May 25, 2000

Dr. Edward A. Deutsch, Director
Research Reactor Facility
University of Missouri
Columbia, Missouri 65211

SUBJECT: INITIAL EXAMINATION REPORT NO. 50-186/OL-00-02

Dear Dr. Deutsch:

During the week of May 1, 2000, the NRC administered an initial 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. At the conclusion of the examination, the examination questions and preliminary findings were discussed with those members of your staff identified in the enclosed report.

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 Paul Doyle at phone number (301)415-1058 or E-mail at pvd@nrc.gov.

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-00-02
2. Examination and answer key (RO/SRO)

cc w/encls:
Please see next page

[illegible] Docket No. 50-186 [illegible]

[illegible]

May 25, 2000

REXB r/f [illegible]

CBassett, RII PDoyle

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ADAMS ACCESSION NO. ML003716194 NRR-074

OFFICE	REXB:CE	E	IOLB	E	REXB:BC/DBC	
NAME	PDoyle		EBarnhill		LMarsh/JLyons	
DATE	05/ 08 /2000		05/ 24 /2000		05/ 25 /2000	

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OPERATOR LICEN

U. S. NUCLEAR

Paul Doyle Jr., Chief Examiner

/RA/

Paul Doyle, Chief Examiner

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Date

REPORT DETAILS

1.

2.

3.

	RO PASS/FAIL	SRO PASS/FAIL	TOTAL PASS/FAIL
	1/0	0/0	1/0
	1/0	0/0	1/0
	1/0	0/0	1/0

Enclosure 1

UNIVERSITY OF MISSOURI–COLUMBIA

With Answer Key

UNITED STATES NUCLEAR REGULATORY COMMISSION

OPERATOR LICENSING
EXAMINATION
May 1, 2000

ENCLOSURE 2

Section A

QUESTION (A.1) [1.0 point]
One minute following a scram from full power, the indications on the nuclear channels are primarily due to:

a. Prompt neutrons

b. Prompt and delayed neutrons

c. Prompt, delayed and photo-neutrons

d. Delayed and photo-neutrons

QUESTION (A.2) [1.0 point]
With the reactor on a constant period, which of the following changes in reactor power would take the **LONGEST** time?

a. 5% — from 1% to 6%

b. 15% — from 20% to 35%

c. 20% — from 40% to 60%

d. 25% — from 75% to 100%

QUESTION (A.3) [1.0 point]

The **MAJOR** contributor to the production and deple[illegible] Xenon respectively in a STEADY STATE OPERATING reactor? Which ONE of the following [illegible]

a. [illegible] Neutron Absorption [illegible] Radioactive Decay

b. [illegible]

c. [illegible]

d. Directly from fission [illegible] Radioactive decay of Iodine

QUESTION (A.4) [1.0 point]
Which factor of the Six Factor formula is most easily varied by the reactor operator?

a. Thermal Utilization Factor (f)

b. Reproduction Factor (η)

c. Fast Fission Factor (β)

d. Fast Non-Leakage Factor (L_f)

QUESTION (A.5) [1.0 point]
Which one of the following is the correct reason that delayed neutrons allow human control of the reactor?

a. More delayed neutrons are produced than prompt neutrons.

b. Delay neutrons increase the mean neutron lifetime.

c. Delayed neutrons take longer to thermalize than prompt neutrons.

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

QUESTION (A.6) [1.0 point]
Which ONE of the following is an example of neutron decay?

a. ${}_{35}Br^{87} \rightarrow {}_{33}As^{83}$

b. ${}_{35}Br^{87} \rightarrow {}_{35}Br^{86}$

c. ${}_{35}Br^{87} \rightarrow {}_{34}Se^{86}$

d. ${}_{35}Br^{87} \rightarrow {}_{36}Kr^{87}$

QUESTION (A.7) [1.0 point]
Which ONE of the following is the reason for the -80 second period following a reactor scram?

a. The ability of U^{235} to fission source neutrons.

b. The half-life to the longest-lived group of delayed neutron precursors is 55 seconds.

c. The amount of negative reactivity added on a scram is greater than the shutdown margin.

d. The doppler effect, which adds positive reactivity due to the temperature decrease following a scram.

QUESTION (A.8) [1.0 point]
A reactor has a moderator temperature coefficient of reactivity is 1.0×10^{-4} βK/K/°C. If the average coolant temperature decreases by 10°C, a regulating rod with a differential rod worth of 0.05%βK/K/inch must be:

a. inserted 2 inches

b. withdrawn 2 inches

c. inserted 0.5 inches

d. withdrawn 0.5 inches

QUESTION (A.9) [1.0 point]
Which ONE of the following is the time period in which the maximum amount of Xe^{135} will be present in the core?

a. 8 to 10 hours after a startup to 100% power

b. 4 t0 6 hours a power increase from 50% to 100% power.

c. 4 to 6 hours after a power decrease from 100% to 50% power.

d. 8 to 10 hours after a scram from 100% power.

QUESTION (A.10) [1.0 point]
Which ONE of the following explains the response of a ***SUBCRITICAL*** reactor to equal insertions of positive reactivity as the reactor approaches criticality?

a. Each insertion causes a SMALLER increase in the neutron flux resulting in a LONGER time to stabilize.

b. Each insertion causes a LARGER increase in the neutron flux resulting in a LONGER time to stabilize.

c. Each insertion causes a SMALLER increase in the neutron flux resulting in a SHORTER time to stabilize.

d. Each insertion causes a LARGER increase in the neutron flux resulting in a SHORTER time to stabilize.

QUESTION (A.11) [1.0 point] Question deleted per facility comment (No correct answer)
~~Which ONE of the following reactor changes require a control rod INSERTION to return reactor power to its initial level following the change?~~

~~a. Formation of N^{16} in the coolant.~~

~~b. Removal of an experiment with positive reactivity from the reactor.~~

~~c. Buildup of Xe^{135}~~

~~d. A fault in the automatic system results in S-1 going to a more open position.~~

QUESTION (A.12) [1.0 point]
Which ONE of the following describes the difference between prompt and delayed neutrons? Prompt neutrons …

a. account for less than 1% of the neutron population, while delayed neutrons account for the rest.

b. are released only during fast-fission events, while delayed neutrons are released during the decay process.

c. are released during the fission process (fast & thermal), while delayed neutrons are released during the decay process.

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

QUESTION (A.13) [1.0 point]
K_{eff} for the reactor is 0.85. If you place an experiment worth +17.6% into the core, what will the new K_{eff} be?

a. 0.995

b. 0.9995

c. 1.005

d. 1.05

QUESTION (A.14) [1.0 point]
The primary flow rate is 3700 gpm. The βT across the primary side of the heat exchanger is 15.5°F. What is the power being transferred to the secondary side of the heat exchanger? (Assume no losses to the ambient surroundings).

a. 12 megawatts.

b. 10 megawatts.

c. 8 megawatts.

d. 6 megawatts.

QUESTION (A.15) [1.0 point]
The frequency on the local power grid increases from 60 Hz to 66 Hz. This results in all of the control rod drives running 10% faster. How will this change in rod speed effect reactor critical conditions compared to normal rod speed?

a. Rod height will be lower, Power will be lower.

b. Rod height will be higher, Power will be higher

c. Rod height will be the same, Power will be lower.

d. Rod height will be the same, Power will be the same.

QUESTION (A.16) [1.0 point]
The source was removed from an operating reactor. Later, the source was reinstalled and the Reactor Operator noted reactor power increasing **LINEARLY**. What was the condition of the reactor when the source was inserted? (Assume source has no reactivity worth, and no other changes in reactor parameters.) The reactor was …

a. very subcritical

b. slightly subcritical

c. exactly critical

d. slightly supercritical

QUESTION (A.17) [1.0 point] Question Deleted per facility Comment (SRO level at MURR)
~~Using the two figures provided in the handout, choose the preferred method for loading fuel while performing a 1/M plot, with the correct reason.~~

~~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.18) [1.0 point]
Which ONE of the following is the correct reason burnable poison is added to the core?

a. To minimize the effects of a rod withdrawal accident.

b. To increase the power achievable for a given core size.

c. To allow addition of additional fuel to compensate for burnup.

d. To decrease the effects of Xenon and Samarium on the core.

QUESTION (A.19) [1.0 point]
Which one of the following is the definition of the FAST FISSION FACTOR?

a. The ratio of the number of neutrons produced by fast fission to the number produced by thermal fission

b. The ratio of the number of neutrons produced by thermal fission to the number produced by fast fission

c. The ratio of the number of neutrons produced by fast and thermal fission to the number produced by thermal fission

d. The ratio of the number of neutrons produced by fast fission to the number produced by fast and thermal fission

QUESTION (A.20) [1.0 point]
The number of neutrons passing through a one square centimeter of target material per second is the definition of which one of the following?

a. Neutron Population (np)

b. Neutron Impact Potential (nip)

c. Neutron Flux (nv)

d. Neutron Density (nd)

QUESTION (B.1) [2.0 points, ● point each]
Match each of the Technical Specification Limits in column A with its corresponding value in column B. (Each limit has only one answer, values in Column B may be used more once, more than once or not at all.)

	Column A	Column B
a.	Minimum Shutdown Margin	0.0200 βK
b.	Each secured Removable Experiment	0.098 βK
c.	Core Excess Reactivity	0.0060 βK
d.	Absolute Value of all experiments in Center test hole	0.0025 βK
e.	Movable parts of any individual experiments	0.0010 βK
f.	Each Unsecured Experiment	

QUESTION (B.2) [1.0 point]
Normally refueling will be performed using the _______ tool with pool level ________.

a. air operated; normal

b. manually operated; normal

c. air operated; lowered

d. manually operated; lowered

QUESTION (B.3) [1.0 point]
During refueling, the lowest level of staff who may move fuel (by him or her self) **INTO OR OUT OF THE CORE** is …

a. Auxiliary Operator

b. Reactor Operator

c. Senior Reactor Operator

d. Operations Manager

QUESTION (B.4) [2.0 points, ½ point each]
Identify each of the following as either a Safety Limit (SL), Limiting Safety System Setting or Limiting Condition for Operation (LCO)

a. the average core temperature coefficient of reactivity shall be more negative than -6.0×10^{-5} βK/°F.

b. Minimum Primary Coolant Pressure for Mode I operation is 75 psia.

c. Reactor Operation is not permitted below a Minimum Reactor Core Flow Rate of 400 gpm. (Modes I and II).

d. All fuel elements or fueled devices outside the reactor core shall be stored in a geometry such that the calculated K_{eff} is less than 0.9 under all conditions of moderation.

QUESTION (B.5) [1.0 point]
During a startup the reactor is not critical at ECP, per SOP I you must inform the ______ and if the cause is ***NOT*** unquestionably resolved, the minimum permission required to continue the startup is from the ________.

a. Reactor Physicist; Reactor Manager

b. Shift Supervisor; Reactor Manager

c. Reactor Physicist; Operations Manager

d. Shift Supervisor; Operations Manager

QUESTION (B.6) [1.0 point]
Which ONE of the following is the 10 CFR 20 definition of **TOTAL EFFECTIVE DOSE EQUIVALENT (TEDE)**?

a. The sum of the deep does equivalent and the committed effective dose equivalent.

b. The dose that your whole body receives from sources outside the body.

c. The sum of the external deep dose and the organ dose.

d. The dose to a specific organ or tissue resulting from an intake of radioactive material.

QUESTION (B.7) [2.0 points, ½ point each]
Match the radiation reading from column A with its corresponding radiation area classification (per 10 CFR 20) listed in column B.

COLUMN A	COLUMN B
a. 10 mRem/hr	1. Unrestricted Area
b. 150 mRem/hr	2. Radiation Area
c. 10 Rem/hr	3. High Radiation Area
d. 550 Rem/hr	4. Very High Radiation Area

QUESTION (B.8) [1.0.]
Which ONE of the following is the MINIMUM time reactor power must be stabilized at 5 MW to allow digital calorimetric meter indication to stabilize?

a. 1 minute

b. 5 minutes

c. 10 minutes

d. 15 minutes

QUESTION (B.9) [1.0 point]
How many hours per calendar quarter must you perform the functions of an RO or SRO to maintain an active RO or SRO license?

a. 2

b. 4

c. 8

d. 12

QUESTION (B.10) [1.0 point]
Which ONE of the following locations is ***NOT*** an Emergency Command Center per the Emergency Plan?

a. Control Room

b. Research Park Development Building

c. Dalton Cardiovascular Research Center

d. Facility Front Lobby

QUESTION (B.11) [1.0 point]
Which ONE of the following Radiation Monitors will ***NOT*** cause a ventilation isolation when it alarms?

a. Bridge

b. Bridge ALARA

c. Building Exhaust Air Plenum #2

d. West Beam Port

QUESTION (B.12) [1.0 point]
10CFR50.54(x) states: *"A licensee may take reasonable action that departs from a license condition or a technical specification (contained in a license issued under this part) in an emergency when this action is immediately needed to protect the public health and safety and no action consistent with license conditions and technical specifications that can provide adequate or equivalent protection is immediately apparent.* 10CFR50.54(y) state that the minimum level of management which may authorize this action is …

a. any Reactor Operator licensed at facility

b. any Senior Reactor Operator licensed at facility

c. Facility Manager (or equivalent name at facility).

d. NRC Manager

QUESTION (B.13) [1.0 point]
The ***Quality Factor*** is used to convert …

a. dose in rads to dose equivalent in rems.

b. dose in rems to dose equivalent in rads.

c. contamination in rads to contamination equivalent in rems

d. contamination in rems to contamination equivalent in rads.

QUESTION (B.14) [1.0 point]
Two inches of shielding reduce the gamma exposure in a beam of radiation from 400 mR/hr to 200 mR/hr. If you add an additional four inches of shielding what will be the new radiation level? (Assume all reading are the same distance from the source.)

a. 25 mR/hr

b. 50 mR/hr

c. 75 mr/hr

d. 100 mr/hr

QUESTION (B.15) [1.0 point]
The reactor has been shutdown for the last three hours to adjust the packing on one of the primary coolant pumps. No shutdown checksheet has been performed. Which of the following meets the MINIMUM requirements to restart the reactor?

a. You may perform a hot startup with the SRO directing.

b. You may startup after performing a short form Startup Checksheet.

c. You may startup after ensuring the Primary system is on-line per the applicable SOP, then performing a short form Startup Checksheet.

d. You may startup after performing a Full Power Startup Checksheet.

QUESTION (B.16) [1.0 point]
The NRC has four standard emergency classifications. Which ONE of the four listed below is NOT applicable at MURR?

a. Notification of Unusual Event

b. General Emergency

c. Site Area Emergency

d. Alert

QUESTION (B.17) [1.0 point]
Which ONE of the following conditions would NOT preclude sending a volunteer into a high radiation area in order to save a life?

a. The radiation levels in the area are unknown.

b. All volunteers are women of child bearing age.

c. All volunteers are men under the age of 45.

d. The only volunteer is a new hire, not trained in the consequences of receiving an emergency dose.

QUESTION (C.1) [1.0 point]
Where does the Drain Collection tank overflow, overflow to?

a. “Floor Drain in room 114".

b. Sanitary Sewer

c. Retention Tank #3

d. Reactor Pool

QUESTION (C.2) [1.0 point]
Which ONE of the following conditions will ***NOT*** result in the changing the regulating blade control from automatic to manual.

a. Scram

b. Run-In

c. Shimming a control blade

d. Operating the regulating blade switch

QUESTION (C.3) [1.0 point]
The reactor reflector is made of …

a. graphite

b. beryllium

c. D_2O

d. H_2O (the pool).

QUESTION (C.4) [2.0 points, 0.125 point each]
Identify each of the following valve operator system valve indications as being either via limit switch on the valve (actual valve position) or air operator position, and whether the OPEN position is GREEN or RED.

a. Pool Loop 6" isolation valve

b. ℞ Loop 12" isolation valve

c. Pressurizer, 2" Bypass Drain

d. Pressurizer 1" Supply Valve

e. Reflector Convective Loop Valve

f. Anti-siphon Valve

g. N_2 ½" Exhaust valve.

h. Liquid Level 2" fill

QUESTION (C.5) [1.0 point]
Starting a Secondary Coolant Pump during reactor startup may cause the reactor to scram due to …

a. low core inlet temperature

b. low core outlet temperature

c. low core discharge pressure

d. low pool temperature

QUESTION (C.6) [1.0 point]
Regarding the five control rods …

a. all five are boron carbide clad in aluminum.

b. the shims are boron carbide clad in aluminum, the regulating rod is stainless steel.

c. the shims are boron carbide clad in stainless steel, the regulating rod is aluminum.

d. all five are stainless steel.

QUESTION (C.7) [1.0 point]
The sensor used to detect the position of a “rabbit” in the core is a …

a. photo-electric cell

b. magnetic switch

c. micro-switch

d. reed switch

QUESTION (C.8) [1.0 point]
Which ONE of the following is **NOT** a feature of the pneumatic tube system designed to limit the radiation hazard?

a. Speed at which the sample container is transported through the system.

b. When the blower is initially turned on, both blowers start simultaneously.

c. Facility Exhaust fans operation prevent stagnant air in the vicinity of the rabbit system.

d. Double encapsulation of samples

QUESTION (C.9) [1.0 point]
Which ONE of the following instrument channels does **NOT** supply a signal to the digital power meter?

a. Pool βT

b. Primary Demineralizer Flow

c. Pool Flow

d. Power Level channel 4

QUESTION (C.10) [1.0 point]
During startup you note that Shim Blade #1 magnet engaged light goes out. Which ONE of the following actions are allowed by the Startup Interlock? (Assume not a bulb problem).

a. Drive in Shim Blade #1, re-engage the magnet

b. You must scram the reactor to reset the interlock, then re-engage all magnets.

c. You may re-energize the magnet as soon as you notice the light is extinguished.

d. You must take the Master Switch to “OFF” then back to “ON” to reset the interlock. Then you must re-engage all magnets.

QUESTION (C.11) [2.0 points, 0.67 point each]
Identify the back-light color (Red, Yellow, White, or Blue) with each of the reactor alarm conditions.

a. Scram

b. Rod Run-in

c. Alarm (No scram or Rod Run-in)

QUESTION (C.12) [2.0 points, 0.33 each]
Identify whether each of the following conditions will cause a scram, a rod run-in, a containment isolation (with scram), or no automatic action: (In the case of two action, choose the one that initiates first.)

a. Source Range Monitor Channel 1 Inoperative (at 10 megawatts power)

b. Low Pool Level

c. West Area Radiation Monitor High Radiation Alarm

d. High Off-Gas Activity

e. Low Reflector Differential Pressure

f. Truck Entry Door Seal Deflated

QUESTION (C.13) [2.0 points, 0.5 each]
For the Alarm and Annunciate system, identify the illumination (bright solid, dim flashing, bright flashing or off) for the following alarm conditions: (Each is choice is used only once.)

a. Alarm was received and the operator pressed the acknowledge pushbutton. The alarm condition has not yet cleared.

b. Alarm was received but the operator has not yet pressed the acknowledge pushbutton. The alarm condition has not yet cleared.

c. Alarm was received and the operator pressed the acknowledge pushbutton. The alarm condition has cleared, but the operator has not yet pressed the reset button.

d. Alarm was received and the operator pressed the acknowledge pushbutton. The alarm condition has cleared and the operator has pressed the reset button.

QUESTION (C.14) [1.0 point]
Which ONE of the following describes the response of the regulating blade to a reactor scram signal?

a. It's electromagnet deenergizes and the rod falls into the core via the force of gravity.

b. The rod will be driven into the core.

c. The rod will withdraw in an attempt to compensate for the shim blades insertion.

d. The rod will remain in its position.

QUESTION (C.15) [1.0 point, 0.33 each]
For the setpoint actions in Column A select the appropriate pressurizer system pressure listed in Column B. Pressures in Column B may be used once, more than once or not at all. Only one answer may occupy each space in column A. (Four answers required at 0.50 each)

COLUMN A ACTIONS	COLUMN B SETPOINTS
a. High pressure scram	1. 69.5 psig
	2. 63 psig
b. Nitrogen makeup valve opens	3. 66.5 psig
	4. 70 psig
c. High pressure relief valve lifts	5. 73.5 psig
	6. 77 psig
	7. 80.5 psig
	8. 100 psig

QUESTION (C.16) [1.0 point]
Which one of the following describes the automatic operation of the Shim Rods?

a. The Shim Rods insert when the Regulating Rod position decreases to 20% withdrawn

b. The Shim Rods withdraw when the Regulating Rod position decreases to 20%

c. The Shim Rods insert when the Regulating Rod position increases to 20% withdrawn

d. The Shim Rods withdraw when the Regulating Rod position increases to 10% withdrawn

A.1 d
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 6.2.1, & 6.2.2 p. 6-2.

A.2 a.
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 3.3.2, ¶ 2, p. 3-18.
$P = P_0 e^{t/\beta}$ $\ln(P/P_0) = t/\beta$ Since you are looking for which would take the longest time it is obvious to the most casual of observers that the ratio P/P_0 must be the largest.

A.3 b
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 8.3, p. 8-7

A.4 a
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 3.3.2, p. 3-19, 2nd ¶.

A.5 b
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 3.2.2, pp. 3-7–3-10.

A.6 b
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 2.4.6, P. 2-33.

A.7 b
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 4.6, Table 4.4, p. 4-18.

A.8 b
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, §

$$-10\times 10^{-4}\frac{\Delta K}{K^\circ C}\times -10^\circ C = +10^{-3}\ \frac{\Delta K}{K}$$

$$+10^{-3}\frac{\Delta K}{K} = 0.0005\frac{\Delta K}{K}\times ?\,Inches$$

$$?\,Inches = \frac{10^{-3}\,\frac{\Delta K}{K}}{5\times 10^{-4}\,\frac{\Delta K}{K}} = +2\,inches(Withdrawn)$$

A.9 d
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 8.4.1, p. 8-10, 2nd ¶.

A.10 b
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 5.3, pp. 5-5–5-12.

~~A.11 b~~ Question Deleted per facility comment.
~~REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, §~~

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

A.13 b
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, §
SDM = $(1-k_{eff})/k_{eff}$ = (1-0.85)/0.85 = 0.15/0.85 = 0.1765, or a reactivity worth (β) of -0.1765. Adding + 0.176 reactivity will result in a SDM of 0.1765 - 0.1760 = 0.0005. K_{eff} = 1/(1+SDM) = 1/(1 + 0.0005) = 0.9995

A.14 c
REF:

$$\dot{Q} = \dot{m}c_P\beta T$$

$$\dot{Q} = 3700\frac{gallons}{minute}\times 8\frac{lbm}{gallon}\times 60\frac{minutes}{hour}\times 1\frac{BTU}{^\circ F\text{-}lbm}\times 15.5^\circ F\times\frac{1\,Mw\text{-}Hr.}{3.412\times 10^6 BTU}$$

A.15 c
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 5.0 *Subcritical Multiplication*, pp. 5-1–5-38

A.16 c
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 5.6, p. 5-25, 2nd ¶

~~A.17 a~~ Question Deleted per facility Comment. (SRO level question for MURR).
~~REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 5.5 "Critical Loading" pp. 5-18 through 5-23.~~

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

A.19 c
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 3.3.1, p. 3-16.

A.20 c
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 2.61

B.1 a, 0.02; b, 0.006; c, 0.098; d, 0.006; e, 0.001; f, 0.0025
REF: Technical Specifications § 3.1 *Reactivity* Specifications e, f, g, h, i, and j.

B.2 a
REF: SOP II, § 2.1.J.

B.3 b
REF: SOP II, 2.1.H.

B.4 a, LCO; b, LSSS; c, SL; d, LCO
REF: T.S. a: § 3.1.a; b: § 2.2.a; c: § 2.1.b; d: § 3.8.d

B.5 a
REF: SOP I, § 4.3.G.5.

B.6 a
*REFERENCE (B.2)
10 CFR 20.1003 *Definititions*

B.7 a, 2; b, 3; c, 3; d, 4
*REFERENCE (B.3)
10 CFR 20.1003, Definitions

B.8 b
REF: SOPII § II.1.1.P

B.9 b
REF: 10CFR55.53(e).

B.10 c
REF: SEP-1, §II.2 and 6.

B.11 d
REF: Hazards Summary Report, § 9.7.1, 3rd ¶.

B.12 b
REF: 10CFR50.54(y)

B.13 a
REF: 10CFR20.1004.

B.14 b
REF: Nuclear Power Plant Health Physics and Radiation Protection, Research Reactor Version©1988, § 9.2.3 "Half-Thickness and Tenth-Thickness"

B.15 d
REF: SOP I.4.3.F.1 Startup Checksheet §§ a & b

B.16 b
REF: MURR Emergency Plan, § 3.0 Classification of Emergency Conditions

B.17 c
REF: Previously asked question from EQB. SEP 11 Monitoring Planned Exposures in excess of Limits in 10 CFR 20. SEP Worksheet D.

C.1 a
REF: Reactor Operator Training Manual, § I.8. *Drain Collection Tank System*, p. I.8.1. ¶ B.6.

C.2 c
REF: SOP II, §§ 1.4 last paragraph, and 1.5.B.

C.3 b
REF: SOP II

C.4 a/b Valve Limit Switch (green), c/d Air Operator (red), e/f Valve Limit Switch (red)
g/h Air Operator (red)
REF: Reactor Operator Training Manual,

C.5 c
REF: SOP II, § 1.1 NOTE.

C.6 b
REF: Reactor Operator Training Manual, §

C.7 a
REF: Reactor Operator Training Manual §

C.8 b
REF: HSR, §§ 8-20–25, Also former NRC question.

C.9 d
REF: Facility Requalification Examination administered 11/17/93.

C.10 c
REF: HSR, Chapter 9.0 Instrumentation and Control, § 9.5 Startup Interlocks.

C.11 a-Red b-Blue c-White
REF: Reactor Operator Training Manual, § II-67

C.12 f, rod run-in c, no automatic action; e, scram; Rod Run-in; d, no automatic action

REF: Reactor Operator Training Manual, §

C.13 a-bright on; b- bright flashing; c-dim flashing; d-off
REF: Reactor Operator Training Manual, pp. IV-1 and 2.

C.14 d
REF: Training Manual for ROs, § II.14 Rod Control System

C.15

REF:

C.16 a

REF:

U. S. NUCLEAR REGU

NON-POWER INITIAL R

FACILITY: University of Missouri-

REACTOR TYPE: TANK

DATE ADMINISTERED: 2006/05/1

CANDIDATE:

INSTRUCTIONS TO CANDIDATE:

Category Value	% of Total	Candidates Score	% of Category Value	Category
20.00	34.5	______	______	A. Reactor Theory, Thermodynamics and Facility Operating Characteristics
20.00	34.5	______	______	B. Normal and Emergency Operating Procedures and Radiological Controls
18.00	31.0	______	______	C. Facility and Radiation Monitoring Systems
58.00		______		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 in each category.
12. There is a time limit of three (3) hours 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

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

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

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

$$\beta_{eff} = 0.1 \; seconds^{-1}$$

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

$$CR_1(1 - K_{eff_1}) = CR_2(1 - K_{eff_2})$$
$$CR_1(-\beta_1) = CR_2(-\beta_2)$$

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

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

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

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

$$P = P_0 \; e^{\frac{t}{\beta}}$$

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

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

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

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

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

$$T_{½} = \frac{0.693}{\beta}$$

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

$$DR = DR_0 \; e^{-\beta t}$$

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

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

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

$$\frac{(\beta_2 - \beta)^2}{Peak_2} = \frac{(\beta_1 - \beta)^2}{Peak_1}$$

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

1 Horsepower = 2.54 x 10^{3} BTU/hr

1 BTU = 778 ft-lbf

1 gal (H_2O) ≈ 8 lbm

c_P = 1.0 BTU/hr/lbm/°F

1 kg = 2.21 lbm

1 Mw = 3.41 x 10^{6} BTU/hr

°F = 9/5 °C + 32

°C = 5/9 (°F - 32)

c_p = 1 cal/sec/gm/°C

Section A

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~~ ___ Question Deleted per facility comment

A.12 1 2 3 4 ___

A.13 1 2 3 4 ___

A.14 a b c d ___

A.15 a b c d ___

A.16 a b c d ___

~~A.17 a b c d~~ ___ Question Deleted per facility comment

A.18 a b c d ___

A.19 a b c d ___

A.20 a b c d ___

Section B

B.1a 0.0200 0.0098 0.0060 0.0025 0.0010 ___

B.1b 0.0200 0.0098 0.0060 0.0025 0.0010 ___

B.1.c 0.0200 0.0098 0.0060 0.0025 0.0010 ___

B.1.d 0.0200 0.0098 0.0060 0.0025 0.0010 ___

B.1.e 0.0200 0.0098 0.0060 0.0025 0.0010 ___

B.1.f 0.0200 0.0098 0.0060 0.0025 0.0010 ___

B.2 a b c d ___

B.3 a b c d ___

B.4a SL LSSS LCO ___

B.4b SL LSSS LCO ___

B.4c SL LSSS LCO ___

B.4d SL LSSS LCO ___

B.5 a b c d ___

B.6 a b c d ___

B.7a 1 2 3 4 ___

B.7b 1 2 3 4 ___

B.7c 1 2 3 4 ___

B.7d 1 2 3 4 ___

B.8 a b c d ___

B.9 a b c d ___

B.10 a b c d ___

B.11 a b c d ___

B.12 a b c d ___

B.13 a b c d ___

B.14 a b c d ___

B.15 a b c d ___

B.16 a b c d ___

B.17 a b c d ___

Section C

C.1 a b c d ___

C.2 a b c d ___

C.3 a b c d ___

C.4a LS AO Green Red ___

C.4b LS AO Green Red ___

C.4c LS AO Green Red ___

C.4d LS AO Green Red ___

C.4e LS AO Green Red ___

C.4f LS AO Green Red ___

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.11a red yellow white blue ___

C.11b red yellow white blue ___

C.11c red yellow white blue ___

C.12a scram run-in none ___

C.12b scram run-in none ___

C.12c scram run-in none ___

C.12d scram run-in none ___

C.12e scram run-in none ___

C.12f scram run-in none ___

C.13a bright dim flashing off ___

C.13b bright dim flashing off ___

C.13c bright dim flashing off ___

C.13d bright dim flashing off ___

C.14 a b c d ___

C.15a 1 2 3 4 5 6 7 8 ___

C.15b 1 2 3 4 5 6 7 8 ___

C.15c 1 2 3 4 5 6 7 8 ___

C.16 a b c d ___

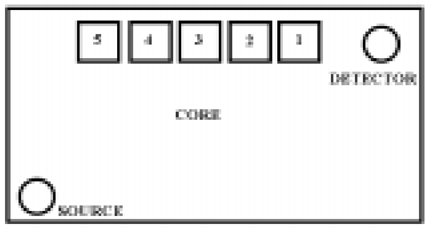

Figure 1

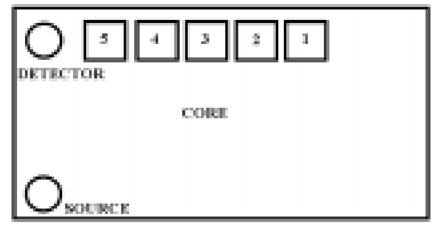

Figure 2

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