March 27, 2000

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-00-01

Dear Mr. Miller:

During the week of December 15, 1999, the NRC administered initial examinations to employees of your facility who had applied for a license to operate your Armed Forces Radiobiological Research Institute Reactor. The examination was conducted in accordance with NUREG-1478, "Non-Power Reactor Operator Licensing Examiner Standards," Revision 1. At the conclusion of the examination, the examination questions and preliminary findings were discussed with those members of your staff identified in the enclosed report.

In accordance with 10 CFR 2.790 of the Commission's regulations, a copy of this letter and the enclosures will be placed in the NRC Public Document Room. 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 me at (301) 415-1168.

Sincerely,

/RA/

Ledyard B. Marsh, Chief
Events Assessment, Generic Communications
and Non-Power Reactors Branch
Division of Regulatory Improvement Programs
Office of Nuclear Reactor Regulation

Docket No. 50-170

Enclosures:
1. Initial Examination Report No. 50-170/OL-00-01
2. Facility comments with NRC resolution
3. Examination and answer key (RO/SRO)

cc w/encls:
Please see next page

March 27, 2000

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Armed Forces Radiobiology
Research Institute
8901 Wisconsin Avenue
National Capitol Region
Bethesda, MD 20889-5603

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Docket No. 50-170
Enclosures: 1. Initial Examination Report
No. 50-170/OL-00-01
2. Facility comments with NRC resolution
3. Examination and answer key (RO/SRO)

cc w/encls:
Please see next page

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

County Executive
Montgomery County Government
Rockville MD 20850

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

REPORT NO.: 50-170/OL-00-01

FACILITY DOCKET NO.: 50-170

FACILITY LICENSE NO.: R-84

FACILITY: Armed Forces Radiobiological Research Institute

EXAMINATION DATES: December 15–17, 1999

EXAMINER: Paul Doyle, Chief Examiner

SUBMITTED BY: _____ _____
Paul Doyle, Chief Examiner Date

SUMMARY:

During the week of December 13, 1999 the NRC administered Operator Licensing Examinations to one Senior Reactor Operator Candidates at the AFRRI facility. One candidate took a full examination (written and operating portions) and the other was granted a waiver of the written examination, and took only the SRO upgrade portions of the operating test. Both candidates passed their respective examinations.

REPORT DETAILS

1. Examiners:
   Paul Doyle, Chief Examiner

2. Results:

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

3. Exit Meeting:
   Paul Doyle, NRC, Examiner
   Stephen Mill, AFRRI
   James Lyons, NRC Deputy Branch Chief, Events Assessment, Generic Communications and Non-Power Reactors Branch

   The NRC conducted an exit meeting on December 17, 1999. During the meeting the NRC thanked the facility staff for their support in the administration of the examinations, and discussed very minor items noted during the administration of the operating tests.

FACILITY COMMENTS ON WRITTEN EXAMINATION
ALONG WITH NRC RESOLUTION

ENCLOSURE 2

Question A.1

Facility Comment:

Fuel burnup will change the core reactivity, however, at AFRRI, we have historically experienced no burnup effects. The single greatest increase in reactivity is caused by Xenon buildup in the core. We have as much as a forty-cent decrement in reactivity after a high power run compared to less then $0.01 burnup per year due to normal operations.

Both (a) and (d) should be correct for AFRRI.

NRC Resolution:

Agree in part with comment. Most reactors perform a core excess calculation and correct this number for cold **CLEAN** critical conditions. This gives the facility an idea of fuel burnup over time. However, AFRRI technical specifications specify that core excess be measured daily, at cold, but not at **CLEAN** conditions. This gives the operator a measure of the core excess at the time for pulsing purposes. Therefore for AFRRI only the correct answer to this question is (d) NOT (a).

Question A.3

Facility Comment:

The answer key shows an incorrect answer. The correct answer is (d). This is a typo.

NRC Resolution:

Agree in full. Answer key changed.

Question A.12

Facility Comment:

The answer is correct if the test taker assumes elastic scattering. However for inelastic scattering d is correct. Please accept either a or d as correct.

NRC Resolution:

Agree in full. In addition, the NRC will rewrite the question to stipulate elastic scattering.

Question A.17

Facility Comment:

With the information given, (a), (b) or (c) could be correct.

a. From critical until about 100 KW, the power increase per unit of reactivity withdrawn is linear. With the information provided (a) could be correct.

b. If all four rod withdrawals take place in the flat part of the rod curve (b) could be correct.

c. If the rod withdrawals take place in a sub-critical configuration (c) could also be correct.

Please accept either (a), (b) or (c) as a correct answer.

NRC Resolution:

Agree in part. Because the question has more than two correct answers, per NRC policy, the question will be deleted.

Question B.6
Facility Comment:

NRC Resolution:

Question C.11
Facility Comment:
The term mode is no longer used. Mode became obsolete when the reactor console was upgraded to the digital mode now in use. This question needs to be removed from the question bank along with any others that refer to mode.

NRC Resolution:
Agree with comment. Question deleted.

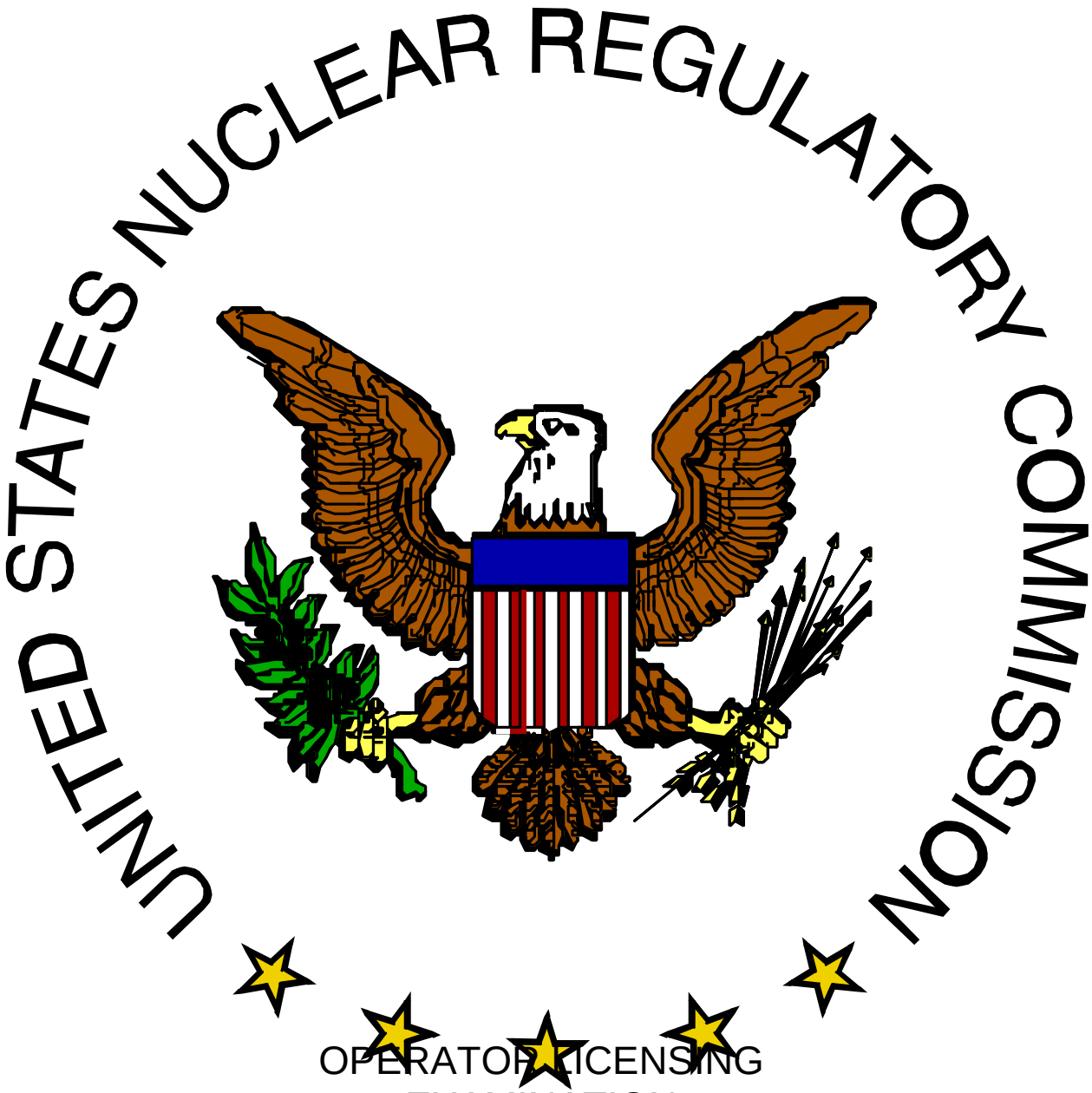
Question C.13
Facility Comment:
The term mode is no longer used. Mode became obsolete when the reactor console was upgraded to the digital mode now in use. This question needs to be removed from the question bank along with any others that refer to mode.

NRC Resolution:
Disagree with facility comment. Upon further discussion with facility staff, the NRC examiner determined that part a to this examination references equipment which is no longer in use at the facility. Therefore, this part of the examination is deleted. As to the rest, the facility re-reviewed the question and agreed that the candidate should be able to answer these with the information provided. The question has been modified to delete part a, and to change the worths of parts b, c and d from 0.25 each to 0.33 each.

Question C.16
Facility Comment:
The question needs to be worded differently because there is no fully correct answer. (C) is the most correct, but the question should be worded as follows: The core may only be moved into region 2 if the lead shield doors are fully open.

NRC Resolution:
Agree.

ARMED FORCES RADIOBIOLOGY
RESEARCH INSTITUTE REACTOR
With Answer Key



OPERATOR LICENSING
EXAMINATION
December 15, 1999

Enclosure 3

Question A.1 [1.0 point]

Core excess reactivity changes with…

a. Fuel burnup

b. Control Rod Height

c. Neutron Level

d. Reactor Power Level

Question A.2 [1.0 point]

Control Rod withdrawal predominantly changes K_{eff} by changing the …

a. fast fission factor (ε).

b. thermal utilization factor (f).

c. neutron reproduction factor (β).

d. resonance escape probability (p).

Question A.3 [1.0 point]

Reactor power increases from 30 watts to 60 watts in one minute. Reactor period is …

a. 30 seconds

b. 42 seconds

c. 60 seconds

d. 87 seconds

Question A.4 [1.0 point]

Which ONE of the following is an example of alpha decay?

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

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

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

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

Question A.5 [1.0 point]

When compared to β, β_{eff} is …

a. smaller, because delayed neutrons are born at lower energies than prompt neutrons.

b. larger, because delayed neutrons are born at lower energies than prompt neutrons.

c. smaller, because delayed neutrons are born at higher energies than prompt neutrons.

d. larger, because delayed neutrons are born at higher energies than prompt neutrons.

Question A.6 [1.0 point]

Five minutes following shutdown, reactor power is 3×10^6 counts per minute. Which ONE of the following is the count rate you would expect to see three minutes later?

a. 10^6

b. 8×10^5

c. 5×10^5

d. 3×10^5

Question A.7 [1.0 point]

The reactor is on a **CONSTANT** positive period. Which ONE of the following power changes will take the longest time to complete?

a. 5%, from 95% to 100%

b. 10%, from 80% to 90%

c. 15%, from 15% to 30%

d. 20%, from 60% to 80%

Question A.8 [1.0 point]

The reactor supervisor tells you the reactor is shutdown with a shutdown margin of 12%. An experimenter inserts an experiment in the core and nuclear instrumentation increases from 100 counts per minute to 200 counts per minute. What is the new K_{eff} of the reactor?

a. 0.920

b. 0.946

c. 0.973

d. 1.000

Question A.9 [1.0 point]

The term ***PROMPT JUMP*** refers to…

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

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

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

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

Question A.10 [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. recoils with a lower 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.11 [2.0 points, 0.5 each]

Match each of the terms in column A with the correct definition from column B.

Column A	Column B
a. Fast neutrons	1. Neutrons released directly from fission.
b. Prompt neutrons	2. High energy neutrons.
c. Slow neutrons	3. Neutrons released from decay of fission products.
d. Delayed neutrons	4. Low energy neutrons.

Question A.12 [1.0 point]

WHICH ONE of the following nuclei will cause a neutron to lose the MOST energy per collision while slowing down?

a. H^{1}

b. H^{2}

c. C^{12}

d. U^{238}

Question A.13 [1.0 point]

WHICH ONE of the following is the **MAJOR** source of energy released during fission?

a. Kinetic energy of the fission neutrons.

b. Kinetic energy of the fission fragments.

c. Decay of the fission fragments.

d. Prompt gamma rays.

Question A.14 [1.0 point]

WHICH ONE of the following describes the **MAJOR** contributions to the production and depletion of xenon in the reactor?

a. Produced from radioactive decay of iodine and depletes by neutron absorption only.

b. Produced from radioactive decay of iodine and depletes by radioactive decay and neutron absorption.

c. Produced directly from fission and depletes by neutron absorption only.

d. Produced directly from fission and depletes by radioactive decay and neutron absorption.

Question A.15 [1.0 point]

An experimenter makes an error loading a rabbit sample. Injection of the sample results in a 100 millisecond period. If the scram setpoint is 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.16 [1.0 point]

The **PRIMARY** reason that a neutron source is installed in the reactor is to …

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

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

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

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

Question A.17 [1.0 point]

You are starting up the reactor and withdraw the control rods in four equal increments. (Equal amounts of reactivity added.) Which ONE of the following statements most accurately describes the expected reactor response?

a. Power increased by the same amount for each withdrawal.

b. The control rods moved by the same amount each time.

c. The time to stabilize reactor power increased with each withdrawal.

d. A lower critical rod height would result if you increased the time interval between the withdrawals.

Question A.18 [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°C

Question A.19 [1.0 point]

By definition, an exactly critical reactor can be made prompt critical by adding positive reactivity equal to …

a. the shutdown margin

b. the K_{excess} margin

c. the β_{eff} value

d. 1.0 %βK/K.

Question B.1 [1.0 point]

Two sheets of ¼ inch thick lead shielding reduces a radiation beam from 200 mR/hr to 100 mR/hr at 1 foot. What will the radiation read at 1 foot if you add another ¼ inch thick lead sheet (for a total of 3 sheets)?

a. 71 mR/hr

b. 50 mR/hr

c. 42 mR/hr

d. 35 mR/hr

Question B.2 [2.0 points, 0.5 each]

Match the 10CFR55 requirements for maintaining an active operator license in column A with the corresponding time period from column B.

	Column A	Column B
a.	Renew License	1 year
b.	Medical Exam	2 years
c.	Pass Requalification Written Examination	4 years
d.	Pass Requalification Operating Test	6 years

Question B.3 [2.0 points, 0.5 each]

Identify each of the following actions as either a *CHANNEL* ***CHECK***, *CHANNEL* ***TEST*** or a *CHANNEL* ***CAL****IBRATION*.

a. Verifying overlap between Nuclear Instrumentation channels.

b. Replacing a Resistance Temperature Detector (RTD) with a precision resistance decade box, to verify proper channel output for a given resistance.

c. Performing a calorimetric (heat balance) calculation on the primary system, then adjusting the Nuclear Instrumentation to agree.

d. During reactor shutdown you verify the period meter reads -80 seconds.

Question B.4 [2.0 points, 0.5 each]

Match the type of radiation in column A with its associated Quality Factor (10CFR20) from column B.

	Column A	Column B
a.	alpha	1
b.	beta	2
c.	gamma	5
d.	neutron (unknown energy)	10
		20

Question B.5 [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.

Question B.6 [1.0 point]

Per Technical Specifications, if purification system water temperature exceeds 60°C, the reactor shall not be operated above a thermal power of …

a. 1 watt

b. 5 watts

c. 1 kilowatt

d. 5 kilowatts

Question B.7 [1.0 point, 0.25 each]

Identify the PRIMARY source (irradiation of air, irradiation of water, or fission product) of **EACH** of the radioisotopes listed.

a. $_{1}H^{3}$

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

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

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

Question B.8 [1.0 point]

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

Question B.9 [2.0 points, 0.4 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	

Question B.10 [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.

Question B.11 [1.0 point, 0.25 each]

Match the Federal Regulation Chapter in column A with the requirements covered.

	Column A		Column B
a.	10 CFR 20	1.	Operator Licenses
b.	10 CFR 50	2.	Operating (Facility) Licenses
c.	10 CFR 55	3.	Radiation Protection
d.	10 CFR 73	4.	Special Nuclear Material

Question B.12 [1.0 point]

Annual Maintenance was last performed on the control rods on October 31, 1998. The last date annual maintenance may be performed on the system without being late is …

a. October 31, 1999

b. December 31, 1999

c. January 31, 2000

d. April 30, 2000

Question B.13 [2.0 points, 0.5 each]

Identify each of the following as either a Safety Limit **(SL)** a Limiting Safety System Setting **(LSSS)** or a Limiting Condition for Operation **(LCO)**.

a. The maximum step insertion in the pulse mode shall be 2.8%βk/k ($4.00) in the pulse mode.

b. The reactor shall not be operated with the maximum available excess reactivity above cold critical with or without all experiments in place greater than $5.00 (3.5% βk/k).

c. The temperature of a fuel element shall not exceed 1000°C.

d. During steady-state operation a minimum of two Reactor Power Level Channels shall be operable.

Question B.14 [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)

Question B.15 [1.0 point]

The ***CURIE*** content of a radioactive source is a measure of

a. the number of radioactive atoms in the source.

b. the amount of energy emitted per unit time by the source

c. the amount of damage to soft body tissue per unit time.

d. the number of nuclear disintegrations per unit time.

Question C.1 [2.0 points, 0.5 each]

MATCH the reactor power instrumentation listed in column A with its corresponding detector type from column B. (Choices from column b may be used more than once or not at all.)

Column A	Column B
a. Multi-range Linear Channel	1. Boron Lined Uncompensated Ion Chamber
b. Wide-Range Log Channel	2. Boron Lined Compensated Ion Chamber
c. High Flux Safety Channel 1	3. Unlined Ion Chamber
d. High Flux Safety Channel 2 (Pulse Mode)	4. Fission Chamber
	5. Cerenkov Detector

Question C.2 [1.0 point]

WHICH ONE of the following components is primarily responsible for maintaining pool water pH?

a. Water Filter

b. Mixed Bed Ion Exchanger

c. Skimmer

d. Ultraviolet lamps

Question C.3 [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.4 [1.0 point]

Which ONE of the following radiation monitors alarming will cause the Reactor Room ventilation system to isolate?

a. Stack Gas Monitor (SGM)

b. Continuous Air Monitor (CAM)

c. Remoter Area Monitor (Bridge)

d. Water Box Gamma Monitor

Question C.5 [1.0 point]

WHICH ONE of the following is the purpose of the diffuser pump?

a. Increase heat transfer rate due to increased mixing within the core.

b. Decrease the activation rate of O^{16} to N^{16} due to reduced time in core.

c. Increase transport time for N^{16} to reach surface of pool.

d. Break up of O^{16} bubbles in pool, thereby decreasing production of N^{16}.

Question C.6 [1.0 point]

WHICH ONE of the following correctly describes the pressure maintained in each area, from lowest to highest.

a. Reactor Room, Reactor Control/Administration Area, Rest of building

b. Reactor Room, Rest of building, Reactor Control/Administration Area

c. Reactor Control/Administration Area, Rest of building, Reactor Room.

d. Reactor Control/Administration Area, Reactor Room, Rest of building.

Question C.7 [1.0 point]

A pipe flange fails just downstream of the primary pump. What design feature of the primary system prevents draining of the pool?

a. Signal from a float switch shuts a valve in the pump suction line.

b. Signal from a float switch shuts off the primary pump.

c. Level in the pool drops below the Net Positive Suction Head pressure minimum required to operate the pump.

d. Level in the pool drops below siphon break holes in the primary suction pipe.

Question C.8 [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.9 [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

Question C.10 [1.0 point]

Due to an interlock failure, the core is driven into region 2 with the lead shield doors closed. Which ONE of the following 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 core shroud itself.

Question C.11 [2.0 points, 0.5 each]

Identify each of the following with its associated mode I, IA, II or III. Rod = rods which receive control signals from the fission chambers. RED and BLUE pen = Information displayed by the RED and BLUE recorders respectively. Scram detectors = the nuclear detectors which supply scram signals.

	Rod	**RED Pen**	**BLUE Pen**	**Scram Detectors**
a.	REG ROD	log power	linear power	UIC (both)
b.	REG + TRANS	log power	linear power	UIC (both)
c.	NONE	Log power	linear power	UIC (both)
d.	NONE	Fuel Temp	Pulse NV or pulsing	UIC (1)

Question C.12 [1.0 point]

Which ONE of the following contaminants is most efficiently removed by the demineralizer.

a. Ar^{41}

b. I^{135}

c. mosquito larvae

d. Oil

Question C.13 [1.0 point, 0.25 each]

For each of the conditions listed below indicate whether it will cause a scram (S), or the reactor will continue to operate (O).

a. The third independent ion chamber above the core loses high voltage in MODE IA at 500 Kilowatts.

b. The wide-range log channel is placed in test while in Mode I at 100 Kilowatts.

c. The C-ring Thermocouple fails high in MODE II at 1 Megawatt.

d. A Safety channel UIC fails to 50% of actual power level while operating in MODE I at 1 Megawatt.

Question C.14 [1.0 point]

Which ONE of the listed annunciators will NOT cause an alarm at the Security Desk in hallway 3101?

a. Tank Pool Level

b. Remote Area Monitor E-3

c. Continuous Air Monitor (CAM) (Reactor Room, Primary)

d. Remote Area Monitor R-1

Question C.15 [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.16 [1.0 point]

Which ONE of the following statements concerning the operation of the fully open and fully closed limit switches on the top of the lead shield door reduction gears is true.

a. The limit switches provide indication only.

b. The control rod magnets may only be energized if the doors are fully open.

c. The core may only be moved if the doors are fully open.

d. Refuel may only be accomplished if the doors are fully closed.

Question C.17 [1.0 point]

Which ONE of the following is the reason that 9 psi air is supplied to the shield door bearings?

a. Prevents grease from escaping from the bearings and binding the door if the seals fail.

b. Prevents air leakage from the reactor tank to the outside atmosphere through the bearings.

c. Provides a lifting “cushion” to minimize bearing wear during door operation.

d. Provides a seal to minimize ingress of water into the door bearing housing if the seals fail.

Answer Key

A.1 a
REF: SAR, § 4.16.2, p. 4-33

A.2 b
REF: Fundamentals of Nuclear Reactor Engineering (FONRE), § 66.a, p. 54

A.3 b
REF: $\ln\left(\frac{P}{P_0}\right)=\frac{t}{t}\ t=\frac{60\text{sec}}{\ln(2)}=86.56$
also FONRE, p. 78, Equation 3-14

A.4 a
REF: AFRRI Triga Reactor Health Physics, Terms and Definitions, p. 3.

A.5 b
REF: FONRE, § 29.d, p. 29

A.6 d
REF: FONRE, p. 78, Equation 3-14

A.7 c
REF: Time is related to ratio of final power to initial power. 2:1 is the largest ratio. Also, FONRE, p. 78, Equation 3-14.

A.8 b
REF: $K_{eff_1}=\frac{1}{1+SDM}=\frac{1}{1+0.12}=0.892857$
$CR_1(1-K_{eff_1})=CR_2(1-K_{eff_2});$
$1-K_{eff_2}=\frac{100}{200}(1-0.892857)=(0.0535715)$
$K_{eff_2}=0.9464285$
Standard NRC Question

A.9 a
REF: FONRE, § 79.h(3), p. 68

A.10 b
REF: FONRE, § 18.e.3.a(1), p. 10

A.11 a, 2; b, 1; c, 4; d, 3
REF: FONRE, §§ 24 & 25, pp. 27 & 28

A.12 a
REF: FONRE, § 45, p. 40.

A.13 b
REF: FONRE, pp. 13 & 14, Table II

A.14 b
REF: FONRE, §§ 92.b & c, pp. 85 &86

A.15 c
REF: $P = P_0 e^{t/\beta}$, P = 1.25 Mwatt × $e^{0.1/0.1}$ = 1.25 × e = 3.3979, Also, FONRE, p. 78, Equation 3-14.

A.16 c
REF: FONRE, § 149.f, p. 137

A.17 c
REF: FONRE, § 149, p.137

A.18 b
REF: Peak Power is proportional to $\beta\$_{prompt}^2$, FWHM is proportional to $1/\beta\$_{prompt}$, and Temperature increase is proportional to $\beta\$_{prompt}$ NOTE: $\beta\$_{prompt} = \beta - \beta$.

A.19 c
REF: FONRE, § 79.b, p. 65

Answer Key

B.1 a
REF: From the stem 2 sheets equal 1 half thickness $I = I_0 (½)^{1.5} = 200 \times 0.3535 = 70.71$

B.2 a, 6; b, 2; c, 2; d, 1
REF: 10CFR55.

B.3 a, CHECK; b, TEST; c, CAL; d, CHECK
REF: T.S. DEFINITIONS

B.4 a, 20; b, 1; c, 1; d, 10
REF: 10CFR20.100x

B.5 a
REF: Emergency Plan § 3.1.1, (2),(a)

B.6 c
REF: Technical Specification 3.3.a.

B.7 a, Water; b, Air; c, Water; d, Fission
REF: Standard NRC question.

B.8 c
REF: Tech. Spec. 3.4.

B.9 a, 3; b, 3; c, 1; d, 3; e, 2
REF: Technical Specifications Table 1.

B.10 b
REF: Technical Specifications § 6.1.3.

B.11 a, 3; b, 2; c, 1; d, 4
REF: 10CFR Chapters 20, 50, 55 and 73.

B.12 c
REF: Technical Specifications § 4.1.a

B.13 a, LCO; b, LCO; c, SL; d, LCO
REF: Technical Specifications §§ 2.1, 2.1 and 2.3.

B.14 d
REF: Emergency Plan § 6.6

B.15 d
REF: Standard Health Physics Definition.

Answer Key

C.1 a, 4; b, 4; c, 1; d, 5
REF: SAR, §§ 4.11.1 through 4.11.3, pp 4-20 – 4-23.

C.2 b
REF: SAR, § 3.3.3, 1st pp. 3-12 – 3-13.

C.3 a
REF: SAR, § 3.4.1 1st ¶.

C.4 b
REF: SAR § 3.6.2, Table 3-2, pp. 3-27 – 3-29.

C.5 c
REF: SAR, § 3.3.5, pp. 3-14 – 3-15.

C.6 a
REF: SAR § 3.2.2, p. 3-6, 2nd ¶.

C.7 d
REF: SAR, § 3.3.1 1st ¶.

C.8 d
REF: SAR, § 5.2.1, 3rd ¶.

C.9 a, 3; b, 2; c, 4; d, 1
REF: SAR, § 4.9, p. 4-11 – 4-13.

C.10 c
REF: Previously administered NRC examination

C.11 a, I; b, II; c, IA; d, III
REF: Previous NRC Examination

C.12 b
REF: SAR § 3.3.3

C.13 a, S; b, O; c, S; d O
REF: Complete rewrite of facility supplied question C.6.

C.14 b
REF: SAR § 3.6, Tables 3-1 and 3-2, and § 3.3.6. 2nd ¶

C.15 b
REF: Rewrite of NRC question

C.16 c
REF: SAR §§ 4.6 and 43.13.

C.17 d
REF: SAR § 3.7.4, p. 3-48.