February 14, 2000

J. Charles McKibben, Deputy Director
Research Reactor Facility
University of Missouri
Columbia, Missouri 65211

SUBJECT: INITIAL EXAMINATION REPORT NO. 50-186/OL-00-01

Dear Mr. McKibben:

During the week of January 17, 2000 the NRC administered an retake examination to an employee of your facility who had applied for a license to operate your University of Missouri – Columbia 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 placed in the NRC Public Document Room.

Should you have any questions concerning this examination, please contact me at (301) 415-1168.

Sincerely,

/RA/

Ledyard B. Marsh, Chief
Events Assessment, Generic Communications
and Non-Power Reactors Branch
Division of Regulatory Improvement Programs
Office of Nuclear Reactor Regulation

Docket No. 50-186

Enclosures:
1. Initial Examination Report No. 50-186/OL-0-01
2. Examination and answer key (RO/SRO)

cc w/encls:
Please see next page

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cc:

University of Missouri
Associate Director
Research Reactor Facility
Columbia, Missouri 65201

A-95 Coordinator
Division of Planning
Office of Administration
P. O. Box 809, State Capitol Bldg.
Jefferson City, Missouri 65101

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

REPORT NO.:	50-186/OL-0-01
FACILITY DOCKET NO.:	50-186
FACILITY LICENSE NO.:	R-103
FACILITY:	University of Missouri — Columbia
EXAMINATION DATES:	January 20, 2000
EXAMINER:	Paul Doyle, Chief Examiner
SUBMITTED BY:	____________________ Paul V. Doyle Jr., Chief Examiner __________ Date

SUMMARY:

On January 20, 2000, the staff at the University of Missouri-Columbia administered an NRC prepared examination to a license candidate who had failed section A of an NRC examination administered in August 1999. The candidate passed the retake examination.

REPORT DETAILS

1. Examiners:
   Paul Doyle, Chief Examiner

2. Results:

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

3. Exit Meeting:

   There was no exit meeting.

UNIVERSITY OF MISSOURI–COLUMBIA

With Answer Key

UNITED STATES NUCLEAR REGULATORY COMMISSION

OPERATOR LICENSING
EXAMINATION
January 20, 1999

ENCLOSURE 2

QUESTION (A.1) [1.0 point]
A reactor is subcritical with a K_{eff} of 0.955. Seven dollars ($7.00) of positive reactivity is inserted into the core (β=0.007). At this point the reactor is …

a. subcritical

b. exactly critical

c. supercritical

d. prompt critical

QUESTION (A.2) [1.0 point]
A reactor is slightly supercritical with the following values for each of the factors in the six-factor formula…

Fast Fission Factor	= 1.03	Fast Non-Leakage probability	= 0.84
Resonance Escape probability	= 0.96	Thermal Non-Leakage probability	= 0.88
Thermal Utilization Factor	= 0.70	Reproduction Factor	= 1.96

A control rod is inserted to bring the reactor back to critical. Assuming all other factors remain unchanged, the new value for the thermal utilization factor is…

a. 0.698

b. 0.702

c. 0.704

d. 0.708

QUESTION (A.3) [1.0 point]
The neutron microscopic cross-section for absorption σ_s generally…

a. increases as neutron energy increases.

b. decreases as neutron energy increases.

c. increases as the mass of the target nucleus increases.

d. decreases as the mass of the target nucleus increases.

QUESTION (A.4) [1.0 point]
Which ONE of the reactions below is an example of a **PHOTONEUTRON** source?

a. ${}_1H^2 + {}_0\gamma^0 \rightarrow {}_1H^1 + {}_0n^1$

b. ${}_{92}U^{238} \rightarrow {}_{35}Br^{87} + {}_{57}La^{148} + 3{}_0n^1 + {}_0\gamma^0$

c. ${}_{51}Sb^{123} + {}_0n^1 \rightarrow {}_1H^1 + {}_0\gamma^0$

d. ${}_4Be^9 + {}_2\alpha^4 \rightarrow {}_6C^{12} + {}_0n^1$

QUESTION (A.5) [1.0 point]
During a reactor startup, the count rate is increasing **LINEARLY** with no rod motion. This means that …

a. The reactor is subcritical, and the count rate increase is due to the buildup of delayed neutron precursors.

b. The reactor is critical, and the count rate increase is due to source neutrons.

c. The reactor is subcritical, and the count rate is due to source neutrons.

d. The reactor is critical and the count rate is due to the buildup of delayed neutron precursors..

QUESTION (A.6) [1.0 point]
A 1/M curve is being generated as fuel is loaded into the core. After some fuel elements have been loaded, the count rate existing at that time is taken to the new initial count rate, C_0. Additional fuel elements are then loaded and the inverse count ratio continues to decrease. As a result of changing the initial count rate …

a. criticality will occur with the same number of elements loaded as if there were no change in the initial count.

b. criticality will earlier (i.e. with fewer elements loaded).

c. criticality will later (i.e. with more elements loaded).

d. criticality will be completely unpredictable.

QUESTION (A.7) [1.0 point]
As a reactor continues to operate over time, for a **CONSTANT** power level, the average fast neutron flux…

a. decreases, due to the increase in fission product poisons.

b. decreases, because the fuel is being depleted.

c. increases, in order to compensate for fuel depletion.

d. remains the same

QUESTION (A.8) [1.0 point]
The two figures below represent the order (number in box) and direction used in placing fuel into a reactor pool. Which of the following choices shows the preferred method for performing a 1/M plot, along with the correct reason.

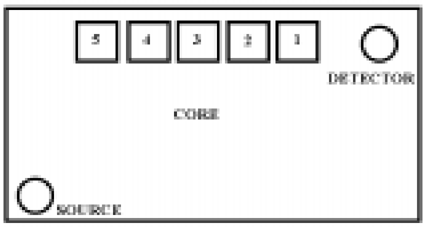

Figure 1

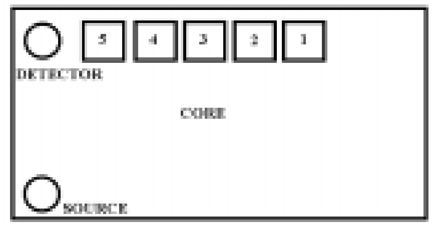

Figure 2

a. Figure 1 because loading from the detector towards the source gives the first fuel element more emphasis resulting in a more conservative estimate of criticality.

b. Figure 2 because loading towards the detector and the source gives the first fuel element more emphasis resulting in a more conservative estimate of criticality.

c. Figure 1 because loading from the detector towards the source gives the last fuel element more emphasis resulting in a more conservative estimate of criticality.

d. Figure 2 because loading towards the detector and the source is gives the last fuel element more emphasis resulting in a more conservative estimate of criticality.

QUESTION (A.9) [1.0 point]
During the minutes following a reactor scram, reactor power decreases on a negative 80 second period corresponding to the half-life of the longest lived delayed neutron precursor, which is approximately …

a. 20 seconds

b. 40 seconds

c. 55 seconds

d. 80 seconds

QUESTION (A.10) [1.0 point]
The moderator to fuel ratio describes the relationship between the number of moderator atoms in a volume of core to the number of fuel atoms. A reactor which is …

a. undermoderated will have a positive moderator temperature coefficient.

b. undermoderated will have a negative moderator temperature coefficient.

c. overmoderated will have a constant moderator temperature coefficient.

d. overmoderated will have a negative moderator temperature coefficient.

QUESTION (A.11) [1.0 point]
Which ONE of the following statements correctly describes a positive temperature coefficient?

a. When moderator temperature increases, positive reactivity is added.

b. When moderator temperature decreases, positive reactivity is added.

c. When moderator temperature increases, negative reactivity is added.

d. When moderator temperature decreases, reactor power increases.

QUESTION (A.12) [1.0 point]
A reactor with an initial population of 1×10^8 neutrons is operating with $K_{eff} = 1.001$. Considering **ONLY** the **INCREASE** in neutron population, how many neutrons (of the INCREASE) will be prompt when the neutron population changes from the current generation to the next? (Assume $\beta = 0.007$.)

a. 700

b. 7,000

c. 99,300

d. 100,000

QUESTION (A.13) [1.0 point]
ELASTIC SCATTERING is the process by which a neutron collides with a nucleus and …

a. recoils with the same kinetic energy it had prior to the collision

b. recoils with less kinetic energy than it had prior to the collision with the nucleus emitting a gamma ray.

c. is absorbed, with the nucleus emitting a gamma ray.

d. recoils with a higher kinetic energy than it had prior to the collision with the nucleus emitting a gamma ray.

QUESTION (A.14) [1.0 point]
A reactor is critical at 18.1 inches on a controlling rod. The controlling rod is withdrawn to 18.4 inches. The reactivity inserted is 0.001 ΔK/K. What is the differential rod worth

a. 0.001 ΔK/K/inch at 18.25 inches

b. 0.001 ΔK/K/inch at 18.25 inches

c. 0.003 ΔK/K/inch at 18.4 inches

d. 0.003 ΔK/K/inch at 18.25 inches

QUESTION (A.15) [1.0 point]
Two critical reactors at low power are identical except that reactor 1 has a effective beta fraction (β_{eff}) of 0.0072 and reactor 2 has a β_{eff} of 0.0060. An equal amount of positive reactivity is added to both reactors. Which ONE of the following will be the response of reactor 2 as compared to reactor 1?

a. The resulting power level will be lower.

b. The resulting power level will be higher.

c. The resulting period will be longer.

d. The resulting period will be shorter.

QUESTION (A.16) [1.0 point]
Which ONE of the following describes the response of the subcritical reactor to **EQUAL** insertions of positive reactivity as the reactor approaches criticality? Each reactivity addition will cause …

a. a **SMALLER** increase in neutron flux, resulting in a **LONGER** time to reach equilibrium.

b. a **LARGER** increase in neutron flux, resulting in a **LONGER** time to reach equilibrium.

c. a **SMALLER** increase in neutron flux, resulting in a **SHORTER** time to reach equilibrium.

d. a **LARGER** increase in neutron flux, resulting in a **SHORTER** time to reach equilibrium.

QUESTION (A.17) [1.0 point]
A reactor fuel consisting of U^{235} and U^{238} only, is 20% enriched. This means that …

a. 20% of the volume of the fuel consists of U^{235}.

b. 20% of the weight of the fuel consists of U^{235}.

c. the ratio of the number of U^{235} atoms to the number of U^{238} atoms is 0.20 (20%).

d. 20% of the total number of atoms in the fuel consists of U^{235}.

QUESTION (A.18) [1.0 point]
Given a fuel temperature coefficient of -1.25×10^{-4} ΔK/K/°C. When a control rod with an average worth of 0.1% ΔK/K/inch is withdrawn 10 inches, reactor power increases and becomes stable at a higher level. At this point fuel temperature has … (neglect power coefficient)

a. increased by 80°C

b. decreased by 80°C

c. increased by 8°C

d. decreased by 8°C

QUESTION (A.19) [1.0 point]
The effective neutron multiplication factor, K_{eff} is defined as…

a. absorption/(production + leakage)

b. (production + leakage)/absorption

c. (absorption + leakage)/production

d. production/(absorption + leakage)

QUESTION (A.20) [1.0 point]
Which ONE of the following statements concerning reactor poisons is NOT true?

a. Following shutdown, Samarium concentration will increase to some value then stabilize.

b. Following shutdown, Xenon concentration will initially increase to some value then decrease exponentially

c. During reactor operation, Samarium concentration is independent of reactor power level.

d. During reactor operation, Xenon concentration is dependent on reactor power level.

A.1 c
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, §

A.2 a
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, §

A.3 b
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, §

A.4 a
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 3.3.1, P. 3-16.

A.5 b
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, §

A.6 a
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, §

A.7 d
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, §

A.8 a
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 5.5 pp. 5-18 through 5-28

A.9 c
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, §

A.10 b
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, §

A.11 a
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, §

A.12 c
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, §

A.13 a
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, §

A.14 d
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, §

A.15 d
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, §

A.16 b
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, §

A.17 b
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, §

A.18 a
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, §

A.19 d
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, §

A.20 c
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, §§ 8.4 & 8.6, pp. 8-10 through 8-14.

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

FACILITY: University of Missouri-Columbia

REACTOR TYPE: TANK

DATE ADMINISTERED: 2000/1/17 (Week of)

REGION: III

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

Category Value	% of Total	% of Candidates Score	Category Value	Category
20.00	33.3	______	____	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 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.

12. There is a time limit of one (1) 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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$T_{½} = \frac{0.693}{\lambda}$$

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

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

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

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

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

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 ___