Dr. Kenan Unlu, Director
Radiation Science and Engineering Center
Breazeale Nuclear Reactor Building
Pennsylvania State University
University Park, PA 16802-2301

SUBJECT: EXAMINATION REPORT NO. 50-005/OL-12-01, PENNSYLVANIA STATE UNIVERSITY

Dear Dr. Unlu:

During the week of September 24, 2012, the NRC administered an operator licensing examination at your Breazeale Nuclear Reactor. The examination was conducted according to NUREG-1478, "Operator Licensing Examiner Standards for Research and Test Reactors," Revision 2. 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 Title 10 of the Code of Federal Regulations Section 2.390, a copy of this letter and the enclosures will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records (PARS) component of NRC's Agencywide Documents Access and Management System (ADAMS). ADAMS is accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html. The NRC is forwarding the individual grades to you in a separate letter which will not be released publicly. Should you have any questions concerning this examination, please contact Mr. Patrick J. Isaac at (301) 415-1019 or via internet e-mail patrick.isaac@nrc.gov.

Sincerely,

Greg Bowman, Chief
Research and Test Reactors Oversight
Branch

Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Docket No. 50-005

Enclosures: 1. Examination Report No. 50-005/OL-12-01
2. Facility Comments on the Written examination with NRC Resolution
3. Written Examination

cc w/o enclosures: See next page

Dr. Kenan Unlu, Director
Radiation Science and Engineering Center
Breazeale Nuclear Reactor Building
Pennsylvania State University
University Park, PA 16802-2301

October 31, 2012

SUBJECT: EXAMINATION REPORT NO. 50-005/OL-12-01, PENNSYLVANIA STATE UNIVERSITY

Dear Dr. Unlu:

During the week of September 24, 2012, the NRC administered an operator licensing examination at your Breazeale Nuclear Reactor. The examination was conducted according to NUREG-1478, "Operator Licensing Examiner Standards for Research and Test Reactors," Revision 2. 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 Title 10 of the Code of Federal Regulations Section 2.390, a copy of this letter and the enclosures will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records (PARS) component of NRC's Agencywide Documents Access and Management System (ADAMS). ADAMS is accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html. The NRC is forwarding the individual grades to you in a separate letter which will not be released publicly. Should you have any questions concerning this examination, please contact Mr. Patrick J. Isaac at (301) 415-1019 or via internet e-mail patrick.isaac@nrc.gov.

Sincerely,

/RA/

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

Docket No. 50-005
Enclosures: 1. Examination Report No. 50-005/OL-12-01
2. Facility Comments on the Written examination with NRC Resolution
3. Written Examination
cc: Mr. Mark Trump, Pennsylvania State University
cc w/o enclosures: See next page
<u>DISTRIBUTION</u> w/ encls.:
PUBLIC PROB r/f Facility File CRevelle (O-7 G-13)

ADAMS ACCESSION #: ML12305A394 **TEMPLATE #:NRR-074**

OFFICE	PROB:CE		IOLB:LA		PROB:BC	
NAME	PIsaac		CRevelle		GBowman	
DATE	10/31 /2012		1031 /2012		10/31/2012	

OFFICIAL RECORD COPY

cc:

Mr. Eric J. Boeldt, Manager of
Radiation Protection
The Pennsylvania State University
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University Park, PA 16802-1504

Dr. Henry C. “Hank” Foley
Vice President for Research &
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Director, Bureau of Radiation Protection
Department of Environmental Protection
P.O. Box 8469
Harrisburg, PA 17105-8469

Test, Research, and Training
Reactor Newsletter
University of Florida
202 Nuclear Sciences Center
Gainesville, FL 32611

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

REPORT NO.: 50-005/OL-12-01

FACILITY DOCKET NO.: 50-005

FACILITY LICENSE NO.: R-2

FACILITY: Pennsylvania State University Breazeale Nuclear Reactor

EXAMINATION DATES: September 24 - 26, 2012

SUBMITTED BY: /RA/ 10/26/2012
Patrick J. Isaac Jr., Chief Examiner Date

SUMMARY:

During the week of September 24, 2012, the NRC administered operator licensing examinations to one Senior Reactor Operator and two Reactor Operator candidates. The candidates passed all portions of the administered examinations.

REPORT DETAILS

1. Examiners: Patrick J. Isaac Jr., Chief Examiner, NRC

2. Results:

	RO PASS/FAIL	SRO PASS/FAIL	TOTAL PASS/FAIL
Written	2/0	N/A	2/0
Operating Tests	2/0	1/0	3/0
Overall	2/0	1/0	3/0

3. Exit Meeting:
Patrick J. Isaac Jr., NRC, Examiner
Brendon Heidrich, Reactor Engineer, Penn State Breazeale Reactor

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

ENCLOSURE 1

FACILITY COMMENTS ON THE WRITTEN EXAM WITH NRC RESOLUTION

Question A. 18. [1.0 point]

You are poolside at the PSBR conducting a tour when someone from the group asks what the “blue glow” around the reactor is. Which of the following would be the most correct response?

a. It is the energy released from the interaction between a neutrino and antineutrino which is known as pair annihilation.

b. It is binding energy released directly through chain reactions of the fission process

c. It is the energy released by thermal neutrons when the K_{eff}= 1.000

d. It is an effect when high energy, charged particles (e.g., electrons) pass through the pool at a speed which is greater than the speed of light

Facility Comment:

Answer Key should be changed to “d” the correct Answer.

Chapter 1.8 of the training manual states:
Cerenkov effect is observed when particles of high energy (charged-particles-electrons) pass through a medium at a speed greater than the speed of light in that medium.

NRC Resolution:

The staff agrees with the facility’s comment. The answer key will be modified to accept “d” as the correct answer for question A.18.

Questions B.19 [1.0 point]

According to AP-1, which of the following activities DOES NOT require an operating license?

a. A boy scout operating the reactor controls as part of a planned facility tour

b An intern participating in a control rod inspection surveillance under the supervision of a licensed reactor operator.

c. A summer hire handling and removing a fuel element from the reactor core under the supervision of a licensed senior reactor operator

d. Authorize a deviation from Technical Specifications in accordance with 10 CFR 50.54 (x).

Facility Comment:

Answer Key should be changed to "c" the correct Answer.

AP-1 States that: A LICENSE IS NOT REQUIRED FOR AN INDIVIDUAL WHO:

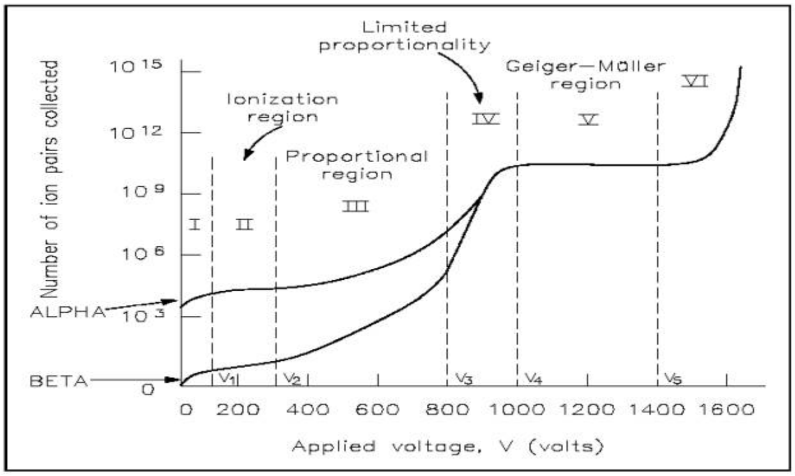
1. Under the direction and in the presence of a licensed operator, manipulates the controls of the reactor as a part of the individual's training as a student or as part of the individuals training to qualify for an operator license.
2. Under the direction and in the presence of a licensed senior operator, participates in reactor fuel, control rod, or graphite reflector movements.

NRC Resolution:

The staff agrees with the facility's comment. The answer key will be modified to accept "c" as the correct answer for question B.19.

Question C.4 [1.0 point total/ 0.25 each]

The following graph shows a composite characteristic curve for ionization chambers that show an increase in ion pairs collected as voltage increases. On your answer key write in which Region (i.e., I-VI) a detector would most likely reside given description below. If the described detector does not reside in one of the Regions (i.e., I-VI), then write "N/A."



a. Typically, these detectors include health physics survey meters and operate by using an integrating current measuring device for beta-gamma detection, indicating in mR/hr.

b. These types of meters operate by using a quench gas (e.g., P-10) and because of differing pulse sizes it allows for the differentiating between different types of radiation and in energy determination of the radiation.

c. These types of counters use crystal materials (i.e., NaI) and use a photomultiplier tube to convert light exposure from ionizing radiation to an electronic signal. They are especially useful for detecting low level radiation emitters, such as Tritium.

d. Survey equipment that operate here have large resolving times and the inability to electronically discriminate between radiations since the pulses are all the same size for this type of detector.

Facility Comment:

Agree with answers provided in parts a, b and c. However for part d, answer key should be changed to Region V – the correct answer.

The description for part d: Survey equipment that operate here have large resolving times and the inability to electronically discriminate between radiations since the pulses are all the same size for this type of detector. – **Correct**

answer should be the Geiger-Muller Region which is indicated as Region V on the graph

NRC Resolution:

The staff agrees with the facility's comment. The answer key will be modified to accept "Region V" as the correct answer for question C.4.d

Question C.11 [1.0 point]

Which of the following is **<u>NOT</u>** an approved operating position for the PSBR?

a. R1

b. D_2O Tank

c. R80-Rotated

d. FFT

Facility Comment:

Answer Key should be changed to "c" the correct Answer.

SOP-1 States:

- If Reactor is to be operated – Then Verify or Move the reactor to an approved location (Refer to SOP-10 FFT/FNI or SOP-11 D2O as applicable)
- Also for pulses/square waves it states: Verify the Reactor is in an approved position to pulse (typically <u>R1 **not** rotated</u>).

Provided Answers:

a. R1 - *This is an approved position*
b. D2O Tank – *This is an approved position*
c. R80- Rotated – *This is **<u>NOT</u>** an approved position* – **Correct Answer**
d. FFT – *This is an approved position.*

NRC Resolution:

The staff agrees with the facility's comment. The answer key will be modified to accept "c" as the correct answer for question C.11.

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

FACILITY: PENN STATE UNIVERSITY

REACTOR TYPE: POOL TYPE, MODIFIED TRIGA

DATE ADMINISTERED:

CANDIDATE: ______________________________

INSTRUCTIONS TO CANDIDATE:
Answers are to be written on the answer sheet provided. Attach the answer sheets to the examination. Points for each question are indicated in parentheses for each question. A 70% overall 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 CHARACTISTICS
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 THE WORK DONE ON THIS EXAMINATION IS MY OWN. I HAVE NEITHER GIVEN NOR RECEIVED AID.

____
CANDIDATE'S SIGNATURE

ENCLOSURE 3

Section A: ReactorTheory, Thermodynamics & Facility Operating Characteristics

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.

MULTIPLE CHOICE

001 a b c d ___

002 a b c d ___

003 a b c d ___

004 a b c d ___

005 a b c d ___

006 a b c d ___

007 a b c d ___

008 a b c d ___

009 a b c d ___

010 a b c d ___

011 a b c d ___

012 a b c d ___

013 a b c d ___

014 a b c d ___

015 a b c d ___

016 a b c d ___

017 a b c d ___

018 a b c d ___

019 a b c d ___

020 a b c d ___

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

Section B Normal, Emergency and Radiological Control Procedures

ANSWER SHEET

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

MULTIPLE CHOICE

001 a b c d __

002 a _____ b _____ c _____ d _____

003 a b c d __

004 a b c d __

005 a b c d __

006 a b c d __

007 a b c d __

008 a b c d __

009 a b c d __

010 a b c d __

011 a b c d __

012 a b c d __

013 See Table 2a on next page

014 a b c d __

015 a b c d __

016 a b c d __

017 a b c d __

018 a b c d __

019 a b c d __

Question B13

Table 2a
Minimum Reactor Safety System Channels

Channel	Number Operable	Function	Effective Mode MN, AU	Pulse	SW
Fuel Temperature	**1**	SCRAM ≤ 650°C*	____	____	____
High Power	**2**	SCRAM ≤ 110% of maximum reactor operational power not to exceed 1.1 MW	**X**	____	**X**
Detector Power Supply	**1**	SCRAM on failure of supply voltage	**X**	____	____
SCRAM Bar on Console	**1**	Manual SCRAM	**X**	**X**	____
Preset Timer	**1**	Transient Rod SCRAM 15 seconds or less after pulse	____	____	____
Watchdog Circuit	**1**	SCRAM on software or self-check failure	____	____	**X**

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

Section C Facility and Radiation 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.

MULTIPLE CHOICE

001 a b c d ___	011 a b c d ___
002 a b c d ___	012 a b c d ___
003 a b c d ___	013 a b c d ___
004 a___ b___ c___ d ___	014 a b c d ___
005 a b c d ___	015 a b c d ___
006 a b c d ___	016 a b c d ___
007 a b c d ___	017 a b c d ___
008 a b c d ___	018 a b c d ___
009 a b c d ___	019 a b c d ___
010 a b c d ___	020 a b c d ___

(********** 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 not received or 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.

6. Fill in the date on the cover sheet of the examination (if necessary).

7. Print your name in the upper right-hand corner of the first page of each section of your answer sheets.

8. The point value for each question is indicated in parentheses after the question.

9. Partial credit will NOT be given.

10. If the intent of a question is unclear, ask questions of the examiner only.

11. When you are done and have turned in your examination, leave the examination area as defined by the examiner.

EQUATION SHEET

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

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

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

$$P=P_0\ e^{t/\mathrm{T}}$$

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

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

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

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

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

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

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

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

$$M=\frac{1-K_{eff_1}}{1-K_{eff\,2}}$$

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

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

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

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

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

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

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

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

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

$$I=I_{oe^{-\mu x}}$$

$$\mu_m=\frac{\mu}{\rho}$$

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

1 Curie = 3.7 x 10^{10} dis/sec

1 kg = 2.21 lbm

1 inch=2.54 cm

1 Horsepower = 2.54 x 10^3 BTU/hr

1 Mw = 3.41 x 10^6 BTU/hr

1 BTU = 778 ft-lbf

°F = 9/5 °C + 32

1 gal (H_2O) ≈ 8 lbm

°C = 5/9 (°F - 32)

c_P = 1.0 BTU/hr/lbm/°F

c_p = 1 cal/sec/gm/°C

QUESTION A.1 [1.0 point]
Complete the following sentence.

A dollar ($) is a unit of reactivity, where one dollar ($1) is equal to the ___________.

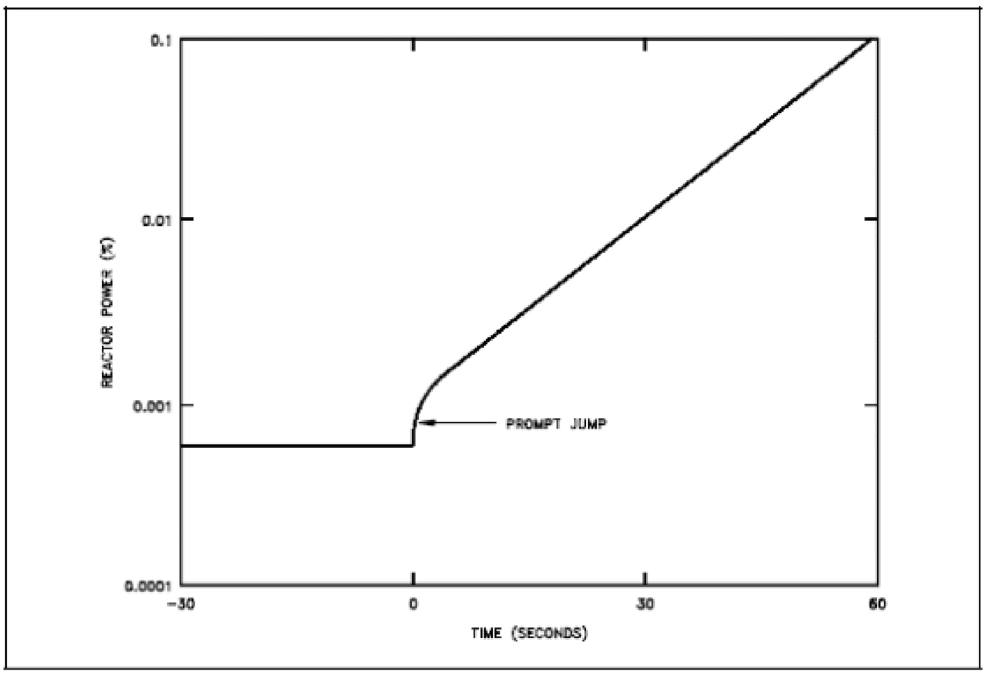
a. Delayed neutron precursor decay constant (λ).

b. Effective delayed neutron precursor decay constant (λ_{eff}).

c. Delayed neutron fraction (β).

d. Effective delayed neutron fraction ($\overline{\beta_{eff}}$).

QUESTION A.2 [1.0 point]
Given the following diagram, which of the following most correctly describe the condition of the reactor?



:

a. The prompt jump occurs because the production rate of delayed neutrons abruptly changes as reactivity is added.

b. At T=15s, the reactor is considered prompt critical.

c. After the prompt jump, the rate of change of power cannot increase any more rapidly than the built-in time delay the neutron precursor half-lives allow.

d. Shortly after T=0s, the reactor power is immediately turned due to the rise in moderator temperature.

QUESTION A.3 [1.0 point]
Complete the following sentence. In a nuclear reactor, 95% of all Xenon production is directly produced through the _________.

a. Decay of I-135

b. Fission of U-235

c. Beta decay of Cs-135

d. Fission of U-238

QUESTION A.4 [1.0 point]
You are performing a 50 Watt Critical Rod Position. Given the following data, calculate what the Shutdown Margin, as defined by Technical Specifications, is in a clean cold core.

Core Reactivity Evaluation Data

Control Rod	Total Worth	Critical Worth
Transient	$2.92	$1.75
Safety	$3.97	$2.63
Shim	$2.85	$1.84
Regulating	$2.92	$1.81
Total	$12.66	$8.03

a. $0.66

b. $3.29

c. $4.06

d. $4.63

QUESTION A.5 [1.0 point]
Which ONE of the following is the correct amount of reactivity added if the multiplication factor, k, is increased from 0.800 to 0.950?

a. 0.150

b. 0.158

c. 0.188

d. 0.197

QUESTION A.6 [1.0 point]
About two 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_0 (i.e., shortly after the scram) was 100 kW power, what will reactor power be three minutes later?

a. 2 kW

b. 10 kW

c. 30 kW

d. 50 kW

QUESTION A.7 [1.0 point]
With the reactor on a constant period, which transient requires the LONGEST time to occur?

a. 5% of rated power - going from 1% to 6% power of rated power

b. 10% of rated power - going from 10% to 20% power of rated power

c. 15% of rated power - going from 20% to 35% power of rated power

d. 20% of rated power - going from 40% to 60% power of rated power

QUESTION A.8 [1.0 point]
The time period in which the MAXIMUM concentration of Xe-135 will be present in the core is approximately 8 hours after:

a. a startup to 100%power.

b. a scram from 100% power.

c. a power increase from 0% to 50%.

d. a power decrease from 100% to 50%.

QUESTION A.9 [1.0 point]
Which ONE of the following conditions will **INCREASE** the core excess of a reactor?

a. Higher moderator temperature (assume negative temperature coefficient)

e. Insertion of a negative reactivity worth experiment

f. Burnout of a burnable poison

g. Fuel depletion

QUESTION A.10 [1.0 point]
A reactor with K_{eff} = 0.8 contributes 1000 neutrons in the first generation. When progressing from the FIRST generation to the SECOND generation, how many **total** neutrons are there after the SECOND generation?

a. 1250

b. 1600

c. 1800

d. 2000

QUESTION A.11 [1.0 point]
Which of the following radiation types has its penetrating ability through biological material impeded the greatest by its high specific ionization?

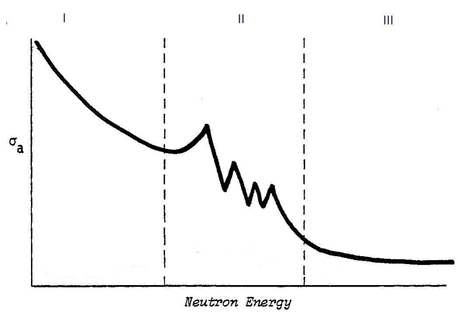
a. Alpha

b. Beta

c. Gamma

d. Neutron

QUESTION A.12 [1.0 point]
Given the associated graph, which answer best describes neutron behavior within Region I.



a. For neutrons with energy levels (E <1 ev) the cross section is inversely proportional to the neutron velocity.

b. For neutrons with energy levels (E >1 ev), the neutron cross section decreases steadily with increasing neutron energy (1/E).

c. For neutrons with energy levels (E < 1 ev), the high energy neutrons' cross section decreases which is proportional to the decrease in their mean free path.

d. Neutrons of specific energy levels (E > 1 ev) are more likely to be readily absorbed than neutrons at other energy levels because of the affinity of the nucleus for neutrons whose energies closely match its discrete, quantum energy levels.

QUESTION A.13 [1.0 point]
A reactor pool contains 106, 000 gallons of water at 90 degrees F, and it heats up to 93 degrees F in two hours. Assuming no ambient losses, the calculated reactor power level is ______.

a. 93 kW.

b. 259 kW.

c. 389 kW
.
d. 777 kW.

QUESTION A.14 [1.0 point]
The effective neutron multiplication factor, K_{eff}, for a critical reactor is:

a. Equal to ∞.

b. Equal to 1.

c. Equal to the effective delayed neutron fraction.

d. Any value < 1.

QUESTION A.15 [1.0 point]
Light water, like that found in the PSBR's pool, is an ideal moderator for thermalizing neutrons. Which of the following most correctly describes the nuclear properties of an ideal moderator?

a. Large absorption cross section.

b. Small energy loss per collision.

c. Large scattering cross section.

d. Small Doppler Broadening effect.

QUESTION A.16 [1.0 point]
You are the reactor operator performing two pulsing operations. The first pulse had a reactivity worth of **$1.50** which resulted in a peak power of **200 MW**. If the second pulse had a reactivity worth of **$3.00**, what is the peak power?

Given:
β_{eff} =0.0070

a. 400 MW

b. 1000 MW

c. 3200 MW

d. 4600 MW

QUESTION A.17 [1.0 point]
Which of the following statements best characterizes Natural Circulation?

a. The driving force is a difference in density.

b. Heat transfer is more efficient as the heat source decays.

c. Heat transfer is more efficient if the difference in temperature between the source and sink is small.

d. The elevation of the heat source must be above that of the heat sink.

QUESTION A.18 [1.0 point]
You are poolside at the PSBR conducting a tour when someone from the group asks what the "blue glow" around the reactor is. Which of the following would be the most correct response?

a. It is the energy released from the interaction between a neutrino and antineutrino which is known as pair annihilation.

b. It is binding energy released directly through chain reactions of the fission process

c. It is the energy released by thermal neutrons when the K_{eff}= 1.000

d. It is an effect when high energy, charged particles (e.g., electrons) pass through the pool at a speed which is greater than the speed of light

QUESTION A.19 [1.0 point]
During a reactor startup, criticality occurred at a lower rod height than the last startup. Which ONE of the following reasons could be the cause?

a. Xe^{135} peaked.

b. Moderator temperature increased.

c. A pre-loaded experiment had positive reactivity.

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

QUESTION A.20 [1.0 point]
In an operating TRIGA reactor, the effect of the Xenon poison is different from that due to samarium because:

a. Xenon will begin to decay 12 to 14 hours after reactor shutdown, whereas the effects of Samarium will remain indefinitely after shutdown because it is stable.

b. The magnitude of the xenon poison effect is much smaller than that for samarium.

c. While both poisons decay with their respective half lives after shutdown, Samarium decays with a shorter half life and its affects are negligible.

d. While both poisons decay after shutdown, samarium decays with a much longer half-life, its affects are negligible.

QUESTION B.1 [1.0 point]
In accordance with the facility Emergency Plan, a tornado event which damages the PSBR confinement structure is a good example of a(n) __________ type event classification.

a. Unusual Event

b. Alert

c. Site Area Emergency

d. General Emergency

QUESTION B.2 [1.0 point]
Identify each of the following surveillances as a channel check (**CHECK)**, a channel test (**TEST)**, or a channel calibration (**CAL)**. Use your pencil/pen to write in the correct answer on your answer sheet next to space given for each example listed below.

a. During performance of the Daily Checklist, you press a SCRAM button to verify a scram on the safety system channel.

b. During performance of the Daily Checklist, you compare the readings of Radiation Area Monitor 1 and Radiation Area Monitor 2.

c. You expose a 2 mCi check source to the continuous air monitor (CAM) detector to verify that its output is operable.

d. Adjustment of the wide range linear channel in accordance with recent data collected during a reactor power calibration.

QUESTION B.3 [1.0 point]
Complete the following sentence. According to PSBR technical specifications, the time from SCRAM initiation to the full insertion of any control rod from a full up position **SHALL be less than** ___ second(s).

a. 0.1

b. 0.5

c. 1

d. 2

QUESTION B.4 [1.0 point]
AP-1 requires there to be a licensed operator and a licensed senior reactor operator present at the facility whenever the reactor is not secured. Which of the following areas meets the definition of the facility?

a. The reactor pool and control room

b. The reactor pool, the control room, and all adjacent laboratories

c. The entire PSBR building

d. All areas within the facility perimeter fence

QUESTION B.5 [1.0 point]
Which of the following is **NOT** an AP-3 requirement requalification of active operators at the PSBR?

a. Each licensee shall actively perform the functions of the licensed position for a minimum of six hours per calendar quarter. A licensee who does not meet this requirement is considered inactive until the requirements are met.

b. Once during the requalification period, each licensee shall take a comprehensive written exam. A licensee receiving a grade of less than 70% in one or more of the three subject areas shall be removed from licensed duties

c. During each calendar year, an oral examination is administered to test the knowledge of normal and abnormal procedures. A licensee receiving a grade of less than 70% in one or more of the three subject areas shall be removed from licensed duties

d. The requalification program shall be conducted over a period of 24 consecutive months.

QUESTION B.6 [1.0 point]
Finger ring dosimetry is typically issued for monitoring the exposure to the skin of the extremities. What is the 10 CFR 20 annual limit associated with determination of the shallow dose equivalent?

a. 100 millirem

b. 500 millirem

c. 5 rem

d. 50 rem

QUESTION B.7 [1.0 point]
A leak has occurred at the PSBR and water level in the pool is decreasing a slow, but constant rate. Given the following sources of water and with all sources available, which would be the MOST preferred source?

a. University water through the demineralizer with resin that had been changed in the past week.

b. University water through the pool floor drains.

c. Thompson Pond water through the secondary heat exchanger and the fire hose connection

d. Fire Hydrant via the Fire Company

QUESTION B.8 [1.0 point]
A building evacuation alarm has just sounded. Where would you expect most people to muster IMMEDIATELY after acknowledging the alarm and need to evacuate from the PSBR?

a. Reactor Bay

b. PSBR Lobby

c. Academic Projects Building

d. Entry gate at the lower end of the parking lot

QUESTION B.9 [1.0 point]
Which of the following demonstrates the most correct example of a contamination survey?

a. Using an ion chamber detector to verify the posting requirements of a high radiation area.

b. Using a neutron detector (i.e., neutron ball) to determine if levels at the beam cave entrance permit entry.

c. Using a Geiger-Mueller detector on a dry mop to determine if activation levels are greater than the minimum detectable.

d. Using a high purity germanium detector to characterize peak profiles of a sample for neutron activation analysis.

QUESTION B.10 [1.0 point]
An element in the core is generating 20 KW and has a NP (Normalized Power) of 2.2. What is the average power level per fuel element in the core?

a. 5.71 kW

b. 7.7 kW

c. 9.09 kW

d. 40.4 kW

QUESTION B.11 [1.0 point]
A partial fuel inspection cycle has been completed. Absent an unusual number of pulses, **all remaining** fuel elements must be inspected:

a. Every year, not to exceed 15 months

b. Every two years, not to exceed 30 months

c. Every four years, not to exceed 54 months

d. Every six years, not to exceed 72 months

QUESTION B.12 [1.0 point]
The radiation from an unshielded Co-60 source is 500 mrem/hr. What thickness of lead shielding will be needed to lower the radiation level to 5 mrem/hr? The HVL (half-value-layer) for lead is 6.5 mm.

a. 26 mm

b. 33 mm

c. 38 mm

d. 44 mm

QUESTION B.13 [2.0 points total/0.167 each]
The following is a **PARTIALLY COMPLETED** table that identifies the Minimum Reactor Safety System Channels for various modes of operation. Using the same table in your answer key, fill in any remaining blanks with an applicable "X". **NOTE: Some parts of the table may remain blank as the condition may already be accounted for with a blank.**

Table 2a
Minimum Reactor Safety System Channels

Channel	Number Operable	Function	Effective Mode MN, AU	Pulse	SW
Fuel Temperature	**1**	SCRAM ≤ 650˚C*	____	____	____
High Power	**2**	SCRAM ≤ 110% of maximum reactor operational power not to exceed 1.1 MW	**X**	____	**X**
Detector Power Supply	**1**	SCRAM on failure of supply voltage	**X**	____	____
SCRAM Bar on Console	**1**	Manual SCRAM	**X**	**X**	____
Preset Timer	**1**	Transient Rod SCRAM 15 seconds or less after pulse	____	____	____
Watchdog Circuit	**1**	SCRAM on software or self-check failure	____	____	**X**

QUESTION B.14 [1.0 point]
In accordance with the Technical Specifications, which ONE condition below is permissible when the reactor is operating?

a. Conductivity of bulk pool water 5.0 microsiemens/cm

b. Reactor bay truck door open.

c. Seventeen (17) feet of water above the top of the grid plate
.
d. Emergency exhaust system inoperable for the day due to repairs.

QUESTION B.15 [1.0 point]
According to the PSBR's R-2 license, reactor power shall NOT exceed ______.

a. 900 kW

b. 1000 kW

c. 1100 kW

d. 1200 kW

QUESTION B.16 [1.0 point]
Maintenance workers need to replace a filter in an area where the dose rate is 100 mrem per hour. The Health Physics personnel are restricting individuals involved with the maintenance from exceeding a dose of 300 mrem per week. At least 8 hours will be required to complete the filter change out. Given the restrictions by Health Physics, how many (minimum) people will be required to complete the job on time? Assume the workers had no previous exposure and only one individual is working at a single time.

a. 1 worker

b. 2 workers

c. 3 workers

d. 4 workers

QUESTION B.17 [1.0 point]
According to 10 CFR 20, the NRC requires that workers exceeding what percentage of the annual dose limit be monitored (i.e., issued dosimetry) for radiation exposure?

a. 5%

b. 10%

c. 20%

d. 50%

QUESTION B.18 [1.0 point]
In the event of a suspected fuel leak from a 30/20 TRIGA element, which of the following nuclides is the **Parent** nuclide of concern when conducting an air sample?

a. Cs-138

b. Rn-226

c. Xe-133

d. Co-60

QUESTION B.19 [1.0 point]
According to AP-1, which of the following activities DOES NOT require an operating license?

a. A boy scout operating the reactor controls as part of a planned facility tour

b An intern participating in a control rod inspection surveillance under the supervision of a licensed reactor operator.

c. A summer hire handling and removing a fuel element from the reactor core under the supervision of a licensed senior reactor operator

d. Authorize a deviation from Technical Specifications in accordance with 10 CFR 50.54 (x).

Section C: Facility and Radiation Monitoring Systems

QUESTION C.1 [1.0 point]
All operational interlocks and safety trips required by technical specifications are performed by the:

a. Reactor safety system (RSS)

b. Digital Control Computer (DCC-Z)

c. Digital Control Computer (DCC-X)

d. Protection, control and monitoring system (PCMS)

QUESTION C.2 [1.0 point]
Which ONE of the following detectors will NOT activate the emergency evacuation alarm upon receipt of a high radiation alarm?

a. Reactor bay air west

b. Reactor Pump Room

c. Co-60 Bay

d. Beam Laboratory

QUESTION C.3 [1.0 point]
Which of the following is an AUTOMATIC action is associated with a pool level low alarm at the PSBR?

a. The primary coolant pump will stop running.

b, The reactor will scram immediately.

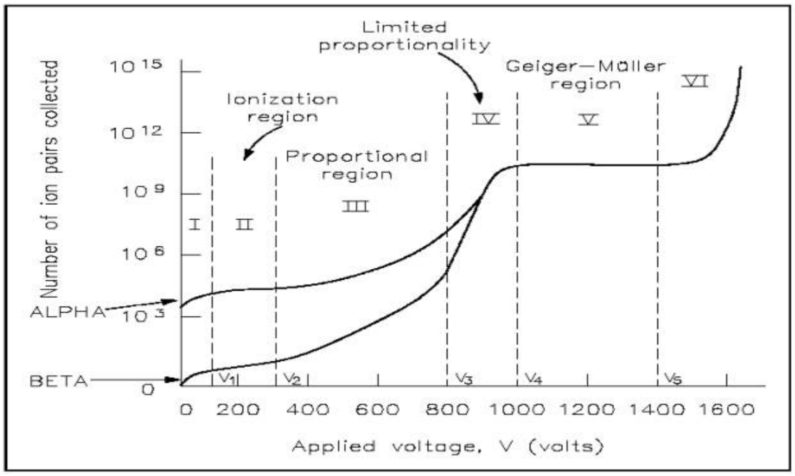
c. Notification will be sent to the University police.

d. The evacuation alarm will be initiated.

Section C: Facility and Radiation Monitoring Systems

QUESTION C.4 [1.0 point total/ 0.25 each]

The following graph shows a composite characteristic curve for ionization chambers that show an increase in ion pairs collected as voltage increases. On your answer key write in which Region (i.e., I-VI) a detector would most likely reside given description below. If the described detector does not reside in one of the Regions (i.e., I-VI), then write “N/A.”



a. Typically, these detectors include health physics survey meters and operate by using an integrating current measuring device for beta-gamma detection, indicating in mR/hr.

b. These types of meters operate by using a quench gas (e.g., P-10) and because of differing pulse sizes it allows for the differentiating between different types of radiation and in energy determination of the radiation.

c. These types of counters use crystal materials (i.e., NaI) and use a photomultiplier tube to convert light exposure from ionizing radiation to an electronic signal. They are especially useful for detecting low level radiation emitters, such as Tritium.

d. Survey equipment that operate here have large resolving times and the inability to electronically discriminate between radiations since the pulses are all the same size for this type of detector.

Section C: Facility and Radiation Monitoring Systems

QUESTION C.5 [1.0 point]

When the reactor is coupled against the D_2O tank and operated at power a phenomenon may exist where there may be greater neutron reflection and less absorption by the D_2O than by H_2O which causes the wide range detector reading to have a higher, observed reading. What is this phenomenon called?

a. Flux capacity

b. Fast flux factor

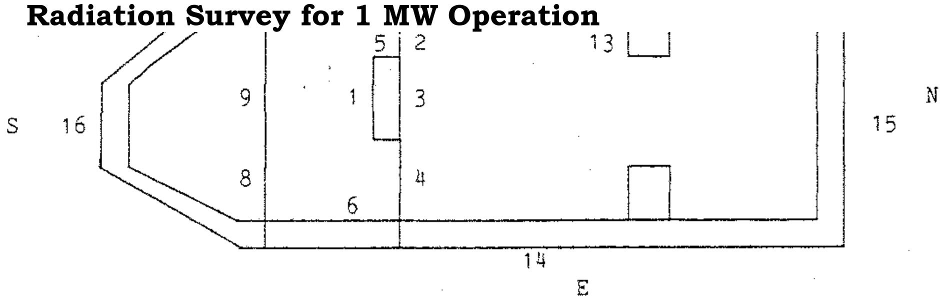
c. Flux tilting

d. Flux fission factor

QUESTION C.6 [1.0 point]

The following shows an example of a radiation survey map for the PSBR at 1 MW operation in the R1 position. Given the position number, which of the following locations (i.e., position numbers) would most likely have the highest radiation reading at the facility?

Radiation Survey for 1 MW Operation



osition No.	Description	Dose Rate (mRem/h
1	Reactor Bridge - Tread Plate	11

a. #1- Reactor Bridge Deck

b. #3- Below Control Rod Drives

c. #8- Below South Edge of Bridge

d. #13- 1” above H_2O, near the Divider Wall

Section C: Facility and Radiation Monitoring Systems

QUESTION C.7 [1.0 point]
Which of the following experimental materials is **strictly forbidden** for use at the PSBR under any condition?

a. Argon, as it can release a large release of radioactive material to the public, higher than the effluent discharge limit.

b. TNT or equivalent explosive material in excess of 2 grams as it could cause catastrophic damage to stainless steel or aluminum clad fuel elements and possibly release fission products.

c. Sodium Chloride as it could cause stainless steel corrosion cracking of the fuel elements in a high temperature environment and possibly release fission products.

d. Fissionable or fertile material as it could cause higher than analyzed peaking factors that could overheat fuel elements and possibly release fission products.

QUESTION C.8 [1.0 point]
Which ONE of the following controls the AMOUNT OF REACTIVITY that is inserted by the transient rod during pulse operations?

a. The preset pulse timer setting that vents the pneumatic piston

b. The steady state power of the reactor prior to firing the pulse

c. The pressure of the air applied to the pneumatic piston

d. The position of the cylinder

Section C: Facility and Radiation Monitoring Systems

QUESTION C.9 [1.0 point]

The PSBR has what is known as a prompt negative temperature coefficient associated with the fuel in the core. As the homogenous fuel-moderator mixture heats up, the total reactivity of the core decreases. Which of the following is **NOT** considered a contributing factor to the prompt negative temperature coefficient during a pulse?

a. There is a “Doppler effect” which causes the broadening of epithermal cross-section resonance peaks for U-238, thereby decreasing the probability of resonance escape.

b. As temperature increases, the fission cross-section for U-235 decreases, thereby increasing the amount of leakage from the core.

c. Hydrogen atoms impart kinetic energy to neutrons (i.e., upscattering), thereby reducing the fission cross-section.

d. As the moderator heats up, the density decreases and with more neutrons born at higher energies there will be increased leakage from the core.

QUESTION C.10 [1.0 point]

Which of the following nuclides does the carbon filter have a high efficiency for removal when it is in service?

a. N-16

b. Ar-41

c. Co-60

d. I-131

QUESTION C.11 [1.0 point]

Which of the following is **NOT** an approved operating position for the PSBR?

a. R1

b. D_2O Tank

c. R80-Rotated

d. FFT

Section C: Facility and Radiation Monitoring Systems

QUESTION C.12 [1.0 point]
Which of the following is NOT part an input to SCRAM Logic Circuit #1 or #2?

a. DCC-X Watchdog SCRAM

b. Loss of *PROTROL* on DCC-Z

c. Fuel temperature high

d. GIC bias voltage low

QUESTION C.13 [1.0 point]
Which of the following locations has the highest neutron flux level based solely on the given condition? Disregard any reactor safety functions. Assume the core is in an approved position for the condition listed below.

a. Central Thimble @ 1 MW Steady State

b. D_2O tank @ 900 kW Steady State, with the diffuser pump secured

c. Core Face with a 2000 MW pulse

d. Fast Flux Tube (FFT) with a 2000 MW pulse

QUESTION C.14 [1.0 point]
You are performing a radiation survey around the reactor pool using a Geiger Mueller detector. Which of the following is a **disadvantage** of using this type of detector?

a. It is sensitive to light

b. It is unable to electronically discriminate different types of radiation

c. It has a separate alpha and beta plateau curve which must be accounted for

d. It has a short resolving time when detecting radiation

Section C: Facility and Radiation Monitoring Systems

QUESTION C.15 [1.0 point]
Which one of the following will initiate a Reactor Scram AND a Reactor Operation Inhibit?

a. High Radiation Co-60 Lab Monitor

b. High pool temperature.

c. Reactor Bay Truck Door open.

d. Both East and West Bay Radiation Trips defeated.

QUESTION C.16 [1.0 point]
Which ONE of the following is considered a control rod interlock at the PSBR?

a. Above reactor power of 1 kW, the transient rod cannot be operated in the pulse mode.

b. Only one standard rod at a time can be moved in the pulse mode.

c. Control rods cannot be withdrawn unless the count rate is greater than 1 CPS in the manual mode.

d. Two control rods cannot be moved at the same time above 1 kW in the manual mode.

QUESTION C.17 [1.0 point]
Which of the following would be the most likely expected PSBR system response if the pool recirculation pump had a malfunction and had flow rate lower than the desired setpoint while operating at 900 kW?

a. A flow transducer in the recirculation loop sends an input to the console and activates a DCC-X status alarm if flow is low.

b. A pressure switch trips on the discharge side of the pump and sends and input to the console and activates an RSS-Scram.

c. DCC-X would initiate a stepback due to excessive fuel temperature.

d. RSS would activate a rod inhibit to prevent the operator from withdrawing control rods until the condition clears.

Section C: Facility and Radiation Monitoring Systems

QUESTION C.18 [1.0 point]
After the ventilation systems have switched modes during Evacuation Initiation, which of the following is the **MOST POSITIVE** indication that the Emergency Ventilation system has flow?

a. All control rods have scrammed and all rod bottom lights are indicating DOWN

b. A DCC-X message "Emergency Ventilation Flow On" displays on the reactor console.

c. When the louvers of the facility exhaust fans close there will be an "East and West Fans Off" message on DCC-X

d. A red power-on light on the Cobalt-60 lobby control panel turns on, as does a red pilot light on the circuit box on the east wall of the reactor bay.

QUESTION C.19 [1.0 point]
What is the approximate, total volume of the PSBR pool?

a. ≈40,000 gallons

b. ≈55,000 gallons

c. ≈71,000 gallons

d. ≈82, 000 gallons

QUESTION C.20 [1.0 point]
What is the most correct purpose for the DCC-X bulk temperature alarm setting at 35°C/ 60° F?

a. This limits the amount of nuclear boiling that occurs on the surface of the fuel cladding in order to preclude excessive temperature rise and damage.

b. This limits the maximum temperature of purification system water in order to preclude damage to the ion exchanger resin.

c. This limits maximum temperature effects to the reactor pool's liner in order to preclude leakage.

d. This limits the maximum temperature rise of the fuel in the event of a Loss of Coolant Accident (LOCA).

Section A: Reactor Theory, Thermodynamics, and Fac. Operating Characteristics

A.1
Answer: d
Reference: Reactor Theory (Neutron Characteristics) DOE-HDBK-1019/1-93 PROMPT AND DELAYED NEUTRONS

A.2
Answer: c
Reference: DOE Fundamentals Handbook *Nuclear Physics and Reactor Theory Vol. 2*

A.3
Answer: a
Reference: DOE Fundamentals Handbook *Nuclear Physics and Reactor Theory Vol. 2*

A.4
Answer: c
Reference: SDM = Critical worth – Most reactive Rod worth remaining out of core
SDM = 8.03-3.97 = $4.06

PSU Exam Reference Material (Adapted CP-11 data)

A.5
Answer: d
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1982, Sec 3.3.3, page 3-21.

At K_{eff} =0.8; $\rho = K_{eff} -1/ K_{eff} = -0.2/0.8 = -0.25$.
At K_{eff} =0.95, $\rho = -0.05/0.95 = -0.053$.
$\Delta \rho = \rho 1 - \rho 2 = -0.053-(-0.25)=0.197$

A.6
Answer: b
Reference::$P = P_0 e^{-T/t} = 100e^{(180sec/-80sec)} = 100 e^{-2.25}$ =(0.1054) x 100 kW = 10 kW
DOE Fundamentals Handbook *Nuclear Physics and Reactor Theory Vol. 2*

A.7
Answer: a
Reference: Burn, R., Introduction to Nuclear Reactor Operations, ©1988, § 4.3

T=1 was set arbitrarily for simplicity.
P(t) = P(0) * e ^ (t / T)
6% = 1% * e ^ (t / 1) --> t = 1.79176
20% = 10% * e ^ (t /1) --> t = 0.693147
35% = 20% * e ^ (t / 1) --> t = 0.559616
60% = 40% * e ^ (t / 1) --> t = 0.405465
Hence, the transient that takes the LONGEST time to occur is the 5% increase from 1% to 6% power.

Section A: Reactor Theory, Thermodynamics, and Fac. Operating Characteristics

A.8
Answer: b
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1982, Sec 8.4, page 8-9

A.9
Answer: c
Reference:
DOE Fundamentals Handbook *Nuclear Physics and Reactor Theory Vol. 2*

A.10
Answer: c
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1982, § 5.3, p. 5.6
2-nd generation=n + K*n=1000+800=1800 neutrons

A.11
Answer: a
Reference: PSU Training Manual Chapter 2.1.1 "Alpha Particle Interactions with Matter"

A.12
Answer: a
Reference: PSU Training Manual Chapter 2.3.2.2 "Cross Sections"

A.13
Answer:c
Power = mcΔT/Δt , where: m=106,000 gallons x 8.34 lbs/gal = 884,040 lb; c=1 Btu/°F-lb; ΔT/Δt = 1.5 degrees/hour. Power = 1,326,060 Btu/hour; 3413 Btu/hour = 1 kW. Power = 1,326,060/3413 = 389 kW

Reference: Adapted question taken from NC State's Pulstar Reactor Trainee Notebook, Section 3.7 and TRIGA reactor calibration procedure.

A.14
Answer: b
The effective multiplication factor may be expressed mathematically as shown below.

$$k_{eff} = \frac{\text{neutron production from fission in one generation}}{\text{neutron absorption in the preceding generation} + \text{neutron leakage in the preceding generation}}$$

Reference: DOE Fundamentals Handbook *Nuclear Physics and Reactor Theory Vol. 2*

A.15
Answer: c
Reference: DOE Fundamentals Handbook *Nuclear Physics and Reactor Theory Vol. 1*

Section A: Reactor Theory, Thermodynamics, and Fac. Operating Characteristics

A.16
Answer: c

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

β= \$1.00 of reactivity
P_1=200 MW
P_2= x

$$\frac{(\$3 - \$1)^2}{X} = \frac{(\$1.5 - \$1)^2}{200MW}$$

(200 MW)(\$2)^2=(x)(\$0.5)^2= 3200 MW

Reference: Reactor Physics of Pulsing: Fuchs-Hansen Adiabatic Model
http://www.rcp.ijs.si/ric/pulse_operation-s.html

A.17
Answer: a
Reference: General Physics, HT&FF, pp. 355 - 358

A.18
Answer: d
Reference: PSBR Training Manual, Chapter 1.8 “Bremstrahlung and Cerenkov Effect”

A.19
Answer: c
Reference: DOE Fundamentals Handbook *Nuclear Physics and Reactor Theory Vol. 2 and* PSU Exam Reference Material

A.20
Answer: a
Reference: DOE Fundamentals Handbook *Nuclear Physics and Reactor Theory Vol. 2*

Section B: Normal Emergency Procedures & Radiological Controls

B.1
Answer: b
Reference: EP-1, "PSBR Emergency Procedure," Rev. 15

B.2
Answer: a = TEST; b = CHECK; c = TEST; d = CAL
Reference: AP-5 PSU Technical specification § 1, Definitions

B.3
Answer: c
Reference: AP-5 PSU Technical specification 3.2.6 "Scram Time"

B.4
Answer: d
Reference: AP-1 "Personnel Requirements for Reactor Operations," Rev. 2

B.5
Answer: a
Reference: 10 CFR 20

B.6
Answer: d.
Reference: 10 CFR 20

B.7
Answer a.
Reference: EP-4 "Loss of Pool Water," Rev. 4

B.8
Answer: d
Reference: EP-13 "Building Evacuation," Rev.4

B.9
Answer: c
Reference: AOP-4 "Daily Contamination Procedure," Rev. 9

B.10
Answer: c

1.1.20 Normalized Power

The normalized power, NP, is the ratio of the power of a fuel element to the average power per fuel element.

Reference: AP-5, "Technical Specifications"

Section B: Normal Emergency Procedures & Radiological Controls

B.11
Answer: b
Reference: PSBR Technical Specifications 3.2.4 (table 2)

B.12
Answer: d
$DR = DR_{o} * e^{-\mu X}$
HVL (=6.5 mm) means the original intensity will reduce by half when a lead sheet of 6.5 mm is inserted. Find μ if the HVL is given as follows: $1 = 2 * e^{-\mu * 6.5}$;
μ = 0.10664. Find a thickness of Lead: 5 mrem/hr = 500 mrem/hr* $e^{-0.10664*X}$; X= 43.2 mm
Reference: Bevelacqua, J. *Basic Health Physics*.

B.13
Answer: Based on applicant's answers

Table 2a
Minimum Reactor Safety System Channels

Channel	Number Operable	Function	Effective Mode MN, AU	Pulse	SW
Fuel Temperature	**1**	SCRAM ≤ 650˚C*	**X**	**X**	**X**
High Power	**2**	SCRAM ≤ 110% of maximum reactor operational power not to exceed 1.1 MW	**X**		**X**
Detector Power Supply	**1**	SCRAM on failure of supply voltage	**X**		**X**
SCRAM Bar on Console	**1**	Manual SCRAM	**X**	**X**	**X**
Preset Timer	**1**	Transient Rod SCRAM 15 seconds or less after pulse		**X**	
Watchdog Circuit	**1**	SCRAM on software or self-check failure	**X**	**X**	**X**

Reference: AP-5, "Technical Specifications"

Section B: Normal Emergency Procedures & Radiological Controls

B.14
Answer: d
Reference: AP-5 "Technical Specifications"

B.15
Answer: c
Reference: AP-5, "Technical Specifications"

B.16
Answer: c
Time = Dose/Dose Rate
Time = 300mrem 100mrem per/hour
Time = 3 hours
Each individual assigned to the job could remain in the area for 3 hours without exceeding the administrative limit. If 8 hours are required to complete the job, we need:
□ 8 hours/3hours per individual = 2 and 2/3rds people or three people to complete the job. This assumes that only one individual will be in the area at any one time. If it takes two individuals working together, the total number of individuals required to complete the job doubles.

Reference: Bevelacqua, J. *Basic Health Physics*.

B.17
Answer: b
Reference: 10 CFR 20; Bevelacqua, J. *Basic Health Physics*.

B.18
Answer: c
Reference: PSBR SAR and Operator Training Manual

B.19
Answer: c
Reference: SOP-1 "Reactor Operating Procedure"

Section C: Facility and Radiation Monitoring Systems

C.1
Answer: a
Reference: PSBR Training Manual Chapter 4 Pg. 15

C.2
Answer: b
Reference: PSBR SAR Section 7.0

C.3
Answer: c
Reference: SOP-4 “Radiation, Evacuation, and Alarm Checks,” Rev. 2

C.4
Answer: See Below

a. Typically, these detectors include health physics survey meters and operate by using an integrating current measuring device for beta-gamma detection, indicating in mR/hr. **(Region II)**

b. These types of meters operate by using a quench gas (e.g., P-10) and because of differing pulse sizes it allows for the differentiating between different types of radiation and in energy determination of the radiation. (**Region III)**

c. These types of counters use crystal materials (i.e., NaI) and use a photomultiplier tube to convert light exposure from ionizing radiation to an electronic signal. They are especially useful for detecting low level radiation emitters, such as Tritium. **(N/A)**

d. Survey equipment that operate here have large resolving times and the inability to electronically discriminate between radiations since the pulses are all the same size for this type of detector. **(Region V)**

Reference: PSBR Training Manual Chapter 4

C.5
Answer: c
Reference: PSBR Training Manual, Chapter 3 Section A.6

C.6
Answer: b
Reference: PSBR Training Manual, Chapter 3 Section A.9.6

C.7
Answer: b
Reference: AP-5 “Technical Specificatons”

C.8
Answer: d
Reference: PSBR Training Manual SOP-1 section for a “Pulse”

Section C: Facility and Radiation Monitoring Systems

C.9
Answer: b
Reference: PSBR Training Manual Chapter 3 Appendix A.10

C.10
Answer: d
Reference: PSBR Training Manual Chapter 5.3.4.1 “Emergency Exhaust System”

C.11
Answer: c
Reference: PSBR SOP-1 “Reactor Operating Procedure,” Rev.1 and SOP-10 “Reactor Operations at the FFT and FNI,” Rev.1

C.12
Answer: b
Reference: PSBR SAR Section 7.4.2 “SCRAM Logic”

C.13
Answer: c
Reference: PSBR Training Manual Chapter 3 Appendix: General Operating Characteristics/Miscellaneous TRIGA Data

C.14
Answer: b
Reference: PSBR Training Manual Chapter 4.6 “Geiger Mueller Detectors”

C.15
Answer: c
Reference: PSBR Training Manual, Chapter 4.20.6.1b

C.16
Answer: c
Reference: PSBR Training Manual Chapter 4.22 “Transient Rod Control”

C.17
Answer: a
Reference: PSBR Training Manual Chapter 5.2.3 “Pool Recirculation/Purification System”

C.18
Answer: b
Reference: PSBR Training Manual Chapter 5.3.4.3 EES Function During an Evacuation Initiation

C.19
Answer: c
Reference: PSBR Training Manual Chapter 5.2.1

Section C: Facility and Radiation Monitoring Systems

C.20

Answer: b

Reference: PSBR Training Manual Chapter 5.2.3.1 “Demineralizer”