April 15, 2002

Mr. Ralph A. Butler, Interim Director
Research Reactor Facility
University of Missouri - Columbia
Columbia, MO 65211

SUBJECT: INITIAL EXAMINATION REPORT NO. 50-186/OL-02-01

Dear Mr. Butler:

During the week of March 10, 2002, the NRC administered an operator licensing examination at your University of Missouri – Columbia Reactor. The examination was conducted according to NUREG-1478, "Non-Power Reactor Operator Licensing Examiner Standards," Revision 1. Examination questions and preliminary findings were discussed with those members of your staff identified in the enclosed report at the conclusion of the examination.

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

Sincerely,

/RA by Marvin Mendonca Acting for/

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. 50-186

Enclosures:
1. Initial Examination Report No. 50-186/OL-02-01
2. Facility comments with NRC resolution
3. Examination and answer key (RO/SRO)

cc w/encls:
Please see next page

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CBassett	AAdams	WBeckner

Facility File (EBarnhill) O6-D17

ADAMS ACCESSION #: ML020840277 **TEMPLATE #:NRR-074**

OFFICE	RORP:CE		IEHB:LA	E	RORP:SC	E
NAME	PDoyle		EBarnhill		PMadden	
DATE	03/22 /2002		04/11/2002		04/ 12 /2002	

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

REPORT NO.: 50-186/OL-02-01

FACILITY DOCKET NO.: 50-186

FACILITY LICENSE NO.: R-103

FACILITY: University of Missouri – Columbia

EXAMINATION DATES: March 11-12, 2002

SUBMITTED BY: ***/RA/*** 3/20/2002
Paul Doyle, Chief Examiner Date

SUMMARY:

The NRC administered Operator Licensing examinations to two Reactor Operator license candidates and one Senior Operator license candidate. All three candidates passed their respective examinations.

REPORT DETAILS

1. Examiners:
   Paul Doyle, Chief Examiner

2. Results:

	RO PASS/FAIL	SRO PASS/FAIL	TOTAL PASS/FAIL
Written	2/0	0/0	2/0
Operating Tests	2/0	1/0	3/0
Overall	2/0	1/0	3/0

3. Exit Meeting:
   Paul Doyle, NRC, Examiner
   Paul Hobbs, MURR, Reactor Manager
   Mike Dixon, MURR, Assistant Reactor Manager
   Les Foyto, MURR, Assistant Reactor Manager
   John Fruits, MURR, Assistant Reactor Manager
   Kiratadas Kutikkad, MURR, Assistant Reactor Manager

   Mr. Doyle thanked the facility managers for their support of the examinations and informed them that he did not detect any generic weakness among the candidates. The facility informed Mr. Doyle that they would send any comments on the written examination via E-mail by Monday 03/19/2002, and requested another exam be scheduled for September, 2002.

Facility Comments

After reviewing the questions and answers on the March 12, 2002 Reactor Operator license exam, we had the following comments.

Section A

A.6 Answer key has 'C' we think the correct answer should be 'A' given the % of aluminum in the foil and the 1.49 b scattering cross section.

A.7 Answer key has 'C' should be 'B' since the correction is for leakage.

A.9 Answer key is correct but it could also be 'D' since sources are used to ensure nuclear instrumentation is functioning properly.

A.11 No answer given in the Key, should be 'B'.

A.12 Answer key has 'B', should be 'A' since reg rod goes in to compensate for a positive reactivity addition due to the increase in temperature.

A.16 No answer given in the key, should be 'B'.

A.19 No answer given in the key, should be 'D'.

Section B

B.2 Answer key has a, LSSS; b, LSSS; c, SL; d, SL; Should be a, LSSS; b, LSSS; c, LCO; d, LCO.

Section C

C.5 Answer key has 'B' should be 'C'.

C.7 Answer 'B' is correct but 'D' is also correct since the solenoid will de-energize causing the air on the open side to vent and put air to the close side causing the valve to close.

Mike Dixon
MURR
Assistant Reactor Manager-Operations

NRC ResolutionA

Correct answer for question A.9 is 'd', NOT b. Answer key changed to make 'd' the correct answer. All other comments accepted as written.

ENCLOSURE 2

UNIVERSITY OF MISSOURI–COLUMBIA

With Answer Key

OPERATOR LICENSING
EXAMINATION
March 12, 2002

Enclosure 3

QUESTION A.1 [1.0 point]
An experimenter makes an error loading a rabbit sample. Injection of the sample results in a 100 millisecond period. If the scram setpoint is 12.5 Mwatt and the scram delay time is 0.1 seconds, WHICH ONE of the following is the peak power of the reactor at shutdown. (Assume Rabbit system is operational for this question.)

a. 12.5 Mw

b. 25.0 Mw

c. 34.0 Mw

d. 125 Mw

QUESTION A.2 [1.0 point]
With the reactor on a constant period which transient will take the LONGEST time to complete? A reactor power change of …

a. 5%, going from 1% to 6% of rated power.

b. 10%, going from 10% to 20% of rated power.

c. 15%, going from 20% to 35% of rated power.

d. 20%, going from 40% to 60% of rated power.

QUESTION A.3 [1.0 point]
The term ***PROMPT JUMP*** refers to…

a. the instantaneous change in power due to raising a control rod

b. a reactor which has attained criticality on prompt neutrons alone.

c. a reactor which is critical due to both prompt and delayed neutrons.

d. a negative reactivity insertion which is greater than β_{eff}

QUESTION A.4 [1.0 point]
Which ONE of the following reactions correctly describes Beta$^-$ (β^-) 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.5 [1.0 point]
Reactor power doubles in 42 seconds. Based on the period associated with this transient, how long will it take for reactor power to increase by a factor of 10?

a. 42 seconds

b. 84 seconds

c. 140 seconds

d. 210 seconds

QUESTION A.6 [1.0 point]
A thin foil target of 10% copper and 90% aluminum is in a thermal neutron beam. Given $\sigma_{a\,Cu}$ = 3.79 barns, $\sigma_{a\,Al}$ = 0.23 barns, $\sigma_{s\,Cu}$ = 7.90 barns, and $\sigma_{s\,Al}$ =1.49 barns, which ONE of the following reactions has the highest probability of occurring? A neutron …

a. scattering reaction with aluminum

b. scattering reaction with copper

c. absorption in aluminum

d. absorption in copper

QUESTION A.7 [1.0 point]
Which ONE of the following is the correct definition of $\beta_{effective}$? The relative amount of delayed neutrons compared to the total number of neutrons …

a. per generation.

b. per generation corrected for leakage from the core.

c. per generation corrected for time after the fission event.

d. per generation corrected for both leakage and time after the fission event.

QUESTION A.8 [1.0 point]
Which ONE of the following statements is the definition of ***REACTIVITY***?

a. A measure of the core's fuel depletion.

b. A measure of the core's departure from criticality.

c. Equal to 1.00 ΔK/K when the reactor is critical.

d. Equal to 1.00 ΔK/K when the reactor is prompt critical.

QUESTION A.9 [1.0 point]
Which ONE of the following is the purpose for having a neutron source?

a. To compensate for neutrons absorbed by experiments installed in the reactor.

b. To generate a sufficient population to start a fission chain reaction for reactor startup.

c. To provide a means for allowing reactivity changes to occur in a subcritical reactor.

d. To generate a detectable neutron level for monitoring reactivity changes in a shutdown reactor.

QUESTION A.10 [1.0 point]
Which ONE of the following describes the difference between a moderator and reflector?

a. A reflector increases the fast non-leakage factor and a moderator increases the thermal utilization factor.

b. A reflector increases the neutron production factor and a moderator increases the fast fission factor.

c. A reflector decreases the thermal utilization factor and a moderator increases the fast fission factor.

d. A reflector decreases the neutron production factor and a moderator decreases the fast non-leakage factor.

QUESTION A.11 [1.0 point]
After a week of full power operation, Xenon will reach its peak following a shutdown in approximately:

a. 5 hours

b. 10 hours

c. 20 hours

d. 40 hours

QUESTION A.12 [1.0 point]
Regulating rod worth for a reactor is 0.001 ΔK/K/inch. Moderator temperature increases by 9°F, and the regulating rod moves 4½ inches inward to compensate. The moderator temperature coefficient α_{Tmod} is …

a. $+5 \times 10^{-4}$

b. -5×10^{-4}

c. $+2 \times 10^{-5}$

d. -2×10^{-5}

QUESTION A.13 [1.0 point]
Several processes occur that may increase or decrease the available number of neutrons. SELECT from the following the six-factor formula term that describes an INCREASE in the number of neutrons during the cycle.

a. Thermal utilization factor (f).

b. Resonance escape probability (p).

c. Fast non-leakage probability ($\mathcal{L}_f$).

d. Fast Fission factor (ε).

QUESTION A.14 [1.0 point]
Using the Integral Rod Worth Curve provided identify which ONE of the following represents K_{excess}

a. Area under curve “B”

b. ρ_C

c. $\rho_{max} - \rho_C$

d. Area under curve “A” and “B”

QUESTION A.15 [1.0 point]
Moderating efficiency takes into account how well an isotope will slow down a neutron, combined with its absorption cross-section. We know that $_1H^1$ is best suited for slowing down a neutron. Which ONE of the listed isotopes will have the best overall moderating efficiency?

a. $_1H^2$

b. $_1H^3$

c. $_6H^{12}$

d. $_{92}H^{238}$

QUESTION A.16 [1.0 point]
The neutron microscopic cross-section for absorption σ_a 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.17 [1.0 point]
Which ONE of the following is the reason that Xenon Peaks after a shutdown?

a. Iodine decays faster than Xenon decays

b. Promethium decays faster than Xenon decays

c. Xenon decays faster than Iodine decays

d. Xenon decays faster than Promethium

QUESTION A.18 [1.0 point]
To make a critical reactor prompt critical, by definition you must add an amount of reactivity equal to …

a. K_{eff}

b. β_{eff}

c. λ_{eff}

d. τ_{eff}

QUESTION A.19 [1.0 point]
Which ONE of the following reactor parameter changes would have the ***LEAST*** effect on reactivity of the reactor?

a. Increase moderator temperature by 5°F

b. Increase fuel temperature by 50°F

c. Drain the water out of the center flux trap.

d. Increase the pressure of the moderator by 20 psi.

QUESTION A.20 [1.0 point]
K_{eff} is K_{∞} times …

a. the fast fission factor (ε)

b. the total non-leakage probability ($\mathcal{L}_f \times \mathcal{L}_{th}$)

c. the reproduction factor (η)

d. the resonance escape probability (p)

QUESTION (B.1) [1.0 point]
Consider two point sources each having the same curie strength. Source A's gammas have an energy of 1.0 MeV while Source B's gammas have an energy of 2.0 MeV. You obtain a reading using the same **Geiger Counter** at 10 feet from each source. With respect to the two readings, which ONE of the following statements is correct?

a. The reading from Source B is four times that of Source A.

b. The reading from Source B is twice that of Source A.

c. The two reading are the same.

d. The reading from Source B is half that of Source A.

QUESTION (B.2) [2.0 points, ½ each]
Identify each of the following reactor plant limitations as a Safety Limit (SL), Limiting Safety System Setting (LSSS) or a Limiting Condition for Operation (LCO). (Choices may be used more than once or not at all.)

a. Reactor Inlet Temperature 155°F (Maximum)

b. Primary Coolant Flow, 1625 gpm either Loop (Minimum)

c. The reactor shall be subcritical by a margin at least 0.02 ΔK with an any one shim blade fully withdrawn.

d. The reactor shall not be operated … unless the following are operable: The Siphon Break System

QUESTION B.3 [1.0 point]
A survey instrument with a window probe was used to measure an irradiated experiment. The results were 100 millirem/hr window open and 60 millirem/hr window closed. What was the gamma dose?

a. 100 millirem/hr

b. 60 millirem/hr

c. 40 millirem/hr

d. 140 millirem/hr

QUESTION (B.4) [1.0 point]
Which ONE of the following is the 10CFR20 definitions for "Annual Limit on Intake (ALI)"?

a. The concentration of a radionuclide in air which, if inhaled by an adult worker for a year, would result in a total effective dose equivalent of 100 millirem.

b. 10CFR20 derived limit, based on a Committed Effective Dose Equivalent of 5 Rems whole body or 50 Rems to any individual organ, for the amount of radioactive material inhaled or ingested in a year by an adult worker.

c. The effluent concentration of a radionuclide in air which, if inhaled continuously over a year, would result in a total effective dose equivalent of 50 millirem for noble gases.

d. Projected dose commitment values to individuals, that warrant protective action following a release of radioactive material.

QUESTION (B.5) [1.0 point]
Which ONE of the following is the correct definition of an **INSTRUMENT CHANNEL TEST**?

a. The combination of sensor, line, amplifier, and output devices which are connected for the purposes of measuring the value of a parameter.

b. An adjustment of the channel such that its output corresponds with acceptable accuracy to known values of the parameter which the channel measures.

c. A qualitative verification of acceptable performance by observation of channel behavior. This verification, where possible, shall include comparison of the channel with other independent channels or systems measuring the same variable.

d. The introduction of a signal into the channel for verification that it is operable.

QUESTION (B.6) [1.0 point]
While working in an area marked "Caution, Radiation Area," you discover your dosimeter is off scale and leave the area. Assuming you had been working in the area for 45 minutes, what is the maximum dose you would have received?

a. 3.8 mr

b. 35.6 mr

c. 75 mr

d. 100 mr

QUESTION (B.7) [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.8) [1.0 point]
Which ONE of the following is the minimum number of hours you must stand watch per quarter to maintain your license active?

a. 2

b. 4

c. 8

d. 12

QUESTION (B.9) [1.0 point]
An experiment is removed from the reactor with a radiation level of **10R/hr** at **15 feet**. **15 minutes later**, the radiation level is **7.2 Rem/hr** at **15 feet**. Approximately how long must you let the experiment decay before the radiation level is less than **100 mR/hr** at **1 foot**.

a. 4 hours

b. 8 hours

c. 12 hours

d. 16 hours

QUESTION (B.10) [1.0 point]
According to Technical Specifications, the drop time for each rod shall be measured ____ and one of four blades shall be inspected _____.

a. monthly every six months

b. quarterly every six months

c. quarterly annually

d. every six months annually

QUESTION (B.11) [1.0 point]
During refueling, the lowest level of staff who may move fuel **INTO OR OUT OF THE CORE WITHOUT DIRECT SUPERVISION** is …

a. Auxiliary Operator

b. Reactor Operator

c. Senior Reactor Operator

d. Operations Manager

QUESTION (B.12) [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.13) [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.14) [1.0 point]
How long (by standard practice) must the reactor be secured prior to venting a beam port containing Ar^{41}?

a. 1 hour

b. 12 hours

c. 1 day

d. 2 days

QUESTION (B.15) [1.0 point]
Which ONE of the following is the **MINIMUM** reactor period for placing the regulating blade in automatic mode?

a. 30 seconds

b. 35 seconds

c. 50 seconds

d. 100 seconds

QUESTION (B.16) [1.0 point]
When pumping the Liquid Waste tanks to the sanitary sewer, the maximum accumulated activity for H^3 is 10 millicuries for the Shift Supervisor to authorize the procedure. The maximum accumulated activity for other nuclides is …

a. 1 millicurie

b. 2 millicuries

c. 4 millicuries

d. 20 millicuries

QUESTION (B.17) [1.0 point]
Which ONE of the following correctly defines the Emergency Plan term “Protective Action Guide(s)”?

a. The person or persons appointed by the Emergency Coordinator to ensure that all personnel have evacuated the facility or a specific part of the facility.

b. a condition or conditions which call(s) for immediate action, beyond the scope of normal operating procedures, to avoid an accident or to mitigate the consequences of one.

c. Projected radiological dose or dose commitment values to individuals that warrant protective action following a release of radioactive material.

d. Specific instrument readings, or observations; radiological dose or dose rates; or specific contamination levels of airborne, waterborne, or surface- deposited radioactive materials that may be used as thresholds for establishing emergency classes and initiating appropriate emergency measures.

QUESTION (B.18) [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.19) [1.0 point]
The NRC has four standard emergency classifications. Which ONE of the four listed below is NOT applicable at MURR?

a. Alert

b. General Emergency

c. Notification of Unusual Event

d. Site Area Emergency

QUESTION C.1 [1.0 point]
What type of sensor is used to detect the position of a pneumatic tube sample “rabbit” in the core?

a. photo-electric cell

b. magnetic switch

c. micro-switch

d. reed switch

QUESTION C.2 [1.0 point]
During reactor startup, you notice that Shim Blade #1 magnet engaged light goes out. Assuming it is NOT a blown light bulb, which ONE of the following actions is allowed by the Startup interlock?

a. Drive in Shim Blade#1, then engage Shim Blade #1's magnet

b. You must scram the reactor to reset the interlock, then engage the magnets for all the shim blades.

c. You may engage 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 engage the magnets for all shim blades.

QUESTION C.3 [1.0 point]
In addition to its primary function to supply the gas used for the pressurizer, the N_2 system is used …

a. to act as a backup to the air used in the valve operating system.

b. as a cover gas in the pneumatic tube system.

c. as a purge gas for the beam tubes.

d. as a backup to the air used in the antisiphon system.

QUESTION C.4 [2.0 points, ½ point each]
For each of the Rod Run-In Functions listed below, fill in the minimum number of instrument channels required by Technical Specifications for Reactor Operation in Mode 1.

	Column A Rod Run-In	Minimum Number of Channels
a.	High Reactor Power	1
b.	Reactor Period	2
c.	Rod not in contact with magnet	3
d.	Vent Tank Low Level	4

QUESTION C.5 [1.0 point]
According to Technical Specifications the shim rods shall be capable of insertion to the 20% withdrawn position in less than …

a. 0.3 seconds

b. 0.5 seconds

c. 0.7 seconds

d. 0.9 seconds

QUESTION C.6 [1.0 point]
Per SOP IV.3, which ONE of the following correctly describes the design parameters to be maintained in the antisiphon system? System pressure greater than …

a. 30 psig and water level less than 6 inches above the antisiphon valves

b. 27 psig and water level less than 6 inches above the antisiphon valves

c. 30 psig and water level less than 8 inches above the antisiphon valves

d. 27 psig and water level less than 8 inches above the antisiphon valves

QUESTION C.7 [1.0 point]
Which ONE of the following statements correctly describes operation of the building exhaust valves on a loww of electrical power?

a. Air is supplied to the close side of the east valve (16A) causing the valve to close.

b. Air is supplied to the close side of the west valve (16B) causing the valve to close.

c. Air is vented from the open side of the west valve (16B) causing the valve to close.

d. Air is vented from the open side of the east valve (16A) causing the valve to close.

QUESTION C.8 [1.0 point]
Which ONE of the following choices identifies two of the radiation detectors that upon a trip signal will generate a Reactor Isolation?

a. Air Plenum 2 and Nucleopore

b. North Wall and Room 114

c. Bridge ALARA and Fuel Vault

d. Air Plenum 1 and Bridge

QUESTION C.9 [1.0 point]
The purpose of the thermal column is to …

a. enhance heat transfer characteristics of the core.

b. enhance natural convection flow.

c. provide a thermal temperature rise for experiments.

d. provide a thermal neutron flux for experiments.

QUESTION C.10 [2.0 points, ½ each]
Match each POOL Coolant system function in column A with the component PRIMARILY responsible for that function in column B.

a. Reduce Water Hardness (Remove ions).	1. Filters
b. Reduce doses due to N^{16}.	2. Demineralizer
c. Remove suspended solids.	3. Hold-up Tank
d. Maximize mixing of water in pool	4. Diffuser

QUESTION C.11 [1.0 point]
Given the following conditions, choose the correct reason that the regulating blade will not go into automatic mode.

Wide Range . . . . . 10 Kilowatt range with black pen reading higher than red
Annunciator Panel Status . . . . . All lights deenergized except “Reg Blade out of “Auto”
IRM 2&3 Period . . . . . 45 seconds

a. Wide range meter range selected is too low.

b. Power is too low on selected range.

c. Regulating Blade Position is too low.

d. Intermediate range period is too short.

QUESTION C.12 [2.0 points, ½ each]
For each status description “a” through “d” of the Alarm and Annunciate System, indicate which of the conditions (1) through (4) would result in that status.

a. Illumination On Dim	1. Alarm was received and the operator pressed the acknowledge pushbutton. The alarm condition has not yet cleared.
b. Illumination Flashing	2. Alarm was received but the operator has not yet pressed the acknowledge pushbutton. The alarm conditions has not cleared.
c. Illumination On Bright	3. Alarm was received and the operator pressed the acknowledge pushbutton. The alarm condition subsequently cleared but the operator has not yet pressed the Reset button.
d. Illumination Off	4. Alarm was received and the operator pressed the acknowledge pushbutton. The alarm condition subsequently cleared and the operator pressed the Reset button.

QUESTION C.13 [1.0 point]
Which ONE of the following signals does **NOT** feed into the digital power meter?

a. Pool ΔT

b. Pool Flow

c. Primary Demin Flow

d. Channel 4 Power Level

QUESTION C.14 [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.15 [1.0 point, ¼ each]
List the NORMAL (10 Mwatt operation) positions (Open, Shut) for the following valves:

a. 509 (Pool Loop Isolation)

b. 545 (Pressurizer N2 Exhaust Vent)

c. 527C (Pressurizer Isolation Valve)

d. 547 (Pool Reflector Convective Loop Valve)

QUESTION C.16 [1.0 point]
Which ONE of the following is the method used to DE-ICE the cooling tower fans.

a. Run the cooling tower fan in reverse.

b. Use the facilities steam line located in the area for that purpose.

c. Use a heat gun (similar to a hair dryer) designated for de-icing use.

d. De-icing is not necessary due to anti-freeze added to cooling tower water.

QUESTION C.17 [1.0 point]
On receipt of a scram signal, with the regulating rod controlling in AUTO, the regulating rod will …

a. be magnetically decoupled from the drive, and drop into the core via gravity.

b. receive a rod run-in signal and be driven into the core.

c. receive a mis-match signal and be driven out of the core attempting to maintain power stable.

d. remain at its position at the time of the scram.

A.1 c
REF: Reference 1, Volume 2, Module 4, pp. 11.
$P = P_0 e^{t/\tau}$ P = 1.25 Mwatts × $e^{(0.1/0.1)}$ = 1.25 × 2.71828 = 3.398

A.2 a
REF: Reference 2, (MURR exam administered 4/1994).

A.3 a
REF: Reference 1, Volume 2, Module 4, pp. 14-15.

A.4 d
REF: Reference 1, Volume 1, Module 1, pp 24 - 25.

A.5 c
REF: Reference 1, Volume 2, Module 4, pp. 17-18.
$P = P_0 e^{t/\tau}$ 1st find τ. τ = time/(ln(2)) = 42/0.693 = 60.6 sec. Time = τ × ln(10) = 60.6 × 139.5 sec

A.6 ~~c~~ a Answer changed per facility comment
REF: Reference 1, Volume 1, Module 2, pp. 9-12.

A.7 ~~c~~ b Answer changed per facility comment
REF: Reference 1, Volume 2, Module 4, pp. 11-12.

A.8 b
REF: Reference 1, Volume 3, p. 18.

A.9 d
REF: Reference 1, Volume 2, p. 1.

A.10 a
REF: Reference 1, Volume 2, Module 4, pp. 25-26

A.11 b Answer added per facility comment
REF: Reference 1, Volume 2, Module 3, p. 38.

A.12 b a Answer changed per facility comment
REF: Reference 1, Volume 2, Module 3, p. 26.

A.13 d
REF: Reference 1, Volume 2, Module 3, pp. 3-8

A.14 c
REF: Not found in Reference 1, however K_{excess} is an important measurement required by Tech Specs.

A.15 a
REF: Reference 1, Volume 1, Module 2, p. 27.

A.16 b Answer added per facility comment
REF: Reference 1, Volume 1, Module 2, p. 9.

A.17 a
REF: Reference 1, Volume 2, Module 3, pp. 38.

A.18 b
REF: Reference 1, Volume 2, Module 4, pp. 15-16

A.19 d Answer added per facility comment
REF: Reference 1, Volume

A.20 b
REF: Reference 1, Volume 2, Module 3, pp. 8-9.

References
1. *DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory*
2. NRC Examination Question Bank

B.1 c
REF: GM Tubes are NOT sensitive to energy!!!

B.2 a, LSSS; b, LSSS; c, ~~SL~~ LCO; d, ~~SL~~ LCO Answer changed per facility comment
REF:

B.3 b
REF: 10CFR20.xxxx

B.4 b
REF: 10CFR20.1003 Definitions

B.5 d
REF: Technical Specifications § 1.0 Definitions

B.6 c
REF: 10 CFR 20.1003 Maximum dose in a radiation area is 100 mr/hr. 100 mr/hr × 0.75 hr = 75 mr.

B.7 a
REF: 10CFR20.1004.

B.8 B
REF: 10CFR55.53e

B.9 b
REF: See attached page.

B.10 b
REF: Technical Specification 5.3.

B.11 b
REF: SOP II, 2.1.H.

B.12 a
REF: REF: SOP I, § 4.3.G.5.

B.13 c
REF: SEP-1, §II.2 and 6.

B.14 b
REF: Reactor Operator Training Manual, § I.11 5th ¶.

B.15 b
REF: SOPII § II.1.3.

B.16 b
REF: Reactor Operator Training Manual, § I.10.2, p. 2, 1st ¶.

B.17 c
REF: Emergency Plan, § 9.0 Definitions

B.18 a
REF: 10CFR20.1003 Definitions

B.19 b
REF: Emergency Plan, § 3.0 Classification of Emergency Conditions

Question B.9
first solve for λ_{eff}
$A = A_0 e^{-t \lambda eff}$ $\ln (A/A_0) = \text{time} \times \lambda_{eff}$
$\lambda_{eff} = (\ln (7.2/10)) \div \text{time} = (-0.329)/15 \text{ minutes} = -0.0219 \text{ minutes}^{-1}$

Next solve for initial dose at 1 foot.
$A_{1 ft} = A_{15 ft} \times 15^2 = 10 \text{ R/hr} \times 225 = 2250 \text{ R/hr}$ at 1 foot.

Finally solve for time to get to 0.1 R/hr at 1 foot.
$0.1 = 2250 e^{t \lambda eff}$ ===> time = $\ln (2250/0.1) \div \lambda_{eff}$ = 457.6 minutes = 7.6 hours

C.1 a
REF: Facility Requalification Examination administered 11/17/93)

C.2 a
REF: Hazards Summary Report (HSR) Chapter 9.0, Instrumentation and Control § 9.5 Startup interlocks
C.3 a
REF: MURR Training Manual p. III-10 – III-12

C.4 a. 3; b, 2; c, 4; d, 1
REF: Technical Specification 3.4.c

C.5 ~~b~~ c Answer changed per facility comment
REF: Technical Specification 3.2.c.

C.6 b
REF: SOP IV.3

C.7 b or d Answer added per facility comment
REF: Training Manual for Reactor Operators § 1.11 p. 1-87

C.8 d
REF: RO Training Manual § II.0, p. II.9.2, 4th ¶

C.9 d
REF:

C.10 a, 2; b, 3; c, 1; d, 4.
REF: Draft SAR §§ 5.3.6, 5.3.7, 5.5.2 and 5.5.3.

C.11 c
REF: RO Training Manual § II.14, *Rod Control System*, also SOP II Reactor Operating Procedures § II.1.3 *Assuming Automatic Reactor Control*

C.12 a, 3; b, 2; c, 1; d, 4
REF: RO Training Manual, p. II-68

C.13 d
REF: NRC Exam administered January, 2001

C.14 a
REF: RO Training Manual, § 1.8, *Drain Collection Tank System*, p. I.8.1, B.6

C.15 a, open; b, shut; c, open;d, open
REF: RO Training Manual, § 1.5 Valve Op

C.16 a
REF: SOP VI.3.2.

C.17 d
REF: RO Training Manual, § II.14, Rod Control System

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

FACILITY: University of Missouri-Columbia

REACTOR TYPE: TANK

DATE ADMINISTERED: 2002/03/12

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% in each section is required to pass the examination. Examinations will be picked up three (3) hours 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	33.3	_____	____	B. Normal and Emergency Operating Procedures and Radiological Controls
20.00	33.3	_____	____	C. Facility and Radiation Monitoring Systems
60.00		_____	____% FINAL GRADE	TOTALS

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 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 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

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

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

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

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

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

$$R_1(1-K_{eff_1}) = CR_2(1-K_{eff_2})$$

$$CR_1(-\rho_1) = CR_2(-\rho_2)$$

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

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

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

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

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

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

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

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

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

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

$$T_{½} = \frac{0.693}{\lambda}$$

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

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

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

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

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 ___

B.1 a b c d ___

B.2a SL LSSS LCO ___

B.2b SL LSSS LCO ___

B.2c SL LSSS LCO ___

B.2d SL LSSS LCO ___

B.3 a b c d ___

B.4 a b c d ___

B.5 a b c d ___

B.6 a b c d ___

B.7 a b c d ___

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 ___

B.18 a b c d ___

B.19 a b c d ___

C.1 a b c d ___

C.2 a b c d ___

C.3 a b c d ___

C.4a 1 2 3 4 ___

C.4b 1 2 3 4 ___

C.4c 1 2 3 4 ___

C.4d 1 2 3 4 ___

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.10a 1 2 3 4 ___

C.10b 1 2 3 4 ___

C.10c 1 2 3 4 ___

C.10d 1 2 3 4 ___

C.11 a b c d ___

C.12a 1 2 3 4 ___

C.12b 1 2 3 4 ___

C.12c 1 2 3 4 ___

C.12d 1 2 3 4 ___

C.13 a b c d ___

C.14 a b c d ___

C.15a Open Shut ___

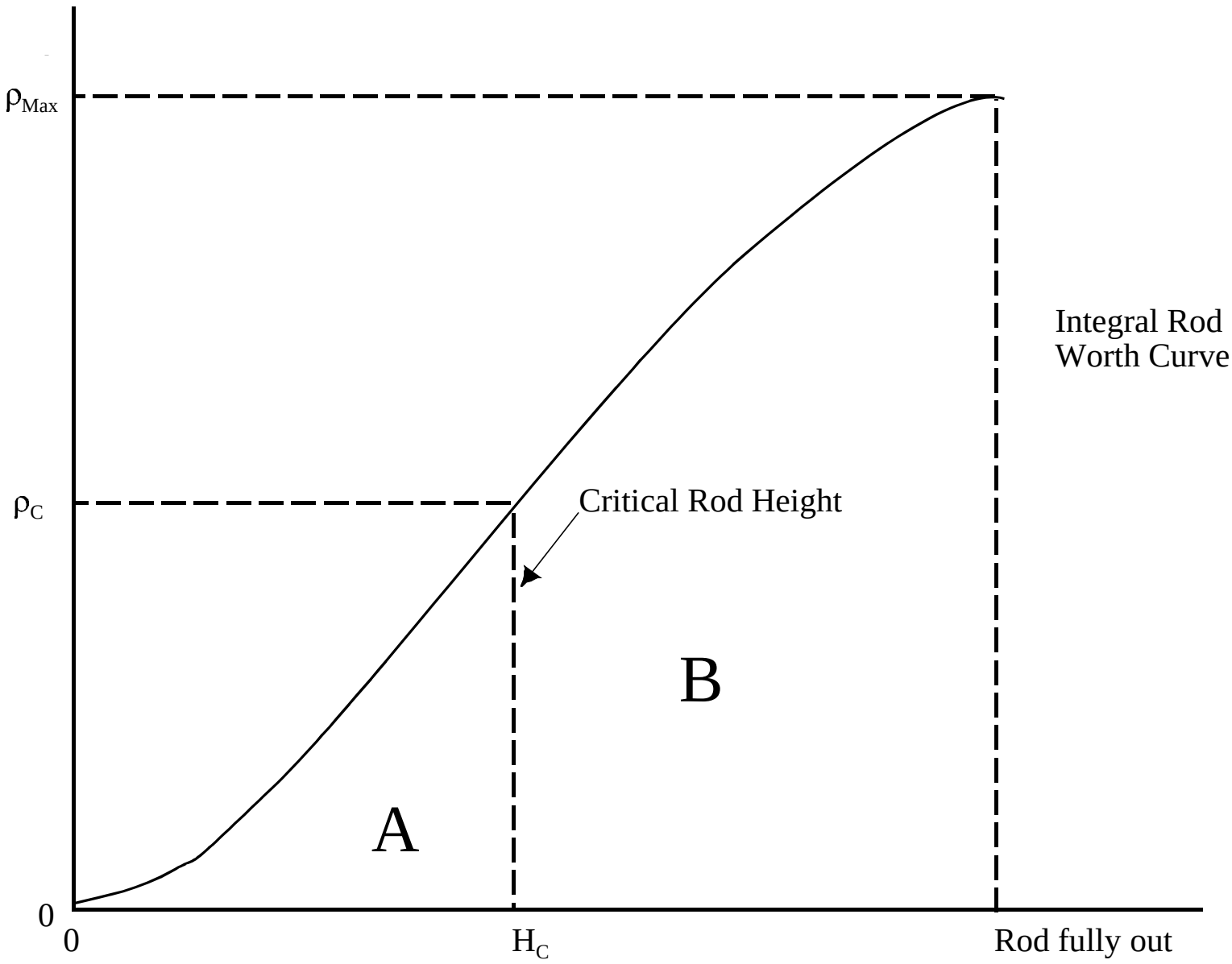
C.15b Open Shut ___

C.15c Open Shut ___

C.15d Open Shut ___

C.16 a b c d ___

C.17 a b c d ___


ρ_{Max}
ρ_C
Critical Rod Height
Integral Rod
Worth Curve
B
A
0
0
H_C
Rod fully out