ENCLOSURE 1

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

REPORT NO.: 50-225/OL-91-02

FACILITY DOCKET NO.: 50-225

FACILITY LICENSE NO.: CX-22

FACILITY: Rensselaer Polytechnic Institute

EXAMINATION DATE: December 26, 1991

EXAMINER: Frank Collins, Chief Examiner

SUBMITTED BY: Frank Collins, Chief Examiner — 1/21/92 Date

APPROVED BY: James L. Caldwell — 1/22/92 Date
James L. Caldwell, Chief
Non-Power Reactor Section
Operator Licensing Branch
Division of Licensee Performance
and Quality Evaluation, NRR

SUMMARY:

The applicant passed an SRO (I) Retake examination consisting of Section A, reactor theory, thermodynamics, and facility operating characteristics, of the written examination. This section had previously been failed in the initial examination administered on September 30, 1991.

Sections B and C of the written examination and the operating examination were waived in accordance with examiner standard ES-204-D.

REPORT DETAILS

1. Examiners:

   Frank Collins, Chief Examiner

2. Results:

	RO (Pass/Fail)	SRO (Pass/Fail)	Total (Pass/Fail)
NRC Grading:	N/A	1/0	N/A

3. Written Examination:

   The SRO (I) retake examination consisted of only Section A, reactor theory, thermodynamics, and facility operating characteristics. Sections B and C were waived in accordance with examiner standard ES-204-D.

4. Operating Examinations:

   The SRO (I) operating examination was waived in accordance with examiner stan ES-204-D.

5. Exit Meeting:

   The candidate traveled to the Region I office where the retake of Section A of the written exam was administered. Since a site visit did not occur, an exit meeting was not conducted.

UNITED STATES NUCLEAR REGULATORY COMMISSION

OPERATOR LICENSING EXAMINATION

RENSSELAER POLYTECHNIC INSTITUTE
12/19/91

Nuclear Regulatory Commission
Operator Licensing
Examination

This document is removed from
Official Use Only category on
date of examination.

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

FACILITY: RENSSELAER POLYTECHNIC INSTITUTE

REACTOR TYPE: CRITICAL EXPERIMENT

DATE ADMINISTERED: 91/12/19

REGION: I

CANDIDATE:

LICENSE APPLIED FOR:

INSTRUCTIONS TO CANDIDATE:

Answers are to be written on the answer sheet provided. Write answers one side ONLY. Attach any work sheets to the examination. Points for each question are indicated in parentheses for each question. A 70% is required to pass the examination.

The examination will be picked up one (1) hour after the examination starts.

CATEGORY VALUE	% OF TOTAL	CANDIDATE'S SCORE	% OF CATEGORY VALUE		CATEGORY
20.00	100.00			A.	REACTOR THEORY, THERMODYNAMICS AND FACILITY OPERATING CHARACTERISTICS
20.00					TOTALS
		FINAL GRADE	%		

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 not received or 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.

6. Fill in the date on the cover sheet of the examination (if necessary).

7. The point value for each question is indicated in parentheses after the question. The amount of blank space on an examination question page is NOT an indication of the depth of answer required.

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. To pass the examination, you must achieve at least 70%.

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

12. When you are done and have turned in your examination, leave the examination area as defined by the examiner. If you are found in this area while the examination is still in progress, your license may be denied or revoked.

QUESTION: 001 (1.00)

Which ONE of the following neutron reactions occurs INDEPENDENT of neutron energy level?

a) inelastic scattering
b) elastic scattering
c) radiative capture
d) alpha emission

QUESTION: 002 (1.00)

Which ONE of the following neutron reactions occurs with a wide variety of elements?

a) neutron absorption - gamma emmision
b) neutron absorption - alpha ejection
c) neutron absorption - proton release
d) neutron absorption - fast fission

QUESTION: 003 (1.00)

The general trend for total neutron cross section in heavy elements is to:

a) increase as neutron energy level increases.
b) decrease as neutron energy level increases.
c) remain constant regardless of neutron energy level.
d) decrease below the resonance peaks as neutron energy level decreases.

QUESTION: 004 (1.00)

70 Thermal neutrons are absorbed in fuel atoms, 50 of these produce fission. What is the Reproduction Factor (η)?

a) 0.448
b) 0.714
c) 1.400
d) 1.790

(***** CATEGORY A CONTINUED ON NEXT PAGE *****)

QUESTION: 005 (1.00)

Which definition describes the infinite multiplication factor (K_∞)?

a) $\frac{\text{neutrons absorbed in one generation}}{\text{neutrons absorbed in preceding generation}}$

b) $\frac{\text{neutrons absorbed in preceding generation}}{\text{neutrons absorbed in one generation}}$

c) $\frac{\text{thermal neutrons absorbed in fuel}}{\text{total thermal neutrons absorbed}}$

d) $\frac{\text{neutrons absorbed in one generation}}{\text{neutrons produced by fission}}$

QUESTION: 006 (1.00)

Which of the following effects and control manipulations by the operator is required to compensate for the insertion of voids by an experiment?

a) Power will remain constant and require no special control manipulations.
b) Power will increase and require regulating blade insertion.
c) Power will decrease and require regulating blade withdrawal.
d) Power will increase to the point where all control rods will need to be inserted.

QUESTION: 007 (1.00)

Which ONE of the following is the LEAST DESIRABLE quality of a moderator?

a) large atomic weight
b) small atomic weight
c) large scattering cross section
d) small absorption cross section

(***** CATEGORY A CONTINUED ON NEXT PAGE *****)

QUESTION: 008 (1.00)

Which ONE of the following describes the power change caused by an increase in moderator temperature while critical?

a) Power will increase due to reduced buckling.
b) Power will increase due to a decrease in thermal neutron absorption in the moderator.
c) Power will decrease due to increased neutron leakage from the core.
d) Power will decrease due to increased reflection from the core.

QUESTION: 009 (1.00)

Which ONE of the following statements describes the effects of the fuel temperature coefficient?

a) Power increases slowly as fuel temperature increases.
b) Power increases rapidly as fuel temperature increases due to increased fuel-moderator differential temperature.
c) Power decreases rapidly as fuel temperature increases due to increased resonance absorption.
d) Power decreases slowly as fuel temperature increases due to the time required for moderator temperature response.

QUESTION: 010 (1.00)

Withdrawal of the highest worth control blade adds sufficient reactivity to make Keff = 0.995. What is the approximate Shutdown Margin?

a) 0.05%
b) 0.5%
c) 0.995%
d) 0.005%

(***** CATEGORY A CONTINUED ON NEXT PAGE *****)

QUESTION: 011 (1.00)

Which factor represents the portion of the neutron population described by this ratio?
the number of neutrons that reach thermal energy levels
the number of neutrons that do not leak while fast

a) Fast Fission Factor
b) Resonance Escape Probability
c) Reproduction Factor
d) Thermal Utilization Factor

QUESTION: 012 (1.00)

A reactor is scrammed from 100 W. If the control blades have a total worth of $2.20, what is the approximate (fission) power before assuming a stable period?

a) 0.35 W
b) 0.67 W
c) 6.03 W
d) 31.8 W

QUESTION: 013 (1.00)

Beta and beta effective both describe the total fraction of delayed neutrons. The difference between these two is:

a) Beta effective is smaller than beta since delayed neutrons are born at lower energy levels than prompt neutrons.
b) Beta effective is larger than beta since delayed neutrons are born at lower energy levels than prompt neutrons.
c) Beta effective is smaller than beta since delayed neutrons are born at higher energy levels than prompt neutrons.
d) Beta effective is larger than beta since delayed neutrons are born at higher energy levels than prompt neutrons.

(***** CATEGORY A CONTINUED ON NEXT PAGE *****)

QUESTION: 014 (1.00)

Which ONE of the following statements describes the operating characteristics of an "undermoderated" reactor?

a) A decrease in core water temperature will cause a negative reactivity response.
b) Reducing the amount of moderation will cause a positive reactivity response.
c) An increase in core water temperature will cause a positive reactivity response.
d) A decrease in core water density will cause a negative reactivity response.

QUESTION: 015 (1.00)

What is the stable reactor period which produces a power rise from 1 watt to 5 KW in 186 secs?

a) 10 secs.
b) 22 secs.
c) 30 secs.
d) 116 secs.

QUESTION: 016 (1.00)

Which ONE of the following statements describes Count Rate characteristics after a control rod withdrawal with the reactor subcritical? (Assume the reactor remains subcritical.)

a) Count Rate will rapidly increase (prompt jump) then gradually increase to a stable value.
b) Count Rate will rapidly increase (prompt jump) then gradually decrease to the previous value.
c) Count Rate will rapidly increase (prompt jump) to a stable value.
d) There will be no change in Count Rate until criticality is achieved.

(***** CATEGORY A CONTINUED ON NEXT PAGE *****)

QUESTION: 017 (1.00)

Which ONE of the following is the time period in which the maximum amount of Xenon 135 will be present in the core?

a) 10 to 12 hours after a startup to 100% power
b) 4 to 6 hours after a power increase from 50% to 100%
c) 4 to 6 hours after a power decrease from 100% to 50%
d) 10 to 12 hours after shutdown from 100% power

QUESTION: 018 (1.00)

In a reactor at full power, the thermal neutron flux is 2.5×10^{12} neutrons per square centimeter per second and the macroscopic fission cross-section is 0.1 per centimeter. The fission reaction rate is:

a) 2.5×10^{11} fissions/sec.
b) 2.5×10^{13} fissions/sec.
c) 2.5×10^{11} fissions/cubic cm/sec.
d) 2.5×10^{13} fissions/cubic cm/sec.

QUESTION: 019 (1.00)

Which condition below describes a reactor which is exactly critical?

a) Keff = 1; $\Delta k/k = 1$
b) Keff = 1; $\Delta k/k = 0$
c) Keff = 0; $\Delta k/k = 1$
d) Keff = 0; $\Delta k/k = 0$

(***** CATEGORY A CONTINUED ON NEXT PAGE *****)

QUESTION: 020 (1.00)

As a result of beta decay:

a) the atomic mass number decreases by 1, and the number of protons remains constant.
b) the atomic mass number remains constant, and the number of protons increases by 1.
c) the atomic mass number remains constant, and the number of protons remains constant.
d) the atomic mass number decreases by 1, and the number of protons decreases by 1.

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

EQUATION SHEET

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

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

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

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

$SUR = 26.06/\tau$

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

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

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

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

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

$\rho = \Delta Keff/Keff$

$\bar{\beta} = 0.00765$

$DR_1D_1^2 = DR_2D_2^2$

$$\text{Cycle Efficiency} = \frac{\text{Net Work (out)}}{\text{Energy (in)}}$$

$SCR = S/(1-Keff)$

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

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

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

$SDM = (1-Keff)/Keff$

$Pwr = W_f\, \dot{m}$

$\ell^* = 1 \times 10^{-5}$ seconds

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

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

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

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

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1 Curie = 3.7×10^{10} dps

1 hp = 2.54×10^3 BtU/hr

1 BTU = 778 ft-lbf

1 kg = 2.21 lbm

1 Mw = 3.41×10^6 BTU/hr

°F = 9/5°C + 32

°C = 5/9 (°F - 32)

A. RX THEORY, THERMO & FAC OP CHARS

ANSWER SHEET

Multiple Choice (Circle or X your choice)

If you change your answer write your selection in the blank

MULTIPLE CHOICE

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 *****)

ANSWER. 001 (1.00)

b)

REFERENCE:

Glasstone & Sesonske, 1.38

ANSWER: 002 (1.00)

a)

REFERENCE:

Glasstone & Sesonske, 2.76

ANSWER: 003 (1.00)

b)

REFERENCE:

Glasstone & Sesonske, 2.137 - 2.140

ANSWER: 004 (1.00)

d)

REFERENCE:

$$\eta = \frac{\text{no of fast n produced by thermal fission}}{\text{no of thermal n absorbed in the fuel}}$$

2.5 neutrons produced per fission (50) X (2.5) = 125 fast n
thermal n absorbed in the fuel = 70
η = 125/70 = 1.790

ANSWER: 005 (1.00)

a)

(***** CATEGORY A CONTINUED ON NEXT PAGE *****)

REFERENCE:

Glasstone & Sesonske, 3.152

ANSWER: 006 (1.00)

c)

REFERENCE:

Lamarsh pp.315-316

ANSWER: 007 (1.00)

a)

PEFERENCE:

Lamarsh Sect. 3.5

ANSWER: 008 (1.00)

c)

REFERENCE:

Lamarsh, Sect. 7.3

ANSWER: 009 (1.00)

c)

REFERENCE:

Lamarsh, Sect. 7.3

ANSWER: 010 (1.00)

b)

(***** CATEGORY A CONTINUED ON NEXT PAGE *****)

REFERENCE:

Technical Specifications, Sect. 2.1;
SDM=(1-Keff)/Keff
=(1-0.995)/0.995
=0.005/0.995
=0.005
=0.5%

ANSWER: 011 (1.00)

b)

REFERENCE:

Lamarsh, Sect. 6.5

ANSWER: 012 (1.00)

d)

REFERENCE:

Lamarsh, Sect. 7.1

$$P=\frac{B(1-p)Po}{B-p}$$

$$=\frac{0.00765(1-(-0.01683))\times 100\ W}{0.00765-(-0.01683)}$$

$$=\frac{0.77787\ W}{0.02448}$$

=31.77 W

ANSWER: 013 (1.00)

b)

REFERENCE:

eqb question 4622 1987/08/22

(***** CATEGORY A CONTINUED ON NEXT PAGE *****)

ANSWER: 014 (1.00)

d)

REFERENCE:

Lamarsh 7.3

ANSWER: 015 (1.00)

b)

REFERENCE:

Equation sheet
$P = P0\ e(t/\tau)$
$\tau = t/\ln P/P0$
$\tau = 186/\ln 5000$
$\tau = 21.8$ sec

ANSWER: 016 (1.00)

a)

REFERENCE:

RRF Training Manual

ANSWER: 017 (1.00)

d)

REFERENCE:

U of L Intro to Nuclear Reactor Ops, Section 8, Fission Product Poisons, part 8.4, page 8-12 through 8-19

ANSWER: 018 (1.00)

c)

(***** CATEGORY A CONTINUED ON NEXT PAGE *****)

REFERENCE:

Fission reaction rate = (flux)(macroscopic cross-section)

ANSWER: 019 (1.00)

b)

REFERENCE:

ENNU 320 MANUAL VOL. 1, Page 7-5

ANSWER: 020 (1.00)

b)

REFERENCE:

ENNU 320 MANUAL, VOL. 1, Page 5-1

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

ANSWER KEY

MULTIPLE CHOICE

001 b
002 a
003 b
004 d
005 a
006 c
007 a
008 c
009 c
010 b
011 b
012 d
013 b
014 d
015 b
016 a
017 d
018 c
019 b
020 b

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