August 14, 2014

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

SUBJECT: EXAMINATION REPORT NO. 50-170/OL-14-01, ARMED FORCES RADIOBIOLOGY RESEARCH INSTITUTE

Dear Mr. Miller:

During the week of June 23, 2014, the U.S. Nuclear Regulatory Commission (NRC) administered operator licensing examinations at your Armed Forces Radiobiology Research Institute TRIGA Reactor. The examinations were conducted according to NUREG-1478, "Operator Licensing Examiner Standards for Research and Test Reactors," Revision 2. Examination questions and preliminary findings were discussed at the conclusion of the examination with those members of your staff identified in the enclosed report.

In accordance with Section 2.390 of Title 10 of the *Code of Federal 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 component of NRC's Agencywide Documents Access and Management System (ADAMS). ADAMS is accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html (the Public Electronic Reading Room). The NRC is forwarding the individual grades to you in a separate letter which will not be released publicly. If you have any questions concerning this examination, please contact Mr. Patrick Isaac at (301) 415-1019 or via email Patrick.Isaac@nrc.gov.

Sincerely,

/RA/

Kevin Hsueh, Chief
Research and Test Reactors Oversight Branch
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Docket No.: 50-170

Enclosures:
1. Examination Report
2. Written Examination

cc: w/o enclosures: See next page

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NAME	PIsaac	CRevelle	KHsueh
DATE	08/06/2014	08/13/2014	08/14/2014

OFFICIAL RECORD COPY

cc:

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

Montgomery County Executive
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U. S. NUCLEAR REGULATORY COMMISSION
OPERATOR LICENSING INITIAL EXAMINATION REPORT

REPORT NO.: 50-170/OL-14-01

FACILITY DOCKET NO.: 50-170

FACILITY LICENSE NO.: R-84

FACILITY: Armed Forces Radiobiology Research Institute TRIGA Reactor

EXAMINATION DATES: June 25, 2014

SUBMITTED BY: ____________________________ __________
Patrick Isaac, Chief Examiner Date

SUMMARY:

During the week of June 23, 2014, the U.S. Nuclear Regulatory Commission (NRC) administered operator licensing examination to one Senior Reactor Operator (SRO) license candidate. The candidate passed all applicable portions of the examinations.

REPORT DETAILS

1. Examiners: Patrick Isaac, Chief Examiner, NRC

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:

Patrick Isaac, Chief Examiner, NRC
Ian Gifford, Reactor Operations Supervisor

The NRC Examiner thanked the facility for their support in the administration of the examinations.

ENCLOSURE 1

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

FACILITY:	Armed Forces Radiobiology Research Institute (AFRRI)
REACTOR TYPE:	TRIGA
DATE ADMINISTERED:	June 25, 2014
CANDIDATE:	_______________________

INSTRUCTIONS TO CANDIDATE:
Answers are to be written on the Answer sheet provided. Attach all Answer sheets to the examination. Point values are indicated in parentheses for each question. A 70% in each category is required to pass the examination. Examinations will be picked up three (3) hours after the examination starts.

CATEGORY VALUE	% OF TOTAL	CANDIDATE'S SCORE	% OF CATEGORY VALUE		CATEGORY
20.00	33.3	________	_____	A.	REACTOR THEORY, THERMODYNAMICS AND FACILITY OPERATING CHARACTERISTICS
20.00	33.3	________	_____	B.	NORMAL AND EMERGENCY OPERATING PROCEDURES AND RADIOLOGICAL CONTROLS
20.00	33.3	________	_____	C.	FACILITY AND RADIATION MONITORING SYSTEMS
60.00		________ FINAL GRADE	_____ %		TOTALS

All work done on this examination is my own. I have neither given nor received aid.

____
Candidate's Signature

ENCLOSURE 2

A. RX THEORY, THERMO & FAC OP CHARS

ANSWER SHEET

Multiple Choice (Circle or X your choice)
If you change your Answer, write your selection in the blank.

A01 a b c d ___

A02 a b c d ___

A03 a b c d ___

A04 a b c d ___

A05 a b c d ___

A06 a b c d ___

A07 a b c d ___

A08 a b c d ___

A09 a b c d ___

A10 a b c d ___

A11 a b c d ___

A12 a b c d ___

A13 a b c d ___

A14 a b c d ___

A15 a b c d ___

A16 a b c d ___

A17 a b c d ___

A18 a b c d ___

A19 a b c d ___

A20 a b c d ___

(***** END OF CATEGORY A *****)

B. NORMAL/EMERG PROCEDURES & RAD CON

ANSWER SHEET

Multiple Choice (Circle or X your choice)
If you change your Answer, write your selection in the blank.

B01 a b c d ___

B02 a b c d ___

B03 a ___ b ___ c ___ d ___ (0.25 each)

B04 a b c d ___

B05 a b c d ___

B06 a b c d ___

B07 a ___ b ___ c ___ d ___ (0.25 each)

B08 a b c d ___

B09 a b c d ___

B10 a b c d ___

B11 a b c d ___

B12 a b c d ___

B13 a b c d ___

B14 a b c d ___

B15 a b c d ___

B16 a b c d ___

B17 a b c d ___

B18 a b c d ___

B19 a b c d ___

B20 a ___ b ___ c ___ d ___ (0.25 each)

(***** END OF CATEGORY B *****)

C. PLANT AND RAD MONITORING SYSTEMS

A N S W E R   S H E E T

Multiple Choice (Circle or X your choice)
If you change your Answer, write your selection in the blank.

C01 a b c d ___

C02 a b c d ___

C03 a b c d ___

C04 a b c d ___

C05 a b c d ___

C06 a b c d ___

C07 a b c d ___

C08 a ___ b ___ c ___ d ___ (0.50 each)

C09 a b c d ___

C10 a b c d ___

C11 a b c d ___

C12 a b c d ___

C13 a b c d ___

C14 a b c d ___

C15 a ___ b ___ c ___ (0.33 each)

C16 a b c d ___

C17 a b c d ___

C18 a b c d ___

C19 a b c d ___

(***** END OF CATEGORY C *****)
(********** END OF EXAMINATION **********)

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.

EQUATION SHEET

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

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

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

$$P = P_0\, e^{t/\tau}$$

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

$$\ell^* = 1\times10^{-4}\sec$$

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

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

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

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

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

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

$$M = \frac{1 - K_{eff_1}}{1 - K_{eff_2}}$$

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

$$\tau = \frac{\ell^*}{\rho - \overline{\beta}}$$

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

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

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

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

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

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

$$DR = \frac{6\,Ci\,E(n)}{R^2}$$

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

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

1 Curie = 3.7×10^{10} dis/sec

1 kg = 2.21 lbm

1 Horsepower = 2.54×10^3 BTU/hr

1 Mw = 3.41×10^6 BTU/hr

1 BTU = 778 ft-lbf

°F = 9/5 °C + 32

1 gal (H_2O) ≈ 8 lbm

°C = 5/9 (°F - 32)

c_P = 1.0 BTU/hr/lbm/°F

c_p = 1 cal/sec/gm/°C

U.S.NRC
UNITED STATES NUCLEAR REGULATORY COMMISSION
Protecting People and the Environment

Armed Forces Radiobiology Research Institute

Operator Licensing Examination

Week of June 23, 2014

QUESTION A.01 [1.0 point]
Which ONE of the following correctly describes the SIX- FACTOR FORMULA?

a. $K_\infty = K_{eff}$ * the reproduction factor

b. $K_\infty = K_{eff}$ * the total leakage probability

c. $K_{eff} = K_\infty$ * the total non-leakage probability

d. $K_{eff} = K_\infty$ * (the resonance escape probability * the reproduction factor)

QUESTION A.02 [1.0 point]
Reactor power is increasing from 100 W to 10 kW in steady state mode. Which ONE of the following best describes the values of K_{eff} and ρ during the power increment?

a. $K_{eff} = 1$ and $\rho = 0$

b. $K_{eff} = 1$ and $\rho = 1$

c. $K_{eff} > 1$ and $0 < \rho < \beta\text{-eff}$

d. $K_{eff} > 1$ and $\beta\text{-eff} < \rho < 1$

QUESTION A.03 [1.0 point]
Few minutes following a reactor scram, the reactor period has stabilized and the power level is decreasing at a **CONSTANT** rate. Given that reactor power at time $t_{constant}$ is 10 kW power, what will it be one minute later?

a. 0.2 kW

b. 4.7 kW

c. 7.5 kW

d. 21 kW

QUESTION A.04 [1.0 point]
A reactor with K_{eff} = 0.7 contributes 2000 neutrons in the first generation. How many **total neutrons** are there after the second generation?

a. 2250

b. 2600

c. 3400

d. 4800

QUESTION A.05 [1.0 point]

Reactor A has a K_{eff} of 0.1 and reactor B has a K_{eff} of 0.8. K_{eff} is increased by 0.1 for each reactor. The amount of reactivity added in reactor A is ______ in reactor B for the same increment.

a. less than

b. same

c. eight times

d. thirty-six times

QUESTION A.06 [1.0 point]
In a just critical reactor, adding $0.50 worth of reactivity in the SQUARE-WAVE MODE will cause:

a. A sudden drop in delayed neutrons

b. The reactor period to be equal to $(\beta-\rho)/\lambda\rho$

c. A number of prompt neutrons equals to a number of delayed neutrons

d. The resultant period to be a function of the prompt neutron lifetime ($T=\ell^*/\rho$)

QUESTION A.07 [1.0 point]
The following data was obtained during a reactor fuel load.

Step	No. of Elements	Detector A (count/sec)
1	0	100
2	4	120
3	8	140
4	12	200
5	15	400

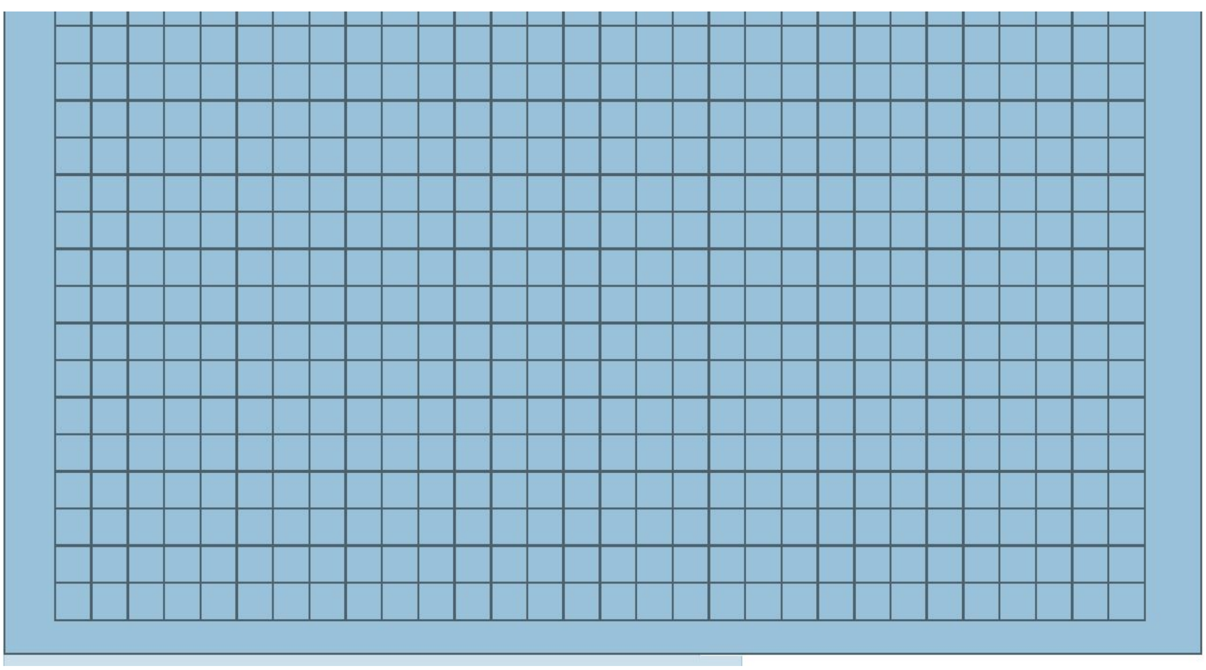
The estimated number of **additional** elements required to achieve criticality is between:

a. 2 to 3

b. 4 to 5

c. 6 to 8

d. 8 to 10



QUESTION A.08 [1.0 point]
If the mean generation time for neutrons in a reactor is 0.1 sec and k = 1.001, the time for the power to double is:

a. 9 seconds

b. 69 seconds

c. 100 seconds

d. 180 seconds

QUESTION A.09 [1.0 point]
Which ONE of the following is a number of neutrons in the tritium nucleus ($_1T^3$ or $_1H^3$)?

a. 1

b. 2

c. 3

d. 4

QUESTION A.10 [1.0 point]
You are the reactor operator performing two pulsing operations. The first pulse has a reactivity worth of **$1.20** which results in a peak power of **200 MW**. If the second pulse has a reactivity worth of **$2.00**, the corresponding peak power is:

Given:
β_{eff} =0.0070

a. 1000 MW

b. 1750 MW

c. 2500 MW

d. 5000 MW

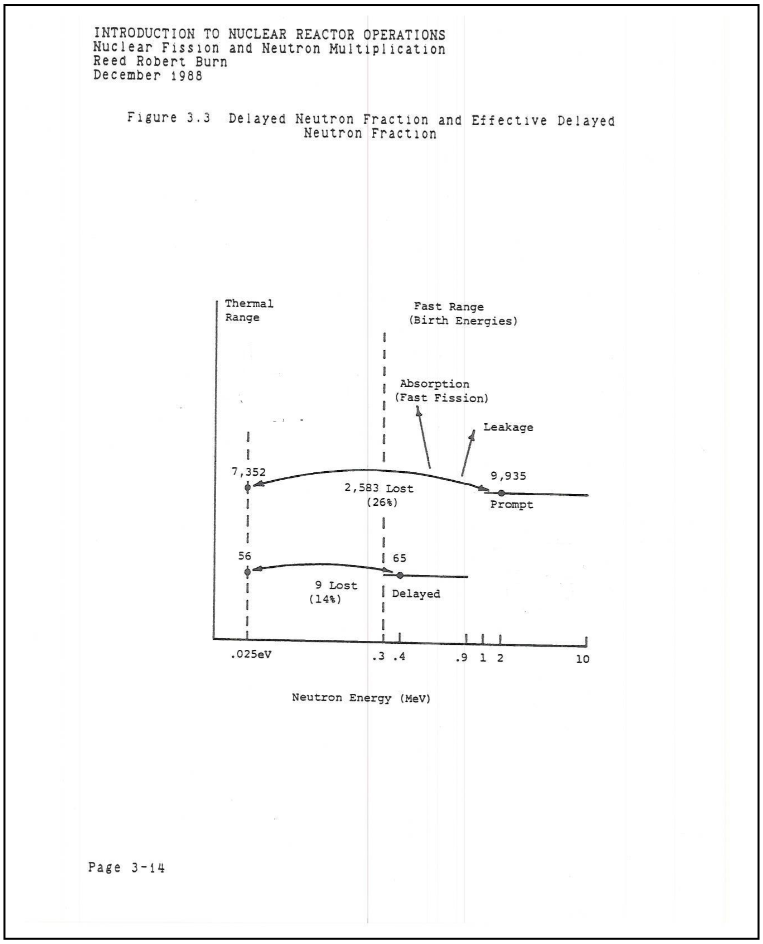
QUESTION A.11 [1.0 point]
Using Figure 3.3 attached, calculate the effective delayed neutron fraction (β-effective). At birth energies, there are 65 delayed neutrons and 9935 prompt neutrons. In the process of slowing down, there are only 56 delayed neutrons and 7352 prompt neutrons at the thermal range. The resultant β-effective of Figure 3.3 is:

a. 0.00654

b. 0.00756

c. 0.00762

d. 0.00348



QUESTION A.12 [1.0 point]
Delayed neutrons are produced by:

a. decay of N-16

b. Photoelectric Effect

c. decay of fission fragments

d. directly from the fission process

QUESTION A.13 [1.0 point]
Which ONE of the following is the MAIN reason for operating reactor with thermal neutrons instead of fast neutrons?

a. The atomic weight of thermal neutrons is larger than fast neutrons, therefore thermal neutrons slow down more easily to be captured by the fuel.

b. The neutron lifetime of thermal neutrons is longer than fast neutrons, so the fuel has enough time to capture thermal neutrons.

c. Fast neutrons give off higher radiation than thermal neutrons. Reactor needs to reduce radiation exposure by using thermal neutrons.

d. The fission cross section of the fuel is much higher for thermal neutrons than fast neutrons.

QUESTION A.14 [1.0 point]
A reactor is subcritical with K_{eff} of 0.955. Which ONE of the following is the MINIMUM reactivity (ρK/K) that must be added to produce PROMPT criticality? Given βeff=0.007

a. 0.0052

b. 0.0070

c. 0.0540

d. 0.9620

QUESTION A.15 [1.0 point]
Which ONE of the following is a fission product that has a large neutron capture cross section and plays a significant role in reactor physics?

a. B-10

b. Ar-41

c. Xe-135

d. Cs-137

QUESTION A.16 [1.0 point]
Which ONE of the following nuclides will cause a fast neutron to lose the most energy per collision?

a. H_1

b. B_{10}

c. C_{12}

d. U_{238}

QUESTION A.17 [1.0 point]
Which ONE of the following best describes the effects of moderator temperature **decrease** on neutron multiplication?

a. Fast non-leakage probability ↑; Thermal non-leakage probability ↓; Rod worth ↑

b. Fast non-leakage probability ↓; Thermal non-leakage probability ↓; Rod worth ↑

c. Fast non-leakage probability ↑; Thermal non-leakage probability ↑; Rod worth ↓

d. Fast non-leakage probability ↑; Thermal non-leakage probability ↑; Rod worth ↑

QUESTION A.18 [1.0 point]
The following graph shows the reactor time behavior following a reactor scram. Which ONE of the following best describes the transition of power between point A and B after the initial insertion? .

a. An **immediate** decrease in the **prompt neutron fraction** due to leakage, absorption, and a reduction in the fission rate

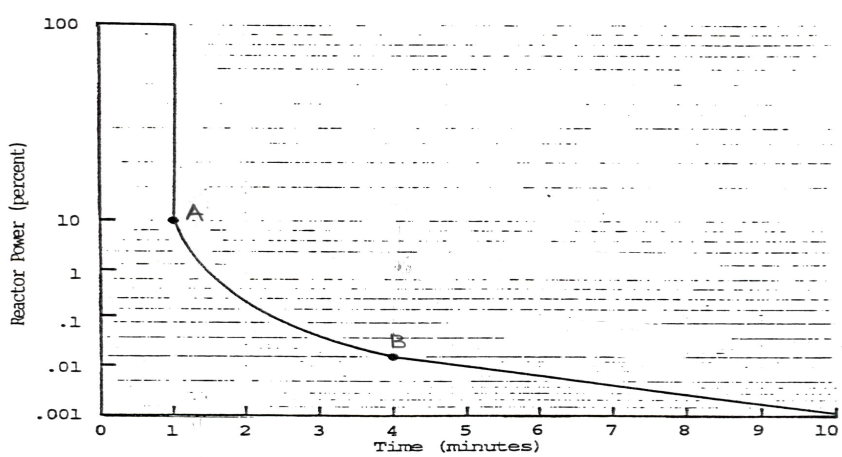
b. Fission product gases such as xenon begin to buildup causing the expansion of fuel density

c. The **longest** lived delayed neutron precursor begins to effect

d. The **short** lived delayed neutron precursors begin to effect

INTRODUCTION TO NUCLEAR REACTOR OPERATIONS
Reactor Kinetics
Reed Robert Burn
December 1988

Figure 4.3 Reactor Time Behavior Following a Reactor Scram



QUESTION A.19 [1.0 point]
Which ONE of the following physical characteristics of the TRIGA fuel is the main contributor for the prompt negative temperature coefficient?

a. As the fuel heats up the resonance absorption peaks broaden and increases the likelihood of neutron absorption in U-238

b. As the fuel heats up a rapid increase in moderator temperature occurs through conduction and convection heat transfer mechanisms which adds negative reactivity

c. As the fuel heats up fission product poisons (e.g., Xe) increase in concentration within the fuel matrix and add negative reactivity via neutron absorption

d. As the fuel heats up the oscillating hydrogen in the ZrH lattice imparts energy to a thermal neutron, thereby increasing its mean free path and probability of escape

QUESTION A.20 [1.0 point]
The effective target area in cm^2 presented by a single nucleus to an incident neutron beam is defined as:

a. a macroscopic cross section

b. a microscopic cross section

c. a mean free path

d. a neutron flux

***************** End of Section A *****************

QUESTION B.01 [1.0 point, 0.25 each]
Per AFRRI Emergency Classification, receiving an official report of a severe natural phenomenon on site causing damage to the reactor facility is an example of:

a. Normal Operations

b. Events Less Severe than the Lowest Category

c. Notification of Unusual Events

d. Alert

QUESTION B.02 [1.0 point]
The radiation from an unshielded source is 1 rem/hr. When you insert 60 mm thickness of lead sheet, the radiation level is reduced to 250 mrem/hr. What is the half-value-layer of lead? (HVL: thickness of lead required so that the original intensity will be reduced by half)?

a. 10 mm

b. 20 mm

c. 30 mm

d. 40 mm

QUESTION B.03 [1.0 point, 0.25 each]
Match each one of the Technical Specification Limits in column A with its corresponding value in column B. (Each limit has only one answer, values in Column B can be used once, more than once or not at all.)

Column A	Column B (limit shall not exceed)
a. Maximum excess reactivity	1. $0.25
b. Sum of all experiments	2. $0.50
c. Minimum Shutdown Margin	3. $2.00
d. Maximum Step Insertion	4. $3.00
	5. $4.00
	6. $5.00

QUESTION B.04 [1.0 point]
Which ONE of the following conditions is NOT a violation of a Limiting Condition for Operations?

a. Reactor operator conducted a pulse. The peak power reached 2500 MW

b. Reactor was at full power. The pumps failed, causing the primary coolant temperature reached 65 °C

c. The minimum shutdown margin was found to be $0.25 in the reference core condition

d. Area Radiation Monitor Exposure Room 1 was NOT operable during reactor operation

QUESTION B.05 [1.0 point]
You are a radiation worker. Which one of the following is your annual limit to the **skin** of the whole body?

a. the deep-dose equivalent of 5 Rems

b. the shallow-dose equivalent of 50 Rems

c. the committed-dose equivalent of 50 Rems

d. the sum of deep-dose equivalent and the committed-dose equivalent of 50 Rems

QUESTION B.06 [1.0 point]
A radioactive source reads 2 Rem/hr on contact. Five hours later, the same source reads 1.0 Rem/hr. How long will it take for the source to decay from a reading of 2 Rem/hr to 20 mRem/hr?

a. 8 hours

b. 16 hours

c. 33 hours

d. 41 hours

QUESTION B.07 [1.0 point]
Match each logbook entry in column A with its corresponding color in column B. (Value in Column B can be used once, more than once or not at all.)

Column A	Column B
a. Close the Pb shield doors	1. Green
b. Move core from 250 to 500 position	2. Red
c. Turn Stack Gas Monitor pump OFF for maintenance	3. Black
d. Load sample to CET	4. Orange

QUESTION B.08 [1.0 point]
Assume an individual has received whole body occupational exposures of:

- 25 mrads of gamma
- 2 mrads of alpha
- 1 mrads of neutrons with **unknown** energy

What would be the cumulative dose equivalent (H_T) in **mrem** for this individual?

a. 28 mrem

b. 55 mrem

c. 66 mrem

d. 75 mrem

QUESTION B.09 [1.0 point]
An example of Byproduct Material would be _____________.

a. Ar-41

b. U-235

c. U-236

d. Pu-239

QUESTION B.10 [1 point]
Which ONE of the following is the **MINIMUM** staffing requirement when the reactor is NOT secured?

a. 1 Reactor Facility Director in the control room + 1 HP on call

b. 1 RO in the control room + 1 staff member + 1 RO on call + 1 HP on call

c. 1 RO in the control room +1 staff member + 1 SRO on call + 1 HP on call

d. 1 SRO in the control room + 1 Reactor Supervisor on call + 1 HP in the control room

QUESTION B.11 [1.0 point]
Reactor is at full power. Half-way through a 6-hour operation, you discover that the ventilation fans are OFF with dampers OPEN. Which ONE of the following actions should you take?

a. Immediately secure reactor operations. This event is a Technical Specification (TS) violation

b. Immediately secure reactor. This event is NOT a TS violation because the dampers are still in opening positions

c. Continue with reactor operation. Up to 48 hours is allowed to run reactor before repairing the fans

d. Continue with reactor operations. The AFRRI Technical Specifications requires the ventilation fans turn OFF during full power.

QUESTION B.12 [1.0 point]
Each fuel experiment shall be limited such that the total radioactivity inventory of iodine isotopes 131 through 135 is no greater than ______.

a. 130 millicuries

b. 300 millicuries

c. 1300 millicuries

d. 3000 millicuries

QUESTION B.13 [1.0 point]
Which ONE of the following requires NRC approval for changes?

a. Revise the Administrative Procedure A3 - Facility Modification

b. Revise the requalification operator licensing examination

c. Delete Operational Procedure 2 – Reactor Staff Training

d. Change the Reactor Operations Supervisor's years of nuclear experience from 3 years to 1 year described in TS 6.1.3

QUESTION B.14 [1.0 point]
You, as a **Reactor Operator,** is performing a fuel element inspection. In measuring the lateral bend, you find the bend of one fuel element exceeds the original bend by 0.10 inches. For this measurement, you will:

a. continue the fuel inspection because this bend is within TS limit

b. continue the fuel inspection because the Technical Specifications require the elongation measurement only

c. stop the fuel inspection; you immediately report the result to the supervisor because it is considered a damaged fuel element

d stop the fuel inspection, you immediately report the result to the U.S. NRC since it is a reportable occurrence

QUESTION B.15 [1.0 point]
Exposing a 2 mCi check source to the continuous air monitor (CAM) detector to verify whether it is operable is considered to be ________________________.

a. a channel calibration

b. a channel check

c. a channel test

d. a channel validation

QUESTION B.16 [1.0 point]
Which ONE of the following modifications would be considered a “50.59” for which the AFRRI Reactor Facility must file a request to NRC for change? The facility plans to:

a. Replace an identical NPP-1000

b. Measure a control rod worth with new method

c. Replace a fission chamber with a compensated ion chamber for the Linear Channel

d. Perform a reactor power calibration with the new resistance temperature detector (RTD) probe

QUESTION B.17 [1.0 point]
A significant loss of water occurs in the reactor pool due to a rupture of the pool wall. Which ONE of the following is most likely the greatest concern as a result of this event?

a. Zirconium-Hydrides interact with oxygen in air, releasing explosive hydrogen gas due to TRIGA fuel overheat

b. Fission products release due to cladding rupture

c. Groundwater contamination to the surrounding water table

d. Increased personnel exposure to higher amounts of radiation

QUESTION B.18 [1.0 point]
You plan to perform a 200 kW in Square Wave Mode (Critical). The worth of the desired insertion for the Transient rod will be _______.

a. $1.00

b. $0.85

c. $0.75

d. $0.60

QUESTION B.19 [1.0 point]
"The reactor room shall contain a minimum free volume of 22,000 cubic feet." This is an example of

a. Design Features

b. Surveillance Requirements

c. Limiting Conditions for Operation (LCO)

d. Limiting Safety System Setting (LSSS)

QUESTION B.20 [1.0 point]
In the event of a suspected fuel leak, which ONE of the following nuclides would most likely be found in the Continuous Air Monitor?

a. Ar-41

b. Kr-85

c. Cs-131

d. Co-60

****************************** End of Section B ********************************

QUESTION C.01 [1.0 point]
Reactor is at 200 kW with the Pb doors fully closed. You accidentally press the Pb-door OPEN switch. Which ONE of the following is an expected reactor system response?

a. Reactor is still in power and the Pb doors start opening

b. Reactor is still in power, but you cannot withdraw the control rods

c. Reactor automatically scrams and the PB doors start opening

d. Reactor automatically scrams and the PB doors stay in fully closed position

QUESTION C.02 [1.0 point]
The MAIN purpose of a 1 foot thick wood lining in both exposure rooms is to:

a. increase the neutron flux for experiments

b. reduce the effects of secondary gamma radiation by minimizing fast neutron activation of the concrete biological shield

c. reduce the amount of Ar-41 produced in the exposure rooms due to neutron activation of Ar-40

d. increase a lifetime of the concrete biological shield by minimizing thermal neutron activation of the concrete materials

QUESTION C.03 [1.0 point]
A purpose of the interlock to prevent withdrawal of more than one control rod at a time is to prevent:

a. inadvertently large reactivity insertion

b. damage of control rod drive system

c. initiation of a pulse while on a positive period

d. increase of prompt neutrons when the reactor is in Square Wave mode

QUESTION C.04 [1.0 point]
An irradiated fuel element is NOT to be removed unshielded from the pool with a power history greater than ____, in the previous ____ from the reactor pool.

a. 10 KW / 1 month

b. 1 KW / 2 weeks

c. 5 KW / 1 weeks

d. 0.1 KW / 2 days

QUESTION C.05 [1.0 point]
The Transient Rod Air Pressure is normally set between:

a. 73 – 77 psig

b. 78 – 82 psig

c. 83 – 87 psig

d. 88 – 92 psig

QUESTION C.06 [1.0 point]
The Safe Rod is located in core position:

a. D-1

b. D-7

c. D-13

d. E-1

QUESTION C.07 [1.0 point]
The source interlock system will prevent rod withdrawal unless source level is above a preset level. This source interlock signal comes from:

a. NPP-1000

b. NP-1000

c. NM-1000

d. Action Pack, AP-1000

QUESTION C.08 [2.0 point, 0.5 each]
Reactor is in operation. Match the input signals listed in column A with their AUTOMATIC responses listed in column B. (Items in column B may be used more than once or not at all.)

Column A	Column B
a. Loss of NPP-1000 High Voltage	1. Normal Operation
b. Low pool level = 8 in.	2. Alarm ONLY
c. Radiation Area Monitor R-1 alarm	3. Interlock
d. Perform pulse at 2 kW	4. Scram

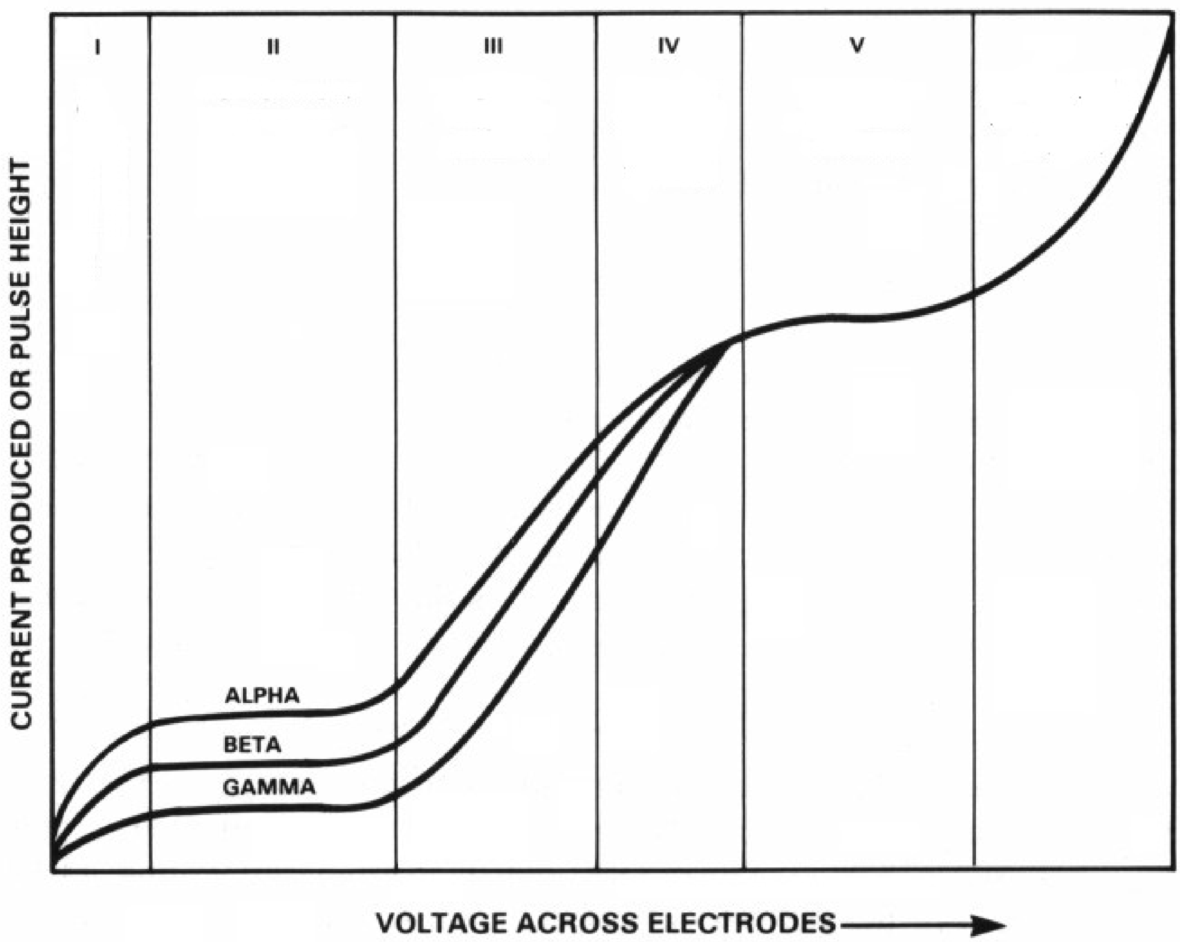
QUESTION C.09 [1.0 point]
Attached is the gas-filled detector curve. Which ONE of the following is the Geiger Mueller region?

a. Region II

b. Region III

c. Region IV

d. Region V



Effect of voltage on a gas-filled detector.

QUESTION C.10 [1.0 point]
The MAIN purpose of the dashpot installed at the bottom of the barrel of a control rod is to:

a. prevent structure damage to the barrel

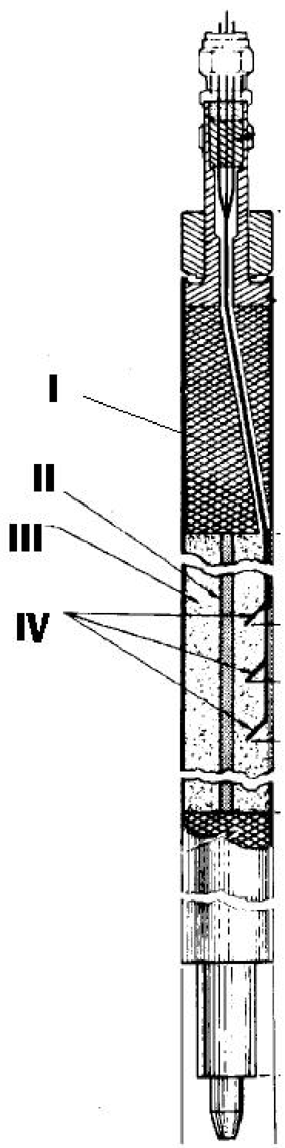
b. reduce bottoming impact during a scram

c. increase the rod scram time for the rod drop test

d. Increase the rod speed during an initial withdrawal

QUESTION C.11 [1.0 point]
Using the diagram of an instrumented fuel element, select the appropriate materials associated with its locator.

Column A	Column B
I	A. Zirconium Hydride-Uranium
II	B. Stainless steel
III	C. Erbium Burnable Poison
IV	D. Graphite Reflector
	E. Zirconium Rod
	F. Spacer
	G. Thermocouples



a. I.A, II.E, III.C, IV.G

b. I.D, II.G, III.A, IV.F

c. I.D, II.E, III.A, IV.G

d. I.C, II.A, III.B, IV.G

QUESTION C.12 [1.0 point]
After the performance of a Thermal Power Calibration, the Safety Channel # 2 indicates only 95 % of actual power. To complete the calibration, you should:

a. raise the NP-1000 detector position to increase channel indication

b. lower the NP-1000 detector position to increase channel indication

c. lower the NPP-1000 detector to increase channel indication

d. No adjustment of detector is required because the actual power and indicated power are within 5% of each other

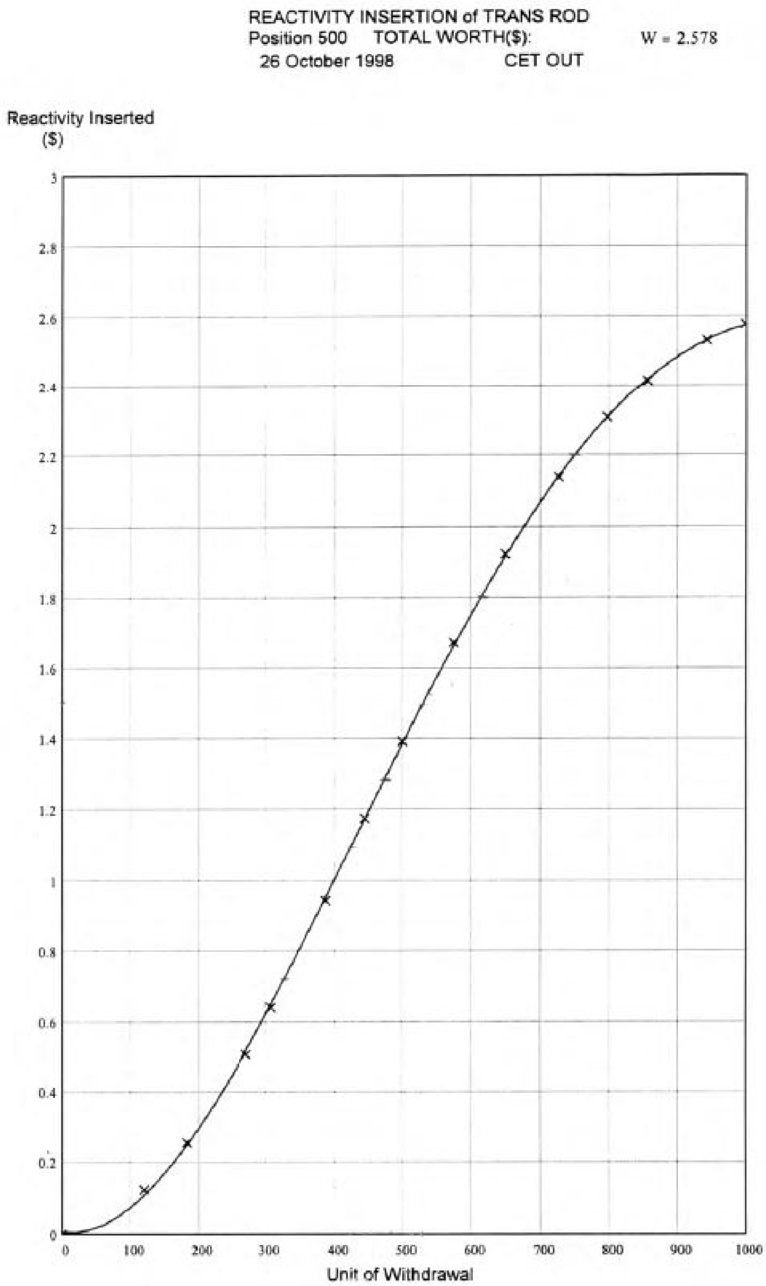
QUESTION C.13 [1.0 point]
You plan to perform a $1.50 **subcritical** pulse. Using the Transient Rod worth curve provided, find the initial transient rod position when you bring the reactor to **cold critical**. The Transient rod will be brought to:

a. fully down position

b. fully up position

c. between 425 – 435 position

d. between 520 – 530 position


REACTIVITY INSERTION of TRANS ROD
Position 500 TOTAL WORTH($):
W = 2.578
26 October 1998
CET OUT
Reactivity Inserted
($)
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
600
700
800
900
1000
Unit of Withdrawal

QUESTION C.14 [1.0 point]
During the annual calibration, you perform a pulsing operation to collect the reading on the peak power channel (nv) and integrated power-time channel (nvt). The nv channel information comes from the _______ and the nvt channel information comes from the _________.

a. NPP 1000 channel, NM 1000 channel

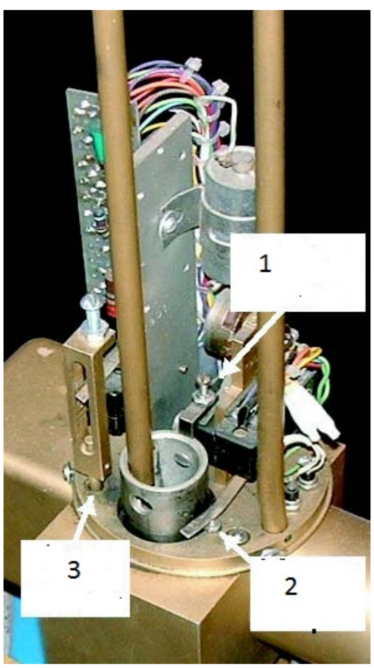
b. NM 1000 channel, NPP 1000 channel

c. NPP 1000 channel, NP 1000 channel

d. NPP 1000 channel; NPP 1000 channel

QUESTION C.15 [1.0 point, 1/3 each]
Use the following diagram of the control rod. Match the three limit switches listed in Column A to the appropriate labels in Column B?

Column A	Column B
a. Magnet Down	1
b. Rod Down	2
c. Magnet Up	3



QUESTION C.16 [1.0 point]
During reactor operation, a leak develops in the SECONDARY to PRIMARY heat exchanger. Which ONE of the following correctly explains how reactor pool level will be affected?

a. Pool level will increase because the Primary pressure is HIGHER than the Secondary pressure

b. Pool Level will increase because the Primary pressure is LOWER than the Secondary pressure

c. Pool Level will be the same because the Primary pressure is EQUAL to the Secondary pressure

d. Pool Level will decrease because the Primary pressure is LOWER than Secondary pressure

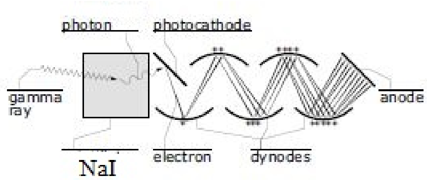
QUESTION C.17 [1.0 point]
The figure attached is a basic design of :

a. Thermoluminescent Dosimeter (TLD)

b. Film badge

c. Pocket ionization chamber

d. Scintillation detector



QUESTION C.18 [1.0 point]
Which ONE of the statements below describes the operation of the solenoid valve of the Transient rod air system? The Transient rod air system is consisted of:

a. Three ways solenoid. When the solenoid valve is **energized**, the vent (exhaust) port is closed, the supply port is opened and the actual port (to the cylinder) is opened. Air from the accumulator is continuously supplied to the pneumatic cylinder of the Transient rod.

b. Two ways solenoid. When the solenoid valve **energized**, the supply port opened and the actual port to the cylinder opened. Air from the accumulator is continuously supplied to the pneumatic cylinder of the Transient rod.

c. Three ways solenoid. When the solenoid valve is **de-energized**, the vent (exhaust) port is closed, the supply port is closed and the actual port (to the cylinder) is opened. Air from the accumulator is continuously supplied to the pneumatic cylinder of the Transient rod.

d. Two ways solenoid. When the solenoid valve **de-energized**; the actual port (to the cylinder) is closed. Air flows from pneumatic cylinder back to the accumulator.

QUESTION C.19 [1.0 point]
Which ONE of the following best describes how to calculate the activity worth of experimental materials?

a. Calculate the radioactive decay of the experimental materials

b. Measure the density and mass of the experimental materials

c. Calculate the difference between K-excess with and without the experimental materials

d. Calculate the difference REG rod position between 5 KW with and without the experimental material, and then determine the worth

******************* End of Section C ****************************
******************* End of the Exam ***************************

A.01
Answer: c
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Sec 3.3

A.02
Answer: c
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Sec 4.2

A.03
Answer: b
Reference: $P = P_0\, e^{-t/T}$ = 10 kW | $e^{(60sec/-80sec)}$ = 10 kW * $e^{-0.75}$ = 0.472 | 10 kW = 4.7 kW

A.04
Answer: c
Reference:Burn, R., Introduction to Nuclear Reactor Operations, © 1982, § 5.3, p. 5.6
2-nd generation=n + K*n=2000+1400=3400 neutrons

A.05
Answer: d
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1982, Sec 3.3.3, page 3-21.
$\Delta\rho$ reactor A = ($Keff_1$-$Keff_2$)/($Keff_1$*$Keff_2$). (0.2-0.1)/(0.2*0.1) = 5 Δk/k
$\Delta\rho$ reactor B = ($Keff_1$-$Keff_2$)/($Keff_1$*$Keff_2$). (0.9-0.8)/(0.9*0.8) = 0.139 Δk/k
5/0.139 = 36

A.06
Answer b
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, Sec 4.6, page 4-17

A.07
Answer: a
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1982, Sec 5.5, page 5-18-5-25.

A.08
Answer: b
Reference: Period T = l*/ρ
ρ = k-1/k = 0.001
T = 0.1 /0.001 = 100
$N = N_o e^{t/T}$
$2 = e^{t/100}$ → 0.693 = t/100 → t = 69.3 seconds

A.09
Answer: b
Reference: Nuclides and Isotopes
N = A – Z 3-1 = 2

A.10
Answer: d

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

ρ =ρ($)*β; ρ1=$1.20*0.007= 0.0084 Δk/k
ρ2=$2.0*0.007= 0.014 Δk/k
Peak2 = Peak1*(0.014-.007/.0084-.007)^2 = 5000 MW
Or
Peak2 = Peak1*($2-$1 / $1.2-$1)^2 = 5000 MW

A.11
Answer: b
Reference: β-effective =56/(56+7352) =0.00756
Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Figure 3.3

A.12
Answer: c
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1982, Sec 3.2.

A.13
Answer: d
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1982, Figure 2.6, page 2-39

A.14
Answer: c
Reference: from k=0.955 to criticality (k=1), ρρ = (k-1)/k = -0.047 ρk/k or ρρ = 0.047 ρk/k needed to reach criticality. From criticality to JUST prompt, ρk/k = βeff required, so minimum reactivity added to produce prompt criticality will be: 0.047+0.007= 0.054

A.15
Answer c
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, Sec 8.1

A.16
Answer: a
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Sec 2.4.5

A.17
Answer: c
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Sec 3.3.2

A.18
Answer: d
Reference: Burn, R., Introduction to Nuclear Reactor Operations, ©4.5, 1988

A.19
Answer: d
Reference: TRIGA Fuel Design

A.20
Answer: b
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, Section 8.2

B.01
Answer: d
Reference: Emergency Plan, Table 4-1

B.02
Answer: c
Reference: $DR = DR_{\circ} * e^{-\mu X}$
Find μ : $250 = 1000 * e^{-\mu * 60}$; μ = 0.0231
If insertion of an HVL (thickness of lead), the original intensity will be reduced by half.
Find X: $1 = 2 * e^{-0.0231 * X}$; X= 30 mm
Find HVL by shortcut:
1000mR- 500 mR is the 1^{st} HVL
500 mR – 250 mR is the 2^{nd} HVL
So HVL=60mm/2 = 30 mm

B.03
Answer: a(6) b(4) c(2) d(5)
Reference: TS 3.1 and 3.6

B.04
Answer: a
Reference: TS 3.1, 3.2 and 3.5

B.05
Answer: b
Reference: 10 CFR 20 (the committed-dose equivalent and the deep-dose equivalent used for individual organ)

B.06
Answer: c
Reference: $DR = DR_{\circ} * e^{-\lambda t}$
1 rem/hr =2 rem/hr* $e^{-\lambda(5hr)}$
Ln(1.0/2) = -λ*5 --> λ=0.1386; solve for t: Ln(.02/2)=-0.1386 (t) → t=33 hours

B.07
Answer: a(3) b(3) c(1) d(2)
Reference: Operational Procedure 8, TAB A

B.08
Answer: d

Qualify factor(Q) - adjusts absorbed dose to dose equivalent
- Q = 1 for x, gamma or beta
- Q = 20 for alphas and other heavy particles
- Q = 10 for neutrons of unknown energy; table 1004(b).2. is for known energies
- Q = 10 for high-energy protons

Reference: 10 CFR 20

B.09
Answer: a
Reference: 10 CFR 20 “Definitions”

B.10
Answer: c
Reference: TS 6.1.3

B.11
Answer: a
Reference: TS 3.4

B.12
Answer: c
Reference: TS 3.6

B.13
Answer: d
Reference: TS 6.1.3.1 and 10 CFR 50.59

B.14
Answer: c
Reference: TS 5.2.2

B.15
Answer: c
Reference: TS, Definitions

B.16
Answer: c
Reference: Administrative Procedure A3 and 10 CFR 50.59

B.17
Answer: d
Reference: SAR 6.3.3

B.18
Answer: c
Reference: Operational Procedure 8, Tab F2

B.19
Answer: a
Reference: TS 5.1

B.20
Answer: b
Reference: SAR 6.3.2.2
Cs-131 is NOT a correct answer since Cs is not “gas” (cannot be detected by CAM)

C.01
Answer: c
Reference: SAR 4.3

C.02
Answer: b
Reference: SAR 5.2

C.03
Answer: a
Reference: TS 3.2.2

C.04
Answer: b
Reference: SOP 7

C.05
Answer: b
Reference: SOP 8, TAB B

C.06
Answer: b
Reference: SAR 4.10

C.07
Answer: c
Reference: SAR 4.11

C.08
Answer: a(4) b(4) c(2) d(3)
Reference: SAR 3.3 and TS 3.2

C.09
Answer: d
Reference: Bevelacqua, J. Basic Health Physics

C.10
Answer: b
Reference: SAR 4.2.2

C.11
Answer: c
Reference: Triga Fuel Element

C.12
Answer: c
Reference: Information during site visit

C.13
Answer: c
Reference: SOP 8, TAB G2

C.14
Answer: d
Reference: SAR 4.11.3

C.15
Answer: a(1) b(3) c(2)
Reference: SAR 4.10.2

C.16
Answer: b
Reference: SAR 3.3

C.17
Answer: d
Reference: Basic knowledge of radiation detector

C.18
Answer: a or b
Reference: SAR 4.10.4

C.19
Answer: c
Reference: SOP 1
“d” cannot a correct answer because you cannot conduct experiment with power (above 1 KW) without knowing the reactivity worth