March 15, 2006

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-06-01, ARMED FORCES RADIOBIOLOGY RESEARCH INSTITUTE

Dear Mr. Miller:

On October 19, and November 15, 2005, 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 2.390 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 Agencywide Documents Access and Management System (ADAMS). ADAMS is accessible from the NRC Web site at (the Public Electronic Reading Room) http://www.nrc.gov/reading-rm/adams.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 Mr. Paul V. Doyle Jr. at (301) 415-1058 or via internet e-mail pvd@nrc.gov.

Sincerely,

/RA/

Brian E. Thomas, Chief
Research and Test Reactors Branch
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Docket No. 50-170

Enclosures:
1. Initial Examination Report No. 50-170/OL-06-01
2. Facility comments with NRC resolution
3. Examination and answer key (RO/SRO)

cc w/encls: Please see next page

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EXAMINATION PACKAGE NO.: ML060330233
REPORT ACCESSION #: ML060600345 **TEMPLATE #: NRR-074**

OFFICE	PRTB:CE		IOLB:LA	E	PRTB:BC	
NAME	PDoyle		EBarnhill		BThomas	
DATE	03 /01/2006		03/08/2006		3/13/2006	

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

REPORT NO.: 50-170/OL-06-01

FACILITY DOCKET NO.: 50-170

FACILITY LICENSE NO.: R-84

FACILITY: Armed Forces Radiobiology Research Institute

EXAMINATION DATES: October 19, 2005 and November 15, 2005

SUBMITTED BY: **/RA/** 3/7/06
Paul V. Doyle Jr., Chief Examiner Date

SUMMARY:

On October 19, 2005, the NRC administered an operating test to one Senior Reactor Operator (Instant) (SRO-I) candidate. On November 15, 2005, the NRC administered a written examination to the same SRO-I candidate. The candidate passed all portions of the administered NRC examination.

REPORT DETAILS

1. Examiners:
   Paul V. Doyle Jr., Chief Examiner

2. Results:

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

3. Exit Meeting:
   Paul V. Doyle Jr., NRC, Chief Examiner
   Harry Spence, Reactor Supervisor, AFRRI TRIGA Reactor

   On November 15, 2005, the chief examiner held an exit meeting following the administration of the written examination. The examiner thanked the facility staff for their support of the administration of the examination. The facility staff e-mailed their written examination comments to the examiner. These comments have been incorporated into the written examination attached to this letter.

Dear Mr. Doyle

Attached please find the response to the examination given November 15th at our facility. The exam was well written and seemed to be appropriate in scope. Several questions were asked during the examination, all of which were dealt with by the examiner.

If you have any questions or comments with the attached, please let me know.

Thank you for your time and efforts with this exam.

Sincerely

Stephen Miller

NRC Resolution:

The NRC accepts all comments and has changed the examination as requested in the attachment.

Question A.06 – This question was originally written for a 200 KW reactor. The examiner told the candidate to multiply all answers by a factor of five, making answer "c" 3.4 Megawatts. Answer "c" remains the correct answer.

Question A.17 – Under AFRRI Technical Specifications (TS) Section 3.1.3.b, the minimum shutdown margin is calculated with only the most reactive control rod fully withdrawn or removed. The NRC answer assumes both the most reactive rod and the regulating rod are removed. The correct calculation is (2.41 + 2.32 + 2.49 + 2.60 + 0.084) – 3.42 – 2.60 = 3.88%. The examiner told the candidate to choose the answer closest to the correct answer. Given that instruction, answer "d" (3.80%) remains the correct answer.

Question B.01 – Since there are only four answers, each one should be listed as being worth 0.5 points rather than 0.4 points.

Question B.08 – This question refers to an obsolete TS section that has been updated. The examined removed the question. To keep the total point value of Section B constant, the examiner changed Question B.10 to be worth 2.0 points total (0.5 points each answer).

Question B.10 – See discussion of Question B.08.

Question B.12 – Under AFRRI TS Section 6.1.3.2, an SRO would only need to be present for transient rod drive maintenance or fuel movement (answers "a" and "c"). The presence of an RO (with an SRO on-call) is sufficient for operator training or "initial startup" as that term is normally interpreted at AFRRI. The staff clarified with the examiner that a routine "startup" is completed as the initial operation each day by checking reactor instrumentation and measuring excess reactivity. The examiner agreed to accept either "b" or "d" as correct answers.

Question B.14 – This question refers to an obsolete Reactor Operating Procedure that has been revised. The examiner replaced this question with Question B.19 from the April 18, 2002 SRO examination. The NRC answer to that question was "c". That is the correct answer if you assume that the period "how long" begins when the sample reads 200mR/hr. If, however, you assume that "how long" begins when the sample initially reads 400mR/hr, then "d" is the correct answer. If the question had asked "how much longer will it take …," then only "c" would be correct. But as the question now reads, both "c" and "d" should be accepted as correct.

Question C.04 – This question is a duplicate of Question C.01. The examiner replaced this question with Question C.3 from the April 18, 2002 SRO examination. The correct answer to that question is "c".

Question C.15 – This question refers to the old shell-and-tube heat exchanger that is no longer in service. None of the possible answers are correct for the current plate-type heat exchanger. The examiner replaced this question with Question C.10 from the April 18, 2002 SRO examination. The correct answer to that question is "a".

Questions C.17 and C.18 – These questions are duplicates of Questions C.12 and C.14. The examiner replaced these two 1-point questions with 2-point Question C.8 from the April 18, 2002 SRO examination. The NRC answers to that question were "a-2, b-3, c-1, d-5, e-4". For part (e), the NRC answer was "4". That answer was taken from SAR section 5.2.1, the last sentence in the second paragraph on page 5-3. The previous sentence in that same paragraph indicates that the cadmium sheet also helps by "reducing the thermal neutron population in ER#1 …." Therefore, both answers "1" and "4" are correct for part (e).

OPERATOR LICENSING EXAMINATION

With Answer Key

UNITED STATES NUCLEAR REGULATORY COMMISSION

Armed Forces Radiobiology Research Institute

November 15, 2005

ENCLOSURE 3

Question A.01 [1.0 point]
Using the data taken during a core loading fuel (Table A.1, provided), estimate the number of fuel elements needed to go critical.

Count Rate	No. of Fuel Bundles
842	2
936	4
1123	7
1684	12
2807	16

a. 18

b. 22

c. 26

d. 30

A.01 b (See attached sketch ~ 22 fuel elements)
REF: *Fund. of Nuclear Rx Engineering,* Chapter 5, § III, ¶ 158, p. 147.

Question A.02 [1.0 point]
The Reactor Operations Supervisor tells you that the reactor is shutdown with a Shutdown Margin of 12.0%. Nuclear Instrumentation reads 100 cpm. An experimenter inserts an experiment into the core and counts increase to 200 cpm. What is the resulting K_{eff} for the core?

a. 0.920

b. 0.946

c. 0.973

d. 1.000
A.02 b
REF: *Fund. of Nuclear Rx Engineering,* §
$K_{eff(l)} = 1/(1+SDM) = 1/1.120 = 0.892857$ $CR_{(l)}[1 - K_{eff(l)}] = CR_{(f)}[1 - K_{eff(f)}]$ $100(1 - 0.893) = 200\ (1 - x)$ ½(1 - 0.893) =
1 - x 1 - x = 0.0535714; x = 1 - 0.0535714 = <u>0.94643</u>

Question A.03 [1.0 point]
Which ONE of the following characterizes how heat is removed from the reactor core?

a. Forced convection

b. Free conduction

c. Natural convection

d. Thermal radiation
A.03 c
REF: Operations manual for the AFRRI TRIGA Mark-F Reactor (pg 37)

Question A.04 [1.0 point]
Which ONE of the following is the cause of the indicated power to stabilize several hours following a reactor scram. (Assume source inserted in core, source range instrument on and reading 3 counts/second and no reactivity changes, i.e. no temperature changes, no fuel movement, no experiments added, etc.)

a. Continuing decay of the shortest lived delayed neutron precursor.

b. Gamma saturation of the source range detector.

c. Subcritical multiplication of source neutrons.

d. Neutron activation of the Source Range Detector.
A.04 c
REF: *Fund. of Nuclear Rx Engineering,* Chapter 5, § III, ¶ 159, p. 145.

Question A.05 [1.0 point]
During a startup you increase reactor power from 50 watts to 1000 watts in 100 seconds. What is reactor period?

a. 25

b. 33

c. 41

d. 50
A.05 b
REF: *Fund. of Nuclear Rx Engineering,* Chapter 3, § III, ¶ 78, p. 64. $P = P_0 e^{t/\tau}$ $\ln(P/P_0) = t/\tau$
$\tau = t/(\ln(P/P_0)$ $\tau = 100/\ln(20) = 33.381$

Question A.06 [1.0 point]
An experimenter makes an error loading a sample. Inserting the sample into the core results in a 100 millisecond period. If the first scram trip setpoint (actual) is 125%, and the scram delay time is 0.1 seconds, which ONE of the following is the resulting peak reactor power before the reactor shuts down? (Assume time is too short for rundown to have an affect.)

a. 280 Kilowatts (1.4 Mw)

b. 560 Kilowatts (2.8 Mw)

c. 680 Kilowatts (3.4 Mw)

d. 1.0 Megawatt (5.00 Mw)
A.06 c
REF: *Fund. of Nuclear Rx Engineering,* §

Question A.07 [1.0 point]
Which ONE of the following parameters is **MOST** significant in determining the differential worth of a control rod?

a. Rod Speed

b. Reactor Power

c. Flux Shape

d. Fuel Loading
A.07 c
REF: *Fund. of Nuclear Rx Engineering, Chapter 3,* § IV, ¶ 84, p. 75.

Question A.08 [1.0 point]
A fissile material is one which will fission upon absorption of a THERMAL neutron. A fertile material is one which upon absorption of a neutron becomes a fissile material. Which ONE of the following isotopes is an example of a fertile material.
a. U^{233}

b. U^{235}

c. U^{238}

d. Pu^{239}
A.08 c
REF: Fund. of Nuclear Rx Engineering, Chapter 1, § II, ¶ 7, p. 7.

Question A.09 [1.0 point]
Which one of the graphs supplied in figure A.1, most closely depicts the reactivity versus time plot for xenon for the following set of evolutions?

TIME	Evolution
1	Startup to 100% power, clean core
2	100% operation for four days
3	Shutdown for 15 hours
4	50% operation for 29 hours

a. a

b. b

c. c

d. d
A.09 a
REF: Fund. of Nuclear Rx Engineering, Chapter 3, § VI, ¶ 94, p. 87.

Question A.10 [1.0 point]
Five minutes after shutting down the reactor, reactor period is 3×10^6 counts per minute. Which ONE of the following is the count rate you would expect to three minutes later?

a. 1×10^6 cpm

b. 8×10^5 cpm

c. 5×10^5 cpm

d. 3×10^5 cpm

A.10 d
REF: *Fund. of Nuclear Rx Engineering,* Chapter 3, § III, ¶ 8(i), p. 69. For S/D reactor τ = -80 seconds. Time = 180 seconds. $P = P_0 e^{t/\tau} = 3 \times 10^6 e^{-180/80} = 3.162 \times 10^5$

Question A.11 [1.0 point]
Excess reactivity is the amount of reactivity …

a. associated with burnable poisons.

b. needed to achieve prompt criticality.

c. available below that which is required to make the reactor subcritical.

d. available above that which is required to keep the reactor critical.

A.11 d
REF: *Fund. of Nuclear Rx Engineering, Chapter 3,* § II, ¶ 75, p. 61

Question A.12 [1.0 point]
Which one of the following is the primary reason a neutron source is installed in the core?

a. To allow for testing and irradiation of experiments when the reactor is shutdown.

b. To supply the neutrons required to start the chain reaction for subsequent reactor startups.

c. To provide a neutron level high enough to be monitored for a controlled reactor startup.

d. To increase the excess reactivity of the reactor which reduces the frequency for refueling.

A.12 c
REF: *Fund. of Nuclear Rx Engineering,* Chapter 5, § II, ¶ 149(f), p. 137.

Question A.13 [1.0 point]
INELASTIC SCATTERING is the process by which a neutron collides with a nucleus and …

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

b. is absorbed, with the nucleus emitting a gamma ray, and the neutron with a lower kinetic energy.

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

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

A.13 b
REF: *Fund. of Nuclear Rx Engineering,* Chapter 1, § V, ¶ 18.e,3,a(1), p. 20.

Question A.14 [1.0 point]
Which one of the following statements details the effect of fuel temperature on core operating characteristics? As fuel temperature …

a. increases, doppler peaks will become higher.

b. decreases, resonance escape probability will increase.

c. decreases, U238 and Erbium will absorb more neutrons.

d. increases, the fast non-leakage probability will decrease.

A.14 b
REF: *Fund. of Nuclear Rx Engineering,* §

Question A.15 [1.0 point]
Which ONE of the following is the correct reason that delayed neutrons enhance control of the reactor?

a. There are more delayed neutrons than prompt neutrons.

b. Delayed neutrons increase the average neutron generation time.

c. Delayed neutrons are born at higher energies than prompt neutrons and therefore have a greater effect.

d. Delayed neutrons take longer to reach thermal equilibrium.

A.15 b
REF: *Fund. of Nuclear Rx Engineering,* Chapter 1, § VII, ¶ 37, p. 36.

Question A.16 [1.0 point]
K_{eff} is K_4 times …

a. the fast fission factor (ε)

b. the total non-leakage probability ($\ell_f \times \ell_{th}$)

c. the reproduction factor (η)

d. the resonance escape probability (p)
A.16 b
REF: *Fund. of Nuclear Rx Engineering,* Chapter 2, § VII, ¶ 68, p. 54.

Question A.17 [1.0 point]
Which one of the following is the calculated SDM assuming no experiments are in the core, xenon free conditions, and the following rod and reactivity worths?

	worth %ΔK/K		worth %ΔK/K
Shim-Safety Blade #1:	2.41	Shim-Safety Blade #2:	2.32
Shim-Safety Blade #3:	2.49	Shim-Safety Blade #4:	2.60
Regulating rod:	0.084	Excess Reactivity:	3.42

a. 9.90%

b. 6.48%

c 6.40%

d. 3.80%
A.17 d
REF: Standard NRC Question. Technical Specification Limits. SDM (cold/clean) = Total Rod worth - K_{excess} - Most reactive blade - Reg Rod SDM = (2.41 + 2.32 + 2.49 + 2.60 + 0.084) - 3.42 - 2.60 - 0.084 = 3.80%

Question A.18 [1.0 point]
The reactor is operating at 100 KW. The reactor operator withdraws the Regulating Rod allowing power to increase. The operator then inserts the same rod to its original position, decreasing power. In comparison to the rod withdrawal, the rod insertion will result in:

a. a longer period due to long lived delayed neutron precursors.

b. a shorter period due to long lived delayed neutron precursors.

c. the same period due to equal amounts of reactivity being added.

d. the same period due to equal reactivity rates from the rod.
A.18 a
REF: *Fund. of Nuclear Rx Engineering,* §

Question A.19 [1.0 point]
For U235, the thermal fission cross-section is 582 barns, and the capture cross-section is 99 barns. When a thermal neutron is absorbed by U^{235}, the probability that a fission will occur is:

a. 0.146

b. 0.170

c. 0.830

d. 0.855
A.19 d
Ref: *Fund. of Nuclear Rx Engineering,* §

Question A.20 [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%
A.20 a
Ref: *Fund. of Nuclear Rx Engineering,* § xxxxxxxxxxx

Question B.01 [2.0 point, 0.5 each]
Match the terms listed in column A with the respective reactivity limit from column B. (Note: Only one answer for each item in column A. Items in column B may be used more than once or not at all.)

Column A	Column B
a. Maximum All Experiments	1. $0.50
b. Maximum Excess Reactivity	2. $1.00
c. Maximum Step Insertion Worth	3. $2.00
d. Minimum Shutdown Margin	4. $3.00
	5. $4.00
	6. $5.00

B.01 a, 4; b, 6; c, 5; d, 1
REF: Technical Specifications §§ 3.1.2, 3.1.3 and 3.6.

Question B.02 [1.0 point]
While working on an experiment, you receive the following radiation doses: 100 mrem (β), 25 mrem (γ), and 5 mrem (thermal neutrons). Which ONE of the following is your total dose?

a. 175 mrem

b. 155 mrem

c. 145 mrem

d. 130 mrem
B.02 d
Ref: A rem is a rem is a rem.

Question B.03 [1.0 point]
In case of an emergency where the primary ERT location is not available [Reactor Control Room (Room 3160)] the ERT will meet …

a. in the AFRRI Director's Office (Room 2151)

b. at the Emergency Response Center, (Room 3430)

c. under the bridge on Palmer Road South.

d. on the patio by AFRRI's front entrance.
B.03 d
Ref: Emergency Plan §§ 6.1 and 6.2

Question B.04 [2.0 points, ½ each]
Identify each of the following as either a Safety Limit (SL), a Limiting Safety System Setting (LSSS) or as a Limiting Condition for Operations (LCO).

a. … fuel Element Temperature shall not exceed 600EC

b. … Reactor Steady State Power shall not exceed 1.1. megawatts

c. … The reactor shall not be operated above 5 kilowatts when the purification system inlet temperature exceeds 60EC.

d. … fuel Element Temperature shall not exceed 1000EC

B.04 a, LSSS; b, LCO; c, LCO; d, SL
Ref: Technical Specifications §§ 2.1, 2.2, 3.1.1 and 3.3.

Question B.05 [1.0 point, ⅓ each]
Identify whether each of the listed experiments requires double encapsulation (DBL), is not allowed (N/A) or has no special requirements (N/R).

a. An experiment containing Corrosive Materials.

b. A fueled experiment generating 2 curies of $I^{131 \text{ through } 135}$

c. An experiment containing 20 milligrams of explosive material
B.05 a. DBL; b, N/A; c, N/R;
Ref: Technical Specifications § 3.6, Limitations on Experiments

Question B.06 [1.0 point]
During an emergency, the lowest level of staff, by title, who may authorize receipt of radiation exposures in excess of 10 CFR 20 occupational limits (according to the Emergency Plan) is …

a. ECP Commander, with concurrence of health physics advisor, if available

b. ECP Commander, with concurrence of ERT commander, and health physics advisor, if available.

c. ERT Commander with concurrence of health physics advisor, if available.

d. ERT Commander with concurrence of health physics coordinator, if available.
B.06 a
REF: Emergency Plan § 3.1.1, (2),(a)

Question B.07 [1.0 point]
Which ONE of the following is the number of Licensed Reactor Operators required to visually inspect the exposure room before the plug door is closed if Exposure Room Number One horn is disconnected for testing?

a. 0

b. 1

c. 2

d. 3
B.07 c
Ref: AFRRI TRIGA MARK-F Operating Procedure I Tab A,section 8.a

Question B.08 [1.0 point] **DELETED per facility comment**
~~Per Technical Specifications the maximum amount of time the ventilation system may be out of service (with the reactor running) is …~~

~~a. 2 hours~~

~~b. a day~~

~~c. 2 days~~

~~d. a week~~
~~B.08 c~~
~~REF: Tech. Spec. 3.4.~~

Question B.09 [1.0 point]
Which ONE of the following is the definition of a **CHANNEL TEST**?

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

b. an adjustment of the channel such that it 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.

d. the introduction of a signal into the channel for verification that It Is operable.
B.09 d
Ref: Technical Specifications § 1.4 Definitions

Question B.10 [2.0 points, ½ each]
Match type of radiation (1 thru 4) with the proper penetrating power (a thru d)

a. Gamma 1. Stopped by thin sheet of paper

b. Beta 2. Stopped by thin sheet of metal

c. Alpha 3. Best shielded by light material

d. Neutron 4. Best shielded by dense material

B.10 a, 4; b, 2; c, 1; d, 3
Ref: Standard NRC Question

Question B.11 [2.0 points, $^2/_5$ each]
Match each of the electronics channels in column A with the reactor modes for which it must be operable in column B.

Column A	Column B
a. Fuel Temperature	1. Steady State ONLY
b. Linear Power Channel	2. Pulse ONLY
c. Log Power Channel	3. All Modes
d. High-Flux Safety Channel	
e. Pulse Energy Integrating Channel	

B.11 a, 3; b, 3; c, 1; d, 3; e, 2
REF: Technical Specifications Table 1.

Question B.12 [1.0 point]
Which ONE of the following operations does NOT require the presence of a licensed SENIOR reactor operator?

a. Maintenance on the Transient Rod Drive Mechanism.

b. An UNLICENSED individual operating the reactor for training.

c. An UNLICENSED individual moving fuel.

d. Initial Startup.

B.12 b
REF: Technical Specifications § 6.1.3.

Question B.13 [1.0 point]
Emergency Response Kits are located in all the following listed locations except …

a. Emergency Response Center (ERC)

b. Hallway 3106 near Emergency Response Team (ERT) Primary Location

c. Stairwell 3317 3rd floor.

d. Emergency Command Post (ECP)
B.13 d
REF: Emergency Plan § 6.6

Question B.14 [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
B.14 c
REF: $A = A0\ e^{-\lambda t}$ Solve for λ:
$200 = 400\ e^{-\lambda 30 minutes}$ ln (200/400) = -λ× 30minutes ln(½)/30 minutes = -λ = 0.0231
Next solve for time:
$20 = 200\ e^{(-0.0231 \times time)}$ ln (1/10)/-0.0231 = time = 99.7 minutes . 100 minutes

Question B.15 [1.0 point]
Most of the penetrations into the reactor room are sealed and cannot be opened. Which ONE of the following is the exception?

a. Control room air conditioner

b. Windows between the control room and adjacent offices

c. Conduit running through "expansion" penetrations

d. Piping which penetrates to another contained area
B.15 a
REF: AFRRI Safety Analysis Report, Section 3.2.4 , pg 3-14

Question B.16 [1.0 point]
Which ONE of the following conditions will NOT initiate a reactor scram?

a. 20% loss of voltage to safety channels.

b. Pulse time in excess of 15 seconds.

c. 20% loss of high voltage to the operational channel

d. Reactor power level in excess of 1.1 MW.
B.16 c
REF: AFRRI SAR , pg 4-34/36

Question B.17 [1.0 point]
According to Technical Specifications, the maximum temperature allowed in a standard TRIGA fuel element is …

a. 400EC

b. 600EC

c. 800EC

d. 1000EC
B.17 d
Ref: Technical Specification 2.1, pg 5

Question C.01 [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

C.01 c
REF: Rewrite of AFRRI Question Bank Category B, pg. 314. Also SAR § 3.4.4. Each inch . 67 gal.

Question C.02 [1.0 point]
Which ONE of the following design features prevents water from being siphoned out of the reactor pool and uncovering the core in the event of a primary coolant pipe rupture?

a. The capacity of the primary water makeup system.

b. All primary coolant pipes and components are located above core height.

c. The suction and discharge lines penetrate the reactor tank approximately 8 feet below pool surface.

d. The small holes that are drilled in the suction and return lines approximately 4 inches below pool surface.

C.02 d
Ref: AFRRI SAR, Section 3.3.1, p 3-15.

Question C.03 [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.

C.03 b
REF: AFRRI Exam Bank Category B, question on pg. 212.

Question C.04 [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.

C.04 c
REF: SAR § 3.6.2, Continuous Air Monitors, Table 3-2.

Question C.05 [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

C.05 d
REF: AFRRI Exam Bank Category B, pg. 174, also SAR § 3.4.2.

Question C.06 [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.

C.06 b
REF: SAR § 4.10.2

Question C.07 [1.0 point]
Which of the rings include the chromel-alumel thermocouples?

a. A and B

b. A and C

c. B and C

d. B and D
C.07 c
REF: AFRRI supplied question (55), also Operations Manual

Question C.08 [2.0 points, ½ each]
Identify whether each of the conditions given will results in either a Rod Withdrawal Prevent (RWP) or a SCRAM.

a) Pool Water Temperature high

b) Source level Low

c) Console Key Removed

d) Loss of NM 1000 High Voltage
C.08 a. RWP b. RWP c. SCRAM d. RWP
REF: AFRRI supplied question 3.115, also procedure 8, Tab B.

Question C.09 [1.0 point]
Due to an interlock failure the core is driven into region 2 with the lead shield doors closed. What will prevent damage to the core or the doors.

a. The clutch on the lead shield door motor.

b. The reverse contact switch on the core shroud.

c. The clutch on the core drive motor.

d. The thickness of the core shroud.
C.09 c
REF: AFRRI supplied question 3.35, also Facility Knowledge.

Question C.10 [1.0 point]
Pool level is decreasing. At what pool level below normal will the reactor scram?

a. 4 inches

b. 6 inches

c. 8 inches

d. 12 inches
C.10 b
REF: AFRRI supplied questions, also Operations Manual Chapter 6 §C.

Question C.11 [1.0 point]
Which ONE of the following describes the automatic action directly associated with a high level reactor room CAM alarm?

a. Reactor scrams.

b. Lead shield doors close.

c. Ventilation system isolation dampers close.

d. Exposure room warning horns actuate.
C.11 c
REF: AFRRI SAR, Section 3.7.4, p 3-47.
REF: AFRRI SAR, Section 4.1.4, p 4-35 and 4-36; TS Table 2, p 10.

Question C.12 [1.0 point]
Which ONE of the following conditions will initiate a reactor scram?

a. Pulse timer greater than 15 seconds in the pulse mode.

b. Reactor tank shield doors fully open.

c. Pool water level 14 feet from the top of core.

d. A 10% loss of high voltage to Safety Channels.
C.12 c
REF: AFRRI SAR, Section 4.1.4, p 4-35 and 4-36; TS Table 2, p 10.

Question C.13 [1.0 point]
Which ONE of the following describes the operation of the Core Carriage?

a. Carriage movement is provided by compressed air pressure applied to the operating piston and ram assembly.

b. To prevent carriage overtravel microswitches are provided at both ends of the carriage track as a safety measure.

c. Rate of carriage movement is controlled at three different speeds, dependant on the region of operation.

d. Movement of the core carriage is initiated from the reactor console and it takes approximately 5 minutes to completely travel the full distance.

C.13 d
REF: AFRRI SAR, Section 4.4, p 4-7.

Question C.14 [1.0 point]
In the event of a large water loss from the pool, the connection in the primary water system for an emergency fill line is located in:

a. Room 3152 near still.

b. Reactor room near pool.

c. Room 2158 near primary pump.

d. Room 3430 near heat exchanger.

C.14 c
REF: AFRRI SAR, Section 3.3.1, p 3-15; Exam Bank

Question C.15 [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.

C.15 a
REF: Standard NRC question.

Question C.16 [1.0 point]
Which ONE of the following describes the purpose for the compressed air connection to the hot liquid radioactive waste tank?

a. Enhance mixing of either the raw water added or prior to sampling.

b. Pressurization of the tank to provide the driving force for discharge.

c. Ensure that an explosive atmoshere condition inside the tank is prevented.

d. Provide positive venting to reduce the buidup concentration of radionuclides above allowable limits.
C.16 a
REF: AFRRI SAR, Section 3.4.2, p 3-25.

Question C.17 [2.0 points, $^{2}/_{5}$ each]
Match the Exposure room # components listed in column A with its primary purpose from Column B. Each item from column B should be used only once.

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

C.17 a, 2; b, 3; c, 1; d, 5; e, 4 or 1
Ref: AFRRI SAR,

Question C.18 [1.0 point]
Which ONE of the following describes the Rod Withdrawal Prevent Interlock?

a. All control rod withdrawal is prevented unless a minimum neutron level is present (10^{-3} thermal watts).

b. Withdrawal is prevented unless power level is changing with a period of less than 3 seconds as measured on the wide-range log channels.

c. All control rod withdrawal is prevented unless the inlet water temperature is greater than 60EC.

d. The transient rod motion is prevented unless reactor power level is greater than 1 kilowatt.
C.16 a
REF: AFRRI SAR, Section 3.4.2, p 3-25.

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

FACILITY: Armed Forces Radiobiology Research Institute

REACTOR TYPE: TRIGA (Pulsing)

DATE ADMINISTERED: 2005/11/15

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

$$Q = mc_p\Delta T = m\Delta H = UA\Delta T \qquad P_{max} = \frac{(\rho\beta)^2}{2\lambda_{eff}\beta} \qquad K = 1x10^{-6}\sec\theta$$

$$\lambda_{eff} = 0.1\ \text{second}^{-1} \qquad SCR = \frac{S}{1-k_e} \qquad CR_1(1-k_{eff1}) = CR_2(1-k_{eff2})$$

$$SUR = 26.06\left[\frac{\lambda_{eff}}{\rho-\beta}\right] \qquad M = \frac{1-k_{eff0}}{1-k_{eff1}} \qquad M = \frac{1}{1-k_{eff}} = \frac{CR_1}{CR_0}$$

$$P = P_0 10^{t/T} \qquad P = P_0 e^{\frac{t}{T}} \qquad P = \frac{\beta-\rho}{\beta-\rho\beta} P_0$$

$$SDM = \frac{1-k_{eff}}{k_{eff}} \qquad T = \frac{K(\rho-\beta)}{\rho\beta} \qquad T = \frac{R(\rho-\beta)}{\rho\lambda_{eff}\beta}$$

$$\Delta\rho = \frac{k_{eff2}-k_{eff1}}{k_{eff1}k_{eff2}} \qquad T_{1/2} = \frac{0.693}{\lambda} \qquad \rho = \frac{(k_{eff}-1)}{k_{eff}}$$

$$DR = DR_0 e^{-\lambda t} \qquad DR = \frac{6CiE(n)}{R^2} \qquad DR_1 t_1^2 = DR_2 t_2^2$$

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

$$\frac{(\rho-\beta)_2}{Peak_2} = \frac{(\rho-\beta)_1}{Peak_1}$$

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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/EF

1 kg = 2.21 lbm

1 Mw = 3.41 x 10^6 BTU/hr

EF = 9/5 EC + 32

EC = 5/9 (EF - 32)

c_p = 1 cal/sec/gm/EC

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

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

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

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

B.2 a b c d ___

B.3 a b c d ___

B.4a SL LCO LSSS ___

B.4b SL LCO LSSS ___

B.4c SL LCO LSSS ___

B.4d SL LCO LSSS ___

B.5a DBL N/A N/R ___

B.5b DBL N/A N/R ___

B.5c DBL N/A N/R ___

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.10a 1 2 3 4 ___

B.10b 1 2 3 4 ___

B.10c 1 2 3 4 ___

B.10d 1 2 3 4 ___

B.11a 1 2 3 ___

B.11b 1 2 3 ___

B.11c 1 2 3 ___

B.11d 1 2 3 ___

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 ___

C.1 a b c d ___

C.2 a b c d ___

C.3 a b c d ___

C.4 a b c d ___

C.5 a b c d ___

C.6 a b c d ___

C.7 a b c d ___

C.8a RWP SCRAM ___

C.8b RWP SCRAM ___

C.8c RWP SCRAM ___

C.8d RWP SCRAM ___

C.9 1 2 3 4 5 ___

C.10 a b c d ___

C.11 a b c d ___

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.17a 1 2 3 4 5 ___

C.17b 1 2 3 4 5 ___

C.17c 1 2 3 4 5 ___

C.17d 1 2 3 4 5 ___

C.18 a b c d ___