September 14, 2016

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

SUBJECT: EXAMINATION REPORT NO. 50-005/OL-16-01, THE PENNSYLVANIA STATE UNIVERSITY BREAZEALE RESEARCH REACTOR

Dear Dr. Unlu:

During the week of August 22, 2016, the U.S. Nuclear Regulatory Commission (NRC) administered operator licensing examinations at The Pennsylvania State University 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 at the conclusion of the examination with those members of your staff identified in the enclosed report.

In accordance with Title 10, Section 2.390 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 (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 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 Phillip T. Young at 301-415-4094 or via e-mail at Phillip.young@nrc.gov.

Sincerely,

/RA/

Anthony J. Mendiola, 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-16-01

cc without enclosures: see next page

Dr. Kenan Unlu, Director
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Sincerely,

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Division of Policy and Rulemaking
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Docket No. 50-005

Enclosures:
1. Examination Report No. 50-005/OL-16-01

cc without enclosures: See next page
DISTRIBUTION w/ encls.:
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ADAMS ACCESSION #: ML16242A210

OFFICE	NRR/DPR/PROB/CE		NRR/DPR/PROB/OLA		NRR/DPR/PROB/BC	
NAME	PYoung		CRevelle		AMendiola	
DATE	09/14/2016		09/12/2016		09/14/2016	

OFFICIAL RECORD COPY

cc:

Jeffrey A. Leavey
Manager of Radiation Protection
The Pennsylvania State University
0201 Academic Project BL
University Park, PA 16802

Dr. Neil A. Sharkey, Interim Vice President
for Research of the Graduate School
The Pennsylvania State University
304 Old Main
University Park, PA 16802

Director, Bureau of Radiation Protection
Department of Environmental Protection
P.O. Box 8469
Harrisburg, PA 17105

Test, Research and Training
Reactor Newsletter
P.O. Box 118300
University of Florida
Gainesville, FL 32611

Mark A. Trump, Associate Director
for Operations
The Pennsylvania State University
Breazeale Nuclear Reactor
Radiation Science and Engineering Center
University Park, PA 16802

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

REPORT NO.: 50-005/OL-16-01

FACILITY DOCKET NO.: 50-005

FACILITY LICENSE NO.: R-2

FACILITY: The Pennsylvania State University Breazeale Reactor

SUBMITTED BY: **/RA/** 9/12/2016
Phillip T. Young, Chief Examiner Date

SUMMARY:

During the week of August 22, 2016, the NRC administered license examinations to two Senior Reactor Operator license candidates. The applicant passed all portions of the examination.

REPORT DETAILS

1. Examiner: Phillip T. Young, Chief Examiner

2. Results:

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

3. Exit Meeting:

Phillip T. Young, Chief Examiner, NRC
Dr. Kenan Unlu, Director PSU Reactor
Alison Portanova, SRO PSU

The examiner thanked the facility for their assistance in completing the examinations. The examiner explained that question B.08 will be deleted from the examination because the structure of the columns created confusion to the applicants during the examination.

ENCLOSURE 1

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

FACILITY: PENN STATE UNIVERSITY

REACTOR TYPE: POOL TYPE, MODIFIED TRIGA

DATE ADMINISTERED: 8/22/2016

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

NRC RULES AND GUIDELINES FOR LICENSE EXAMINATIONS

During the administration of this examination the following rules apply:

1. Cheating on the examination means an automatic denial of your application and could result in more severe penalties.

2. After the examination has been completed, you must sign the statement on the cover sheet indicating that the work is your own and you have neither received nor given assistance in completing the examination. This must be done after you complete the examination.

3. Restroom trips are to be limited and only one candidate at a time may leave. You must avoid all contacts with anyone outside the examination room to avoid even the appearance or possibility of cheating.

4. Use black ink or dark pencil only to facilitate legible reproductions.

5. Print your name in the blank provided in the upper right-hand corner of the examination cover sheet and each answer sheet.

6. Mark your answers on the answer sheet provided. USE ONLY THE PAPER PROVIDED AND DO NOT WRITE ON THE BACK SIDE OF THE PAGE.

7. The point value for each question is indicated in [brackets] after the question.

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

9. When turning in your examination, assemble the completed examination with examination questions, examination aids and answer sheets. In addition turn in all scrap paper.

10. Ensure all information you wish to have evaluated as part of your answer is on your answer sheet. Scrap paper will be disposed of immediately following the examination.

11. To pass the examination you must achieve a grade of 70 percent or greater in each category.

12. There is a time limit of three (3) hours for completion of the examination.

13. When you have completed and turned in you examination, leave the examination area. If you are observed in this area while the examination is still in progress, your license may be denied or revoked.

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

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

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

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

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

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

$$CR_1 (1 - \rho_1) = CR_2 (1 - \rho_2)$$

$$M = \frac{CR_1}{CR_2}$$

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

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

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

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

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

$$T = \frac{\lambda^*}{\rho} + \left[\frac{\beta - \rho}{\rho (K_{eff} - \beta)} \right]$$

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

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

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

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

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

$$DR_1 d_1^2 = DR_2 d_2^2$$

DR – Ci – curies, E – Mev, R – feet

Rem,

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

1 Curie = 3.7×10^{10} dis/sec
1 Horsepower = 2.54×10^3 BTU/hr
1 BTU = 778 ft-lbf
1 gal (H_2O) . 8 lbm
c_P = 1.0 BTU/hr/lbm/EF

1 kg = 2.21 lbm
1 Mw = 3.41×10^6 BTU/hr
EF = 9/5 EC + 32
EC = 5/9 (EF - 32)
c_p = 1 cal/sec/gm/EC

Section A Reactor Theory, Thermo, and Facility Characteristics

Question A.01 [1.0 point] (1.0)
Which ONE of the following is true concerning the differences between prompt and delayed neutrons?

a. Prompt neutrons account for less than one percent of the neutron population while delayed neutrons account for approximately ninety-nine percent of the neutron population.

b. Prompt neutrons are released during fast fissions while delayed neutrons are released during thermal fissions.

c. Prompt neutrons are released during the fission process while delayed neutrons are released during the decay of fission products.

d. Prompt neutrons are the dominating factor in determining the reactor period while delayed neutrons have little effect on the reactor period.

Answer: A.01 c.
Reference: Reactor Training Manual, Page 2-16.

Question A.02 [1.0 point] (2.0)
A reactor scram has resulted in the instantaneous insertion of .006 ΔK/K of negative reactivity. Which one of the following is the stable negative reactor period resulting from the scram?

a. 45 seconds

b. 56 seconds

c. 80 seconds

d. 112 seconds

Answer: A.02 c.
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1982, § 4.6,

Section A Reactor Theory, Thermo, and Facility Characteristics

Question A.03 [1.0 point] (3.0)
Which ONE of the following isotopes has the largest microscopic cross-section for absorption for thermal neutrons?

a. Sm^{149}

b. U^{235}

c. Xe^{135}

d. B^{10}

Answer: A.03 c.
Reference: Lamarsh, J. "Introduction to Nuclear Engineering" p. 738
Sm^{149} (41,000 b); U^{235} (687 b); Xe^{135} (2.65×10^6 b); B^{10} (3840 b)

Question A.04 [1.0 point] (4.0)
When the excess reactivity (K_{ex}) exceeds the delayed neutron fraction (β), a reactor is said to be:

a. Subcritical

b. Critical

c. Within its shutdown margin requirements

d. Prompt critical

Answer: A.04 d.
Reference: Bevelacqua, J. 2009. *Basic Health Physics*. p.391

Question A.05 [1.0 point] (5.0)
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 (β_{eff}).

Answer: A.05 d.
Reference: Reactor Theory (Neutron Characteristics) DOE-HDBK-1019/1-93 PROMPT AND DELAYED NEUTRON

Section A Reactor Theory, Thermo, and Facility Characteristics

Question A.06 [1.0 point] (6.0)
In accordance with the PSBR Technical Specifications, the term "Shutdown Margin" describes:

a. the time required for the rods to fully insert

b. the departure from K-effective = 1.00

c. the amount of subcriticality, considering the worth of all rods

d. the amount of subcriticality with the most reactive rod fully withdrawn

Answer: A.06 d.
Reference: PSBR Technical Specifications, Section 1.1.42.

Question A.07 [1.0 point] (7.0)
The count rate is 50 cps. An experimenter inserts an experiment into the core, and the count rate decreases to 25 cps. Given the initial K_{eff} of the reactor was 0.8, what is the worth of the experiment?

a. $\Delta\rho = -0.42$

b. $\Delta\rho = +0.42$

c. $\Delta\rho = -0.21$

d. $\Delta\rho = +0.21$

Answer: A.07 a.
Reference: $CR_1 / CR_2 = (1 - Keff_2) / (1 - Keff_1) \rightarrow 50 / 25 = (1 - Keff_2) / (1 - 0.8)$
Therefore $Keff_2 = 0.6$
$\Delta\rho = Keff_2 - Keff_1 / Keff_2 \cdot Keff_1 = (0.6 - 0.8)/(0.6 \cdot 0.8) = -0.41667$

Section A Reactor Theory, Thermo, and Facility Characteristics

Question A.08 [1.0 point] (8.0)

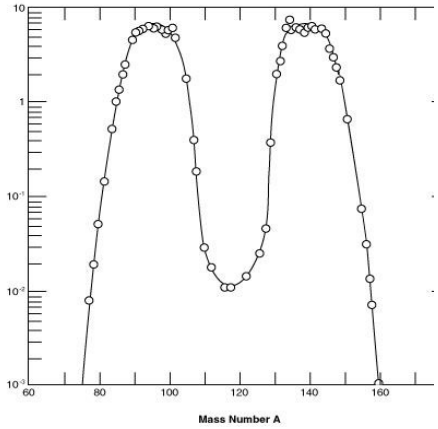
The following graph for U-235 depicts……

a. neutron energy distribution in the moderator

b. axial flux distribution in the core

c. radial flux distribution in the core

d. fission product yield distribution



Answer: A.08 d.
Reference: DOE Manual Vol. 1, pg. 57

Question A.09 [1.0 point] (9.0)

A nuclear reactor startup is being performed by adding equal amounts of positive reactivity and waiting for neutron population to stabilize. As the reactor approaches criticality, the numerical change in stable neutron population after each reactivity addition _____, and the time required for the neutron population to stabilize after each reactivity addition _____.

a. increases; remains the ame

b. increases; increases

c. remains the same; remains the same

d. remains the same; increases

Answer: A.09 b.
Reference: Question ID #P1766, ***NRC Generic Fundamentals Examination Question Bank—PWR2010***

Section A Reactor Theory, Thermo, and Facility Characteristics

Question A.10 [1.0 point] (10.0)
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

Answer: A.10 a.
Reference: DOE Fundamentals Handbook *Nuclear Physics and Reactor Theory Vol. 2*

Question A.11 [1.0 point] (11.0)
As primary coolant temperature increases, control rod worth:

a. decreases due to lower reflector efficiency.

b. decreases due to higher neutron absorption in the moderator.

c. increases due to the increase in thermal diffusion length.

d. remains the same due to constant poison cross-section of the control rods..

Answer: A.11 c.
Reference: Reactor Training Manual - *Reactivity Feedback*

Question A.12 [1.0 point] (12.0)
Excess reactivity is the amount of reactivity:

a. associated with samples.

b. needed to achieve prompt criticality.

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

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

Answer: A.12 d.
Reference: Glasstone and Sesonske, *Nuclear Reactor Engineering*,
Chapter 5, Section 5.114

Section A Reactor Theory, Thermo, and Facility Characteristics

Question A.13 [1.0 point] (13.0)
You are conducting a reactor startup after installing 2 new fuel assemblies in the core. Given the following rod withdrawal data, estimate the rod position when criticality would occur. The initial count rate on the nuclear instrumentation prior to rod withdrawal is 55 cps.

a. 11 in
b. 13 in
c. 15 in
d. 20 in

Rod Withdrawal (Inches)	Count Rate (cps)
0	55
2	58
4	60
6	61
8	69
10	85
12	275

Answer: A.13 b.
Reference

Question A.14 [1.0 point] (14.0)
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

Answer: A.14 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)

Section A Reactor Theory, Thermo, and Facility Characteristics

Question A.15 [1.0 point] (15.0)
In a subcritical reactor, K eff is increased from 0.861 to 0.946. Which ONE of the following is the amount of reactivity that was added to the reactor core?

a. 0.085 delta k/k

b. 0.104 delta k/k

c. 0.161 delta k/k

d. 0.218 delta k/k.

Answer: A.15 b.
Reference: Reactor Training Manual - *Reactor Kinectics*

Question A.16 [1.0 point] (16.0)
If reactor power is increasing by a decade every minute, it has a period of:

a. 13 sec

b. 26 sec

c. 52 sec

d. 65 sec

Answer: A.16 b.
Reference: *Glasstone, S. and Sesonske, A, Nuclear Reactor Engineering*, Kreiger Publishing, Malabar, Florida, 1991,
$P = P_o e^{t/T}$ $10 = 1e^{60/T}$ $\ln 10 = 60/T$ $2.3 = 60/T$ $T = 60/2.3$ $T = 26$ seconds

Question A.17 [1.0 point] (17.0)
With the reactor critical at 10 KW a rod is pulled to insert a positive reactivity of $0.18. Which one of the following will be the stable reactor period as a result of this reactivity insertion?

a. 10 seconds

b. 45 seconds

c. 55 seconds

d. 65 seconds

Answer: A.17 b.
Reference: Reactivity added = $0.18 x .007 = 0.00126
$\tau = (\beta-\rho)/\lambda_{eff}\rho = \frac{.007 - .00126}{(.1)(.00126)} = 45.6$ seconds

Section A Reactor Theory, Thermo, and Facility Characteristics

Section A Reactor Theory, Thermo, and Facility Characteristics

Question A.18 [1.0 point] (18.0)
Which ONE of the following conditions will **INCREASE** the core excess of a reactor?

a. Higher moderator temperature (assume negative temperature coefficient)

b. Insertion of a negative reactivity worth experiment

c. Burnout of a burnable poison

d. Fuel depletion

Answer: A.18 c.
Reference: DOE Fundamentals Handbook *Nuclear Physics and Reactor Theory Vol. 2*

Question A.19 [1.0 point] (19.0)
Following the reactor started up and it has been at 100% power for 3 hours. The Reactor Operator notes that several small control rod withdrawals are required to maintain power at 100%. Which of the following is the reason for the rod withdrawals?

a. Fuel temperatures are decreasing.

b. Xenon is building in to equilibrium concentration.

c. Pool water temperatures are decreasing.

d. Samarium is burning out from equilibrium concentration.

Answer: A.19 b.
Reference: Reactor Training Manual - *Reactor Physics and Kinetics*

Question A.20 [1.0 point] (20.0)
Given: Primary coolant flow rate is 500 gallons/minute and secondary flow rate is 700 gallons/minute. The ΔT across the primary side of the heat exchanger is 13°F and secondary inlet temperature to the heat exchanger is 73°F. Assuming both the primary and secondary coolants have the same Cp value, which ONE of the following is the secondary outlet temperature?

a. 82° F

b. 85° F

c. 89° F

d. 91° F

Answer: A.20 a.
Reference:
$\Delta T_{sec} = (Flow_{pri}/Flow_{sec}) \times \Delta T_{pri}$ $\Delta T_{sec} = (500/700) \times 13°F = 9.28°F$
Secondary outlet = 73°F + 9.28°F = 82.3°F

Section B Normal/Emergency Procedures & Radiological Controls

Question B.01 [1.0 point] (1.0)
While working on an experiment, you receive the following radiation doses: 100 mrem (β), 25 mrem (γ), and 5 mrem (thermal neutrons). Which ONE of the following is your total dose?

a. 175 mrem

b. 155 mrem

c. 145 mrem

d. 130 mrem

Answer: B.01 d.
Reference: Reactor Training Manual - *Ionizing Radiation*

Question B.02 [1.0 point] (2.0)
Which one of the following statements defines the Technical Specifications term "Channel Test?"

a. The adjustment of a channel such that its output corresponds with acceptable accuracy to known values of the parameter which the channel measures.

b. The qualitative verification of acceptable performance by observation of channel behavior.

c. The introduction of a signal into a channel for verification of the operability of the channel.

d. The combination of sensors, electronic circuits and output devices connected to measure and display the value of a parameter.

Answer: B.02 c.
Reference: TS 1.1.6

Question B.03 [1.0 point] (3.0)
A radioactive source generates a dose of 100 mr/hr at a distance of 10 feet. Using a two inch thick sheet of lead for shielding the reading drops to 50 mr/hr at a distance of 10 feet. What is the minimum number of **sheets** of the same lead shielding needed to drop the reading to less than 5 mr/hr at a distance of 10 ft?

a. 1

b. 3

c. 5

d. 7

Answer: B.03 c.
Reference: Two inches = one-half thickness ($T_{1/2}$). Using 5 half-thickness will drop the dose by a factor of $(1/2)^5$ = 1/32 100/32 = 3.13

Section B Normal/Emergency Procedures & Radiological Controls

Question B.04 [1.0 point] (4.0)
The following statement from the PSBR TS is a good example of a(n) _____ requirement. "The maximum excess reactivity above cold, clean, critical plus samarium poison of the core configuration with experiments and experimental facilities in place SHALL be 4.9% $\Delta k/k$ (~$7.00)."

a. Surveillance

b. Limiting Safety System Settings (LSSS)

c. Administrative

d. Limiting Condition for Operation (LCO)

Answer: B.04 d.
Reference: AP-5 and PSBR TS, Section 3.1.2

Question B.05 [1.0 point] (5.0)
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

Answer: B.05 b.
Reference: EP-1, "PSBR Emergency Procedure," Rev. 15

Question B.06 [1.0 point] (6.0)
A small radioactive source is to be stored in an accessible area of the reactor building. The source reads 2 R/hr at 1 foot. Assuming no shielding is to be used, a Radiation Area barrier would have to be erected from the source at least a distance of approximately:

a. 400 feet

b. 40 feet

c. 20 feet

d. 10 feet

Answer: B.06 c.
Reference: $DR_1D_1^2 = DR_2D_2^2$

Section B Normal/Emergency Procedures & Radiological Controls

Question B.07 [1.0 point] (7.0)
Which ONE of the following would be classified as an OPERATIONAL EVENT?

a. Operation in violation of a safety limit

b. Release of fission products from a fuel element

c. Unanticipated reactivity change greater than $1.00

d. Reactor scram

Answer: B.07 d.
Reference: AP-4. - B.2

Question B.08 [1.0 points, 0.25 each] (8.0)
Deletd by the examiner
Match the requirements (10 CFR 55) for maintaining an active operator license in column A with the correct time period from column B.

Column A	Column B
1. Renewal of license	a. 4 months
2. Medical examination	b. 1 year
3. Console manipulation evaluation	c. 2 years
4. Requalification exam (written)	d. 6 years

Answer: B.08 1 = d; 2; = c; 3 = b; 4 = c
Reference: 10CFR55

Question B.09 [1.0 point] (9.0)
Which one of the following statements describes the basis for the Safety Limit?

a. High fuel temperature could result in clad melt.

b. Excessive gas pressure may result in loss of fuel element cladding integrity.

c. High fuel temperature combined with lack of adequate cooling could result in fuel melt.

d. Excessive hydrogen produced as a result of the zirconium-water reaction is potentially explosive.

Answer: B.09 b.
Reference: T.S. 2.1 - Basis

Section B Normal/Emergency Procedures & Radiological Controls

Question B.10 [1.0 point] (10.0)
Reactor operations are being conducted around the clock over the weekend, during which time the Reactor Operator (RO) becomes ill and is taken to the hospital. Only the Senior Reactor Operator (SRO) and an experienced student remain in the facility. Reactor operations:

a. must be discontinued because both an RO and an SRO must be in the facility to satisfy PSBR Administrative Policy

b. must be discontinued because both an RO and an SRO must be in the facility to satisfy Technical Specifications

c. may continue until a replacement RO can arrive at the facility within 30 minutes

d. may continue since the SRO can monitor the console while the student makes the required periodic tours

Answer: B.10 a.
Reference: AP-1

Question B.11 [1.0 point] (11.0)
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

Answer: B.11 d.
Reference: 10 CFR 20

Question B.12 [1.0 point] (12.0)
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

Answer: B.12 d.
Reference: EP-13 “Building Evacuation,” Rev.4

Question B.13 [1.0 point, 0.25 points each] (13.0)
Match type of radiation (1 thru 4) with the proper penetrating power (a thru d)

a. Gamma	1. Stopped by thin sheet of paper
b. Beta	2. Stopped by thin sheet of metal
c. Alpha	3. Best shielded by light material
d. Neutron	4. Best shielded by dense material

Answer: B.13 a. = 4; b. = 2; c. = 1; d. = 3
Reference: Reactor Training Manual - *Health Physics*

Question B.14 [1.0 point] (14.0)
Prior to insertion into a pneumatic transfer system, a rabbit sample must be inspected by:

a. the reactor operator
b. the Health Physics office
c. the experimenter
d. the senior reactor operator

Answer: B.14 d
Reference: SOP-9.

Question B.15 [1.0 point] (15.0)
In the event of a credible bomb threat, the person receiving the threat should...

a. ask the person making the threat for his name and address.
b. call 911 after the call has ended.
c. immediately activate the Emergency Plan.
d. immediately evacuate the reactor building and proceed to the facility gate.

Answer: B.15 a
Reference: PSBR EP-8

Question B.16 [1.0 point] (16.0)
A room contains a source which, when exposed, results in a general area dose rate of 175 millirem per hour. This source is scheduled to be exposed continuously for 35 days. Select an acceptable method for controlling radiation exposure from the source within this room.

a. Lock the room to prevent inadvertent entry into the room.

b. Equip the room with a device to visually display the current dose rate within the room.

c. Equip the room with a motion detector that will alarm in the control room.

d. Post the area with the words "Danger-Radiation Area".

Answer: B.16 a.
Reference: PSBR Training Manual, Chapter 7 and 10CFR20.1601(a)(3)

Question B.17 [1.0 point] (17.0)
The Safety System channels required to be operable in all modes of operation are:

a. fuel element temperature scram, reactor high power scram, and manual scram

b. fuel element temperature scram and manual scram

c. manual scram and reactor high power scram

d. reactor high power scram, detector power supply scram, and fuel element temperature scram

Answer: B.17 b.
Reference: T.S. 3.2.4

Question B.18 [1.0 point] (18.0)
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

Answer: B.18 c.
Reference: AP-5 PSU Technical specification 3.2.6 “Scram Time”

Section B Normal/Emergency Procedures & Radiological Controls

Question B.19 [1.0 point] (19.0)
The capsule in a pneumatic transfer system fails to return from the reactor core at the proper time. The reactor operator must:

a. turn off the RABBIT 1 fan

b. reduce power and notify the SRO

c. shutdown the reactor and turn off the RABBIT 1 fan and RABBIT 1 Master

d. investigate the cause of the alarm and, if necessary, contact the RPO.

Answer: B.19 c.
Reference: SOP-9.C.2

Question B.20 [1.0 point] (20.0)
Which of the following statements is true regarding radiation safety protocol at the PSBR?

a. Category II individuals may escort a Category I individual only if they have watched the safety video first.

b. Category III individuals include police officers making routine checks.

c. Category II individuals may only perform work with sources of radiation only after watching the safety video.

d. Category I individuals do not have to watch the safety video and are typically escorted by Category III individuals.

Answer: B.20 d.
Reference: AP-8 - “Radiation Protection Orientation Requirements”
Section V.C - Category 3 includes student, staff, faculty, or facility industrial users working independently
Section V.B - Category 2 individuals may have access to the facility during normal working hours (but may not independently work with radioactive materials or escort Category 1 persons) after receiving the following orientation
Sections V.A - Category 1 individuals shall be accompanied by a Category 3 qualified individual who is authorized to serve as an escort

Question C.01 [1.0 point] (1.0)
What instrumentation region associated with "the voltage is such that every primary ion produces an avalanche of secondary ions"? This region also cannot differentiate between types of radiation.

a. Region I, Recombination

b. Region II, Ionization

c. Region III, Proportional

d. Region V, Geiger-Mueller

Answer: C.01 d.
Reference: PSBR Training Manual Chapter 4.1.1

Question C.02 [1.0 point] (2.0)
Which ONE of the following is the purpose of the diffuser on the N-16 recirculation pump?

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

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

c. Breakup O^{16} bubbles in pool, thereby decreasing production of N^{16}

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

Answer: C.02 b.
Reference: PSBR SAR 5.6

Question C.03 [1.0 point] (3.0)
What status alarm message will be indicated if the secondary outlet pressure is **NOT** greater than the primary inlet pressure by the preset amount?

a. Heat exchanger differential pressure low

b. Heat exchanger differential pressure high

c. Reactor pool level low

d. Reactor pool level high

Answer: C.03 a.
Reference: PSBR Training Manual Chapter 5.2.5

Question C.04 [1.0 point] (4.0)
PSBR Technical Specifications requires fuel elements be stored in a safe array where the MAXIMUM k_{eff} is _____.

a. 0.6

b. 0.7

c. 0.8

d. 0.9

Answer: C.04 c.
Reference: PSBR Technical Specifications 5.4.a

Question C.05 [1.0 point] (5.0)
A signal of notification to Penn State University Police Services is initiated by:

a. reactor bay truck door open.

b. UPS battery low.

c. emergency exhaust system initiation.

d. DCC-Z watchdog trip.

Answer: C.05 b.
Reference: PSBR Training Manual, 4.2.9.1bv - Facilities Systems Support pg. 51

Question C.06 [1.0 point] (6.0)
Which ONE of the following materials is inserted in the top and bottom of the active fuel portion of each fuel element to reduce neutron leakage?

a. Aluminum

b. Boron

c. Cadmium

d. Graphite

Answer: C.06 d.
Reference: PSBR Training Manual Chapter 5.1.4

Question C.07 [1.0 point] (7.0)
Which ONE of the following will initiate a reactor step back?

a. Pool outlet conductivity low

b. Reactor key on

c. Fuel temperature high

d. Facility exhaust is off

Answer: C.07 c.
Reference: PSBR Training Manual Chapter 4.2.9.1i

Question C.08 [1.0 point] (8.0)
The power range channel consists of:

a. A gamma ion chamber, in-core thermocouples, and the wide range monitor

b. A fission chamber, wide range channel, and power range monitor

c. A gamma ion chamber, in-core thermocouples, and the power range monitor

d. A fission chamber, gamma ion chamber, and in-core thermocouples

Answer: C.08 c.
Reference: PSBR SAR 7.2.3.1 & Training Manual 4.2.3 & 4.2.7

Question C.09 [1.0 point] (9.0)
The pneumatic transfer system uses _____ to reduce the production of _____.

a. CO_2, N^{16}

b. CO_2, Ar^{41}

c. Compressed air, Ar^{41}

d. D_2O, N^{16}

Answer: C.21 b.
Reference: PSBR SAR 10.2.6

Section C Facility and Radiation Monitoring Systems

Question C.10 [1.0 point, 0.25 each] (10.0)
Match the control rod drive mechanism from Column A with the correct function in Column B.

Column A	Column B
a. Potentiometer	1. Switch will reverse position according to whether the magnet is at or above its completely depressed position
b. Rod down limit switch	2. Provides rod position indication
c. Drive up limit switch	3. Switch reverses position according to whether the magnet is at or below its full up position
d. Drive down limit switch	4. Foot is depressed by armature when rod is fully lowered

Answer: C.10 a. = 2; b. = 4; c. = 3; d. = 1
Reference: PSBR Training Manual 4.2.11

Question C.11 [1.0 point] (11.0)
Which ONE of the following radiation monitoring systems will NOT activate the emergency evacuation alarm upon receipt of a high radiation alarm?

a. Reactor pump room
b. Reactor bay air west
c. Co^{60} bay
d. Beam laboratory

Answer: C.11 a.
Reference: PSBR SAR 7.7

Question C.12 [1.0 point, 0.33 each] (12.0)
Match the exhaust system filter in Column A with its purpose in Column B

Column A	Column B
a. Pre-filter	1. High efficiency for removing fission gases
b. Absolute filter	2. Filter atmospheric dust
c. Carbon filter	3. High efficiency for removing particulate radiation

Answer: C.12 a. = 2; b. = 3; c. = 1
Reference: PSBR Training Manual 5.3.4.1

Question C.13 [1.0 point] (13.0)
Which one of the following is correct for the air compressors?

a. Compressed air for the facility is provided by two air compressors located in the demineralizer room.

b. Either air compressor can supply the entire system.

c. Normally, the 20 horsepower air compressor supplies the reactor transient rod, and the 1.5 horsepower air compressor supplies the rest of the facility.

d. Both compressors are set to start at 60 psig and stop at 120 psig, are equipped with a low pressure alarm at 55 psig, and deliver air at about 80 psig to both the transient rod and the rest of the facility.

Answer: C.13 b.
Reference: PSBR Training Manual, Section 5.3.1

Question C.14 [1.0 point] (14.0)
PSBR uses the Compensated Ion Chamber as what measuring channel?

a. Linear power channel

b. Wide range monitor

c. Percent power channel

d. Not used as a measuring channel, used in experimental work

Answer: C.14 d.
Reference: PSBR Training Manual 4.1.6

Question C.15 [1.0 point] (15.0)
Which ONE of the following experimental facilities provides for the irradiation of samples at the point of maximum neutron flux?

a. Central thimble

b. Vertical tubes

c. Beam ports

d. Pneumatic transfer system

Answer: C.15 a.
Reference: PSBR SAR 10.2.5

Section C Facility and Radiation Monitoring Systems

Question C.16 [1.0 point] (16.0)
Which region of the pulse size versus applied voltage characteristic curve does the fission chamber operate?

a. Proportional

b. Limited proportional

c. Geiger-Mueller

d. Ion chamber

Answer: C.16 a.
Reference: PSBR Training Manual 4.1.1 Figure 4.1 and 4.1.7

Question C.17 [1.0 point] (17.0)
Per **PSBR TS**, what MAXIMUM water temperature would result in an alarm and an automatic stepback?

a. 35^{o}C

b. 60^{o}C

c. 110^{o}F

d. 120^{o}F

Answer: C.17 a.
Reference: PSBR TS 3.3.6

Question C.18 [1.0 point] (18.0)
Which ONE of the following statements describes the moderating properties of zirconium-hydride in the PSBR TRIGA fuel elements when temperature increases?

a. The ratio of hydrogen atoms to zirconium atoms increases the effectiveness of the moderator

b. The probability that a neutron will return to the fuel element before being captured elsewhere is a function of the temperature of the hydride

c. Elevation of the hydride temperature increases the probability that a thermal neutron will escape the fuel-moderator element before being captured

d. The hydride mixture is very effective in slowing down neutrons with energies below 0.025 eV

Answer: C.18 c.
Reference: PSBR SAR 4.2.3

Question C.19 [1.0 point] (19.0)

Which ONE of the following conditions will automatically scram the operating reactor?

a. 18.25 feet of water above the top of the bottom grid plate

b. 102% reactor power

c. Bulk pool water temperature = 40^{o}C

d. Loss of high voltage to the percent power channel

Answer: C.19 d.
Reference: PSBR TS 3.2.4, 3.3.1, & 3.3.6

Question C.20 [1.0 point] (20.0)

Which ONE of the following is the neutron absorber in the PSBR reactor control rods?

a. Powdered graphite

b. Zirconium hydride

c. Powered boron carbide

d. Aluminum oxide

Answer: C.20 c.
Reference: PSBR Training Manual Chapter 5.1.6