June 29, 2004

Mr. Steven G. Frantz, Director
Reed Reactor Facility
3203 SE Woodstock Blvd.
Portland, OR 97202

SUBJECT: INITIAL EXAMINATION REPORT NO. 50-288/OL-04-01, REED COLLEGE

Dear Mr. Frantz:

During the week of May 3, 2004, the NRC administered an operator licensing examination at your Reed College Reactor. The examination was conducted according to NUREG-1478, "Non-Power Reactor Operator Licensing Examiner Standards," Revision 1. Examination questions and preliminary findings were discussed with those members of your staff identified in the enclosed report at the conclusion of the examination.

In accordance with 10 CFR 2.390 of the Commission's 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 (the Public Electronic Reading Room) http://www.nrc.gov/NRC/ADAMS/index.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 Paul V. Doyle at (301) 415-1058 or via internet E-mail at pvd@nrc.gov.

Sincerely,

/RA/

Patrick M. Madden, Section Chief
Research and Test Reactors Section
New, Research and Test Reactors Program
Division of Regulatory Improvement Programs
Office of Nuclear Reactor Regulation

Docket No. 50-288

Enclosures:
1. Initial Examination Report No. 50-288/OL-04-01
2. Facility comments with NRC resolution
3. Examination and answer key (RO/SRO)

cc w/encls:
Please see next page

cc:

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

Reed College
ATTN: Dr. Peter Steinberger
Dean of Faculty
3203 S.E. Woodstock Boulevard
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Oregon Department of Energy
ATTN: David Stewart-Smith, Director
Division of Radiation Control
625 Marion Street, N.E.
Salem, OR 97310

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

June 29, 2004

Mr. Steven G. Frantz, Director
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3203 SE Woodstock Blvd.
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SUBJECT: INITIAL EXAMINATION REPORT NO. 50-288/OL-04-01, Reed College

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cc w/encls: Please see next page

DISTRIBUTION w/ encls.:

PUBLIC	RNRP R&TR r/f	PMadden
DHughes	Facility File (EBarnhill) O-6 F-2	

ADAMS EXAMINATION PACKAGE ACCESSION NO.: ML040410707
ADAMS EXAMINATION REPORT ACCESSION #: ML041540071 **TEMPLATE #: NRR-074**

OFFICE	RNRP:CE	RNRP:E(Cert)	IROB:LA	RNRP:SC
NAME	PDoyle:vmj	KWitt	EBarnhill	PMadden
DATE	6/ 8 /2004	6/ 8 /2004	6/ 8 /2004	6/ 9 /2004

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

REPORT NO.: 50-288/OL-04-01

FACILITY DOCKET NO.: 50-288

FACILITY LICENSE NO.: R-112

FACILITY: Reed College

EXAMINATION DATES: May 3-8, 2004

SUBMITTED BY: **/RA/** 2/20/2004
Paul Doyle, Chief Examiner Date

SUMMARY:

During the week of May 3, 2004, the NRC administered operator licensing examinations to seven Senior Reactor Operator (Upgrade) candidates and twenty Reactor Operator candidates. All seven Senior Operator Upgrades and eighteen Reactor Operator candidates passed the examinations. Two Reactor Operator candidates failed section A of the written examination only.

REPORT DETAILS

1. Examiners:
    Paul Doyle, Chief Examiner
    Kevin Witt, Certifying Examiner

2. Results:

	RO PASS/FAIL	SRO PASS/FAIL	TOTAL PASS/FAIL
Written	18/2	N/A	18/2
Operating Tests	20/0	7/0	27/0
Overall	18/2	7/0	25/2

3. Exit Meeting:
    Paul Doyle, NRC, Examiner
    Kevin Witt, NRC, Certifying Examiner
    Rachel Barnett, RRF, Associate Director
    Megan Othus, RRF, Operations Supervisor

    The NRC thanked the facility staff for their assistance and cooperation during the examination. The facility staff presented the Chief Examiner with comments on the written examination. Generic weaknesses noted were minor, and included confusion about power channels, detectors, control rod insertion verification, etc.

ENCLOSURE 1

Facility Comments with NRC Resolution

Question A.8:
The flux peak in a reactor with a reflector is ________ the peak in a reactor without a reflector.

A. Equal to

B. Higher than

C. Lower than

D. Not related to

Facility Comment:

Answer “b” should also be allowed. The flux peak may be higher in a reflected reactor depending on the assumptions. Just adding a reflector and changing nothing else should cause the peak to increase. The flux peak ratio will be lower, but that was not the question.

NRC Resolution:
Comment accepted. The answer key will be modified to accept both “b” and “c” as correct answers.

Question A.12:
Assume that the total worth of the Safety, Shim, and Reg rods are, respectively, \$4.04, \$3.82, and \$1.60. The reactor is exactly critical at 5 W with the following control rod worth removed from the core: Safety \$3.06, Shim \$2.85, Reg \$1.16. What is the shutdown margin in %ΔK/K?

$\bar{\beta}_{eff} = 0.0075 \, {}^{\Delta K}\!/_{K}$

A. 0.018

B. 0.053

C. 1.8

D. 5.3

Facility Comment:

Many students did not notice the “%” sign at the end of the question stem so answer “b” looked correct. We would recommend that units normally be included with each of the answer alternatives to avoid this confusion. Many students felt tricked.

NRC Resolution:
Comment not accepted. The standard NRC question format requires all repeated information to be included in the question stem instead of listing it for each answer choice. The NRC highly recommends that all candidates should thoroughly read the question before selecting the answer.

Question A.14:
The term prompt critical refers to:

A. the instantaneous jump in power due to a rod withdrawal

B. a reactor which is supercritical using only prompt neutrons

C. a reactor which is critical using both prompt and delayed neutrons

D. a reactivity insertion which is less then b_{eff}

Facility Comment:
Option "b", which is the correct answer by the answer key, is not worded correctly. Our training manual says a reactor which is "critical using only prompt neutrons", not "supercritical".

NRC Resolution:
Comment accepted. The question will be reworded to define prompt critical as critical using only prompt neutrons.

Question A.16:
The prompt negative temperature coefficient of the Reed Reactor core is $0.007\,\$/_{kW}$ and the **average** control rod worth of the safety control rod is $0.27\,\$/_{inch}$. If the power increases from 100 to 240 kW, how much will the operator pull the regulating rod out to compensate for power in inches? ($\bar{\beta}_{eff} = 0.0075\,\Delta K/_{K}$)

A. 1.2

B. 2.7

C. 3.6

D. 4.3

Facility Comment:
The answer should be "c". The calculation in the answer key is correct, but the wrong letter is listed for the answer.

NRC Resolution:
Comment accepted. The answer key will be modified to accept "c" as the correct answer.

Question B.17:
Which ONE of the following items will ALLOW a reactor operator to continue to operate the reactor? (Assume today is the three year anniversary of receiving your RO license)

A. Last physical was 20 months ago.

B. Number of reactivity manipulations last year was 7.

C. Hours on the console last quarter was 3 hours.

D. Operating exam administered by supervisor was 16 months ago.

Facility Comment:
Reeds operating exams are required every academic year. Thus an exam in September 2002 and in April 2004 is acceptable. This is more than 16 months, so answer "d" could be correct.

NRC Resolution:
Comment accepted. The Reed Reactor Facility Requalification Plan states that an operating test is required every academic year. The answer key will be modified to accept both "a" and "d" as correct answers.

Question C.7:
Where in the ventilation system is the gaseous stack monitor sampling loop located?
Fan A is the reactor loop supply unit and Fan B is the reactor loop exhaust unit.

A. After the outlet of Fan B.

B. Before the inlet to Fan A.

C. After the outlet of Fan A.

D. Before the inlet to the Fan B.

Facility Comment:
The answer should be "a". The gas sampling line is at the outlet of Exhaust Fan B.

NRC Resolution:
Comment accepted. The answer key will be modified to accept "a" as the correct answer.

Question C.10:
Which ONE of the following describes the automatic actions for a high bulk water temperature alarm?

A. Display turns orange and buzzer turns on.

B. Old rotating red APM light turns on and buzzer turns on.

C. Display turns orange and old rotating red APM light turns on.

D. Buzzer turns on and display starts blinking.

Facility Comment:

The display turns red, not orange. Please remove the reference to the “old APM” alarm, since many operators don’t remember the old APM.

NRC Resolution:
Comment accepted. The correct answer will be reworded to accurately describe the automatic actions for a high bulk water temperature alarm.

Question C.19:
What is one of the purposes for the neutron count interlock?

A. To prevent the reactor from being manipulated to a critical position before the count rate channel is verified to be operable.

B. To provide a reference point where all instruments undergo a check before the reactor is brought to a critical position.

C. To allow for all experiments to be installed before the reactor is critical.

D. To ensure that a steady rate of startup to the critical position is achieved.

Facility Comment:

Answer “d” should also be allowed. We teach that a source is necessary to allow a controlled approach to criticality, which is expressed in answer “d”. Also the interlock is not required to be on the count rate channel; we plan to move it to the log channel this summer.

NRC Resolution:
Comment not accepted. As shown in the safety evaluation for amendment #7 to the license, the purpose of the interlock is to prevent the startup of the reactor with inoperable instrumentation. An uncontrolled approach to criticality, with the source in the core, can be achieved by quickly pulling the control rods out of the core. This type of startup cannot be prevented by the neutron count interlock, therefore the interlock is not necessary to allow a controlled approach to criticality.

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

FACILITY: Reed College Docket # 50-288

REACTOR TYPE: TRIGA MARK-I

DATE ADMINISTERED: 05/03/04

CANDIDATE: ____________________________

INSTRUCTIONS TO CANDIDATE:
Answers are to be written on the answer sheet provided. Attach the answer sheets to the examination. Points for each question are indicated in brackets for each question. A 70% in each section is required to pass the examination. Examinations will be picked up three (3) hours after the examination starts.

Category Value	% of Total	Candidates 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 3

QUESTION A.1 [1.0 point]
What is the definition of a cross section?

A. The probability that a neutron will be captured by the nucleus.

B. The most likely energy at which a charged particle will be captured.

C. The length a charged particle travels past the nucleus before being captured.

D. The area of the nucleus including the electron cloud.

QUESTION A.2 [1.0 point]
What does the unit of electron volt (eV) measure?

A. electrostatic potential

B. electric current

C. mass

D. energy

QUESTION A.3 [1.0 point]
As a result of β^- decay:

A. The atomic mass number decreases by one, and the atomic number remains constant.

B. The atomic mass number remains constant, and the atomic number increases by 1.

C. The atomic mass number and the atomic number remain constant.

D. The atomic mass number and the atomic number decrease by 1.

QUESTION A.4 [1.0 point]
Which ONE of the following is the direct cause of Cerenkov radiation in the Reed Reactor?

A. An atom splitting apart due to fission.

B. The absorption of a neutron by ^{238}U.

C. Particles scattering off the reactor's structural materials.

D. Electrons moving faster than the speed of light in water.

(*** Category A continued on next page *****)**

QUESTION A.5 [1.0 point]
Which ONE of the following neutrons would result in the highest probability of fission for ^{235}U?

A. Thermal neutron (0.025 eV)

B. Epi-Thermal neutron (1 eV)

C. Prompt neutron (0.7 MeV)

D. Fast neutron (2 MeV)

QUESTION A.6 [1.0 point]
What is the primary reason delayed neutrons are so effective at controlling reactor power?

A. A very large fraction of the fission neutrons in the core are delayed.

B. Prompt neutrons have a much shorter mean lifetime than delayed neutrons.

C. Delayed neutrons are born at higher energies than prompt neutrons.

D. Delayed neutrons are born at thermal energies.

QUESTION A.7 [1.0 point]
Which one of the following describes the general shape of a differential rod worth curve?

A. Parabolic shaped, with the maximums at the top and bottom of the core height.

B. S shaped, with the maximum at the top of the core height.

C. Cosine shaped, with the maximum at the middle of the core height.

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

QUESTION A.8 [1.0 point]
The flux peak in a reactor with a reflector is ________ the peak in a reactor without a reflector.

A. Equal to

B. Higher than

C. Lower than

D. Not related to

(*** Category A continued on next page *****)**

QUESTION A.9 [1.0 point]
Which ONE of the following describes the effect of increasing moderator temperature in the Reed Reactor?

A. Decreased neutron mean free path.

B. Decreased time for the neutrons to leak out while still fast.

C. Increased probability of absorption by a ^{238}U resonance peak.

D. Increased number of neutrons produced by fission.

QUESTION A.10 [1.0 point]
Which ONE of the following is the direct source of delayed neutrons in the fission process?

A. Fissioning of ^{235}U

B. Spontaneous fissioning of the fission products

C. Absorption by ^{238}U

D. Decay of the fission product daughters

QUESTION A.11 [1.0 point]
The reactor has been stable at 20 Watts for about an hour. Removing the source from the core causes reactor power to:

A. Decrease since the reactor is under-moderated.

B. Increase due to an increase in the amount of moderator.

C. Stay the same due to k_{eff} being constant.

D. Decrease due to fast neutron leakage.

(*** Category A continued on next page *****)**

QUESTION A.12 [1.0 point]
Assume that the total worth of the Safety, Shim, and Reg rods are, respectively, $4.04, $3.82, and $1.60. The reactor is exactly critical at 5 W with the following control rod worth removed from the core: Safety $3.06, Shim $2.85, Reg $1.16. What is the shutdown margin in %ΔK/K?
$\bar{\beta}_{eff} = 0.0075 \, {}^{\Delta K}\!/\!{}_{K}$

A. 0.018

B. 0.053

C. 1.8

D. 5.3

QUESTION A.13 [1.0 point]
What is the primary mechanism of Samarium (^{149}Sm) removal from the core when it is shutdown?

A. The isotope cannot be depleted in the absence of a neutron flux.

B. Electron capture from fission products emitting β^- rays.

C. Absorption of decay alphas from the fuel.

D. Decay of the isotope
.

QUESTION A.14 [1.0 point] Question changed to incorporate facility comments.
The term prompt critical refers to:

A. the instantaneous jump in power due to a rod withdrawal

B. a reactor which is ~~supercritical~~ critical using only prompt neutrons

C. a reactor which is critical using both prompt and delayed neutrons

D. a reactivity insertion which is less then β_{eff}

(*** Category A continued on next page *****)**

QUESTION A.15 [1.0 point]
The _________ of the six factor formula _________ due to the insertion of control rods in the Reed core.

A. reproduction factor; increases

B. resonance escape probability; decreases

C. fast non-leakage probability; increases

D. thermal utilization factor; decreases

QUESTION A.16 [1.0 point]
The prompt negative temperature coefficient of the Reed Reactor core is $0.007 \,{}^{\$}\!/_{kW}$ and the **average** control rod worth of the safety control rod is $0.27 \,{}^{\$}\!/_{inch}$. If the power increases from 100 to 240 kW, how much will the operator pull the regulating rod out to compensate for power in inches? ($\bar{\beta}_{eff} = 0.0075 \,{}^{\Delta K}\!/_{K}$)

A. 1.2

B. 2.7

C. 3.6

D. 4.3

QUESTION A.17 [1.0 point]
Which ONE of the following materials in the core contributes the most to neutron moderation?

A. Zirconium Hydride

B. H_2O

C. Graphite

D. Stainless Steel

(*** Category A continued on next page *****)**

QUESTION A.18 [1.0 point]
Which ONE of the following statements listing the heat transfer flow mechanisms is correct?

A. fuel meat to fuel cladding by convection

B. primary coolant to secondary coolant by convection

C. water from core to bulk pool water by conduction

D. secondary water to outside air by convection

QUESTION A.19 [1.0 point]
Before the reactor is started up, k_{eff} is 0.8 and the count rate meter is reading 250 counts per minute. After pulling the control rods for a short time, you notice that the count rate has doubled to 500 counts per minute. What is the new k_{eff}?

A. 0.1

B. 0.6

C. 0.9

D. 1.1

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

A. Prompt gamma rays

B. Fission fragments

C. Neutrinos

D. Fission neutrons

(*** End of Category A *****)**

QUESTION B.1 [1.0 point]
Which is the definition of the site boundary for the Reed reactor facility?

A. The area inside the reactor bay.

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.2 [1.0 point]
Why is algaecide added weekly to the secondary cooling loop?

A. Suppresses biological growth in the cooling tower.

B. Minimizes corrosion of the pipes.

C. Increases thermal conductivity of the water.

D. Prevents the water from freezing in cold temperatures.

QUESTION B.3 [1.0 point]
What is the maximum licensed power level that the Reed Reactor can be operated at?

A. 200 kW

B. 232.5 kW

C. 265 kW

D. 287.5 kW

QUESTION B.4 [1.0 point]
Which ONE of the following is TRUE regarding crane operation while the Reed Reactor is operating?

A. The crane bridge may not be moved over the reactor.

B. The crane trolley may not be moved over the reactor.

C. Permission to operate the crane must be obtained from the RO on duty.

D. Permission to operate the crane must be obtained from the SRO on duty.

(*** Category B continued on next page *****)**

QUESTION B.5 [1.0 point]
During an emergency situation response activities are coordinated from the Emergency Support Center, which is the…

A. Control room

B. Directors office

C. Break room

D. Outside the facility

QUESTION B.6 [1.0 point]
What is the definition of Total Effective Dose Equivalent (TEDE)?

A. Sum of external and internal dose.

B. Dose equivalent at tissue depth of 1 cm.

C. Dose equivalent to organs or tissues.

D. Sum of dose multiplied by weighting factors.

QUESTION B.7 [1.0 point]
As a licensed reactor operator at the Reed Reactor Facility, who is allowed to operate the controls of the reactor under your direction?

A. A local college newspaper reporter who wants to write a story on the safety of nuclear reactors.

B. A new student participating in the Reed reactor operator seminar.

C. A health physicist who is trying to gain a certified health physicist (CHP) license.

D. An NRC inspector trying to make sure that all set points of the reactor are the same as those in the technical specifications.

(*** Category B continued on next page *****)**

QUESTION B.8 [1.0 point]
How often is a status stamp required to be completed in the log book during operations at constant power?

A. 15 minutes

B. 30 minutes

C. 60 minutes

D. 90 minutes

QUESTION B.9 [¼ point each]
Match the following activities with the placement of the SRO:

A. Recovery from a planned shutdown.	1. Must be in facility
B. Insertion of a routine experiment while shutdown.	2. May be on call
C. Operation at a steady power level.	3. SRO not required
D. Initial startup of the day to full power.	

QUESTION B.10 [1.0 point]
Which ONE of the following conditions requires immediate actions as specified in the technical specifications?

A. Bulk pool water temperature is 100^{o}F.

B. An in-core experiment has a reactivity worth of \$1.50.

C. The shim control rod drop time is 0.5 seconds.

D. Pool water level is 18 feet above the top grid plate of the core.

QUESTION B.11 [1.0 point]
Which ONE of the following situations requires a radiation work permit (RWP)?

A. Conducting fuel inspections with personnel around the pool.

B. Walking on the bridge during a beam irradiation.

C. Calibration of RAM using Ra-226 source.

D. Removal of lazy susan samples.

(*** Category B continued on next page *****)**

QUESTION B.12 [1.0 point]
During a rabbit irradiation at full power, which ONE of the following precautions must be followed as part of the procedure?

A. Do not allow the rabbit motor to be turned on after the reactor has been at power for a while.

B. The rabbit operator must not allow anyone except him/herself to have complete control over the insertion and removal of the sample in the core.

C. The reactor operator must scram the reactor if there is a power level change greater than 10% when the sample is inserted in the core.

D. Discolored rabbit tubes must be used since they are more brittle and will allow a greater percentage of neutrons to irradiate the sample.

QUESTION B.13 [1.0 point]
Which ONE of the following activities must be carried out on a weekly basis?

A. Test the evacuation alarm.

B. Test the water level low/hi alarm.

C. Inventory licensed radioactive material.

D. Radiation Area Monitor (RAM) check.

QUESTION B.14 [1.0 point]
If there is a sudden loss of all pool water and you are the most senior person on-site, what would be your immediate response after scramming the reactor and notifying the SRO?

A. Try to connect pool water makeup to ensure the fuel elements remain cooled.

B. Move fuel from inner ring to storage racks to prevent inadvertent criticality.

C. Place lead shielding above the pool deck plates in order to lower radiation dose rates.

D. Evacuate the reactor bay to reduce unnecessary exposure to radiation.

(*** Category B continued on next page *****)**

QUESTION B.15 [1.0 point]
The condition of “Notification of Unusual Event” encompasses all of the following except:

A. There is time available to take precautionary corrective steps.

B. Release is expected of radioactive material, which will require off-site response.

C. One or more elements of the emergency organization are likely to be notified.

D. Can be initiated by manmade events or natural phenomena.

QUESTION B.16 [1.0 point]
The radiation from an unshielded Cs-137 source is 250 mrem/hr at a distance of 30 cm. What thickness of lead shielding will be needed to lower the radiation level to values so that a “Radiation Area” is not required? The HVL (half-thickness) for Cs-137 and lead is 6.5 mm.

A. 6.5 mm

B. 19.5 mm

C. 26 mm

D. 39 mm

QUESTION B.17 [1.0 point]
Which ONE of the following items will ALLOW a reactor operator to continue to operate the reactor? (Assume today is the three year anniversary of receiving your RO license)

A. Last physical was 20 months ago.

B. Number of reactivity manipulations last year was 7.

C. Hours on the console last quarter was 3 hours.

D. Operating exam administered by supervisor was 16 months ago.

(*** Category B continued on next page *****)**

QUESTION B.18 [1.0 point]
What type of radiation detector is used for surveying contaminated areas?

A. Ionization chamber

B. Proportional counter

C. Geiger-Mueller tube

D. Scintillation detector

QUESTION B.19 [1.0 point]
Which ONE of the following radio-isotopes is of highest concern due to its ionizing energy?

A. ^{3}H

B. ^{16}N

C. ^{41}Ar

D. ^{235}U

QUESTION B.20 [1.0 point]
Why is the technical specification limit for maximum available excess reactivity set at 2.25% $\Delta k/k$ ($3)?

A. Correlates to the maximum fuel load the grid plates can hold.

B. Insures that there will be enough neutrons to conduct the experiments it is designed for.

C. In case of an accidental pulsing of the reactor without hazard to the staff or the public.

D. It is the maximum power level that the reactor support structures are designed to withstand.

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

QUESTION C.1 [1.0 point]
Which ONE of the following is NOT a control rod limit switch?

A. Motor in the up position

B. Motor in the down position

C. Rod in the up position

D. Rod in the down position

QUESTION C.2 [⅓ point each]
Match the following materials with the mechanism used to remove them from the primary coolant.

A. Suspended solids	1. Demineralizer
B. Soluble impurities	2. Filter
C. Dust	3. Skimmer

QUESTION C.3 [1.0 point]
What is the source of air for the pneumatic transfer system when inserting a sample into the reactor?

A. Mechanical room

B. Radiochemistry laboratory A

C. Outside air intake

D. Loft free air space

QUESTION C.4 [1.0 point]
What is the purpose of the orifice in the Primary Cooling System?

A. To limit excessive pressure in the system.

B. To ensure coolant flow is in the correct direction.

C. To establish proper flow through the purification loop.

D. To prevent excessive back pressure on the heat exchanger.

(*** Category C continued on next page *****)**

QUESTION C.5 [1.0 point]
Where is the Zirconium Hydride located in the fuel element used in the Reed Reactor core?

A. Above and below the fuel material.

B. On the outside of the fuel material in the cladding.

C. In the middle of the fuel element.

D. Intimately mixed with the fuel material.

QUESTION C.6 [1.0 point]
Which one of the following situations will cause the reactor to automatically SCRAM?

A. Low linear power channel voltage

B. High Radiation level at top of pool

C. Low pool water level

D. Sudden decrease in neutron induced signal

QUESTION C.7 [1.0 point]
Where in the ventilation system is the gaseous stack monitor sampling loop located?
Fan A is the reactor loop supply unit and Fan B is the reactor loop exhaust unit.

A. After the outlet of Fan B.

B. Before the inlet to Fan A.

C. After the outlet of Fan A.

D. Before the inlet to the Fan B.

QUESTION C.8 [1.0 point]
What is the minimum amount of water that the central thimble is designed to operate with?

A. The entire thimble must be filled with water.

B. Half of the thimble has to be filled with water.

C. The active lattice portion of the thimble has to be filled with water.

D. The thimble can be operated without any water in it.

(*** Category C continued on next page *****)**

QUESTION C.9 [1.0 point]
What type of detectors are used in the APM, GSM, and CAM radiation monitoring systems?

A. Geiger-Mueller

B. Proportional counter

C. Ionization chamber

D. β^- Scintillation

QUESTION C.10 [1.0 point] Question changed to incorporate facility comments.
Which ONE of the following describes the automatic actions for a high bulk water temperature alarm?

A. Display turns orange and buzzer turns on.

B. Old rotating red APM light turns on and buzzer turns on.

C. Display turns ~~orange~~ red and ~~old~~ rotating red ~~APM~~ light on control room ceiling turns on.

D. Buzzer turns on and display starts blinking.

QUESTION C.11 [1.0 point]
Which ONE of the following neutron flux monitoring channels provides a signal indicating the period of the reactor?

A. Linear Channel

B. Count Rate Channel

C. Log Channel

D. Percent Power Channel

QUESTION C.12 [1.0 point]
What material is in the absorbing section of the shim control rod? An alloy of Boron and...

A. Carbon

B. Aluminum

C. Cadmium

D. Stainless steel

(*** Category C continued on next page *****)**

QUESTION C.13 [0.5 point each]
Match the problems on the left with its possible plant conditions on the right.
(No changes to any equipment have been made, e.g. no valves manipulated)

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

QUESTION C.14 [1.0 point]
What prevents water from being drained out of the pool if there is a leak in the primary coolant piping?

A. ½ inch diameter holes drilled into the pipe one foot from the surface of the pool.

B. Water detection systems that stop all flow of water in the pipes.

C. The inlet and outlet pipes are short enough to only extend a minimal depth into the pool.

D. Anti-syphon valves that prevent water from flowing in the absence of water.

QUESTION C.15 [1.0 point]
SELECT the method by which gamma ray compensation is accomplished in a compensated ion chamber such as the linear power channel. Gamma-ray compensation is accomplished by:

A. a pulse height discriminator that eliminates or discriminates the pulses from the low energy gammas and allows only the higher energy neutron signals through.

B. the comparison of the currents generated in two concentric chambers in the detector, one sensitive only to gammas one sensitive to neutrons and gammas.

C. varying the amount and concentration of the boron tri-fluoride gas in the compensated ion chamber thus reducing the detectors sensitivity to gamma induced ionizations.

D. varying the pressure of the detector Argon charge gas in conjunction with a low boron concentration coating the inside walls of the outer chamber.

(*** Category C continued on next page *****)**

QUESTION C.16 [1.0 point]
How does the control rod position indicator measure rod height?

A. A potentiometer is attached to the control rod drive motor.

B. A radio-frequency detector measures the height of the control rod extension tube above the piston.

C. An accelerometer determines the relative movement of the control rod.

D. A sonar detector measures the amount of control rod still in the core.

QUESTION C.17 [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?
Fan A is the reactor loop supply unit and Fan B is the reactor loop exhaust unit.

A. Fan A and Fan B are off.

B. Fan A is on and Fan B is off.

C. Fan A is off and Fan B is on.

D. Fan A and Fan B are on.

QUESTION C.18 [1.0 point]
Which ONE of the following is NOT the location of a radiation area monitor?

A. Sample Holding Pit

B. Rabbit Terminus

C. Control Room

D. Counting Room

(*** Category C continued on next page *****)**

QUESTION C.19 [1.0 point]
What is one of the purposes for the neutron count interlock?

A. To prevent the reactor from being manipulated to a critical position before the count rate channel is verified to be operable.

B. To provide a reference point where all instruments undergo a check before the reactor is brought to a critical position.

C. To allow for all experiments to be installed before the reactor is critical.

D. To ensure that a steady rate of startup to the critical position is achieved.

(*** End of Category C *****)**

Section A: R Theory, Thermodynamics & Facility Operating Characteristics ANSWERS

A.1 A
REF: Reed instructor manual - Introduction - Radioactivity pg. 2.2

A.2 D
REF: Reed Reactor Facility Training Manual Pg. 9

A.3 B
REF: Reed Reactor Facility Training Manual Pg. 136

A.4 D
REF: Reed Reactor Facility Training Manual Pg. 25

A.5 A
REF: Reed Reactor Facility Training Manual Pg. 122

A.6 B
REF: Reed Reactor Facility Training Manual Pg. 156

A.7 C
REF: Reed Reactor Facility Training Manual Pg. 176

A.8 C or B, 2nd correct answer added per NRC review of question commented on by facility.
REF: Reed Reactor Facility Training Manual Pg. 126

A.9 C
REF: Reed Reactor Facility Training Manual Pg. 139

A.10 D
REF: Reed Reactor Facility Training Manual Pg. 153

A.11 B
REF: Standard NRC Question

A.12 D
REF: Reed Reactor Facility Training Manual Pg. 165

$$S/D\ Margin = (\$3.06 + 2.85 + 1.16) * \frac{0.0075\,\Delta K/K}{\$1} = .053\,\Delta K/K = 5.3\%\,\Delta K/K$$

A.13 A
REF: Reed Reactor Facility Training Manual Pg. 181

A.14 B
REF: Reed Reactor Facility Training Manual Pg. 160

A.15 D
REF: Reed Reactor Facility Training Manual Pg. 139

Section A: ~~R~~ Theory, Thermodynamics & Facility Operating Characteristics ANSWERS

A.16 ~~B~~ C (Answer changed to incorporate facility comments.)
REF: Reed Reactor Facility Training Manual Pg. 166

$$0.007 \,{}^{\$}\!/\!_{kW} * 140kW = 0.98\$$$

$$D = \frac{0.98\$}{0.27 \,{}^{\$}\!/\!_{inch}} = 3.62 \;\; inches$$

A.17 A
REF: Reed Reactor Facility Training Manual Pg. 192

A.18 D
REF: Reed Reactor Facility Training Manual Pg. 194

A.19 C
REF: Reed Reactor Facility Training Manual Pg. 144-146

$$CR_1\left(1-k_{eff\,1}\right) = CR_2\left(1-k_{eff\,2}\right) \rightarrow k_{eff\,2} = 1-\frac{CR_1\left(1-k_{eff\,1}\right)}{CR_2} = 1-\frac{250cpm(1-0.8)}{500cpm} = 0.9$$

A.20 B
REF: Reed Reactor Facility Training Manual Pg. 171

Section B: Normal / Emergency Procedures & Radiological Controls ANSWERS

B.1 B
REF: Reed instructor manual - Lectures - Lecture 8; Practical Health Physics. Slide 3 of 36

B.2 A
REF: Reed Reactor Facility Training Manual Pg. 215

B.3 D
REF: Reed Reactor TS A.2

B.4 B
REF: Reed Reactor Facility Administrative Procedures §3.2

B.5 B
REF: Reed Reactor Facility Emergency Plan §2.9

B.6 A
REF: Reed instructor manual - Lectures - Lecture 10; Admin proc waste regs. Slide 15 of 47

B.7 B
REF: 10 CFR 55.13

B.8 C
REF: Reed Research Reactor SOP-3 §3.7.4.3

B.9 A 2; B 3; C 2; D 1
REF: Reed Reactor Facility Administrative Procedures §3.1; 10 CFR 50.54(m)(1)

B.10 B
REF: Reed Research Reactor TS J.4(a)

B.11 B
REF: Reed Research Reactor SOP-28 §28.2

B.12 C
REF: Reed Research Reactor SOP-53; Rabbit Irradiations §51.5.3

B.13 D
REF: Reed Research Reactor SOP-70; Weekly Checklist §70.7.5

B.14 D
REF: Reed Reactor Facility Emergency Implementing Procedures - Situation 2

B.15 B
REF: Reed Reactor Facility Emergency Plan §4.2

B.16 D
REF: 10 CFR 20.1003

B.17 A or D, 2nd correct answer added per NRC review of question commented on by facility.
REF: Reed Research Reactor SOP-13; Requalification §13.2

Section B: Normal / Emergency Procedures & Radiological Controls ANSWERS

B.18 C
REF: Reed instructor manual - Lectures - Lecture 8; Practical Health Physics. Slide 11 of 36

B.19 B
REF: Chart of The Nuclides: http://www2.bnl.gov/ton

B.20 C
REF: Reed College Safety Analysis Report §7.1

Section C: Facility and Radiation Monitoring Systems ANSWERS

C.1 C
REF: Reed Reactor Facility Training Manual Pg. 208

C.2 A2; B1; C3
REF: Reed Reactor Facility Training Manual Pg. 214

C.3 A
REF: Reed Reactor Facility Training Manual Pg. 212

C.4 C
REF: Reed Reactor Mechanical Maintenance Manual §5.8

C.5 D
REF: Reed Reactor Facility Training Manual Pg. 204

C.6 A
REF: Reed instructor manual - Lectures - Lecture 4; Reactor Electronics. Slide 35 of 39

C.7 ~~D~~ A (Answer changed to incorporate facility comments.)
REF: Reed instructor manual - Lectures - Lecture 3; Cooling, etc. Slide 19 of 23

C.8 C
REF: Reed Reactor Mechanical Maintenance Manual §4.7

C.9 B
REF: Reed Reactor Procedure Change Notice 03-01

C.10 C
REF: Reed Reactor Procedure Change Notice 03-02

C.11 C
REF: Reed Reactor Facility Training Manual Pg. 215

C.12 A
REF: Reed Reactor Facility Training Manual Pg. 205

C.13 A 2; B 3; C 1; D 4
REF: Reed Reactor Mechanical Maintenance Manual §5.6
Reed instructor manual - Lectures - Lecture 3; Cooling, etc. Slide 4 of 23
Reed Reactor Mechanical Maintenance Manual §5.11.1

C.14 A
REF: Reed Reactor Mechanical Maintenance Manual §5.11.10

C.15 B
REF: Reed instructor manual - Lectures - Lecture 4; Reactor Electronics. Slide 20 of 39

C.16 A
REF: Reed Reactor Facility Training Manual Pg. 205

Section C: Facility and Radiation Monitoring Systems ANSWERS

C.17 C
REF: Reed Reactor Facility Training Manual Pg. 217

C.18 D
REF: Reed Reactor Facility SOP 30 – RAM Calibration §30.1

C.19 A
REF: Pg. 1 of 3; Safety Evaluation for Issuance of Amendment #7 to Amended Facility Operating License #R-112
Glasstone, S. and Sesonske, Nuclear Reactor Engineering, § 2.70 – 2.74, pp. 65 – 66.

MULTIPLE CHOICE (Circle your choice)
If you change your answer, write your selection in the blank.

A.1 a b c d ___

A.2 a b c d ___

A.3 a b c d ___

A.4 a b c d ___

A.5 a b c d ___

A.6 a b c d ___

A.7 a b c d ___

A.8 a b c d ___

A.9 a b c d ___

A.10 a b c d ___

A.11 a b c d ___

A.12 a b c d ___

A.13 a b c d ___

A.14 a b c d ___

A.15 a b c d ___

A.16 a b c d ___

A.17 a b c d ___

A.18 a b c d ___

A.19 a b c d ___

A.20 a b c d ___

MULTIPLE CHOICE (Circle your choice)
If you change your answer, write your selection in the blank.

B.1 a b c d ___	B.12 a b c d ___
B.2 a b c d ___	B.13 a b c d ___
B.3 a b c d ___	B.14 a b c d ___
B.4 a b c d ___	B.15 a b c d ___
B.5 a b c d ___	B.16 a b c d ___
B.6 a b c d ___	B.17 a b c d ___
B.7 a b c d ___	B.18 a b c d ___
B.8 a b c d ___	B.19 a b c d ___
B.9 a__ b__ c__ d__	B.20 a b c d ___
B.10 a b c d ___	
B.11 a b c d ___	

MULTIPLE CHOICE (Circle your choice)
If you change your answer, write your selection in the blank.

C.1 a b c d ___

C.2 a__ b__ c__

C.3 a b c d ___

C.4 a b c d ___

C.5 a b c d ___

C.6 a b c d ___

C.7 a b c d ___

C.8 a b c d ___

C.9 a b c d ___

C.10 a b c d ___

C.11 a b c d ___

C.12 a b c d ___

C.13 a__ b__ c__ d__

C.14 a b c d ___

C.15 a b c d ___

C.16 a b c d ___

C.17 a b c d ___

C.18 a b c d ___

C.19 a b c d ___

EQUATION SHEET

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

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

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

$$\lambda_{eff} = 0.1 \text{ seconds}^{-1}$$

$$CountRate = \frac{S}{-\rho} \approx \frac{S}{1-K_{eff}}$$

$$CR_1(1-K_{eff_1}) = CR_2(1-K_{eff_2})$$
$$CR_1(-\rho_1) = CR_2(-\rho_2)$$

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

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

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

$$P = P_0 e^{\frac{t}{\tau}}$$

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

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

$$\tau = \frac{\ell^*}{\rho - \bar{\beta}}$$

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

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

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

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

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

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

$$DR_1 d_1^2 = DR_2 d_2^2$$

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

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

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

1 kg = 2.21 lbm

1 Horsepower = 2.54 x 10^3 BTU/hr

1 Mw = 3.41 x 10^6 BTU/hr

1 BTU = 778 ft-lbf

°F = 9/5 °C + 32

1 gal (H_2O) ≈ 8 lbm

°C = 5/9 (°F - 32)

c_P = 1.0 BTU/hr/lbm/°F

c_p = 1 cal/sec/gm/°C