September 30, 2003

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-03-01, ARMED FORCES RADIOBIOLOGY RESEARCH INSTITUTE

Dear Mr. Miller:

During the week of August 25, 2003, 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 internet E-mail at pvd@nrc.gov.

Sincerely,

/RA/

Patrick M. Madden, Section Chief
Research and Test Reactors Section
New, Research and Test Reactors Program (RNRP)
Division of Regulatory Improvement Programs
Office of Nuclear Reactor Regulation

Docket No. 50-170

Enclosures: 1. Initial Examination Report No. 50-170/OL-03-01
2. Examination and answer key (Comments Incorporated)

cc w/encls: Please see next page

cc:

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DISTRIBUTION w/ encls.:

PUBLIC	RNRP\R&TR r/f	PMadden
PIsaac (PM)	Facility File (EBarnhill) O6-D17	

ADAMS EXAMINATION PACKAGE ACCESSION NO.: ML031970375
ADAMS EXAMINATION REPORT ACCESSION NO.: ML032671180 **TEMPLATE No.: NRR-074**

OFFICE	RNRP:CE		IROB:LA	E	RNRP:SC	E
NAME	PDoyle:rdr		EBarnhill		MADDEN	
DATE	08/ 29 /2003		09/ 26 /2003		09/ 29 /2003	

C = COVER **E = COVER & ENCLOSURE** **N = NO COPY**

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

REPORT NO.: 50-170/OL-03-01

FACILITY DOCKET NO.: 50-170

FACILITY LICENSE NO.: R-84

FACILITY: Armed Forces Radiobiology Research Institute

EXAMINATION DATES: August 27, 2003

SUBMITTED BY: ***/RA/*** 08/29/2003
Paul V. Doyle Jr., Chief Examiner Date

SUMMARY:

On August 27, 2003, the NRC administered an operator licensing examination to one Senior Reactor Operator (Instant) candidate. The candidate passed all portions of the examination.

REPORT DETAILS

1. Examiners:
   Paul Doyle, 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 Doyle, NRC, Examiner
   Stephen I. Miller, AFRRI, Facility Director

   The facility director presented the examiner with some minor typographical corrections which have been incorporated into the copy of the examination attached.

ENCLOSURE 1

Armed Forces Radiobiology Research Institute

With Answer Key

OPERATOR LICENSING EXAMINATION

August 27, 2003

Enclosure 2

QUESTION A.1 [1.0 point]
The reactor is at a power of 1 watt, with a 26 second stable period. How long will it take for power to reach 1000 watts?

a. ≈180 seconds

b. ≈153 seconds

c. ≈121 seconds

d. ≈78 seconds

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

a. 5% — from 1% to 6%

b. 15% — from 20% to 35%

c. 20% — from 40% to 60%

d. 25% — from 75% to 100%

QUESTION A.3 [1.0 point]
The difference between K_{eff} and K_{∞} is that K_{eff} is K_{∞} corrected for …

a. resonance escape probability

b. total non-leakage (fast and thermal) probabilities

c. U^{238} fast fissions

d. Pu^{239} production in the fuel

QUESTION A.4 [1.0 point]
An experimenter makes an error loading a rabbit sample. Sample injection results in a 100 millisecond period. If the scram set point is 1.25 MW 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. 1.25 MW

b. 2.5 MW

c. 3.4 MW

d. 12.5 MW

QUESTION A.5 [1.0 point]
Which ONE of the following is an example of alpha 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 fast neutron will lose the most energy by elastically colliding with which ONE of the following nuclei?

a. $_{1}H^{1}$

b. $_{1}H^{2}$

c. $_{4}Be^{8}$

d. $_{5}B^{10}$

QUESTION A.7 [1.0 point]
You enter the control room and note that all nuclear instrumentation show a steady neutron level, and no rods are in motion. Which ONE of the following conditions CANNOT be true?

a. The reactor is critical.

b. The reactor is subcritical.

c. The reactor is supercritical.

d. The neutron source has been removed from the core.

QUESTION A.8 [1.0 point]
The number of neutrons passing through a one square centimeter of target material per second is the definition of which one of the following?

a. Neutron Population (np)

b. Neutron Impact Potential (nip)

c. Neutron Flux (nv)

d. Neutron Density (nd)

QUESTION A.9 [1.0 point]
ELASTIC SCATTERING is the process by which a neutron collides with a nucleus and …

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

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

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

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

QUESTION A.10 [1.0 point]
Which ONE of the following statements concerning reactor poisons is NOT true?

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

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

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

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

QUESTION A.11 [1.0 point]
If a $1.5 pulse results in a peak power of 250 MW, (FWHM) of 100 milliseconds and fuel temperature rise of 145°C, a $2.00 pulse would result in …

	Peak Power	FWHM	Temp. Rise
a.	780 MW	80	210°C
b.	1000 MW	50	290°C
c.	1200 MW	50	350°C
d.	900 MW	80	210

QUESTION A.12 [1.0 point]
β and β_{eff} both describe the total fraction of delayed neutrons. The difference between the two is that β_{eff} is …

a. smaller than β since delayed neutrons are born at lower energy levels than prompt neutrons.

b. larger than β since delayed neutrons are born at lower energy levels than prompt neutrons.

c. smaller than β since delayed neutrons are born at higher energy levels than prompt neutrons.

d. larger than β since delayed neutrons are born at higher energy levels than prompt neutrons.

QUESTION A.13 [1.0 point]
Given the following data, which ONE of the following is the closest to the half life of the material?

TIME	***ACTIVITY***
0	2400 cps
10 min.	1757 cps
20 min.	1286 cps
30 min.	941 cps
60 min.	369 cps

a. 11 minutes

b. 22 minutes

c. 44 minutes

d. 51 minutes

QUESTION A.14 [1.0 point]
Which ONE of the following conditions will INCREASE the shutdown margin of a reactor.

a. Insertion of a positive reactivity worth experiment

b. Lowering moderator temperature (Assume negative temperature coefficient).

c. Burnout of a burnable poison.

d. Fuel depletion.

QUESTION A.15 [1.0 point]
Which one of the following statements correctly describes the property of a **GOOD MODERATOR**?

a. It slows down fast neutrons to thermal energy levels via a large number of collisions.

b. It reduces gamma radiation to thermal energy levels via a small number of collisions.

c. It slows down fast neutrons to thermal energy levels via a small number of collisions.

d. It reduces gamma radiation to thermal energy levels via a large number of collisions.

QUESTION A.16 [1.0 point]
Which ONE of the listed reactivity coefficients will be FIRST to turn reactor power following a rod withdrawal. [Assume no manual, (i.e. experiment insertion) or automatic (i.e. scram) reactivity additions.]

a. Fuel-Moderator

b. Water-Moderator

c. Void

d. Pressure

QUESTION A.17 [1.0 point]
The main source of heat in the reactor one hour after shutdown is due to …

a. Decay of fission products

b. Fission due to delayed neutrons

c. Spontaneous fission within the core

d. Decay of radioactive structural materials

QUESTION A.18 [1.0 point]
The ratio of the number of neutrons that reach thermal energy to the number of neutrons that start to slow down, is defined as the …

a. fast non-leakage probability ($\mathbb{L}_f$)

b. resonance escape probability (p)

c. reproduction factor (η)

d. thermal utilization factor (f)

QUESTION A.19 [1.0 point]
Which ONE of the following explains why the transient rod is worth approximately twice as much as the regulating rod.

a. The neutron absorbing material in the transient rod is hafnium, where as the regulating rod is boron.

b. The active (absorber filled) section of the transient rod is longer than the regulating rod.

c. The lower section of the transient rod contains a U-Rh fuel mixture where as the regulating rod contains air.

d. The transient rod is located in a region of higher flux as compared to the regulating rod.

QUESTION A.20 [1.0 point]
For U^{235}, 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

QUESTION B.1 [2.0 points, ½ each]
Identify the **PRIMARY** source (irradiation of air, irradiation of water, irradiation of structural material or fission product) of **EACH** of the radioisotopes listed.

a. $_{7}N^{16}$

b. $_{11}Na^{24}$

c. $_{18}Ar^{41}$

d. $_{54}Xe^{135}$

QUESTION B.2 [2.0 points, ½ each]
Identify whether each of the following experiments has no special requirements (NR), requires Double encapsulation (DOUBLE), or in Not Authorized (NA).

a. Corrosive Materials

b. the total inventory of Iodine (isotopes 131 through 135) is 0.5 curies

c. contains 50 milligrams of explosive material

d. possibility of release of radioactive gases and aerosols in excess of double the 10 CFR 20, Appendix B limits.

QUESTION B.3 [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. For purposes of testing and calibration, the reactor may be operated at power levels not to exceed 1.1 megawatts during the testing period.

b. Maximum temperature in a standard TRIGA fuel element shall not exceed 1000°C.

c. … for these instrumented fuel elements' temperature shall not exceed 600°C.

d. The reactor shall not be operated with the maximum available excess reactivity above cold clean critical with or without experiments in place greater than $5.00 (0.35% Δk/k) for any condition of operation.

QUESTION B.4 [1.0 point]
Which ONE of the following classifications for an emergency is not credible for the AFRRI reactor? (Note: Items are listed alphabetically, NOT in order of severity!)

a. Alert

b. Events Less Severe than the Lowest Cagetory

c. Notification of Unusual Event

d. Site Area Emergency

QUESTION B.5 [1.0 point]
An experiment irradiated in the pool reads 50mr/hr at 2 feet below the pool surface and 100 mr/hr at 1 foot below the pool surface. You decide to place the experiment at 20 feet below the surface of the pool. Based on the attenuation you noted between the 2 foot and 1 foot levels, you would expect the shielding due to 20 feet of water to reduce the dose by a factor of approximately … (Note: Ignore dose decrease due to distance.)

a. 1,000

b. 10,000

c. 100,000

d. 1,000,000

QUESTION B.6 [1.0 point]
Consider two point sources, each having the SAME curie strength. Source A's gammas have an energy of 0.5 MeV, while Source B's gammas have an energy of 1.0 MeV. Using a Geiger-Müller detector the reading from source B will be … (NOTE: Ignore detector efficiency.)

a. four times that of source A.

b. twice that of source A.

c. the same.

d. half that of source A.

QUESTION B.7 [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 minimum shutdown margin (Xenon free, with the most reactive rod in the fully withdrawn position) of $0.25 (0.175% Δk/k).

b. Operation of the reactor with a minimally detectable fuel leak.

c. Operation of the reactor with the Ventilation System out of Service. All dampers are closed.

d. Any unanticipated or uncontrolled positive change in reactivity greater than $0.50.

QUESTION B.8 [1.0 point]
Per Technical Specifications the person "ON-CALL" must be able to get to the reactor facility within …

a. 15 minutes

b. 30 minutes

c. 45 minutes

d. 60 minutes

QUESTION B.9 [1.0 point]
Which ONE of the following is the definition of a CHANNEL TEST?

a. the combination of sensor, line, interconnecting cables or lines, amplifiers, and output devices that are connected for the purpose of measuring the value of a parameter.

b. using a known signal to verify or adjust a channel to produce an output that corresponds with acceptable accuracy to known values of the parameter which the channel measures.

c. a verification of acceptable performance by observation of channel behavior.

d. the introduction of a signal into the channel for verification that It Is operable.

QUESTION B.10 [1.0 point]
An accessible area with a radiation level of 50 mR/hr should be posted as a:

a. restricted area

b. radiation area

c. high radiation area

d. very high radiation area

QUESTION B.11 [1.0 point]
An experiment is removed from the reactor with a radiation level of 10R/hr at 1 foot. The radioisotope has a half-life of 120 seconds. Approximately how long must you let the experiment decay before the radiation level has decreased by a factor of 1000?

a. 600 seconds (ten minutes)

b. 1200 seconds (twenty minutes)

c. 6000 seconds (1hour 40 minutes)

d. 12000 seconds (3 hours 20 minutes)

QUESTION B.12 [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

QUESTION B.13 [1.0 point]
According to the Emergency Plan, the title of the lowest level of staff who may authorize receipt of radiation exposures in excess of 10 CFR 20 occupational limits is the …

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.

QUESTION B.14 [1.0 point]
Which ONE of the listed materials is so hazardous to the reactor that it is NEVER allowed into the reactor room?

a. Alcohol

b. Liquid Nitrogen

c. Mercury

d. Hydrofluoric Acid

QUESTION B.15 [1.0 point]
Which ONE of the following persons is the minimum level of management who may make the decision to downgrade an emergency classification?

a. Emergency Response Team Commander

b. Emergency Command Post Commander

c. Emergency Coordinator

d. AFRRI Director

QUESTION B.16 [1.0 point]
Which ONE of the following would require a GREEN entry in the reactor operations logbook?

a. Reactor scram.

b. Fuel movement.

c. K_{excess} measurements.

d. Disconnecting an exposure room warning horn.

QUESTION C.1 [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.2 [1.0 point]
Which **ONE** of the following detectors is used primarily to measure N^{16} release to the environment?

a. NONE, N^{16} has too short a half-life to require environmental monitoring.

b. Stack Gas Monitor

c. Stack Particulate Monitor

d. Bridge Area Monitor

QUESTION C.3 (2 points, ⅔ each)]
Match the radiation detectors listed in Column "A" with its corresponding detector type from column "B".

a. Continuous Air Monitor (CAM)	1. BF_3 detector
b. Stack Gas Monitor(SGM)	2. Geiger-Mueller detector
c. Radiation Area Monitors (RAMs)	3. Scintillation detector
	4. Ion Chamber

QUESTION C.4 [1.0 point]
Which rings within the core include the chromel-alumel thermocouples?

a. A and B

b. A and C

c. B and C

d. B and D

QUESTION C.5 [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.

QUESTION C.6 [1.0 point]
What would prevent the pool from draining if a pipe joint downstream of the primary pump failed?

a. An automatic valve closes on receipt of a low pool level alarm.

b. Siphon breaks located below the normal water level.

c. The pump stops on receipt of a low pool level alarm.

d. There is no provision to prevent draining the pool.

QUESTION C.7 [2.0 points, 0.4 each]
Describe the status of each of the items listed in column A on a loss of power.

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
e. Reactor Room Dampers, E-29 & D-30	

QUESTION C.8 [1.0 point, ¼ each]
Identify each of the following as being either a SCRAM or a Rod Withdrawal Prohibit (RWP).

a. Pool Water Temperature high

b. Source Level Low

c. Console Key Removed

d. Loss of NM1000 High Voltage

QUESTION C.9 [1.0 point]
Backup power for the Reactor Security System is supplied by …

a. UPS in Room 3161

b. AFRRI Emergency Generator

c. UPS in ERT Room

d. UPS in Room 3152

QUESTION C.10 [1.0 point]
The purpose of the UV light in the purification system is to _____ in the primary water.

a. breakdown oil molecules

b. remove ionic impurities

c. remove suspended solids

d. kill biologic impurities

QUESTION C.11 [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.

QUESTION C.12 [1.0 point]
Which ONE of the following fission products are most likely to be released from the POOL following a fuel element failure?

a. Heavy Metals and argon

b. Low Z materials and uranium

c. Noble gases and Iodine

d. Transuranium elements and zirconium

QUESTION C.13 [1.0 point]
The cadmium-gadolinium (Cd-Gd) shields mounted on the pool tank projection are designed to reduce which ONE of the following types of radiation?

a. Fast Neutrons

b. Thermal Neutrons

c. Beta particles

d. Gamma radiation

QUESTION C.14 [1.0 point]
Which ONE of the following radiation monitoring devices will initiate a closure of the reactor room ventilation supply and exhaust dampers?

a. RAM R-1 Pool Surface

b. RAM R-6 On the Air Exhaust Duct

c. Primary CAM In Reactor Room

d. RAM E-3 In Prep Area

QUESTION C.15 [1.0 point]
Which **ONE** of the following is the design feature which limits Ar^{41} production in the exposure rooms?

a. Ventilation within the exposure rooms keeps the room at a low pressure thereby decreasing the amount of Argon in the air.

b. The inside of the exposure rooms is slightly pressurized with a CO_2 purge, decreasing the amount of Argon in the air.

c. The inside of the exposure rooms is slightly pressurized with an N_2 purge, decreasing the amount of Argon in the air.

d. The walls of the exposure rooms have a gadolinium-oxide paint decreasing the amount of thermal neutrons in the room, thereby decreasing the activation of Argon in the air.

QUESTION C.16 [1.0 point]
Which **ONE** of the following methods is the one actually used to reduce streaming from the Core Experiment Tube (CET)? The tube …

a. is filled with water.

b. contains a large “S” bend in it.

c. has a poly shield plug.

d. has a wooden shield plug.

QUESTION C.17 [2.0 points, 0.5 each]
Match each component of a fuel element from column A with its respective primary function in column B.

Column A	Column B
a. zirconium rod	1. moderator
b. samarium wafer	2. Burnable Poison
c. graphite plug	3. Structural integrity
d. Zirconium-Hydride	4. Reflection of Neutrons

A.1 a, $P = P_0 e^{t/T}$ ➔ ln(1000/1) = t/26sec ➔ 26sec × 6.9078 = 179.6 ≈ 180
REF: Fundamentals of Nuclear Engineering (FONE) §

A.2 a
REF: FONE §

A.3 b
REF: FONE §

A.4 c, $P = P_0 e^{t/\tau}$, P = 12.5 Mwatt × $e^{0.1/0.1}$ = 12.5 × e = 33.979.
REF: FONE §

A.5 a
REF: FONE §

A.6 a
REF: FONE §

A.7 c
REF: FONE §

A.8 c
REF: FONE §

A.9 a
REF: FONE §

A.10 c
REF: FONE §

A.11 b
REF: Peak Power is proportional to $\Delta\$_{prompt}^2$, FWHM is proportional to $1/\Delta\$_{prompt}$, and Temperature increase is proportional to $\Delta\$_{prompt}$ NOTE: $\Delta\$_{prompt} = \rho - \beta$.

A.12 b
REF: FONE §

A.13 b 1285 is close to ½ activity, so time should be close. Also, $A = A_0 e^{-\lambda t}$ so: ln (1286/2400) = -λ(20 min)
λ = -(ln(1286/2400))/20min = -0.0312 min t = ln(½)/-0.0312 = 22.19
REF: FONE §

A.14 d
REF: FONE §

A.15 c
REF: FONE §

A.16 a
REF: FONE §

A.17 a
REF: Standard NRC question

A.18 b
REF:

A.19 d
REF: Fundamentals of Nuclear Reactor Engineering, C. 3, Para. 85.(pg 76)

A.20 d *Probability = $\sigma_f/(\sigma_f + \sigma_a)$ = 582/(528 + 99) = 582/681 = 0.855*
REF: FONE §

B.1 a, water; b, structural c, air d, fission product
REF:

B.2 a, DOUBLE; b, NR; c, NA; d, NA
REF: Technical Specifications § 3.6, Limitations on Experiments

B.3 a, LCO; b, SL; c, LSSS; d, LCO
REF: Technical Specifications 2.1, 2.2, 3.1.1 and 3.1.3(a)

B.4 d
REF: Emergency Plan § 4 page 4-1.

B.5 d
REF: 2^{20} = 1,048,756 ≈ 1,000,000

B.6 c
REF: Standard NRC Health Physics Question. G-M detector is not sensitive to incident energy levels.

B.7 b
REF: Technical Specification 1.21

B.8 d
REF: Technical Specification 1.14.

B.9 d
REF: Technical Specifications §§ 1.2, 1.3, 1.4 and 1.13.

B.10 b
REF: 10CFR20.1003

B.11 b
REF: Standard NRC question 1/1000 ≈ ½10

B.12 a, 4; b, 2; c, 1; d, 3
REF: Standard NRC question

B.13 a
REF: Emergency Plan § 3.1.1, (2),(a)

B.14 c
REF: Operational Procedure 9.

B.15 b
REF: Emergency Plan § 7.0.

B.16 d
REF: AFRRI Operational Procedure 1, Step 8, p 6; OP 8,Tab A, p 2.

C.1 a
REF: Standard NRC Question

C.2 a
REF: SAR, § 3.4.1 1st ¶.

C.3 a. 2 b. 3 c. 3
REF: AFRRI supplied questions 3.77

C.4 c
REF: AFRRI supplied question (55), also Operations Manual

C.5 c
REF: AFRRI supplied question 3.35, also Facility Knowledge.

C.6 b
REF: SAR § 3.3.1

C.7 a, 3; b, 2; ~~c, 4~~; d, 3; e, 2; Part c deleted during exam (no correct answer)
REF: AFRRI Operations manual, Chapter 4, § D, Distribution System for Electrical Power, also, SAR § 4.10.2, Standard Control Rod Drives, § 4.10.4, Transient Control Rod Drive.

C.8 a, RWP; b, RWP; c, SCRAM; d, RWP
REF: Procedure 8 Tab B. (Also AFRRI supplied Question)

C.9 d
REF: Facility supplied question dealing with recent change to facility.

C.10 d
REF: New question based on examiner knowledge of facility.

C.11 c
REF: SAR , pg 4-34/36, also NRC exam administered 04/1991.

C.12 c
REF: Safety Analysis Report § 6.3.2.2,pg 6-17, also NRC exam administered 04/1991.

C.13 b
REF: Safety Analysis Report § 5.2.1, pg 5-4, also NRC exam administered 04/1991.

C.14 c
REF: Safety Analysis Report, § 3.6.2

C.15 d
REF: SAR, § 5.2.1, 3rd ¶.

C.16 b
REF: NRC examination administered, December 1999.

C.17 a, 3; b, 2; c, 4; d, 1
REF: SAR, § 4.9, p. 4-11 – 4-13.

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

FACILITY: Armed Forces Radiobiology Research Institute

REACTOR TYPE: TRIGA (Pulsing)

DATE ADMINISTERED: 2003/08/26

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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 Horsepower = 2.54 x 10^3 BTU/hr

1 BTU = 778 ft-lbf

1 gal (H_2O) ≈ 8 lbm

c_P = 1.0 BTU/hr/lbm/°F

1 kg = 2.21 lbm

1 Mw = 3.41 x 10^6 BTU/hr

°F = 9/5 °C + 32

°C = 5/9 (°F - 32)

c_p = 1 cal/sec/gm/°C

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 air water Structural Fission Product ___

B.1b air water Structural Fission Product ___

B.1c air water Structural Fission Product ___

B.1d air water Structural Fission Product ___

B.2a NR NA DOUBLE ___

B.2b NR NA DOUBLE ___

B.2c NR NA DOUBLE ___

B.2d NR NA DOUBLE ___

B.3a SL LSSS LCO ___

B.3b SL LSSS LCO ___

B.3c SL LSSS LCO ___

B.3d SL LSSS LCO ___

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.12d 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 ___

C.1 a b c d ___

C.2 a b c d ___

C.3a 1 2 3 4 ___

C.3b 1 2 3 4 ___

C.3c 1 2 3 4 ___

C.4 a b c d ___

C.5 a b c d ___

C.6 a b c d ___

C.7a a b c d ___

C.7b 1 2 3 4 ___

~~C.7c 1 2 3 4 ___~~

C.7d 1 2 3 4 ___

C.7e 1 2 3 4 ___

C.8a SCRAM RWP ___

C.8b SCRAM RWP ___

C.8c SCRAM RWP ___

C.8d SCRAM RWP ___

C.9 a b c d ___

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 ___

C.17b 1 2 3 4 ___

C.17c 1 2 3 4 ___

C.17d 1 2 3 4 ___