September 19, 2002

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

SUBJECT: INITIAL EXAMINATION REPORT NO. 50-288/OL-02-03, REED COLLEGE

Dear Mr. Frantz:

During the week of September 2, 2002, the NRC administered examinations to an employee of your facility who had applied for a license to operate your Reed College Reactor. The examination was conducted in accordance with NUREG-1478, "Non-Power Reactor Operator Licensing Examiner Standards," Revision 1.

In accordance with 10 CFR 2.790 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 document system (ADAMS). ADAMS is accessible from the NRC Web site at (the Public Electronic Reading Room) http://www.nrc.gov/NRC/ADAMS/indesx.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 Patrick Isaac at 301-415-1019.

Sincerely,

/RA/

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

Docket No. 50-288

Enclosures: 1. Initial Examination Report No. 50-288/OL-02-03
2. Examination and answer key

cc w/enclosures:
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
Portland, OR 97202-8199

Reed College
ATTN: Dr. Colin Diver, President
3203 S.E. Woodstock Boulevard
Portland, OR 97202-8199

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

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OFFICE	**RORP:CE**		**IEHB:LA**		**RORP:SC**	
NAME	**PIsaac:rdr**		**EBarnhill**		**PMadden**	
DATE	**09/ 16 /2002**		**09/ 17 /2002**		**09/ 18 /2002**	

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

REPORT NO.:	50-288/OL-02-03
FACILITY DOCKET NO.:	50-288
FACILITY LICENSE NO.:	R-112
FACILITY:	Reed College
EXAMINATION DATES:	09/03/2002
EXAMINER:	Patrick Isaac, Chief Examiner

SUBMITTED BY: ***/RA/*** — Patrick Isaac, Chief Examiner — 09/12/2002 Date

SUMMARY:

During the week of September 02, 2002, NRC administered a retake of Section A of the Operator Licensing written examinations to one Reactor Operator (RO) candidate. The candidate passed the examinations.

REPORT DETAILS

1. Examiners:

   Patrick Isaac, Chief Examiner

2. Results:

	RO PASS/FAIL	SRO PASS/FAIL	TOTAL PASS/FAIL
Written	**1/0**	**N/A**	**1/0**
Operating Tests	**N/A**	**N/A**	**N/A**
Overall	**1/0**	**N/A**	**1/0**

ENCLOSURE 1

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

FACILITY: Reed College

REACTOR TYPE: TRIGA

DATE ADMINISTERED: 2002/09/03

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% is required to pass the examination. Examinations will be picked up one (1) hour after the examination starts.

CATEGORY VALUE	% OF TOTAL	CANDIDATE'S SCORE	% OF CATEGORY VALUE	CATEGORY
20.00	100	____________	_____	A. REACTOR THEORY, THERMODYNAMICS AND FACILITY OPERATING CHARACTERISTICS
20.00		____________ FINAL GRADE	_____%	TOTALS

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

____
Candidate's Signature

ENCLOSURE 2

A. RX THEORY, THERMO & FAC OP CHARS

A N S W E R   S H E E T

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

001 a b c d ___

002 a b c d ___

003 a b c d ___

004 a b c d ___

005 a b c d ___

006 a b c d ___

007 a b c d ___

008 a b c d ___

009 a b c d ___

010 a b c d ___

011 a b c d ___

012 a b c d ___

013 a b c d ___

014 a b c d ___

015 a b c d ___

016 a b c d ___

017 a b c d ___

018 a b c d ___

019 a b c d ___

020 a b c d ___

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

12. There is a time limit of one (1) hour for completion of the examination.

EQUATION SHEET

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

$\dot{Q} = \dot{m} \Delta h$

$\dot{Q} = UA \Delta T$

$SUR = \dfrac{26.06 (\lambda_{eff}\rho)}{(\beta - \rho)}$

$SUR = 26.06/\tau$

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

$P = P_0 e^{(t/\tau)}$

$P = \dfrac{\beta(1-\rho)}{\beta-\rho} P_o$

$\tau = (\ell^*/\rho) + [(\beta-\rho)/\bar{\lambda}_{eff}\rho]$

$\rho = (Keff-1)/Keff$

$\rho = \Delta Keff/Keff$

$\bar{\beta} = 0.007$

$DR_1D_1^2 = DR_2D_2^2$

$Cp (H20) = 0.146 \dfrac{kw}{gpm \cdot {}^\circ F}$

$SCR = S/(1-Keff)$

$CR_1 (1-Keff)_1 = CR_2 (1-Keff)_2$

$M = \dfrac{(1-Keff)_0}{(1-Keff)_1}$

$M = 1/(1-Keff) = CR_1/CR_0$

$SDM = (1-Keff)/Keff$

$I = I_o e^{-ux}$

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

$\tau = \ell^*/(\rho-\bar{\beta})$

$R = 6 C E n$

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

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

$P = S / (1 - Keff)$

---

1 Curie = 3.7×10^{10} dps

1 kg = 2.21 lbm

1 hp = 2.54×10^3 BTU/hr

1 Mw = 3.41×10^6 BTU/hr

1 BTU = 778 ft-lbf

$^\circ F = 9/5 {}^\circ C + 32$

931 Mev = 1 amu

$^\circ C = 5/9 ({}^\circ F - 32)$

Section A ℞ Theory, Thermo & Fac. Operating Characteristics

QUESTION (A.1) [1.0]
Shortly after a reactor trip, reactor power indicates 0.5% where a stable negative period is attained. Reactor power will be reduced to 0.05% in approximately _______ seconds.

a. 90

b. 180

c. 270

d. 360

QUESTION (A.2) [1.0]
The following data was obtained during a reactor fuel load.

No. of Elements	Detector A (cps)
0	20
8	28
16	30
24	32
32	42
40	80

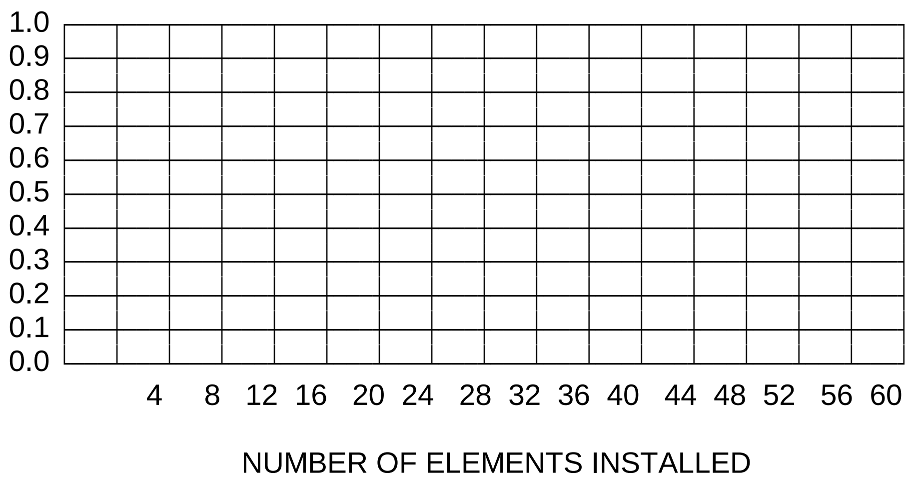
Which one of the following represents the number of fuel elements predicted to reach criticality?

a. 48

b. 52

c. 56

d. 60



QUESTION (A.3) [1.0]
An initial count rate of 100 is doubled five times during startup. Assuming an initial Keff = 0.950, what is the new Keff?

a. 0.957

b. 0.979

c. 0.988

d. 0.998

QUESTION (A.4) [1.0]
When a reactor is critical on prompt neutrons alone, it is said to be prompt critical. If Keff equals 1.0, how much reactivity must be added to make the reactor prompt critical? The amount of reactivity added equals:

a. the β fraction.

b. the amount to make Keff equal to 1.1.

c. the amount to make the reactor period infinite.

d. the amount needed to increase the mean neutron lifetime to 0.080 seconds.

QUESTION (A.5) [1.0]
The reactor is shutdown by 0.05 ΔK/K, this would correspond to Keff of:

a. 0.9995

b. 0.9524

c. 0.7750

d. 0.0500

QUESTION (A.6) [1.0]
Which one of the following is the effect due to an INCREASE in water temperature?

a. Neutron spectrum hardens due to less moderation.

b. Neutron spectrum softens due to increased leakage.

c. Reactivity increases due to less leakage.

d. Reactivity decreases due to more moderation.

QUESTION (A.7) [1.0]
A reactor is subcritical with a shutdown margin of 0.0526 ΔK/K. The addition of a reactor experiment increases the indicated count rate from 10 cps to 20 cps.

Which one of the following is the new Keff of the reactor?

a. .53

b. .90

c. .975

d. 1.02

QUESTION (A.8) [1.0]
Which one of the following statements describes how fuel temperature affects the core operating characteristics?

a. Fuel temperature increase will decrease the resonance escape probability.

b. Fuel temperature decrease results in Doppler Broadening of U238 and Pu240 resonance peaks and the decrease of resonance escape probability.

c. Decrease in fuel temperature will increase neutron absorption by U238 and Pu240.

d. Fuel temperature increase results in Doppler Broadening of U238 and PU240 resonance peaks and the decrease of neutron absorption during moderation.

QUESTION (A.9) [1.0]
Which statement illustrates a characteristic of Subcritical Multiplication?

a. As Keff approaches unity (1), for the same increase in Keff, a greater increase in neutron population occurs.

b. The number of neutrons gained per generation gets larger for each succeeding generation.

c. The number of fission neutrons remain constant for each generation.

d. The number of source neutrons decreases for each generation.

QUESTION (A.10) [1.0]
Select the statement that describes why neutron sources are used in reactor cores.

a. Increase the count rate by an amount equal to the source contribution.

b. Increase the count rate by 1/M (M = Subcritical Multiplication Factor).

c. Provide the source neutrons to initiate the chain reaction when first starting-up the reactor.

d. Provide a neutron level high enough to be monitored by source range instrumentation.

QUESTION (A.11) [1.0]
With the reactor critical at 50% power, the reactor operator withdraws the regulating rod. As power increases, a stable doubling time (DT) of 24 seconds is recorded. (Assume a λ of 0.1 sec-1) Which one of the following is the reactivity added to the core by the operator?

a. 0.14% ΔK/K

b. 0.16% ΔK/K

c. 0.18% ΔK/K

d. 0.20% ΔK/K

QUESTION (A.12) [1.0]
The term "Shutdown Margin" describes:

a. the time required for the rods to fully insert

b. the departure from Keff $\equiv$ 1.00

c. the amount of reactivity by which the reactor is subcritical

d. the amount of reactivity inserted by all the rods except the most reactive rod.

QUESTION (A.13) [1.0]
Which one of the following factors is the most significant in determining the differential worth of a control rod?

a. The rod speed.

b. Reactor power.

c. The flux shape.

d. The amount of fuel in the core.

QUESTION (A.14) [1.0]
Assuming the Samarium worth is 0.006 ΔK/K at full power, which one of the following is the Samarium worth 10 days after shutdown from full power?

a. Essentially zero.

b. It increases by a factor of 2.

c. Less than 0.006 ΔK/K but greater than zero.

d. Greater than 0.006 ΔK/K

QUESTION (A.15) [1.0]
The reactor is operating at 100 KW. The reactor operator withdraws the Regulating Rod adding $0.15 of reactivity and allowing power to increase. The operator then inserts the same rod to its original position, decreasing power.

In comparison to the rod withdrawal, the rod insertion will result in:

a. a longer period due to long lived delayed neutron precursors.

b. a shorter period due to long lived delayed neutron precursors.

c. the same period due to equal amounts of reactivity being added.

d. the same period due to equal reactivity rates from the rod.

QUESTION (A.16) [1.0]
The reactor is shutdown after an extended, 24 hours, run at 240 kilowatts. Which one of the following is the time it takes for the MAXIMUM Xenon concentration to be achieved?

a. 0 to 1 hours

b. 2 to 6 hours

c. 8 to 12 hours

d. 18 to 22 hours

QUESTION (A.17) [1.0]
The Reed Reactor is operating at 250 KW and the reactor scram is set for 110% of full power. What will be the power at the time of the scram if a nuclear excursion creates a 0.5 second period and the scram delay time is 1.0 second?

a. 275 KW

b. 670 KW

c. 1847 KW

d. 25000 KW

QUESTION (A.18) [1.0]
An experiment to be placed in the central thimble has been wrapped in cadmium. Which one of the following types of radiation will be most effectively blocked by the cadmium wrapping?

a. Thermal neutrons

b. Fast neutrons

c. Gamma rays

d. X-rays

QUESTION (A.19) [1.0]
Which one of the following factors in the "six factor" formula is the most strongly affected by the Negative Temperature Coefficient ?

a. The fast fission factor

b. The thermal utilization factor

c. The resonance escape probability

d. The thermal non-leakage probability

QUESTION (A.20) [1.0]
A reactor with an initial population of 24000 neutrons is operating with Keff = 1.01. Of the CHANGE in population from the current generation to the next generation, how many are prompt neutrons?

a. 25

b. 238

c. 2500

d. 24240

ANSWER (A.1)
b
REFERENCE (A.1)
Lamarsh, J.R., Introduction to Nuclear Engineering, Addison-Wesley
Publishing, Reading, Massachusetts, 1983. § 7.1, p. 289.

ANSWER (A.2)
a
REFERENCE (A.2)
Burn, R., Introduction to Nuclear Reactor Operations, © 1982, § 5.5, pp. 5-18 — 5-25.

ANSWER (A.3)
d
REFERENCE (A.3)
Burn, R., Introduction to Nuclear Reactor Operations, — 1982, § 5.7, pp. 5-28 — 5-38.
$CR_1/CR_2 = (1 - Keff_2)/(1 - Keff_1)$
$1/32\ (1 - 0.95) = 1 - Keff_2$
$1 - 0.05/32 = Keff_2 = 0.9984$

ANSWER (A.4)
a
REFERENCE (A.4)
Burn, R., Introduction to Nuclear Reactor Operations, © 1982, § 4.2, p. 4-1.

ANSWER (A.5)
b
REFERENCE (A.5)
Burn, R., Introduction to Nuclear Reactor Operations, © 1982, § 3.3.4, p. 3-21.
p=(k-1)/k; p= -0.05; -0.05k = k-1; 1 = k-(-0.05k) = k(1+0.05); k=1/1.05; k=0.9524

ANSWER (A.6)
a
REFERENCE (A.6)
Lamarsh, J.R., Introduction to Nuclear Engineering, Addison-Wesley Publishing, Reading, Massachusetts, 1983. § 5.10, p. 213 — 215.

ANSWER (A.7)
c
REFERENCE (A.7)
SDM = (1-Keff)/Keff
Keff = 1/(SDM + 1)
Keff = 1/(.0526 + 1) = .95

$CR_1/CR_2 = (1 - Keff_2) / (1 - Keff_1)$
$10/20 = (1 - Keff_2) / (1 - 0.95)$
$(0.5) \times (0.05) = (1 - Keff_2)$
$Keff_2 = 1 - (0.5)(0.05) = 0.975$

ANSWER (A.8)
a
REFERENCE (A.8)
Glasstone, S. and Sesonske, A, Nuclear Reactor Engineering, 1991, § 5.98, p. 264.

ANSWER (A.9)

a
REFERENCE (A.9)
Glasstone, S. and Sesonske, Nuclear Reactor Engineering, §§ 3.161 — 3.163, pp. 190 — 191.

ANSWER (A.10)
d
REFERENCE (A.10)
Glasstone, S. and Sesonske, Nuclear Reactor Engineering, §§ 2.70 — 2.74, pp. 65 -- 66.

ANSWER (A.11)
b
REFERENCE (A.11)
$T = (\beta-\rho)/\lambda\rho$ $T = t/\ln 2 = 24/.693 = 34.6$ seconds
$34.6 = .0070 - \rho/0.1 \times \rho$ $3.46 = .007-\rho/\rho$
$\rho(3.46+1)= .007$ $\rho = .007/4.46 = .00157 = .16\%\ \Delta K/K$

ANSWER (A.12)
c
REFERENCE (A.12)
Burn, R., Introduction to Nuclear Reactor Operations, © 1982, § 6.2.3, p. 3-4.

ANSWER (A.13)
c
REFERENCE (A.13)
Burn, R., Introduction to Nuclear Reactor Operations, © 1982, § 7.2 & 7.3, pp. 7-1 — 7-10.

ANSWER (A.14)
d.
REFERENCE (A.14)
Burn, R., Introduction to Nuclear Reactor Operations, © 1982, § 8.5 — 8.7, pp. 8-15 — 8-18.

ANSWER (A.15)
a
REFERENCE (A.15)

ANSWER (A.16)
c
REFERENCE (A.16)
Burn, R., Introduction to Nuclear Reactor Operations, © 1988, §§ 8.1 —8.4, pp. 8-3 — 8-14.

ANSWER (A.17)
c
REFERENCE (A.17)
$P_f = P_0\ e^{t/T}$
$P_f = 250\ KW\ e^{(1\ sec/0.5\ sec)} = 1847\ KW$

ANSWER (A.18)
a
REFERENCE (A.18)
Glasstone, S. and Sesonske, 1991, § 10.34, pp. 639.

ANSWER (A.19)
b
REFERENCE (A.19)
Glasstone, S. and Sesonske, 1991, § 5.98, p. 264.

ANSWER (A.20)
b
REFERENCE (A.20)
24000 x 1.01 = 24240 neutrons in next generation
24240 - 24000 = 240 neutrons added
240 neutrons added - 0.7% delayed neutron fraction = 238 prompt neutrons added