June 14, 2002

Mr. Stephen I. Miller, Reactor Facility Director
Armed Forces Radiobiology Research Institute
Naval Medical Center
8901 Wisconsin Avenue
Bethesda, MD 20889-5603

SUBJECT: INITIAL EXAMINATION REPORT NO. 50-170/OL-02-01, ARMED FORCES RADIOBIOLOGY RESEARCH INSTITUTE

Dear Mr. Miller:

On April 18, 2002, the NRC administered an operator licensing examination at your Armed Forces Radiobiology Research Institute 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 via E-mail at pvd@nrc.gov.

Sincerely,

/RA/

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. 50-170

Enclosures: 1. Initial Examination Report No. 50-170/OL-02-01
2. Examination and answer key including facility comments

cc w/encls:
Please see next page

cc:

Director, Maryland Office of Planning
301 West Preston Street
Baltimore, MD 21201

County Executive
Montgomery County Government
Rockville, MD 20850

Mr. Stephen I. Miller
Reactor Facility Director
Armed Forces Radiobiology
Research Institute
8901 Wisconsin Avenue
Bethesda, MD 20889-5603

Roland Fletcher, Manager
Radiological Health Program
Air and Radiation Management Administration
Maryland Department of the Environment
2500 Broening Highway
Baltimore, MD 21224

Rich McLean, Manager
Nuclear Programs
Maryland Department of Natural Resources
Tawes B-3
Annapolis, MD 21401

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DISTRIBUTION w/ encls.:

PUBLIC	RORP r/f	PMadden
MMendonca	Facility File (EBarnhill) O6-D17	

ADAMS ACCESSION #: ML021560640 **TEMPLATE #:NRR-074**

OFFICE	RORP:CE		IEHB:LA	E	RORP:SC	
NAME	PDoyle:rdr		EBarnhill		PMadden	
DATE	06/ 07 /2002		06/ 11 /2002		06/ 12 /2002	

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

REPORT NO.: 50-170/OL-02-01

FACILITY DOCKET NO.: 50-170

FACILITY LICENSE NO.: R-84

FACILITY: Armed Forces Radiobiological Research Institute

EXAMINATION DATES: 04/18/2002

SUBMITTED BY: ***/RA/*** 5/28/2002
Paul Doyle, Chief Examiner Date

SUMMARY:

On April 18, 2002, the NRC administered Operator Licensing examinations to two Senior Operator License candidates. Both candidates passed all portions of their examinations.

REPORT DETAILS

1. Examiners:
   Paul Doyle, Chief Examiner

2. Results:

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

3. Exit Meeting:
   Paul Doyle Paul Doyle, NRC, Examiner
   Stephen Miller, Facility Director AFRRI

   During the exit meeting Mr. Doyle thanked the facility for their support in the administration of the operating tests. The examiner stated that he did not note any generic weaknesses on the part of the candidates. Mr. Miller stated that the facility had reviewed the written examination, and presented his comments. The examination in this report has been modified to incorporate the comments.

Armed Forces Radiobiology Research Institute

With Answer Key

OPERATOR LICENSING EXAMINATION

April 18, 2002

Enclosure 3

QUESTION A.1 [1.0 point]
Which ONE of the following isotopes has the largest microscopic cross-section for absorption for thermal neutrons?

a. Sm^{149}

b. U^{235}

c. Xe^{135}

d. B^{10}

QUESTION A.2 [1.0 point]
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.3 [1.0 point]
A reactor (not AFRRI) has the following reactivity characteristics.
K_{excess} ... \$2.50 Standard Rod 1 .... \$2.25
Standard Rod 2 .... \$2.30 Reg Rod \$1.10
Which ONE of the following is the shutdown margin allowable by Technical Specifications. (NOTE: All rods are scrammable, same condition as AFRRI Tech Spec.)

a. \$5.60

b. \$3.90

c. \$3.10

d. \$0.85

QUESTION A.4 [1.0 point]
Which ONE of the following conditions describes a critical reactor?

a. $K_{eff} = 1$; $\Delta k/k$ (ρ) = 1

b. $K_{eff} = 1$; $\Delta k/k$ (ρ) = 0

c. $K_{eff} = 0$; $\Delta k/k$ (ρ) = 1

d. $K_{eff} = 0$; $\Delta k/k$ (ρ) = 0

QUESTION A.5 [1.0 point]
Which ONE of the following is an example of beta 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.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]
You are increasing reactor power on a steady +26 second period. How long will it take to increase power by a factor of 1000?

a. 60 seconds (1 minute)

b. 180 seconds (3 minutes)

c. 300 seconds (5 minutes)

d. 480 seconds (8 minutes)

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 deviation 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 correctly describes the generation of neutrons from the Am-Be source?

a. $_{95}Am^{241} \rightarrow {}_{93}Np^{237} + {}_{2}\alpha^{4}$; $\quad {}_{2}\alpha^{4} + {}_{4}Be^{9} \rightarrow [{}_{6}C^{13}]^{*} \rightarrow {}_{6}C^{12} + {}_{0}n^{1}$

b. $_{95}Am^{241} \rightarrow {}_{96}Np^{241} + {}_{-1}\beta^{0} + \gamma$; $\quad {}_{0}\gamma^{0} + {}_{4}Be^{9} \rightarrow [{}_{4}Be^{9}]^{*} \rightarrow {}_{4}Be^{8} + {}_{0}n^{1}$

c. $_{95}Am^{241} \rightarrow {}_{96}Np^{241} + {}_{-1}\beta^{0} + \gamma$; $\quad {}_{-1}\beta^{0} + {}_{4}Be^{9} \rightarrow [{}_{3}Li^{9}]^{*} \rightarrow {}_{3}Li^{8} + {}_{0}n^{1}$

d. $_{95}Am^{241} \rightarrow$; [S.F.] $\rightarrow$ 2 fission products + $_{0}n^{1}$

QUESTION A.10 [1.0 point]
A complete core load is in progress on a research reactor. The following data has been taken.

Number of Elements Installed	Detector A Counts (cpm)
0	11
2	13
4	17
6	22
8	34

Using the graph paper provided, determine which of the following is the approximate number of fuel elements that will be required to be loaded for a critical mass.

a. 8

b. 10

c. 12

d. 14

QUESTION A.11 [1.0 point]
Initially Nuclear Instrumentation is reading 30 CPS and the reactor has a K_{eff} of 0.90. You add an experiment which causes the Nuclear instrumentation reading to increase to 60 CPS. Which ONE of the following is the new K_{eff}?

a. 0.91

b. 0.925

c. 0.95

d. 0.975

QUESTION A.12 [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.13 [1.0 point]
After a week of full power operation, Xenon will reach its peak following a shutdown in approximately:

a. 6 hours

b. 12 hours

c. 24 hours

d. 48 hours

QUESTION A.14 [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.15 [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.16 [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.17 [1.0 point]
When performing rod calibrations, many facilities pull the rod out a given increment, then measure the time for reactor power to double (doubling time), then calculate the reactor period. If the doubling time is 42 seconds, what is the reactor period?

a. 29 sec

b. 42 sec

c. 61 sec

d. 84 sec

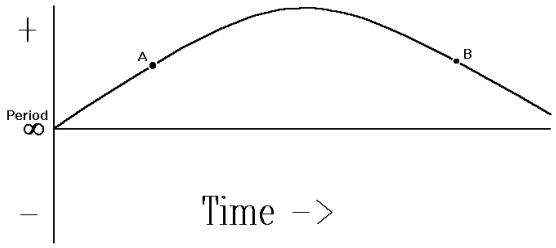
QUESTION A.18 [1.0 point]
Shown below is a trace of reactor period as a function of time. Between points A and B reactor power is:

a. continually increasing.

b. continually decreasing.

c. increasing, then decreasing.

d. constant.



QUESTION A.19 [1.0 point]
Which ONE of the following is the correct definition of $\beta_{effective}$ for a TRIGA reactor? The relative amount of delayed neutrons …

a. per generation corrected for resonance absorption.

b. per generation corrected for leakage.

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

d. per generation corrected for both leakage and resonance absorption.

QUESTION A.20 [1.0 point]
During a reactor startup, criticality occurred at a lower rod height than the last startup. Which ONE of the following reasons could be the cause?

a. Adding an experiment with positive reactivity.

b. Xe^{135} peaked.

c. Moderator temperature increased.

d. Maintenance on the control rods resulted in a slightly faster rod speed.

QUESTION B.1 [1.0 point]
Which ONE of the following correctly defines a Safety Limit?

a. Limits on important process variables which are found to be necessary to reasonably protect the integrity of certain physical barriers which guard against the uncontrolled release of radioactivity.

b. The Lowest functional capability of performance levels of equipment required for safe operation of the facility.

c. Settings for automatic protective devices related to those variables having significant safety functions.

d. a measuring or protective channel in the reactor safety system.

QUESTION B.2 [2.0 points, ½ each]
Match the values from column B for the Technical Specification limits listed in column A. (Values in Column B may be used more than once or not at all. Each limit in section A should have only one answer.)

Column A	Column B
a. Minimum Shutdown margin provided by the remaining control rods with the most reactive control rod fully withdrawn or removed.	$0.50 (0.35% Δk/k)
b. Total Maximum Reactivity worth of all experiments.	$1.00 (0.7% Δk/k)
c. Total Maximum available Excess Reactivity above cold critical with or without all experiments in place	$2.00 (1.4% Δk/k)
d. Maximum allowable pulse (by Technical Specifications).	$3.00 (2.1% Δk/k)
	$4.00 (2.8% Δk/k)
	$5.00 (3.5% Δk/k)

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

a. 40 mrem/hr

b. 60 mrem/hr

c. 100 mrem/hr

d. 140 mrem/hr

QUESTION B.4 [1.0 point]
You use a **Geiger-Müller detector** at the same distance from two point sources 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. Which ONE of the following would you expect for the readings due to each source?

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. Both readings are the same.

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

QUESTION B.5 [1.0 point]
Which ONE of the following is the correct definition of a **CHANNEL CHECK**?

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]
Which ONE of the following is the definition for "Annual Limit on Intake (ALI)"?

a. The concentration of a radio-nuclide in air which, if inhaled by an adult worker for a year, results 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 radio-nuclide 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.8 [1.0 point]
You been assigned to decrease the dose rate from a point source by about a factor of 10. The point source emits a 1.5 MeV gamma. Your shielding consists of ½ inch thick lead sheets. How many sheets (minimum) are required? Given: the mass attenuation coefficient for lead (for 1.5 MeV gammas = 0.051 cm^2/gram and density of lead is 11.4 gram/cm^3.

a. 1 sheet

b. 2 sheets

c. 3 sheets

d. 5 sheets

QUESTION B.9 [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.10 [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.11 [1.0 point]
Which ONE of the following conditions is an Reportable Occurrence per the Technical Specification definition?

A. Operation of the reactor with a fuel temperature scram set at 550°C.

B. Operation of the reactor at 10 kilowatts with purification system inlet temperature at 65°C.

C. Irradiation of a sample containing 15 milligrams of explosive material.

D. Operation with a pool level scram setpoint of 15 ft. above the top of the core.

QUESTION B.12 [1.0 point, ⅓ each]
Match the level of control for each of the experiment authorizations listed.

Column A	Column B (Performed …
A. Special Reactor Authorization	1. under the direct supervision of the Reactor Facility Director.
B. Routine Reactor Authorization	2. under the authorization of the Reactor Facility Director or Reactor Operations Supervisor.
C. Reactor Parameters Authorization	3. at the discretion of the Reactor Facility Director and coordinated with the Safety and Health department when appropriate.
	4. under the direct supervision of the Reactor Facility Director and coordinated with the Reactor and Radiation Safety Committee.

QUESTION B.13 [1.0 point]
Fill in the blank: According to Technical Specifications, a person is considered on call if: ... the individual is capable of getting to the reactor facility within _____ minutes under normal circumstances.

a. 15

b. 30

c. 45

d. 60

QUESTION B.14 [1.0 point]
You (a licensed Senior Reactor Operator) and an unlicensed person capable of carrying out written emergency procedures, your instructions, or summoning help are operating the reactor on the weekend. You are both the control room operator and the SRO on-call position. To meet Technical Specifications …

a. another staff person is required.

b. you and the unlicensed person must both remain in the control room.

c. you must remain in the control room, the unlicensed person may be anywhere within the AFRRI complex.

d. either you or the unlicensed person must be in the control room the other may be anywhere within the AFRRI complex.

QUESTION B.15 [1.0 point]
Which ONE of the materials listed is required to doubly encapsulated prior to irradiation per Technical Specifications?

a. Explosive

b. Corrosive

c. Fueled

d. Gaseous

QUESTION B.16 [1.0 point]
Your Annual limit (Occupational Dose Limit for an adult) for Total Effective Dose Equivalent is …

a. 1.25 rems

b. 5.0 rems

c. 15.0 rems

d. 50 rems

QUESTION B.17 [1.0 point]
Per procedure you may work in an exposure room only when the maximum dose reading in area which may be occupied is less than or equal to …

a. 1 mR/hr

b. 100 mR/hr

c. 1 R/hr

d. 10 R/hr

QUESTION B.18 [1.0 point]
According to Technical Specifications the allowable range for pool water pH is …

a. 3.5 to 6.0

b. 4.0 to 6.5

c. 4.5 to 6.0

d. 5.0 to 6.5

QUESTION B.19 [1.0 point]
A small experiment sample reads 200 mR/hr with the sample 1 foot under water and the meter at the surface of the water. A reading taken ½ hour ago with both the sample and the meter in the same positions was 400 mR/hr. Approximately how long will it take for the reading to drop to 20 mR/hr with the sample and the meter in the same positions?

a. 40 minutes

b. 70 minutes

c. 100 minutes

d. 130 minutes

QUESTION C.1 [2.0 points, ½ each]
Match the purification system functions in column A with the purification component listed in column B

Column A	Column B
a. remove floating dust, bug larvae, etc.	1. Demineralizer (Ion Exchanger)
b. remove dissolved impurities	2. Skimmer
c. remove suspended solids	3. Filter
d. maintain pH	

QUESTION C.2 [1.0 point]
The gas used to move pneumatic tube “rabbit” samples into and out of the reactor (when installed) is …

a. H_2

b. Air

c. CO_2

d. N_2

QUESTION C.3 [1.0 point]
The High Level Alarm on the primary Continuous Air Monitor causes …

a. the supply damper closes automatically

b. the exhaust dampers close automatically

c. the supply and exhaust dampers close automatically.

d. an audible and visual alarm, warning the Console Operator to manually secure the supply and exhaust dampers.

QUESTION C.4 [1.0 point]
Where would you go to fine the primary water system connection for Emergency Fill?

a. Reactor Room, near the pool.

b. Room 3152, near the still.

c. Room 2158, near the primary pump.

d. Room 3430, near the heat exchanger.

QUESTION C.5 [2.0 points, ½ each]
Match of the items in column A with the correct status on a loss of power from column B.

Column A	Column B
a. Shim, Safety and Regulating Blades.	1. Open
b. Control Room Dampers D-27 & D-28	2. Closed
c. Main Isolation Dampers	3. Inserted
d. Transient Rod	4. No Change

QUESTION C.6 [1.0 point]
Which ONE of the following choices, correctly lists the audible and visual alarms associated with the Hall Alarm Panel?

a. Stack Gas Monitor, bulk water temperature, reactor room exhaust fan.

b. RAM, pool water level, both reactor room CAMs.

c. Stack Gas Monitor, pool water conductivity, primary coolant pump

d. Primary CAM, pool water level, criticality monitor.

QUESTION C.7 [1.0 point]
Which Radiation Area Radiation Monitors have a battery backup?

a. R-1 and R-2.

b. R-1 and R-5.

c. R-2 and E-3.

d. R-5 and E-6.

QUESTION C.8 [2.0 points, 0.4 each]
Match the Exposure Room #1 component in column A with its primary purpose from Column B. Each item in Column A has only one answer. Each item from column B should be used only once.

Column A	Column B
a. Concrete	1. Reduce Thermal Neutron Flux
b. Wood Lining	2. Primary Biological Shield
c. Gadolinium Oxide Paint	3. Reduce Fast Neutron Flux (Thermalize neutrons).
d. Lead curtains	4. Reduce secondary Beta emissions from Gadolinium
e. Cadmium Sheet	5. Reduce scattered gamma radiation

QUESTION C.9 [1.0 point]
WHICH ONE of the following detectors is used primarily to measure Ar^{41} release to the environment?

a. NONE, Ar^{41} has too short a half-life to require environmental monitoring.

b. Stack Gas Monitor

c. Air Particulate Monitor

d. Reactor Room Area Radiation Monitor R-1

QUESTION C.10 [1.0 point]
An experimenter drops and breaks open a sample vial in a laboratory room. He immediately runs out of the room and closes the door. You are called in to assist in the cleanup. Prior to opening the door you would take a reading using a(n)

a. Ion Chamber portable radiation detector to determine the radiation field strength.

b. Geiger-Müller portable radiation detector to determine the radiation field strength.

c. Ion Chamber portable radiation detector to determine whether contamination is present.

d. Geiger-Müller portable radiation detector to determine whether contamination is present.

QUESTION C.11 [1.0 point, ¼ each]
Identify each of the items listed as pertaining to a Standard (STD)or a Transient Rod (TRANS)or either (EITHER), according to the Safety Analysis Report.

a. Larger diameter of the two.

b. May have a fuel follower.

c. May have an air follower

d. May have a poison follower

QUESTION C.12 [1.0 point]
A sample placed in which ONE of the following positions will have the greatest effect on core reactivity?

a. Exposure Room #1

b. Pneumatic Transfer System

c. In-Core Experiment Tube (CET)

d. Pool Irradiation

QUESTION C.13 [1.0 point]
Which ONE of the following is the method used to minimize mechanical shock to the standard control rods on a scram?

a. A small spring located at the bottom of the rod.

b. A piston attached to the upper end of the safety rod enters a dash port section of the barrel as the rod approaches the full insert position.

c. An electrical-mechanical brake energizes when the rod down limit switch is energized.

d. A piston (part of the connecting rod) drives air out of a dashpot as the rod nears the bottom of travel.

QUESTION C.14 [1.0 point]
The “Warm” Radioactive Waste system consists of

a. one 500 gallon tank

b. five 500 gallon tanks

c. one 5000 gallon tank

d. five 5000 gallon tanks

QUESTION C.15 [1.0 point]
The water monitor box contains detectors to measure all of the parameters below except…

a. conductivity

b. pH

c. reactivity (gamma)

d. temperature

QUESTION C.16 [1.0 point]
Pool level is decreasing at a rate of 3 inches per hour. This corresponds to approximately

a. 1 gallon/minute

b. 2 gallons/minute

c. 3 gallons/minute

d. 4 gallons/minute

QUESTION C.17 [1.0 point]
You energize the control panel, when both lead shield doors closed. A warning horn will sound in …

a. Neither exposure room.

b. The exposure room nearest to the core.

c. Exposure room 1, by default.

d. Both exposure rooms.

A.1 c
REF: Fundamentals of Nuclear Engineering (FONE) §

A.2 c
REF: FONE §

A.3 d
Worth of rods: \$2.50 + \$2.25 + \$1.10 = \$5.85. SDM = Worth of rods less K_{excess} less reactivity of most worth rod. SDM = \$5.85 - \$2.50 - 2.25 = 5.85 - \$4.75 = \$0.85
REF: FONE §

A.4 b
REF: FONE §

A.5 d
REF: FONE §

A.6 a
REF: FONE §

A.7 b
REF: FONE § ln (P/P_0) × period = time, ln(1000) × 26 = 6.908 × 26 = 179.6 ≈ 180 seconds

A.8 b
REF: FONE §

A.9 a
REF: FONE §

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

A.11 c
REF: FONE § $CR_2/CR_1) = (1 - K_{eff1})/(1 - K_{eff2})$ $60/30 = (1 - 0.900)/(1 - K_{eff2})$
$1- K_{eff2} = ½ × 0.1 = 0.05$ $K_{eff2} = 1 - 0.05 = 0.95$

A.12 a
REF: FONE §

A.13 b
REF: FONE §

A.14 b
REF: FONE § $(4.5 × 0.001) ÷ 9 = 0.0045 ÷ 9 = 0.0005 = 5 × 10^{-4}$

A.15 d
REF: FONE §

A.16 c
REF: FONE §

A.17 c
REF: FONE § ln (2) = -time/τ τ = time/(ln(2)) = 60.59 ≈ 61 seconds

A.18 a
REF: FONE §

A.19 b or d, Second answer added per facility comment
REF: FONE §

A.20 a
REF: FONE §

B.1 a
REF: Technical Specifications §

B.2 a, \$0.50; b, \$3.00; c, \$5.00 d, \$3.00
REF: Technical Specification 3.1.3 *Reactivity Limitations* and 3.6 *Limitations on Experiments*

B.3 a
REF: Instrument reads only γ dose with window closed. Instrument reads both β and γ dose with window open. Therefore, β dose is window open dose less window closed dose.

B.4 c
REF: GM tubes are NOT sensitive to energy level.

B.5 c
REF: Technical Specifications § 1, 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 b
REF: 10CFR20.1003

B.8 c
REF: First calculate μ = 0.051 cm^2/g × 11.4 g/cm^3 = 0.5814 cm^{-1}. Next calculate thickness.
$I = I_0 e^{-\mu x}$ $\ln(1/10) = -\mu x$ $x = -[\ln(1/10)]/\mu = \ln(0.1)/0.5814 = 3.96 \approx 4.0$ cm
Finally calculate number of sheets: (4.0 cm)/(2.54cm/in) = 1.57 inches or about 3 sheets.

B.9 a
REF: 10CFR20.1004.

B.10 b
REF: 10CFR55.53e

B.11 b
REF: Technical Specifications, 2.2, 3.3.a, 3.6.d and 3.2.2 (Table 2)

B.12 a, 1; b, 3; c, 2
REF: Technical Specification 6.4.

B.13 d
REF: Technical Specification 1.14.

B.14 a or c, Second answer added per facility comment.
REF: SOP 101, General Operating Procedures, § B.2

B.15 b
REF: T.S 3.6.4.

B.16 b
REF: 10CFR20.2001.a(1)

B.17 c
REF: Procedure 1, Tab A § D Routine Entry.

~~B.18 B.18 c~~ Question deleted per facility comment (pH no longer a Tech Spec requirement.)
~~REF: NRC examination question administered February 1993.~~

B.19 c
REF: $A = A_0 e^{-\lambda t}$
Solve for λ $200 = 400\ e^{-\lambda 30 min}$ $\ln (200/400) = -\lambda \times 30$minutes $\ln(½)/30$ minutes $= -\lambda = 0.0231$
Next solve for time $20 = 200\ e^{(-0.0231 \times time)}$ $\ln (1/10)/-0.0231 = time = 99.7$ minutes $\approx$ 100 minutes

C.1 a, 2; b, 1; c, 3; ~~d, 1~~ part d deleted per facility comment.
REF: SAR § 3.3.3

C.2 b
REF: SAR § 5.3,

C.3 c
REF: SAR § 3.6.2, Continuous Air Monitors, Table 3-2.

C.4 c
REF: NRC Exam question administered February 1993, also Safety Analysis Report (SAR) § 3.3.1

(C.5) a, 3 b, 2 or 4 c, 4 or 2 d, 3 Second answers added per facility comment.
REF: AFRRI OPS Manual, Chapt. D, SAR §§ 4.10.2 and 4.10.4

C.6 b
REF: NRC examination administered February 1993.

C.7 b
REF: NRC examination question administered February 1993.

C.8 a, 2; b, 3 c, 1; d, 5 e, 4 or 1, Second correct answer added per facility comment.
REF:

C.9 b
REF: Operational Procedure 10 *Stack Gas Monitor Procedure*

C.10 a
REF: Standard NRC question.

C.11 a, Trans; b, Std; c, Either; d, Trans
REF: SAR § 4.10.1 and § 4.10.3

C.12 c
REF: SAR § 4.8 & § 5.

C.13 b
REF: SAR § 4.10.2

C.14 d
REF: AFRRI Exam Bank Category B, pg. 174, also SAR § 3.4.2.

C.15 b
REF: Rewrite of AFRRI Question Bank Category B, pg. 270. Also SAR § 3.3.3

C.16 c
REF: Rewrite of AFRRI Question Bank Category B, pg. 314. Also SAR § 3.4.4. Each inch ≈ 67 gal.

C.17 b
REF: AFRRI Exam Bank category B question on page 212, also T.S. 3.2.3.

U. S. NUCLEAR REGULATORY COMMISSION
RESEARCH AND TEST REACTOR OPERATOR LICENSING EXAMINATION

FACILITY: Armed Forces Radiobiology Research Institute

REACTOR TYPE: TRIGA (Pulsing)

DATE ADMINISTERED: 2002/04/18

CANDIDATE: _____

INSTRUCTIONS TO CANDIDATE:
Answers are to be written on the answer sheets provided. Points for each question are indicated in brackets for each question. You must score 70% in each section to pass. 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. Facillity and Radiation Monitoring Systems
60.00		_____	____%	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 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

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

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

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

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

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

$$R_1(1-K_{eff_1}) = CR_2(1-K_{eff_2})$$
$$CR_1(-\rho_1) = CR_2(-\rho_2)$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$DR_1 d_1^{\,2} = DR_2 d_2^{\,2}$$

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

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

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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 $0.5 $1 $2 $3 $4 $5 ___

B2b $0.5 $1 $2 $3 $4 $5 ___

B.2c $0.5 $1 $2 $3 $4 $5 ___

B.2d $0.5 $1 $2 $3 $4 $5 ___

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.12a 1 2 3 4 ___

B.12b 1 2 3 4 ___

B.12c 1 2 3 4 ___

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.1a 1 2 3 ___

C.1b 1 2 3 ___

C.1c 1 2 3 ___

C.1d 1 2 3 ___

C.2 a b c d ___

C.3 a b c d ___

C.4 a b c d ___

C.5a 1 2 3 4 ___

C.5b 1 2 3 4 ___

C.5c 1 2 3 4 ___

C.5d 1 2 3 4 ___

C.6 a b c d ___

C.7 a b c d ___

C.8a 1 2 3 4 5 ___

C.8b 1 2 3 4 5 ___

C.8c 1 2 3 4 5 ___

C.8d 1 2 3 4 5 ___

C.8e 1 2 3 4 5 ___

C.9 a b c d ___

C.10 a b c d ___

C.11a STD TRANS EITHER ___

C.11b STD TRANS EITHER ___

C.11c STD TRANS EITHER ___

C.11d STD TRANS EITHER ___

C.12 a b c d ___

C.13 a b c d ___

C.14 a b c d ___

C.15 a b c d ___

C.16 a b c d ___

C.17 a b c d ___