Facility and Radiation Monitoring Systems

QUESTION C.01 [1.0 point, 0.25 each]
Match the facility radiation detector in Column A with the type of radiological problem it detects in Column B.

Column A	Column B
a. RAM	1. Gases Only
b. GSM	2. Radiation Level
c. ~~APM~~	3. Particulates Only
d. CAM	4. Gases and Particulates

QUESTION C.02 [1.0 point]
Which ONE of the following is the purpose of the diffuser on the return of the primary coolant system?

a. Increase heat transfer rate due to increased mixing within the core

b. Increase transport time for N^{16} to reach the surface of the pool

c. Breakup O^{16} bubbles in pool, thereby decreasing production of N^{16}

d. Decrease the activation rate of O^{16} to N^{16} due to reduced time in the core

QUESTION C.03 [1.0 point]
Which ONE of the following is the design feature that prevents siphoning of pool water on a failure of the purification system?

a. A valve downstream of the primary pump will shut automatically

b. A valve upstream of the primary pump will shut automatically

c. Vacuum breaks in the system that prevent draining the pool 40 inches below the surface of water

d. The emergency fill system will automatically maintain the pool level

Category C: Facility and Radiation Monitoring Systems

QUESTION C.04 [1.0 point]
During the thermal power calibration, if the percent power channel output is about 5% HIGHER than the calculated thermal power calibration, the reactor operator:

a. Does not need to adjust the percent power channel output

b. Needs to adjust the percent power channel output by physically LOWERING the height of the detectors in the support assembly

c. Needs to adjust the percent power channel output by physically RAISING the height of the detectors in the support assembly

d. Needs to adjust the percent power channel output by adjusting the percent power channel gain

QUESTION C.05 [1.0 point]
Reed Technical Specifications requires fuel elements be stored in a safe array where the k_{eff} is less than _____.

a. 0.6

b. 0.7

c. 0.8

d. 0.9

QUESTION C.06 [1.0 point]
Which ONE of the following materials is inserted in the top and bottom of the active fuel portion of each fuel element to reduce neutron leakage?

a. Aluminum

b. Boron

c. Cadmium

d. Graphite

Category C: Facility and Radiation Monitoring Systems

QUESTION C.07 [1.0 point]
Which ONE of the following will cause a HIGH conductivity reading at the inlet of the demineralizer?

a. Pool water temperature low

b. High reactor water pump flow

c. Reactor water system pressure greater than secondary water pressure

d. Failure of fuel elements

QUESTION C.08 [1.0 point]
The Log channel consists of:

a. A fission chamber, both pre-amplifier and amplifier, and period amplifier

b. A fission chamber, amplifier, and 110% scram

c. A compensated ion chamber, pre-amplifier, and period amplifier

d. An uncompensated ion chamber, amplifier, and 110% scram

QUESTION C.09 [1.0 point]
Which ONE of the following parameters is NOT measured in the primary cooling/purification system loops?

a. Conductivity

b. Temperature

c. Flow rate

d. pH

Category C: Facility and Radiation Monitoring Systems

QUESTION C.10 [1.0 point, 0.25 each]
Match the control rod drive mechanism from Column A with the correct function in Column B.

Column A	Column B
a. Push Rod	1. Provide rod position indication when the electromagnet engages the armature
b. Pull Rod	2. Provide rod full withdrawn indication
c. Piston	3. Provide rod full bottom indication
d. Potentiometer	4. Work with dash pot to slow rod near bottom of its travel

QUESTION C.11 [1.0 point]
What radiological monitoring systems will be inoperable if the stack sampling pump fails?

a. Air particulate monitor and radiation area monitor

b. Air particulate monitor and gaseous stack monitor

c. Radiation area monitor and continuous air monitor

d. Continuous air monitor and air particulate monitor

QUESTION C.12 [1.0 point]
Which ONE of the following describes the correct state of operation when the Reed Reactor ventilation system is in isolation mode?

a. The recirculation damper: CLOSED; the HEPA inlet damper: CLOSED

b. The recirculation damper: CLOSED; the HEPA inlet damper: OPEN

c. The recirculation damper: OPEN; the HEPA inlet damper: OPEN

d. The recirculation damper: OPEN; the HEPA inlet damper: CLOSED

Category C: Facility and Radiation Monitoring Systems

QUESTION C.13 [1.0 point]
Reed Research Reactor uses the Compensated Ion Chamber as what measuring channel?

a. Linear power channel

b. Log power channel

c. Percent power channel

d. Startup channel

QUESTION C.14 [1.0 point]
The reactor is operating at 100 kW. Which ONE of the following experimental facilities provides the HIGHEST neutron flux?

a. Pneumatic transfer system

b. Central thimble facility

c. Rotary specimen rack

d. Single element replacement located at C-ring

QUESTION C.15 [1.0 point]
Which region of the pulse size versus applied voltage characteristic curve does the fission chamber operate?

a. Limited Proportional

b. Ion Chamber

c. Geiger-Mueller

d. Proportional

Category C: Facility and Radiation Monitoring Systems

QUESTION C.16 [1.0 point]
Per Reed SOP 30, what MAXIMUM water temperature would result in an alarm and require an immediate scram of the reactor?

a. 45°C

b. 35°C

c. 30°C

d. 25°C

QUESTION C.17 [1.0 point]
Which ONE of the following statements describes the moderating properties of zirconium-hydride in the Reed TRIGA fuel elements when temperature increases?

a. The ratio of hydrogen atoms to zirconium atoms affects the moderating effectiveness for slow neutrons

b. The probability that a neutron will return to the fuel element before being captured elsewhere is a function of the temperature of the hydride

c. Elevation of the hydride temperature increases the probability that a thermal neutron will escape the fuel-moderator element before being captured

d. The hydride mixture is very effective in slowing down neutrons with energies below 0.025 eV

QUESTION C.18 [1.0 point]
Which ONE of the following conditions will cause the operating reactor to automatically scram?

a. Reactor period = 6 seconds

b. 105% reactor power

c. Bulk pool water temperature = 40°C

d. Loss of high voltage to the percent power channel

Category C: Facility and Radiation Monitoring Systems

QUESTION C.19 [1.0 point]
Which ONE of the following is the neutron absorber in Reed's reactor control rods?

a. Graphite powder

b. Zirconium hydride

c. Boron powder

d. Aluminum oxide

QUESTION C.20 [1.0 point]
Where is the majority of the facility's Ar-41 produced?

a. Reactor lab

b. Reactor bay

c. Pneumatic transfer tube

d. Rotary specimen rack

(***** END OF CATEGORY C *****)
((***** END OF EXAM *****))

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

A.01
Answer: a
Reference: Reed Training Manual, Section 10.4

A.02
Answer: b
Reference: ρ=(k-1)/k-0.05→1=k-(-0.05k)=k(1+0.05)→k=1/1.05 =0.9524

A.03
Answer: a 3 b 1 c 4 d 2
Reference: DOE Fundamentals Handbook *Nuclear Physics and Reactor Theory*, Volume 1, Module 1, Page 43-46

A.04
Answer: d
Reference: Burn, *Introduction to Nuclear Reactor Operations,* Section 3.3.2, Page 3-7

A.05
Answer: b
Reference: Chart of the Nuclides

A.06
Answer: b
Reference: Total Worth = $3.70+$4.45+$2.10=$10.25
Reactivity at 15 W=$2.10+$3.50+$1.50 = $7.10
Core Excess = Total Worth – Reactivity@15 W = $10.25-$7.10= $3.15

A.07
Answer: c
Reference: DOE Fundamentals Handbook *Nuclear Physics and Reactor Theory*, Volume 1, Module 2, Page 24

A.08
Answer: d
Reference: Burn, *Introduction to Nuclear Reactor Operations,* Section 8.1, Page 8-1

Question deleted prior to administration of the examination based on facility comment
~~**A.09**~~
~~Answer: c~~
~~Reference: Burn, *Introduction to Nuclear Reactor Operations,* Section 3.3.2, Page 7-15~~

A.10
Answer: d
Reference: DOE Fundamentals Handbook *Nuclear Physics and Reactor Theory,* Volume 2, Module 4, Pages 1-6

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

A.11
Answer: c
Reference: Burn, *Introduction to Nuclear Reactor Operations*, Section 3.3.4, Page 3-20&21
$\Delta\rho=(k_{eff2}-k_{eff1})/(k_{eff1}*k_{eff2})$ = (0.965-0.914)/(0.965*0.914) = 0.0578Δk/k=5.78%Δk/k

A.12
Answer: c
Reference: Burn, *Introduction to Nuclear Reactor Operations*, Section 2.5.1, Pages 2-38-43

A.13
Answer: a
Reference: Burn, *Introduction to Nuclear Reactor Operations*, Section 6.2.2, Page 6-2

A.14
Answer: b
Reference: Burn, *Introduction to Nuclear Reactor Operations*, Section 4.5, Page 4-12

A.15
Answer: a
Reference: $P=P_oe^{t/T}\rightarrow t=T*\ln(P/P_o)$ assume constant period=1
The smallest ratio of P/P_o is the shortest time to complete

A.16
Answer: c
Reference: Burn, *Introduction to Nuclear Reactor Operations*, Section 5.2.2, Pages 5-2 - 5-4

A.17
Answer: c
Reference: DOE Fundamentals Handbook *Nuclear Physics and Reactor Theory,* Volume 1, Module 2.0, Pages 7-10

A.18
Answer: b
Reference: Burn, *Introduction to Nuclear Reactor Operations*, Section 7.2

A.19
Answer: d
Reference: $CR=S/(1-k)\rightarrow 150/(1-0.7)$ = 500 N/sec

A.20
Answer: a
Reference: Burn*, Introduction to Nuclear Reactor Operations*, Table 3.2, Page 3-5

Category B: Normal/Emergency Operating Procedures and Radiological Controls

B.1
Answer: b
Reference: Reed TS 3.3

B.2
Answer: d
Reference: Reed Emergency Plan definitions

B.3
Answer: c
Reference: 10CFR20.1003

B.4
Answer: a
Reference: Reed Administrative Procedures 1.6

B.5
Answer: c
Reference: Reed TS 6.1.3.c.5

Question deleted prior to administration of the examination based on facility comment

~~**B.6**~~
~~Answer: a~~
~~Reference: Reed Emergency Plan 3.1.13~~

B.7
Answer: c
Reference: $T A = A_{\circ} * e^{-\lambda t}$
$2Ci = 50Ci * e^{-\lambda(t)}$
$Ln(2/50) = -ln2/5.27\ yr*(t)$ --> -3.2189/-0.1315 →
solve for t: 24.47 years

B.8
Answer: b
Reference: Reed SOP 60.17

B.9
Answer: a (3), b (2), c (1)
Reference: Reed Emergency Plan 4

B.10
Answer: d
Reference: 10 CFR 20.1201

B.11
Answer: c
Reference: Reed TS 3.1.1

B.12
Answer: c
Reference: 5mrad Alpha x 20=100mrem, 10mrad Gamma x 1=10mrem, 10mrad neutron x 10 = 100mrem →100mrem+10mrem+100mrem= 210mrem

Category B: Normal/Emergency Operating Procedures and Radiological Controls

B.13
Answer: b
Reference: $I_1D_1^2=I_2D_2^2 \rightarrow$ 250mR/hr@$(3ft)^2=I_2$@$(9ft)^2 \rightarrow$28mR/hr

B.14
Answer: d
Reference: 10CFR55.59

B.15
Answer: d
Reference: Reed, SOP 23

B.16
Answer: c
Reference: Reed Emergency Plan 3.4

B.17
Answer: b
Reference: Reed SOP 1

B.18
Answer: a (2), b (1), c (3)
Reference: TS Chap 1, Definitions

B.19
Answer: d
Reference: 10CFR20.1301(a)(2)

B.20
Answer: d
Reference: I=6CEn=R/hr@ft.$\rightarrow$2Ci x 2Mev x 100% = 24 R/hr@ $(1ft)^2$ =
24 R/hr = 0.1 R/hr@ $D^2 = \sqrt{240}$ R/hr = 15.5 ft.

Category C: Facility and Radiation Monitoring Systems

C.01
Answer: a (2), b (1), ~~c (3)~~, d (3)
Reference: SOP-41A, *RAM Calibration*; SOP-40B,*CAM Calibration*; SOP-40C, *APM Calibration* §32.1*;* SOP-40D, *GSM Calibration* §33.1

C.02
Answer: b
Reference: Reed SAR 5.2.6

C.03
Answer: c
Reference: Reed Training Manual 11.6

C.04
Answer: c
Reference: Reed SOP 33.7.1

C.05
Answer: d
Reference: Reed Technical Specifications 5.5.a

C.06
Answer: d
Reference: Reed Training Manual 10.5

C.07
Answer: d
Reference: Reed Training Manual 11.6

C.08
Answer: a
Reference: Reed Training Manual 11.8 & Figure 11.12

C.09
Answer: d
Reference: Reed Training Manual 11.6

C.10
Answer: a (2), b (3), c (4), d (1)
Reference: Reed SAR 5.2.8, 5.3.1, & 5.3.3

C.11
Answer: b
Reference: Reed Training Manual 5.2.3

C.12
Answer: b
Reference: Reed Training Manual 11.9

C.13
Answer: a
Reference: Reed Training Manual 5.2.2

Category C: Facility and Radiation Monitoring Systems

C.14
Answer: b
Reference: Highest flux in center of core

C.15
Answer: d
Reference: Reed Training Manual 5.2.2 Figure 5.2

C.16
Answer: b
Reference: Reed SOP 30 and Reed SOP 33C

C.17
Answer: c
Reference: Reed SAR, Appendix E; Reed Training Manual 10.6

C.18
Answer: b or d
Reference: Reed TS 3.2.2 & 3.2.3

C.19
Answer: c
Reference: Reed SAR 8.3 & 11.3

C.20
Answer: d
Reference: Reed SAR 7.5