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

REPORT NO.: 50-166/OL-98-01

FACILITY DOCKET NO.: 50-166

FACILITY LICENSE NO.: R-70

FACILITY: University of Maryland

EXAMINATION DATES: October 13, 1998

EXAMINER: Patrick Isaac, Chief Examiner

SUBMITTED BY: [signature] 10/20/98
Patrick Isaac, Chief Examiner Date

SUMMARY:

On October 13, 1998, the NRC administered a retake examination (Section A of the written only) to one Senior Reactor Operator (Instant) Candidate. The candidate passed the examination.

REPORT DETAILS

1. Examiners:
   Patrick Isaac, Chief Examiner

2. Results:

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

3. Exit Meeting:

   There was no exit meeting

ENCLOSURE 1

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

FACILITY: University of Maryland

REACTOR TYPE: MUTR

DATE ADMINISTERED: 10/13/98

REGION: I

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	100.0	______	____	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

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 *****)

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. Mark your answers on the answer sheet provided. USE ONLY THE PAPER PROVIDED AND DO NOT WRITE ON THE BACK SIDE OF THE PAGE.

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

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

9. When turning in your examination, assemble the completed examination with examination questions, examination aids and answer sheets. In addition turn in all scrap paper.

10. Ensure all information you wish to have evaluated as part of your answer is on your answer sheet. Scrap paper will be disposed of immediately following the examination.

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

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

13. When you have completed and turned in you examination, leave the examination area. If you are observed in this area while the examination is still in progress, your license may be denied or revoked.

EQUATION SHEET

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

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

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

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

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

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

$$\overline{\beta} = 0.007$$

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

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

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

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

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

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

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

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

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

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

$$T_{½} = \frac{0.693}{\lambda}$$

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

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

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

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

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

$$I = I_o e^{-\mu x}$$

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

1 kg = 2.21 lbm

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/lbm/°F

c_p = 1 cal/sec/gm/°C

Question (A.1) [1.0]

A reactor is critical at 1 Watt. Subsequent rod motion causes a power increase at an indicated period of 30 seconds. Reactor power 2 minutes later will be approximately:

a. 55 Watts

b. 35 Watts

c. 15 Watts

d. 5 Watts

Question (A.2) [1.0]

Which one of the following describes the response of the subcritical reactor to <u>equal</u> insertions of positive reactivity as the reactor approaches criticality at low power?

a. Each reactivity insertion causes a SMALLER increase in the neutron flux, resulting in a LONGER time to reach equilibrium.

b. Each reactivity insertion causes a LARGER increase in the neutron flux, resulting in a LONGER time to reach equilibrium.

c. Each reactivity insertion causes a SMALLER increase in the neutron flux, resulting in a SHORTER time to reach equilibrium.

d. Each reactivity insertion causes a LARGER increase in the neutron flux, resulting in a SHORTER time to reach equilibrium.

Question (A.3) [1.0]

Which one of the following is true concerning the differences between prompt and delayed neutrons?

a. Prompt neutrons account for less than one percent of the neutron population while delayed neutrons account for approximately ninety-nine percent of the neutron population

b. Prompt neutrons are released during fast fissions while delayed neutrons are released during thermal fissions

c. Prompt neutrons are released during the fission process while delayed neutrons are released during the decay process

d. Prompt neutrons are the dominating factor in determining the reactor period while delayed neutrons have little effect on the reactor period

Question (A.4) [1.0]

Which one of the following elements will slow down fast neutrons <u>least</u> quickly, i.e. produces the smallest energy loss per collision?

a. Oxygen-16

b. Boron-10

c. Hydrogen-1

d. Uranium-238

Question (A.5) [1.0]

A reactor contains three control rods and a regulating rod. Which one of the following would result in a determination of the excess reactivity of this reactor?

a. The reactor is critical at a low power level, with all control rods full out and the regulating rod at some position. The reactivity remaining in the regulating rod (i.e. its rod worth from its present position to full out) is the excess reactivity.

b. All four rods are full in. The control rods and the regulating rod are withdrawn until the reactor becomes critical. The total rod worth withdrawn is the excess reactivity.

c. The reactor is at full power. The total rod worth of all rods withdrawn is the excess reactivity.

d. The reactor is at full power. The total rod worth remaining in all rods (i.e. their rod worths from their present positions to full out) is the excess reactivity.

Question (A.6) [1.0]

Which one of the following statements concerning reactivity values of equilibrium (at power) xenon and peak (after shutdown) xenon is correct? Equilibrium xenon is _________ of power level; peak xenon is _______ of power level.

a.	INDEPENDENT	INDEPENDENT
b.	INDEPENDENT	DEPENDENT
c.	DEPENDENT	INDEPENDENT
d.	DEPENDENT	DEPENDENT

Question (A.7) [1.0]

Reactor A increases power from 10% to 20% with a period of 50 seconds. Reactor B increases power from 20% to 30% with a period of also 50 seconds. Compared to Reactor A, the time required for the power increase of Reactor B is:

a. longer than A.

b. exactly the same as A.

c. approximately the same as A.

d. shorter than A.

Question (A.8) [1.0]

In an operating TRIGA reactor, the effect of the xenon poison is different from that due to samarium because:

a. The xenon poison will begin to decay twelve to 14 hours after reactor shutdown, whereas samarium poison will peak and its effects will remain indefinitely after shutdown.

b. The magnitude of the xenon poison effect is usually much smaller than that for samarium.

c. While both poisons decay with their respective half lives after shutdown, the samarium poison decays with a shorter half life.

d. While both poisons decay after shutdown, xenon decays 12 times faster than samarium.

Question (A.9) [1.0]

A reactor is subcritical with a shutdown margin of 0.0526 delta k/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.10) [1.0]

Following a scram, the value of the stable reactor period is:

a. approximately -50 seconds, because the rate of negative reactivity insertion rapidly approaches zero.

b. approximately -10 seconds, as determined by the rate of decay of the shortest lived delayed neutron precursors.

c. approximately -80 seconds, as determined by the rate of decay of the longest lived delayed neutron precursors.

d. infinity, since neutron production has been terminated.

Question (A.11) [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 U^{238} and Pu^{240} resonance peaks and the decrease of resonance escape probability.

c. Decrease in fuel temperature will increase neutron absorption by U^{238} and Pu^{240}.

d. Fuel temperature increase results in Doppler Broadening of U^{238} and PU^{240} resonance peaks and the decrease of neutron absorption during moderation.

Question (A.12) [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.13) [1.0]

Which one of the following is the MAXIMUM amount of reactivity that can be promptly inserted into the reactor WITHOUT causing the reactor to go "Prompt Critical"?

a. 0.10 dollars

b. 0.46 dollars

c. 0.75 dollars

d. 1.90 dollars

Question (A.14) [1.0]

If we assume that the core excess reactivity (cold critical conditions) is worth $3.25, which one of the following is the minimum amount of negative reactivity that must inserted to assure that the reactor is "shutdown" as defined per Tech. Specs.

a. $2.25

b. $2.75

c. $3.75

d $4.25

Question (A.15) [1.0]

Which one of the following statements describes the effect of an increase in fuel temperature in a TRIGA fuel element.

a. The probability that a thermal neutron will lose energy in a collision with an excited state hydrogen atom in $UZrH_x$ increases.

b. The probability that a neutron will escape from the element before being captured in the fuel meat increases.

c. A shift in the thermal neutron spectrum, towards lower energies, occurs in the fuel element.

d. The mean free path for fast neutrons in the fuel element in decreased.

Question (A.16) [1.0]

A reactor with an initial population of 24000 neutrons is operating with K_{eff} = 1.01. Of the CHANGE in population from the current generation to the next generation, how many are prompt neutrons?

a. 24

b. 238

c. 240

d. 24240

Question (A.17) [1.0]

Following a significant reactor power increase, the moderator temperature coefficient becomes increasingly more negative. This is because:

a. as moderator density decreases, less thermal neutrons are absorbed by the moderator than by the fuel.

b. the change in the thermal utilization factor dominates the change in the resonance escape probability.

c. a greater density change per degree F occurs at higher reactor coolant temperatures.

d. the core transitions from an under-moderated condition to an over-moderated condition.

Question (A.18) [1.0]

Experimenters are attempting to determine the critical mass of a new fuel material. As more fuel was added to the reactor, the following fuel to count rate data was taken:

Fuel	Counts/Sec
1.00 kg	500
1.50 kg	800
2.00 kg	1142
2.25 kg	1330
2.50 kg	4000
2.75 kg	15875

Which one of the following is the amount of fuel needed for a critical mass?

a. 2.60 kg

b. 2.75 kg

c. 2.80 kg

d. 2.95 kg

Question (A.19) [1.0]

Which one of the following will be the resulting stable reactor period when a $0.25 reactivity insertion is made into an exactly critical reactor core? (Assume a β of .0070 and a λ of .1 sec^{-1})

a. 18 seconds

b. 30 seconds

c 38 seconds

d. 50 seconds

Question (A.20) [1.0]

Which alteration or change to the core will most strongly affect the thermal utilization factor.

a. Build up of fission products in fuel.

b. Removal of moderator.

c. Addition of U^{238}

d. Removal of a control rod.

ANSWER: 01 (1.00)
a
REFERENCE
$P=P_0e^{t/\tau} = 1e^{120sec/30sec} = 54.6$

ANSWER: 02 (1.00)
b
REFERENCE
Glasstone, S. and Sesonske, A, *Nuclear Reactor Engineering,* Kreiger Publishing, Malabar, Florida, 1991, §§ 3.161 — 3.163, pp. 190 — 191.
Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, Chapt. 5, pp. 5-1 — 5-28.

ANSWER: 03 (1.00)
c
REFERENCE
Lamarsh, J.R., *Introduction to Nuclear Engineering,* - 1983. § 7.1, pp. 280 — 284.
Burn, R., *Introduction to Nuclear Reactor Operations,* © 1982, §§ 3.2.2 — 3.2.3, pp. 3-7 — 3-12.

ANSWER: 04 (1.00)
d
REFERENCE
Standard NRC Question

ANSWER: 05 (1.00)
a
REFERENCE
Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, §§ 6.2.1, pp. 6-2.

ANSWER: 06 (1.00)
d
REFERENCE
Lamarsh, J.R., *Introduction to Nuclear Engineering,* - 1983. § 7.4, pp. 316 — 322.
Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, §§ 8.1 —8.4, pp. 8-3 — 8-14.

ANSWER: 07 (1.00)
d
REFERENCE
The power of reactor A increases by a factor of 2, while the power of reactor B increases by a factor of 1.5. Since the periods are the same (rate of change is the same), power increase B takes a shorter time.

ANSWER: 08 (1.00)
a
REFERENCE
Lamarsh, J.R., *Introduction to Nuclear Engineering,* - 1983. § 7.4, pp. 316 — 322.
Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, §§ 8.1 —3.4, pp. 8-3 — 8-14.

ANSWER: 09 (1.00)
c
REFERENCE:
$SDM = 1-K_{eff}/K_{eff} \rightarrow K_{eff} = 1/SDM + 1 \rightarrow K_{eff} = 1/0.0526 + 1 \rightarrow K_{eff} = .95$
$CR_1/CR_2 = (1 - K_{eff2}) / (1 - K_{eff1}) \rightarrow 10/20 = (1 - K_{eff2}) / (1 - 0.95)$
$(0.5) \times (0.05) = (1 - K_{eff2}) \rightarrow K_{eff2} = 1 - (0.5)(0.05) = 0.975$
Burn, R., *Introduction to Nuclear Reactor Operations,* © 1982, § 6.2.3, p. 3-4.

ANSWER: 10 (1.00)
c
REFERENCE
Lamarsh, J.R., *Introduction to Nuclear Engineering,* - 1983. § 7.1, p. 289.
Burn, R., *Introduction to Nuclear Reactor Operations,* © 1982, § 4.6, p. 4-16.

ANSWER: 11 (1.00)
a
REFERENCE
Glasstone, S. and Sesonske, A, *Nuclear Reactor Engineering,* 1991, § 5.98, p. 264.

ANSWER: 12 (1.00)
c
REFERENCE
Lamarsh, J.R., *Introduction to Nuclear Engineering,*1983. § 7.2, p. 303.
Burn, R., *Introduction to Nuclear Reactor Operations,* © 1982, § 7.2 & 7.3, pp. 7-1 — 7-9.

ANSWER: 13 (1.00)
c
REFERENCE
Glasstone S. and Sesonske, Nuclear Reactor Engineering, 1991, p. 264.

ANSWER: 14 (1.00)
d
REFERENCE
T.S. 1.22

ANSWER: 15 (1.00)
b
REFERENCE
FSAR Section 3.3.2; SER Section 4.6

ANSWER: 16 (1.00)
b
REFERENCE
24000 neutrons in current generation * 1.01 = 24240 neutrons in next generation
240 neutrons added - 0.7% delayed neutron fraction = 238 prompt neutrons added

ANSWER: 17 (1.00)
c
REFERENCE
Burn, R., *Introduction to Nuclear Reactor Operations,* © 1982, § 6.4.1, pp. 6-5.

ANSWER: 18 (1.00)
c
REFERENCE
Lamarsh, J.R., *Introduction to Nuclear Engineering,* - 1983. § , p. 102.
Burn, R., *Introduction to Nuclear Reactor Operations,* © 1982, § 5.5, pp. 5-18 — 5-25.

ANSWER: 19 (1.00)
b
REFERENCE
Glasstone, S. and Sesonske, A, *Nuclear Reactor Engineering,* 1991, § 5.18, p. 234.
$T = (\beta-\rho)/\lambda\rho$ $T = (.0070 - .00175)/.1 \times .00175 = 30$ seconds

ANSWER: 20 (1.00)
d
REFERENCE
Lamarsh, J.R., *Introduction to Nuclear Engineering,* - 1983. § 7.2, p. 300
Burn, R., *Introduction to Nuclear Reactor Operations,* © 1982, § 3.3, pp. 3-13 — 3-18.