July 13, 2016

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

SUBJECT: EXAMINATION REPORT NO. 50-288/OL-16-01, REED COLLEGE

Dear Dr. Krahenbuhl:

During the weeks of May 2 and May 9, 2016, the U.S. Nuclear Regulatory Commission (NRC) administered an operator licensing examination at your Reed Research 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 those members of your staff identified in the enclosed report, at the conclusion of the examination.

In accordance with Title 10 of the *Code of Federal Regulations,* Section 2.390, a copy of this letter and the enclosures will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records (PARS) component of NRC's Agencywide Documents Access and Management System (ADAMS). ADAMS is accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html. The NRC is forwarding the individual grades to you in a separate letter which will not be released publicly. Should you have any questions concerning this examination, please contact Ms. Michele DeSouza at (301) 415-1169 or via e-mail at Michele.DeSouza@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. 50-288

Enclosures: 1. Examination Report No. 50-288/OL-16-01
2. Written Examination

cc: w/o enclosures: See next page

July 13, 2016

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

SUBJECT: EXAMINATION REPORT NO. 50-288/OL-16-01, REED COLLEGE

Dear Dr. Krahenbuhl:

During the weeks of May 2 and May 9, 2016, the U.S. Nuclear Regulatory Commission (NRC) administered an operator licensing examination at your Reed Research 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 those members of your staff identified in the enclosed report, at the conclusion of the examination.

In accordance with Title 10 of the *Code of Federal Regulations,* Section 2.390, a copy of this letter and the enclosures will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records (PARS) component of NRC's Agencywide Documents Access and Management System (ADAMS). ADAMS is accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html. The NRC is forwarding the individual grades to you in a separate letter which will not be released publicly. Should you have any questions concerning this examination, please contact Ms. Michele DeSouza at (301) 415-1169 or via e-mail at Michele.DeSouza@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. 50-288

Enclosures: 1. Examination Report No. 50-288/OL-16-01
2. Written Examination

cc: w/o enclosures: See next page

DISTRIBUTION w/ encls.:
PUBLIC

ADAMS ACCESSION No.: ML16180A494 **TEMPLATE #:NRR-079**

OFFICE	NRR/DPR/PROB/CE	NRR/DPR/PROB/OLA	NRR/DPR/PROB/BC
NAME	MDeSouza	CRevelle	AMendiola
DATE	06/28/2016	06/28/2016	07/13/2016

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

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 97301-3737

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-16-01

FACILITY DOCKET NO.: 50-288

FACILITY LICENSE NO.: R-112

FACILITY: Reed Research Reactor

EXAMINATION DATES: May 2-10, 2016

SUBMITTED BY: **/RA/** **06/14/2016**
Michele DeSouza, Chief Examiner Date

SUMMARY:
During the weeks of May 2 and May 9, 2016, the NRC administered an operator licensing examination to nine Senior Reactor Operator (SRO) candidates and thirteen Reactor Operator candidates (RO). The Senior Reactor Operator candidates passed all applicable portions of the examinations. Twelve Reactor Operator candidates passed all applicable portions of the examinations. One Reactor Operator candidate failed Category B of the written examination and that same Reactor Operator candidate, due to illness, was unable to complete the operating test.

REPORT DETAILS

1. Examiner: Michele DeSouza, Chief Examiner, NRC

2. Results:

	RO PASS/FAIL	SRO PASS/FAIL	TOTAL PASS/FAIL
Written	12/1	0/0	12/1
Operating Tests	12/1	9/0	21/1
Overall	12/1	9/0	21/1

3. Exit Meeting:
Michele C. DeSouza, Chief Examiner, NRC
John Nguyen, Examiner, NRC
Dr. Melinda Krahenbuhl, Director, Reed Research Facility
Christina Barrett, Reed Operations Manager
Ilana Novakoski, Reed Operations Supervisor

Per discussion with the facility, prior to administration of the examination, adjustments were accepted. Upon completion of the examination, 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 examination.

ENCLOSURE 1

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

FACILITY: Reed Research Facility

REACTOR TYPE: TRIGA

DATE ADMINISTERED: 05/04/2016

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
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

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 ___

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 ___ (0.25 each)

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 ___ (0.25 each)

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 ____ (0.25 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 ___ (0.25 each)

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 ___

C02 a b c d ___

C03 a b c d ___

C04 a b c d ___

C05 a b c d ___

C06 a b c d ___

C07 a b c d ___

C08 a b c d ___

C09 a b c d ___

C10 a b c d ___

C11 a b c 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 ___ (0.33 each)

C20 a ___ b ___ c ___ (0.33 each)

(***** 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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

1 kg = 2.21 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, & Facility Operating Characteristics

QUESTION A.01 [1.0 point]
What is β?

a. The fractional change in neutron population per generation

b. The fraction of all fission neutrons that are born as delayed neutrons

c. The time required for the reactor to change by power by a factor of e

d. The fraction of all delayed neutrons that reach thermal energy

QUESTION A.02 [1.0 point]
Which ONE of the following is the expected stable neutron count rate given a source strength of 300 neutrons per second (N/sec) and a multiplication factor of 0.5?

a. 150 N/sec

b. 300 N/sec

c. 450 N/sec

d. 600 N/sec

QUESTION A.03 [1.0 point]
Which ONE of the following conditions will DECREASE the reactor core excess?

a. Fuel depletion

b. Burnable poison burnout

c. Insertion of a positive reactivity worth experiment

d. Lowering moderator temperature (assume negative temperature coefficient)

QUESTION A.04 [1.0 point]
What are the two common FISSION PRODUCTS that have especially large neutron cross sections and play a significant role in reactor physics?

a. Nitrogen-16 and Argon-41

b. Argon-41 and Cobalt-60

c. Iodine-131 and Cesium-137

d. Xenon-135 and Samarium-149

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

QUESTION A.05 [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

QUESTION A.06 [1.0 point]
Which ONE of the following statements correctly differentiates between operating a reactor with thermal neutrons instead of fast neutrons?

a. The fission cross section of the fuel is much higher for fast neutrons than thermal energy neutrons. Since fast neutrons are easier to cause fission, a reactor cannot control with fast neutrons

b. The neutron lifetime of thermal neutrons is longer than fast neutrons, so the fuel has enough time to capture thermal neutrons

c. The fission cross section of the fuel is much higher for thermal energy neutrons than fast neutrons, so thermal neutrons are easier to cause fission

d. The atomic weight of thermal neutrons is larger than fast neutrons, so thermal neutrons are easy to slow down and be captured by the fuel

QUESTION A.07 [1.0 point]
Which ONE of the following describes the general shape in determining the integral rod worth of a control rod?

a. Parabolic shaped, with the maximum at the top and bottom of the core height

b. S-shaped, with the net change in reactivity from bottom to top

c. Cosine shaped, with the largest change in the middle of the core height

d. Exponentially shaped, with the maximum at the bottom of the core height

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

QUESTION A.08 [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 increase the average neutron lifetime that allows a reactor to be controlled

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

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

QUESTION A.09 [1.0 point]
Which factors of the six factor formula are affected by an INCREASE in core temperature and how are they affected? L_f - Fast non-leakage probability L_t – Thermal non-leakage probability ε - Fast fission factor p – Resonance escape probability η – Thermal fission factor f – Thermal utilization factor

a. $\downarrow L_f, \downarrow p, \uparrow f$

b. $\uparrow \varepsilon, \uparrow L_f, \downarrow L_t, \uparrow p$

c. $\uparrow \varepsilon, \downarrow L_f, \downarrow L_t, \downarrow p, \uparrow \eta, \uparrow f$

d. $\uparrow \varepsilon, \uparrow L_f, \downarrow L_t, \downarrow p, \uparrow \eta, \uparrow f$

QUESTION A.10 [1.0 point, 0.25 each]
Match the following Neutron term in Column A with the appropriate definition in Column B (each used only once)

Column A	Column B
a. Delayed Neutron	1. Neutron born directly from fission
b. Fast Neutron	2. Neutron in equilibrium with its surroundings
c. Thermal Neutron	3. Neutron born due to decay of a fission product
d. Prompt Neutron	4. Neutron at an energy level greater than its surroundings

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

QUESTION A.11 [1.0 point]
Which ONE of the following directly produces 95% of all Xenon in a nuclear reactor?

a. Fission of Th-233

b. Fission of Th-238

c. Beta decay of Cs-135

d. Decay of I-135

QUESTION A.12 [1.0 point]
Which ONE of the following is the MAJOR source of heat released after shutdown?

a. Production of prompt gamma rays

b. Spontaneous fission of U^{238}

c. Decay of fission products

d. Production of delayed neutrons

QUESTION A.13 [1.0 point]
A subcritical reactor, k_{eff} is increased from 0.924 to 0.987. Which ONE of the following is the amount of reactivity that was added to the core?

a. 0.034 $\Delta k/k$

b. 0.069 $\Delta k/k$

c. 5.53%$\Delta k/k$

d. 6.53%$\Delta k/k$

QUESTION A.14 [1.0 point]
Reactor is critical. What would be the corresponding k_{eff} when removing 5% $\Delta k/k$ from its criticality?

a. 0.922

b. 0.943

c. 0.952

d. 0.973

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

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

a. From 1 W to 5 W

b. From 10 W to 30 W

c. From 10 kW to 20 kW

d. From 100 kW to 150 kW

QUESTION A.16 [1.0 point]
Which ONE of the following conditions would INCREASE the shutdown margin of a reactor?

a. Inserting an experiment adding positive reactivity

b. Depletion of Uranium fuel

c. Depletion of a burnable poison

d. Lowering moderator temperature if the moderator temperature coefficient is negative

QUESTION A.17 [1.0 point]
Which ONE of the following best describes the difference between reflectors and moderators?

a. Reflectors decrease thermal leakage while moderators decrease fast leakage

b. Reflectors thermalize neutrons while moderators decrease core leakage

c. Reflectors decrease core leakage while moderators thermalize neutrons

d. Reflectors shield against neutrons while moderators decrease core leakage

QUESTION A.18 [1.0 point]
How high will the reactor power get given the following: the lowest of the reactor high power scram set points is 120%, the scram delay time is 0.5 seconds, the reactor is operating at 100% power prior to the scram, and the reactor period is positive 20 second?

a. 113%

b. 119%

c. 123%

d. 125%

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

QUESTION A.19 [1.0 point]

The following shows part of a decay chain for the radioactive element Pb-190:

$_{82}Pb^{190} \rightarrow {}_{83}Bi^{190}$

This decay chain is an example of _____ decay.

a. Alpha

b. Beta

c. Gamma

d. Neutron

QUESTION A.20 [1.0 point]

What is the condition of the reactor when $k = \frac{1}{1-\beta}$? (Note: β not β_{eff})

a. Subcritical

b. Critical

c. Super critical

d. Prompt critical

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

Category B: Normal/Emergency Operating Procedures and Radiological Controls

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

a. Primary coolant conductivity is 4 μS/cm averaged over a month

b. Pool level is 6 meters above the upper core plate

c. Primary coolant outlet temperature is 60°C

d. Primary coolant radioactivity measured quarterly

QUESTION B.02 [1.0 point]
In accordance with Reed emergency plan exposure guidelines, which ONE of the following is the exposure and intake limit for life saving and corrective action that mitigates the consequences of the emergency event?

a. 25 Rem

b. 30 Rem

c. 45 Rem

d. 50 Rem

QUESTION B.03 [1.0 point]
Which ONE of the following is the 10CFR20 definition for “Derived Air Concentration-hour”?

a. Product of concentration of radioactive material in air and time of exposure in hours, Committed Effective Dose Equivalent of 5 Rems

b. 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. Projected Committed Effective Dose Equivalent commitment to individuals that warrants protective action following a release of radioactive material

d. 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

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.04 [1.0 point, 0.25 each]
Match the emergency situation listed in Column A with the classification level listed in Column B. (Answers may be used more than once or not at all)

Column A	Column B
a. Tornado	1. Alert
b. 15mrem at the site boundary	2. Unusual Event
c. Reactor facility fire extinguished in 10 minutes	3. No Classification
d. Security breach of the reactor facility	

QUESTION B.05 [1.0 point]
Per Reed Technical Specifications, what is the MINIMUM shutdown margin required with the reactor in reference core condition, the most reactive rod fully withdrawn, and experiments in their most reactive state?

a. $0.50

b. $1.00

c. $2.50

d. $3.00

QUESTION B.06 [1.0 point]
According to the Reed Emergency Plan, who is the on-site Health Physicist during non-emergency situations?

a. Reed, Training Supervisor

b. Reactor Operations Manager

c. Senior Reactor Operator

d. Reactor Operator

QUESTION B.07 [1.0 point]
A radioactive source has a current activity of 3 Curies. The activity 30 years ago was 300 Curies. What is the half-life of the radioactive source?

a. 4.5 years

b. 10.5 years

c. 15 years

d. 20 years

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.08 [1.0 point]
How many hours (MINIMUM) are Test and Research Reactors licensed operators required to perform the functions of a licensed operator to resume activities if a licensee has not been actively performing the functions of a reactor operator or senior reactor operator?

a. 4 hours

b. 6 hours

c. 8 hours

d. 10 hours

QUESTION B.09 [1.0 point, 0.25 each]
Identify each of the following surveillances as a channel check (CHECK), a channel test (TEST), or a channel calibration (CAL). Write the correct answer on your answer sheet next to the space given for each example listed below.

a. During performance of the daily checklist, you compare the readings of radiation area monitor one and radiation monitor two

b. During performance of the daily checklist, you press the scram button to verify a scram on the safety system channel

c. Adjustment of the wide range monitor channel in accordance with recent data collected during a reactor power calibration

d. You expose a 2 mCi check source to the continuous air monitor detector to verify that its output is operable

QUESTION B.10 [1.0 point]
Reed Technical Specification requires the worth of all single unsecured experiments shall be < _____ and the worth of all experiments shall be < _____.

a. $0.25 and $0.50

b. $0.50 and $1.00

c. $1.00 and $2.00

d. No limit and $1.00

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.11 [1.0 point]
Which ONE of the following meets the MINIMUM staffing requirement when the reactor is NOT shutdown?

a. 1 RO in the control room, 1 SRO on call, and a second person to summon help

b. 1 SRO in the control room and Reactor Operations Manager on call

c. 1 RO in the control room, Reactor Operations Manager on call

d. 1 SRO in the control room and a second person to summon help

QUESTION B.12 [1.0 point]
Calculate an individual's total whole body dose given the individual received the following doses: 20 mrad of alpha, 10 mrad of gamma, and 5 mrad of neutron (unknown energy)

a. 35 mrem

b. 415 mrem

c. 435 mrem

d. 460 mrem

QUESTION B.13 [1.0 point]
A radiation field is 330 mR/hr at 4 feet. What is your dose rate at 2 feet away from the source?

a. 499 mR/hr

b. 580 mR/hr

c. 660 mR/hr

d. 1320 mR/hr

QUESTION B.14 [1.0 point]
Which ONE of the following experiments is required to be doubly encapsulated?

a. Liquid fissionable materials

b. Compounds highly reactive with water

c. Explosive materials

d. Materials corrosive to reactor components

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.15 [1.0 point]
Where are the emergency first aid and medical supply kits NOT located?

a. Counting room

b. Evacuation corridor

c. Psychology exit corridor

d. Reactor bay emergency exit

QUESTION B.16 [1.0 point, 0.25 each]
Match the appropriate 10CFR part in Column A with the requirements in Column B.

Column A	Column B
a. 10CFR19	1. Technical information including the proposed maximum power level
b. 10CFR20	2. Individual radiation exposure data
c. 10CFR50	3. Postings of notices to workers
d. 10CFR55	4. Medical examination by a physician every two years

QUESTION B.17 [1.0 point]
Which ONE of the following meets the required MINIMUM radiation monitoring channels for reactor operation?

a. 4 environmental dosimeters, 1 RAM, and 1 substituted CAM

b. 4 environmental dosimeters, 1 substituted RAM, and 1 CAM

c. 2 environmental dosimeters, 1 substituted RAM, and 1 CAM

d. Environmental dosimeters are not required, 1 RAM, and 1substituted CAM

QUESTION B.18 [1.0 point, 0.33 each]
Match the following limitations in Column A with its specification in Column B (Assume natural convection; Answers may be used more than once or not at all)

Column A	Column B
a. Safety Limit	1. Shutdown Margin $0.50
b. Limiting Safety System Setting	2. Maximum fuel temperature 1000^{o}C
c. Limiting Condition for Operation	3. Maximum 300 kW

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.19 [1.0 point]
A 25 curie source emits a 1.332MeV gamma and a 1.117 MeV gamma 100% of the time. The source will be placed in the reactor storage room. How far from the source should a high radiation area sign be posted?

a. Not required

b. 10 feet

c. 15 feet

d. 25 feet

QUESTION B. 20 [1.0 point]
Which ONE of the following surveillance checks shall be tested at least quarterly?

a. Pool water radioactivity

b. Scram times

c. Rod withdrawal and insertion speeds

d. Reactivity worth of control devices

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

Category C: Facility and Radiation Monitoring Systems

QUESTION C.01 [1.0 point]
What instrumentation region is associated with "the voltage is such that every primary ion produces an avalanche of secondary ions"? This region also cannot differentiate between types of radiation.

a. Region I, Recombination

b. Region II, Ionization

c. Region III, Proportional

d. Region IV, Geiger-Mueller

QUESTION C.02 [1.0 point]
While a rabbit is going into or out of the core, a power indication change more than 10% of the linear power range occurs. Why is the Operator of Record required to scram the reactor and notify the Rabbit Operator and the Reactor Operations Manager?

a. Violated technical specification of change in power

b. Generated excess sample reactivity worth

c. Created an unbalanced power distribution

d. Achieved the power range required

QUESTION C.03 [1.0 point]
Which ONE of the following is the primary function of the demineralizer?

a. Remove large particles to increase convective flow

b. Stabilize temperature to allow even secondary flow

c. Dissipate heat from the primary system to prevent degradation of systems

d. Maintain conductivity low to prevent corrosion of reactor components

QUESTION C.04 [1.0 point]
Reed SOP 30 identifies a pool level of 7.3 meters, from the bottom of the tank, as the _____?

a. Low alarm setpoint

b. High alarm setpoint

c. Technical specification level

d. Normal pool level

Category C: Facility and Radiation Monitoring Systems

QUESTION C.05 [1.0 point]
The Log Channel is the neutron flux monitoring channel that provides a signal indicating which ONE of the following?

a. Percent power – ability to readout in a way specified by a certain amount resulting from the reactor power

b. Linear – a result from the reactor power in a generally straight or nearly straight line

c. Count rate – the total number of emissions per amount of time as a result of the reactor power

d. Period – the time required for reactor power to change by a factor of about 2.718

QUESTION C.06 [1.0 point]
When fuel is stored in a safe array outside of the reactor core what is the maximum k_{eff} allowed per Reed Technical Specifications?

a. 0.5

b. 0.6

c. 0.7

d. 0.8

QUESTION C.07 [1.0 point]
Which ONE of the following will NOT immediately require a reactor SCRAM? (Assume reactor is critical)

a. RAM readout of 3mR/hr

b. GSM fast readout of 1E-3uCi/cm^3

c. Pool temperature is 35^oC

d. Pool level is 7300mm

QUESTION C.08 [1.0 point]
Which ONE of the following is the poison used in Reed's control rods?

a. Boron Carbide

b. Zirconium Hydride

c. Aluminum Oxide

d. Graphite

Category C: Facility and Radiation Monitoring Systems

QUESTION C.09 [1.0 point]
The Continuous Air Monitor (CAM) and the Gas Stack Monitor utilize two detectors in order to remove which alpha emitter found in background radiation?

a. Radon

b. Tritium

c. Nitrogen

d. Sodium

QUESTION C.10 [1.0 point]
What is the purpose of the control rod drive system using the connecting rod piston and the vents in the rod drive barrel?

a. The piston and the small grated vents along the length of the rod barrel prevent excessive rod withdrawal speeds

b. The piston and the small grated vents near the bottom of the rod barrel slow the rod speed before bottoming impact during scrams

c. The piston weight holds the control rods fully inserted while the large slotted vents along the length of the rod barrel provide for unrestricted cooling water flow to the control rods

d. The piston and the large slotted vents along the length of the rod barrel prevent excessive rod speeds during accidental rod drops while allowing unrestricted normal rod drive speeds

QUESTION C.11 [1.0 point]
Which ONE of the following is design feature of the purification system that prevents siphoning of pool water upon a failure?

a. Emergency fill system will automatically maintain the pool level

b. A valve upstream of the primary pump maintains the positive pressure necessary to maintain the level

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

d. A valve downstream of the primary pump will automatically shutdown

Category C: Facility and Radiation Monitoring Systems

QUESTION C.12 [1.0 point]
Which ONE of the following regions of the pulse size versus applied voltage characteristic curve does Reed's % power channel operate?

a. Proportional

b. Ion Chamber

c. Geiger-Mueller

d. Limited Proportional

QUESTION C.13 [1.0 point]
The radial graphite reflector is encased by which ONE of the following materials?

a. Aluminum

b. Boron

c. Cadmium

d. Steel

QUESTION C.14 [1.0 point]
If high airborne radiation readings occur on the CAM or GSM which of the following occurs within the ventilation isolation system?

a. Supply inlet is open and HEPA bypass is closed

b. Supply inlet is closed and HEPA inlet is open

c. HEPA bypass is open and HEPA inlet is closed

d. HEPA bypass is closed and HEPA inlet is open

QUESTION C.15 [1.0 point]
How does the control rod position indicator measure rod height?

a. Sonar detector measures the amount of control rod still in the core

b. Radio-frequency detector measures the height of the control rod extension tube above the piston

c. Potentiometer is attached to the control rod drive motor

d. Accelerometer determines the relative movement of the control rod

Category C: Facility and Radiation Monitoring Systems

QUESTION C.16 [1.0 point]
Oxygen-16 in the reactor pool water produces significant quantities of which ONE of the following isotopes?

a. N-16

b. Ar-41

c. Co-60

d. I-131

QUESTION C.17 [1.0 point]
Which ONE of the following conditions is the MAIN purpose a nuclear reactor core requires a neutron source for startup?

a. Prevent the period becoming too short and resulting in an inadvertent power excursion

b. Provide enough delayed neutrons for all nuclear instrumentations before the reactor can go to a critical position

c. Ensure the reactor change from subcritical to critical by using neutron source ONLY

d. Provide a reference point for the % power channel to undergo a check before the reactor is brought to a critical position

QUESTION C.18 [1.0 point]
Which ONE of the following is the primary function of the graphite sections on both sides of the fuel element?

a. Absorb thermal neutrons

b. Absorb fission product gases

c. Reduces neutron leakage

d. Increases fast neutron flux

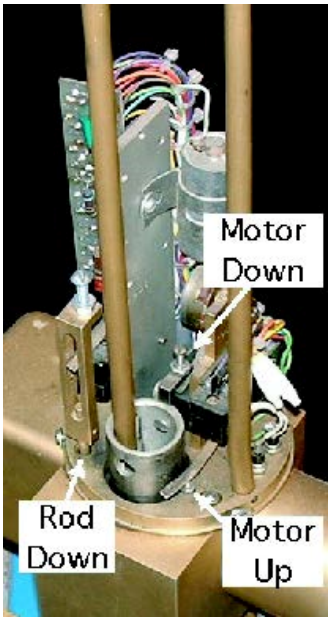
Category C: Facility and Radiation Monitoring Systems

QUESTION C.19 [1.0 point, 0.33 each]
Match the problems on the left with its possible plant conditions on the right (Answers may be used more than once or not at all; No changes or manipulations of equipment)

Column A	Column B
a. High radiation level in demineralizer tanks	1. Clogging
b. High pressure on demineralizer inlet	2. High water temperature
c. High flow through demineralizer tanks	3. Fission product release
	4. Resin separation (channeling)

QUESTION C.20 [1.0 point, 0.33 each]
Match the control rod limit switch in Column A with the correct function in Column B. (Answers used once)

Column A	Column B
a. Motor Down	1. Provides the motor full withdrawn indication
b. Motor Up	2. Provides the rod full bottom indication
c. Rod Down	3. Magnet presses the relay closed



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

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

A.01
Answer: b
Reference: DOE Fundamentals Handbook *Nuclear Physics and Reactor Theory*, Volume 2, Module 4

A.02
Answer: d
Reference: CR=S/(1-k)→300/(1-0.5) = 600 N/sec

A.03
Answer: a
Reference: NRC standard question

A.04
Answer: d
Reference: Burn, *Introduction to Nuclear Reactor Operations*, Section 8.1, Page 8-1

A.05
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.06
Answer: c
Reference: Burn, *Introduction to Nuclear Reactor Operations,* Figure 2.6, Page 2-39

A.07
Answer: b
Reference: Reed Training Manual, Chapter 10.3, Figure 10.6

A.08
Answer: b
Reference: Burn, *Introduction to Nuclear Reactor Operations,* Section 3.3.2, Page 3-7

A.09
Answer: a
Reference: DOE Fundamentals Handbook *Nuclear Physics and Reactor Theory*, Volume 2, Module 1

A.10
Answer: a(3), b(4), c(2), d(1)
Reference: DOE Fundamentals Handbook *Nuclear Physics and Reactor Theory*, Volume 1, Module 2, Pages 29-37

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

A.11
Answer: d
Reference: DOE Fundamentals Handbook *Nuclear Physics and Reactor Theory*, Volume 2, Module 3, Page 35

A.12
Answer: c
Reference: Burn*, Introduction to Nuclear Reactor Operations*, Section 4.10.14, Page 4-33

A.13
Answer: b
Reference: Burn, *Introduction to Nuclear Reactor Operations*, Section 3.3.4, Page 3-20&21
$\Delta\rho=(k_{eff2}-k_{eff1})/(k_{eff1}*k_{eff2})$ = (0.987-0.924)/(0.987*0.924) = 0.0690Δk/k or 6.9%Δk/k

A.14
Answer: c
Reference: $\rho=(k-1)/k-0.05\rightarrow 1=k-(-0.05k)=k(1+0.05)\rightarrow k=1/1.05 =0.952$

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

A.16
Answer: b
Reference: Burn, *Introduction to Nuclear Reactor Operations*, Section 6.2.3

A.17
Answer: c
Reference: Burn, *Introduction to Nuclear Reactor Operations,* Section 5.4

A.18
Answer: c
Reference: P/P_o = 120%, T = 20 seconds, t = 0.5, P/P_o = 120 e^$^{0.5/20}$ = 123%

A.19
Answer: b
Reference: Chart of the Nuclides

A.20
Answer: d
Reference: LaMarsh, *Introduction to Nuclear Engineering*, Page 340-341
(1- β)k=1 manipulated reads k=1/(1- β)

Category B: Normal/Emergency Operating Procedures and Radiological Controls

B.1
Answer: c
Reference: Reed Technical Specification 3.3

B.2
Answer: a
Reference: Reed, Emergency Plan 3.5

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

B.4
Answer: a(2),b(2),c(3),d(1)
Reference: Reed Emergency Plan 4.1 & 4.2

B.5
Answer: a
Reference: Reed TS 3.1.2

B.6
Answer: b
Reference: Reed Emergency Plan 3.1.3

B.7
Answer: a
Reference: $T\ A = A_{\circ} * e^{-\lambda t}$
$3Ci = 300Ci * e^{-\lambda(t)}$ Note: $\lambda = -\ln 2/t^{1/2}$
$\ln(3/300) = -\ln 2/X\ yr * (30\ years)$ --> -4.605/-1.021 →
solve for t: 4.51 years

B.8
Answer: b
Reference: 10CFR55.53(f)(2)

B.9
Answer: a (check), b (test), c (cal) , d (test)
Reference: Reed Technical Specifications 1, definitions

B.10
Answer: c
Reference: 10 CFR 20.1201

B.11
Answer: a
Reference: Reed Technical Specifications 6.1.3

B.12
Answer: d
Reference: 20mrad Alpha x 20 = 400mrem, 10mrad Gamma x 1 = 10mrem, 5mrad neutron x 10 = 50mrem → 400mrem + 10mrem + 50mrem = 460mrem

Category B: Normal/Emergency Operating Procedures and Radiological Controls

B.13
Answer: d
Reference: $I_1D_1^2=I_2D_2^2 \rightarrow$ 330mR/hr@$(4ft)^2=I_2$@$(2ft)^2 \rightarrow$1320mR/hr

B.14
Answer: d
Reference: Reed Technical Specifications 3.6.2

B.15
Answer: a
Reference: Reed Emergency Plan 8.2

B.16
Answer: a (3), b(2), c(1), d(4)
Reference: 10CFR19.11, 10CFR20.1501(2)(i), 10CFR50.34(1)(ii)(A), 10CFR55.21

B.17
Answer: b
Reference: Reed Technical Specifications 3.5.1, Table 5

B.18
Answer: a(2),b(3),c(1)
Reference: Technical Specifications 2.1 2.2 3.1.2

B.19
Answer: d
Reference: I=6CEn=R/hr@ft.$\rightarrow$25Ci x [(1.332Mev x 100%)+(1.117x100%)] = 62.625 R/hr@ $(1ft)^2$ = 626.25 R/hr = 0.1 R/hr@ D^2 = $\sqrt{}$626 R/hr = 25 ft.

B.20
Answer: a
Reference: Reed Technical Specifications 4.2 & 4.3

Category C: Facility and Radiation Monitoring Systems

C.01
Answer: d
Reference: NRC standard question

C.02
Answer: b
Reference: Reed SOP 13, 13.5.1.7

C.03
Answer: d
Reference: Reed SAR, Chapter 5, Section 5.2.4

C.04
Answer: a
Reference: Reed SOP 30B

C.05
Answer: d
Reference: Reed Training Manual, Section 11.8

C.06
Answer: d
Reference: Reed TS 5.5.a

C.07
Answer: a
Reference: Reed EIP-U

C.08
Answer: a
Reference: Reed Facility Reference Manual 1.2.8

C.09
Answer: a
Reference: Reed Training Manual, Section 11.3

C.10
Answer: b
Reference: Reed Training Manual, Section 11.3

C.11
Answer: c
Reference: Reed Training Manual, Section 11.6

C.12
Answer: b
Reference: Reed Training Manual 5.2.2, Page 80

C.13
Answer: a
Reference: Reed Training Manual 11.1

Category C: Facility and Radiation Monitoring Systems

C.14
Answer: d
Reference: Reed Training Manual 11.9

C.15
Answer: c
Reference: Reed Training Manual 11.3

C.16
Answer: a
Reference: NRC Standard Question

C.17
Answer: a
Reference: Reed Technical Specifications 3.2.3

C.18
Answer: c
Reference: Reed Training Manual 11.2

C.19
Answer: a(3), b(1), c(4)
Reference: Reed Training Manual 11.6

C.20
Answer: a(3), b(1), c(2)
Reference: Reed Training Manual, Section 11.3, Figure 11.6