May 30, 2012

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

SUBJECT: EXAMINATION REPORT NO. 50-288/OL-12-02, REED COLLEGE

Dear Dr. Krahenbuhl:

During the weeks of May 7 and May 14, 2012 the U.S. Nuclear Regulatory Commission (NRC) administered operator licensing examination at your Reed Reactor Facility. The examination was conducted according to NUREG-1478, "Operator Licensing Examiner Standards for Research and Test Reactors," Revision 2, published in June 2007. 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 John Nguyen at 301-415-4007 or via email at John.nguyen@nrc.gov.

Sincerely,

/RA/

Johnny H. Eads, Jr., 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-12-02
2. Written Examination

cc w/o enclosures: See next page

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OFFICE	PROB:CE	IOLB:LA	PROB:BC
NAME	JNguyen	CRevelle	JEads
DATE	5/22/2012	5/29/2012	5/30/2012

OFFICIAL RECORD COPY

cc:

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

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Dean of Faculty
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Portland, OR 97202-8199

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Portland, OR 97232-2162

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

EXAMINATION REPORT NO:	50-288/OL-12-02
FACILITY:	Reed Reactor
FACILITY DOCKET NO.:	50-288
FACILITY LICENSE NO.:	R-112

SUBMITTED BY: /RA/ 05/23/2012
John Nguyen, Chief Examiner Date

SUMMARY:

During the week of May 7, 2012, the NRC administered operator licensing examinations to fifteen Reactor Operator (RO) and ten Senior Reactor Operator Upgrade (SROU) candidates. One RO candidate failed both the written and operating examinations. Two RO candidates failed Section A of the written examination. All the other candidates passed all portions of the examinations.

REPORT DETAILS

1. Examiner: John Nguyen, Chief Examiner

2. Results:

	RO PASS/FAIL	SRO PASS/FAIL	TOTAL PASS/FAIL
Written	12/3	N/A	12/3
Operating Tests	14/1	10/0	24/1
Overall	12/3	10/0	22/3

3. Exit Meeting:

Dr. Melinda Krahenbuhl, Director, Reed Reactor
Reuven Lazarus, Associate Director, Reed Reactor
Patrick Isaac, NRC, Examiner
John Nguyen, NRC, Examiner
Phillip Young, NRC, Examiner

The NRC Examiner thanked the facility for their support in the administration of the examinations. The facility licensee had no comments on the written examination except the comments presented during the administration of the examination. The NRC examiners noted that most of the license candidates were well prepared for the examinations. The examiner also discussed generic weaknesses noted during the operating examination. The facility licensee promised taking actions to improve program performance in those areas.

U. S. NUCLEAR REGULATORY COMMISSION
RESEARCH AND TEST REACTOR OPERATOR LICENSING EXAMINATION

FACILITY: REED COLLEGE

REACTOR TYPE: TRIGA

DATE ADMINISTERED: 5/8/2012

CANDIDATE: ______________________________________

INSTRUCTIONS TO CANDIDATE:

Answers are to be written on the answer sheets provided. Points for each question are indicated in brackets for each question. You must score 70% in each section to pass. Examinations will be picked up three (3) hours after the examination starts.

Category Value	% of Total	Candidates Score	% of Category Value	Category
18.00	33.33	______	____	A. Reactor Theory, Thermodynamics and Facility Operating Characteristics
18.00	33.33	______	____	B. Normal and Emergency Operating Procedures and Radiological Controls
18.00	33.33	______	____	C. Plant and Radiation Monitoring Systems
FINAL GRADE		______	% TOTALS	

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

____
Candidate's Signature

NRC RULES AND GUIDELINES FOR LICENSE EXAMINATIONS

During the administration of this examination the following rules apply:

1. Cheating on the examination means an automatic denial of your application and could result in more severe penalties.

2. After the examination has been completed, you must sign the statement on the cover sheet indicating that the work is your own and you have neither received nor given assistance in completing the examination. This must be done after you complete the examination.

3. Restroom trips are to be limited and only one candidate at a time may leave. You must avoid all contacts with anyone outside the examination room to avoid even the appearance or possibility of cheating.

4. Use black ink or dark pencil <u>only</u> to facilitate legible reproductions.

5. Print your name in the blank provided in the upper right-hand corner of the examination cover sheet and each answer sheet.

6. The point value for each question is indicated in [brackets] after the question.

7. If the intent of a question is unclear, ask questions of the examiner only.

8. To pass the examination you must achieve a grade of 70 percent or greater in each category.

9. There is a time limit of three (3) hours for completion of the examination.

10. When you have completed and turned in you examination, leave the examination area

EQUATION SHEET

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

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

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

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

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

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

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

$$M = \frac{1 - K_{eff_0}}{1 - K_{eff_1}}$$

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

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

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

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

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

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

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

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

$$T_{‰} = \frac{0.693}{\lambda}$$

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

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

$$DR = \frac{6CiE(n)}{R^2}$$

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

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

1 Curie = 3.7×10^{10} dis/sec	1 kg = 2.21 lbm
1 Horsepower = 2.54×10^{3} BTU/hr	1 Mw = 3.41×10^{6} BTU/hr

1 BTU = 778 ft-lbf	$^\circ$F = 9/5 $^\circ$C + 32
1 gal (H_2O) $\approx$ 8 lbm	$^\circ$C = 5/9 ($^\circ$F - 32)

Section A Ŗ Theory, Thermo, and Facility 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.

A001 a b c d _____

A002 a b c d _____

A003 a b c d _____

A004 a b c d _____

A005 a b c d _____

A006 a b c d _____

A007 a b c d _____

A008 a b c d _____

A009 a b c d _____

A010 a b c d _____

A011 a b c d _____

A012 a b c d _____

A013 a b c d _____

A014 a b c d _____

A015 a b c d _____

A016 a b c d _____

A017 a b c d _____

A018 a b c d _____

Section 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.

B001 a b c d _____

B002 a b c d _____

B003 a b c d _____

B004 a b c d _____

B005 a b c d _____

B006 a b c d _____

B007 a b c d _____

B008 a b c d _____

B009 a b c d _____

B010 a b c d _____

B011 a b c d _____

B012 a b c d _____

B013 a b c d _____

B014 a b c d _____

B015 a b c d _____

B016 a _____ b _____ c _____ d _____ (1 point, 0.25 each)

B017 a b c d _____

B018 a b c d _____

Section 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.

C001   a   b   c   d _____

C002   a   b   c   d _____

C003   a   b   c   d _____

C004   a   b   c   d _____

C005   a _____   b _____   c _____   d ____(2 points, 0.5 each)

C006   a   b   c   d _____

C007   a   b   c   d _____

C008   a   b   c   d _____

C009   a   b   c   d _____

C010   a   b   c   d _____

C011   a _____   b _____   c _____   d _____(2 points, 0.5 each)

C012   a   b   c   d _____

C013   a   b   c   d _____

C014   a   b   c   d _____

C015   a   b   c   d _____

C016   a   b   c   d _____

***** END OF EXAMINATION *****

Section A R Theory, Thermo, and Facility Characteristics

Question A.1 [1.0 point]

In a subcritical reactor with K_{eff} of 0.931, a reactivity worth of 1.70 %Δk/k is inserted into the reactor core. Which ONE of the following is the NEW K_{eff} ?

a. 0.933

b. 0.946

c. 0.972

d. 1.101

Question A.2 [1.0 point] **Changes made during the administration of the examination**

The reactor is critical. At time t=0, K_{eff} is changed to ~~1.001~~ 1.010. What is the period of the reactor? Given a prompt neutron lifetime (ℓ*) of 1 x 10 $^{-4}$ seconds.

a. ~~0.1 sec~~ 0.01 sec

b. ~~1.0 sec~~ 0.1 sec

c. ~~10 sec~~ 1 sec

d. ~~100 sec~~ 10 sec

Question A.3 [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 1 W to 5 W

b. From 10 W to 30 W

c. From 10 kW to 20 kW

d. From 100kW to 150 kW

Question A.4 [1.0 point] **New question added during the administration of the examination**

Which ONE of the following isotopes has the highest thermal neutron absorption cross section?

a. Xe-135

b. Sm-149

c. U-235

d. U-238

Question A.5 [1.0 point]

Given the following Core Reactivity Data during startup:

Control Rod	Total Rod Worth ($)	Rod Worth still in the core (excess) ($)
SAFE Rod	3.50	1.00
SHIM Rod	2.50	0.80
REG Rod 1	1.80	0.50
Total	7.80	2.30

Which ONE of the following would be the Shutdown Margin specified in the Reed Tech Spec?

a. $2.00

b. $2.30

c. $5.50

d. $7.80

Question A.6 [1.0 point]

Which ONE of the following is the **most correct reason** for having an installed neutron source within the core?

An installed neutron source is very important during startup because without of a neutron source...

a. the chain reaction in the reactor core would NOT start

b. the startup channel would NEVER indicate neutron population

c. the compensating voltage on the source range detector doesn't work

d. the reactor could result in a sudden increase in power if the control rods were pulled out far enough

Question A.7 [1.0 point]

Two critical reactors at low power are identical, except that Reactor 1 has a beta fraction of 0.0065 and Reactor 2 has a beta fraction of 0.0072. Which ONE of the following best describes the response if an equal amount of positive reactivity is inserted into both reactors?

a. Period of the Reactor 1 will be longer than the period of the Reactor 2

b. Period of the Reactor 1 will be shorter than the period of the Reactor 2

c. The final power in the Reactor 1 will be lower than the final power in the Reactor 2

d. The trace (power vs. time) of the Reactor 1 will be identical to the trace of the Reactor 2

Question A.8 [1.0 point]

Which ONE of the following best describes the effects of moderator temperature increase on neutron multiplication?

a. Resonance escape probability ↑; Thermal non-leakage↓; Rod worth ↑

b. Resonance escape probability ↓; Thermal non-leakage↓; Rod worth ↑

c. Resonance escape probability ↑; Thermal non-leakage↑; Rod worth ↓

d. Resonance escape probability ↓; Thermal non-leakage↓; Rod worth ↓

Question A.9 [1.0 point]

In a just critical reactor, the reactor operator immediately inserts a rabbit of $0.50 reactivity worth into the core. This insertion will cause:
Given:
T: reactor period, ℓ^*: Prompt neutron lifetime; ρ: reactivity insertion; β: beta fraction

a. A sudden drop in delayed neutrons

b. A number of prompt neutrons equals to a number of delayed neutrons

c. The resultant period to be a function of the prompt neutron lifetime ($T=\ell^*/\rho$)

d. A sudden change of power that equals to the initial power multiplied by $\beta(1-\rho)/(\beta-\rho)$

Question A.10 [1.0 point]

Which ONE of the following is a correct statement of why delayed neutrons enhance the ability to control reactor power?

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

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

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

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

Question A.11 [1.0 point]
TRIGA reactor fuel has a unique feature known as the prompt negative temperature coefficient (PNTC). Which ONE of the following is the MAJOR contributor of the PNTC?

a. As the fuel heats up, the resonance absorption peaks broaden and increases the likelihood of absorption in U-238 and/or Pu-240.

b. As the fuel heats up, a moderator temperature increase reduces the non-leakage and resonance escape probability.

c. As the fuel heats up, fission product poisons (e.g., Xe) increase in concentration within the fuel matrix and add negative reactivity via neutron absorption.

d. As the fuel heats up, the oscillating hydrogen atoms in the ZrH have more energy than the thermal neutrons, thus they transfers energy to the thermal neutrons, cause the thermal neutron to leave the fuel without fissions.

Question A.12 [1.0 point]
Which ONE of the following statements correctly describes thermal neutrons?

a. A neutron that experiences a linear decrease in energy as the temperature of the moderator increases.

b. A neutron at resonant epithermal energy levels that causes fissions to occur in U-238.

c. A neutron that experiences an increase in energy levels after collisions with larger atoms of the moderator.

d. A neutron that experiences no net change in energy after several collisions with atoms of the moderator.

Question A.13 [1.0 point]
Reactor power is increasing by a factor of 10 <u>every minute</u>. The reactor period is:

a. 65 seconds

b. 52 seconds

c. 26 seconds

d. 13 seconds

Question A.14 [1.0 point]
Given a source strength of 100 neutrons per second (N/sec) and a multiplication factor of 0.75, which ONE of the following is the expected stable neutron count rate?

a. 125 N/sec

b. 250 N/sec

c. 400 N/sec

d. 500 N/sec

Question A.15 [1.0 point]
During a reactor startup, the reactor operator calculates that the current core excess is HIGHER than the last startup. Which ONE of the following reasons could be the cause?

a. Higher moderator temperature (assume negative temperature coefficient)

b. Insertion of a negative reactivity worth experiment

c. Burnout of a burnable poison

d. Fuel depletion

Question A.16 [1.0 point]
About two minutes following a reactor scram, the reactor period has stabilized and the power level is decreasing at a CONSTANT rate. Given that reactor power at time t_0 is 9 kW power, what will it be five minutes later?

a. 0.21 kW

b. 2.1 kW

c. 3.4 kW

d. 11.7 kW

Question A.17 [1.0 point]
Which ONE of the following is an example of alpha decay?

a. $_{35}Br^{87} \rightarrow {}_{33}As^{83}$

b. $_{35}Br^{87} \rightarrow {}_{35}Br^{86}$

c. $_{35}Br^{87} \rightarrow {}_{34}Se^{86}$

d. $_{35}Br^{87} \rightarrow {}_{36}Kr^{87}$

Question A.18 [1.0 point]
Xenon-135 (Xe^{135}) is produced in the reactor by two methods. One is directly from fission; the other is indirectly from the decay of :

a. Xe^{136}

b. Sm^{136}

c. Cs^{135}

d. I^{135}

Section B Normal, Emergency and Radiological Control Procedures

Question B.1 [1.0 point]

Which ONE of the following statements is NOT a limitation of experiments?

a. Explosive experiments shall be doubly encapsulated

b. The sum of the absolute values of the reactivity worths of all experiments shall be less than $2.00.

c. Explosive materials in quantities greater than 25 mg TNT equivalent shall not be irradiated in the reactor or irradiation facilities

d. The absolute value of the reactivity worth of any single unsecured experiment shall be less than $1.00

Question B.2 [1.0 point]

Which ONE of the following radioisotopes will decay with the SHORTEST half-life?

a. Al^{28}

b. N^{16}

c. Ar^{41}

d. Xe^{135}

Question B.3 [1.0 point] **Changes made during the administration of the examination**

Which ONE of the following conditions requires a radiation work permits (RWPs) in accordance with SOP 53?

a. Conduct a thermal power calibration

b. Inspect stainless steel clad control rods per SOP ~~35~~ 34

c. A deep dose equivalent to an individual in excess of ~~3~~ 2 mRem

d. Insert ~~Remove~~ samples from the lazy susan, central thimble, or rabbit

Section B Normal, Emergency and Radiological Control Procedures

Question B.4 [1.0 point]

The Reed TRIGA reactor has been shutdown due to a fuel element leak. Which ONE of the following radioactive nuclides poses the most significant hazard during the research for the leaking fuel element? (Assume the fuel element is leaking during the search)?

a. Ar-41

b. H-3

c. Cs-137

d. N-16

Question B.5 [1.0 point]

Which ONE of the following is the definition of the **Site Boundary** for the Reed reactor facility?

a. The reactor bay and reactor room

b. 250 feet from the center of the reactor

c. The physical boundary of Reed College

d. Within the confines of the Psychology building

Question B.6 [1.0 point]

Before entering to the experimental facility, you see a sign at the door “CAUTION, HIGH RADIATION AREA”. You would expect that radiation level in the facility could result in an individual receiving a dose equivalent of:

a. 5 mRem/hr at 30 cm from the source

b. 20 mRem/hr at 30 cm from the source

c. 100 mRem/hr at 30 cm from the source

d. 500 Rads/hr at 1 m from the source

Section B Normal, Emergency and Radiological Control Procedures

Question B.7 [1.0 point]
According to Reed Tech Spec, which ONE of the following would most likely be considered a Special Report (the Director shall report to the NRC no later than the following working day)?

a. You receive a bomb threat directed toward the facility

b. You did not pay attention while raising the control rods to power, which causes reactor scram

c. You observe an abnormal loss of core coolant at a rate that exceeds the normal makeup capacity.

d. You load an unknown sample to the core, which causes an unexplained change in a $1.20 worth of reactivity.

Question B.8 [1.0 point]
Assume that there is no leak from outside of the demineralizer tank. You use a survey instrument with a window probe to measure the dose rate from the demineralizer tank. Compare to the reading with a window **CLOSED,** the reading with a window **OPEN** will :

a. increase, because it can receive an additional alpha radiation from (Al-27) (n,α), (Na-24) reaction

b. remain the same, because the Quality Factors for gamma and beta radiation are the same

c. increase, because the Quality Factor for beta and alpha is greater than for gamma

d. remain the same, because the survey instrument would not be detecting beta and alpha radiation from the tank

Question B.9 [1.0 point]

The radiation from an unshielded Co-60 source is 1 rem/hr. What thickness of lead shielding will be needed to lower the radiation level to 50 mrem/hr? The HVL (half-value-layer) for lead is 6.5 mm.

a. 28 mm

b. 33 mm

c. 38 mm

d. 44 mm

Question B.10 [1.0 point]

Which ONE of the following would be an initiating condition for Non-Reactor Safety Related Events?

a. Fuel cladding damage

b. Earthquake with damage to reactor systems

c. Pool level alarm due to abnormal loss of water

d. Radioactive contamination of a reactor operator during removal of experiment

Question B.11 [1.0 point]

During reactor operations, the Reactor Operator (RO) becomes ill and is taken to the hospital. Only the Senior Reactor Operator (SRO) and an experienced student remain in the facility. Reactor operations:

a. must be discontinued because both an RO and an SRO must be in the facility to satisfy Reed Administrative Policy

b. may continue since the SRO can monitor the console while the student can be able to scram the reactor and summon helps.

c. may continue until a replacement RO can arrive at the facility within 15 minutes

d. must be discontinued because both an RO and an SRO must be in the facility to satisfy Technical Specifications

Question B.12 [1.0 point]
You receive an unexpected package without a return address. The label addresses to:

Mr. Joe Doe
Reactor Facility Director
Reed Research Reactor
3203 SE Woodstock Blvd
Portland, OR 97202

You should:

a. place the package in the current Reactor Facility Director mail box

b. open the package and check whom you need to deliver

c. show the package to the SRO-duty in the control room

d. contact Community Safety for assistance

Question B.13 [1.0 point]
"The steady-state reactor power level shall not exceed 250 kW." This is an example of:

a. Safety Limit (SL)

b. Limiting Safety System Setting (LSSS)

c. Limiting Conditions for Operation (LCO)

d. Safety Operational Limit (SOL)

Question B.14 [1.0 point]
During the control rod calibration, you find some errors in that procedure. Per Reed Technical Specification, what is the MINIMUM level of management who may authorize **temporary** deviations from that procedure?

a. Yourself as a Reactor Operator

b. Senior Reactor Operator in charge

c. Reactor Facility Director

d. The Reactor Operations Committee

Question B.15 [1.0 point]

Which ONE of the following logbook entries would be made in **Black with Green Underline** (**BLACK G/U**)?

a. Failure of primary water pump

b. Removal of fuel element from core

c. Removal of neutron source from core

d. Reactor scram due to electrical transient

Question B.16 [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)**.

a. During performance of the Daily Checklist, you verify the reactor pool water level.

b. During 200 kW power, you compare the readings of Percent Power and Linear Power.

c. Exposing a 2 mCi check source to the continuous air monitor (CAM) detector to verify that its output is operable.

d. Adjust the linear channel in accordance with recent data collected on the reactor power calibration.

Question B.17 [1.0 point]
A radioactive source reads 35 Rem/hr on contact. Five hours later, the same source reads 1.5 Rem/hr. How long is the time for the source to decay from a reading of 35 Rem/hr to 100 mRem/hr?

a. 6.5 hours

b. 7.5 hours

c. 8.5 hours

d. 9.5 hours

Question B.18 [1.0 point]
Which ONE of the following documents requires the NRC approval for changes?

a. Major changes in the startup checklist

b Minor modification to the Technical Specifications

c Rearrange chapters in the Safety Analysis Report

d Revise the requalification operator licensing examination

Section C Plant and Radiation Monitoring Systems

Question C.1 [1.0 point]

The source interlock system will prevent rod withdrawal unless source level is above a preset level. This source interlock signal comes from:

a. Log-n Channel

b. Linear Channel

c. Percent Power Channel

d. Motor up limit switch

Question C.2 [1.0 point]

Given the configuration of the LIGHTS associated with the SHIM rod/drive as follows: UP (RED):OFF, DOWN (WHITE): ON, CONT/ON (BLUE): OFF, YELLOW: OFF, and no failure of switch lights. Identify the conditions of the SHIM rod.

a. Normal condition, rod insertion permissible

b. Abnormal condition, misadjusted rod down limit switch

c. Normal condition, either rod insertion or withdrawal permissible

d. Abnormal condition, drive has stuck above “motor down” limit switch

Section C Plant and Radiation Monitoring Systems

Question C.3 [1.0 point]

Which ONE of the following best describes on how the Uncompensated Ion Chamber (UIC) and Compensated Ion Chamber (CIC) operate?

a. The CIC has two chambers, both can sense gamma rays but only one is coated with boron-10 for (n,α) reaction; whereas the UIC has only one chamber coated with boron-10 for (n,α) reaction.

b. The CIC has two chambers, one is coated with U-235 for fission reaction and the other is coated with boron-10 for (n,α) reaction; whereas the UIC has only one chamber coated with U-235 for fission reaction.

c. The CIC has only one chamber coated with boron-10 for (n,α) reaction; whereas the UIC has two chambers, one is coated with U-235 for fission reaction and the other is coated with boron-10 for (n,α) reaction.

d. The CIC has only one chamber coated with U-235 for fission reaction, whereas the UIC has two chambers, both can sense gamma rays but only one is coated with boron-10 for (n,α) reaction.

Question C.4 [1.0 point]

Which ONE of the following is the correct reason for running the primary pump at least 15 minutes before reading the reactor water conductivity?

1. To allow the conductivity meter to warm up

2. To clear any standing water out of the system

3. To allow the reactor water temperature to stabilize

4. To ensure the water in the reactor tank is thoroughly mixed

Section C Plant and Radiation Monitoring Systems

Question C.5 [2.0 points, 0.5 each]
Match the input signals listed in column A with their respective responses listed in column B. (Items in column B may be used more than once or not at all.)

	Column A		Column B
a.	Loss of AC power	1.	Indication only
b.	Raise two rods at once	2.	Indication and alarm
c.	Bulk pool water temperature = 40 °C	3.	Interlock only
d.	Primary pump is OFF	4.	Indication and scram

Question C.6 [1.0 point]
The Reg rod drive has:

a. a single-phase stepper motor and moves at 19 inches/minute

b. a variable-phase stepper motor and moves at 24 inches/minute

c. a single-phase stepper motor and moves at 24 inches/minute

d. a variable-phase stepper motor and moves at 19 inches/minute

Question C.7 [1.0 point]
Which ONE of the following is the material used for the neutron absorber in the Reed control rods?

a. Boron carbide

b. Graphite powder

c. Aluminum oxide

d. Zirconium hydride

Question C.8 [1.0 point]

You conduct a Linear Channel Scram test during the startup. After pressing/releasing the test button, you notice the following indications:

(1) The Linear Power light goes on

(2) The Linear Power Scram annunciator goes on

(3) All three yellow magnet power ON lights go off

Which additional actions and/or indications will occur in the raised control rod?

a. The raised control rod drops and its motor stops

b. The raised control rod drops and its motor drives down

c. The blue CONT light for the raised rod goes on then off, and its motor stops

d. The blue CONT light for the raised rod continuously blinks after the scram

Question C.9 [1.0 point]

Which ONE of the following is the actual design feature which prevents siphoning of pool water on a failure of the purification system?

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

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

c. The Emergency Fill system will automatically maintain pool level

d. “Vacuum breaks” are located in the system which prevents draining the pool 40 inches below the surface of water

Section C Plant and Radiation Monitoring Systems

Question C.10 [1.0 point]

Per SOP 34, the control rod worth calibration, the operators will establish the critical power level at ________ before withdrawal of the calibrated rod.

a. 1 W

b. 5 W

c. 50 W

d. 100 W

Question C.11 [2.0 points, 0.5 each]

Match each monitor and instrument (channel) listed in column A with a specific purpose in column B. Items in column B is to be used only once.

	Column A		Column B
a.	Log Channel	1.	Provide a wide range of power
b.	Percent Power Channel	2.	Provide a full power scram.
c.	Automatic Rod Control	3.	Provide a reactor period.
d.	Linear Channel	4.	Control the regulating rod in automatic mode.

Question C.12 [1.0 point]

When the Reed Reactor ventilation system is in the isolation mode, which one of the following describes the correct state of operation?

a. The fresh supply inlet damper: OPEN; the HEPA inlet damper: OPEN

b. The fresh supply inlet damper: OPEN; the HEPA inlet damper: CLOSED

c. The fresh supply inlet damper: CLOSED; the HEPA inlet damper: OPEN

d. The fresh supply inlet damper: CLOSED; the HEPA inlet damper: CLOSED

Section C Plant and Radiation Monitoring Systems

Question C.13 [1.0 point]
The Log Channel consists of :

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

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

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

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

Question C.14 [1.0 point] Changes made during the administration of the examination
During a reactor operation, you discover both the Air Particulate Monitor (APM) and the Continuous Air Monitor (CAM) pump failure. Other monitors are operating. Which ONE of the following is the best action?

a. Continue to operate because the pump failure does NOT affect the operation of the CAM.

b. Continue to operate because the CAM may be out of service for a period of 1 week.

c. Shutdown the reactor; immediately report the result to the supervisor because the pump failure could place the CAM in the inoperable mode.

d Shutdown the reactor, immediately report the result to the U.S. NRC because it is a reportable occurrence.

Question C.15 [1.0 point]
Significant quantities of Nitrogen-16 are produced by the irradiation of :

a. air in the beam ports

b. oxygen-16 in the reactor pool

c. air in irradiation cell

d. reactor building atmosphere

Section C Plant and Radiation Monitoring Systems

Question C.16 [1.0 point]
You perform a fuel element inspection. In measuring the elongation, you find the length of one fuel element exceeds the original length by 0.25 (1/4) inches. For this measurement, you will:

a. continue the fuel inspection because this elongation is within TS limit

b. continue the fuel inspection because the Reed Tech Spec requires the transverse bend measurement 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, report the result to Department of Energy for exchange of new fuel

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

Answer Key

A.1
Answer: b
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1982, Sec 3.3.3, page 3-21.
$\Delta\rho = (Keff_1-Keff_2)/(Keff_1*Keff_2)$. 0.017 = (x-0.931)/(x*0.931); 0.017*0.931*x =x-0.931
0.01583x=x-0.931; 0.98417x =0.931; x=0.931/0.98417; x=0.946

A.2
Answer: a
Reference: Reed Training Manual, Section 9.4: $T=\ell^*/(K_{eff}-1)$
T= 0.0001/0.010=0.01 sec
If using equations provided in the equation sheet:

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

ρ = (1.01-1)/1.01
ρ = 0.01
For promt,

$$T = \frac{\ell^*}{\rho} = 0.0001/0.01 = 0.01 \text{ sec}$$

A.3 d
Reference: $P = P_0 e^{t/T}$ —> t= T*Ln(P/ P_0) assume constant period = 1
t= Ln(P/ P_0) —> the smallest ratio of P/ P_0 is the shortest time to complete; so it is 150kW/100kW.

A.4
Answer: a
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, Table2.5, page 2-59.

A.5
Answer: a
Reference: TS 3.1.2
Shut Down Margin = ∑rod worth – (Core excess + most active rod worth)
= $7.8 –(2.3+3.5) =$2.00

A.6
Answer: d
Reference: Reed Training Manual, Section 9.4

A.7
Answer: b
Reference: Equation Sheet. $\tau = (\ell^*/\rho) + [(\beta-\rho)/\lambda_{eff}\rho]$

A.8
Answer: b
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Sec 3.3.2

A.9
Answer d
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, Sec 4.6, page 4-17

A.10
Answer: d
Reference: Reed Training Manual, Section 9.6

A.11
Answer: d
Reference: Reed Training Manual, Section 10.6

A.12
Answer: d
Reference: NRC Standard Question

A.13
Answer: c
Reference: $P=P_oe^{t/\tau}$ τ = 60 sec/ln(10) = 26.06 sec

A.14
Answer: c
Reference: CR = S/(1-K) $\rightarrow$ CR = 100/(1 - .75) = 400

A.15
Answer c
Reference: Standard NRC question.

A.16
Answer: a
Reference: $P = P_0\ e^{-T/\tau} = 9\ kW \times e^{(300sec/-80sec)} = 9\ kW \times e^{-3.75} = 0.0235 \times 9\ kW = 210\ W$

Section A ℞ Theory, Thermo, and Facility Characteristics

A.17
Answer a
Reference: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, Volume 1, Module 1

A.18
Answer: d
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, §§ 8.1 —8.4, pp. 8-3 — 8-14.

Section B Normal, Emergency and Radiological Control Procedures

Answer Key

B.1
Answer: a
Reference: Reed Technical Specification, Section 3.6.1 and 3.6.2

B.2
Answer: b
Reference: Chart of the Nuclides

B.3
Answer: b
Reference: SOP 53

B.4
Answer: c
Reference: Standard NRC question

B.5
Answer: b
Reference: Emergency Plan, Section 2

B.6
Answer: c
Reference: 10 CFR 20.1003

B.7
Answer: d
Reference: TS 6.7.2

B.8
Answer: d
Reference: BASIC Radiological Concept (Betas and alpha don't make through the demineralizer tank)

B.9
Answer: a
Reference: $DR = DR_{\circ} * e^{-\mu X}$
HVL (=6.5 mm) means the original intensity will reduce by half when a lead sheet of 6.5 mm is inserted. Find μ if the HVL is given as follows: $1 = 2 * e^{-\mu * 6.5}$; μ = 0.10664
Find X: 50 mrem/hr = 1000 mrem/hr* $e^{-0.10664*X}$; X= 28.1 mm

B.10
Answer: d
Reference: Emergency Plan, Section 4.1, 4.2 and 4.3

Section B Normal, Emergency and Radiological Control Procedures

B.11
Answer: b
Reference: TS 6.1.3

B.12
Answer: d
Reference: SOP 65, Section 65.17

B.13
Answer: c
Reference: Technical Specifications, Section 3.1.1

B.14
Answer: b
Reference: Technical Specifications 6.3

B.15
Answer: a
Reference: Procedure 60, Section 60.17, Ink Color

B.16
Answer: a = CHECK; b = CHECK; c = TEST; d = CAL
Reference: Reed Technical specification, Definitions

B.17
Answer: d
Reference: $DR = DR_o{*}e^{-\lambda t}$
1.5 rem/hr $=35$ rem/hr$*\ e^{-\lambda(5hr)}$
$\ln(1.5/35) = -\lambda{*}5$ --> $\lambda=0.623$; solve for t: $\ln(.1/35)=-0.623\ (t)$ → t=9.4 hours

B.18
Answer: b
Reference: 10 CFR 50.59

Answer Key

C.1
Answer: a
Reference: Reed Training Manual, Figure 11.10

C.2
Answer: b
Reference: Reed Training Manual, Section 11.3

C.3
Answer: a
Reference: Reed Training Manual, Section 5.1

C.4
Answer: b
Reference: SOP 20.16.6

C.5
Answer: a(4) b(3) c(2) d(1)
Reference: Reed TS and Procedure 20

C.6
Answer: c
Reference: Reed Training Manual, Section 11.3

C.7
Answer: a
Reference: Reed Training Manual, Section 11.3

C.8
Answer: b
Reference: SOP 20, Section 20.9

C.9
Answer: d
Reference: Reed Training Manual, Section 11.6

C.10
Answer: b
Reference: SOP 34, Section 34.7.4.11

C.11
Answer: a(3) b(2) c(4) d(1)
Reference : Reed Training Manual, Section 11.8 and 11.9

C.12
Answer: c
Reference: Reed Training Manual, Section 11.9

C.13
Answer: d
Reference: Reed Training Manual, Figure 11.10

C.14
Answer: c
Reference: TS, Section 3.5.1

C.15
Answer: b
Reference: NRC Standard Question

C.16
Answer: c
Reference: TS, Section 3.1.4

******************************END OF THE EXAM ********************************