September 17, 2010

Dr. Kenan Unlu, Director
Breazeale Nuclear Reactor
The Pennsylvania State University
University Park, PA 16802-2301

SUBJECT: INITIAL EXAMINATION REPORT NO. 50-05/OL-10-01, PENNSYLVANIA STATE UNIVERSITY

Dear Dr. Unlu:

During the week of August 16, 2010 the U.S. Nuclear Regulatory Commission (NRC) administered operator licensing examination at your Pennsylvania State University Breazeale Nuclear Reactor. The examination was conducted according to NUREG-1478, "Operator Licensing Examiner Standards for Research and Test Reactors," Revision 2, published in June 2007. 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 Patrick Isaac at 301-415-1019 or via email at patrick.isaac@nrc.gov.

Sincerely,

/RA/
Johnny H. Eads, Jr., Chief
Research and Test Reactors Oversight Branch
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Docket No. 50-05

Enclosures: 1. Examination Report No. 50-05/OL-10-01
2. Corrected Written Examination

cc : Mr. Mark Trump, Pennsylvania State University

cc without enclosures: See next page

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Docket No. 50-05

Enclosures: 1. Examination Report No. 50-05/OL-10-01
2. Corrected Written Examination

cc w/enclosures: Mr. Mark Trump, Pennsylvania State University
cc without enclosures: See next page
DISTRIBUTION w/ encls.:
PUBLIC PROB r/f JEads Facility File CRevelle (O12-D19)
ADAMS ACCESSION #: ML102590417

OFFICE	PROB:CE		IOLB:LA		PROB:BC	
NAME	PIsaac		CRevelle		JEads	
DATE	09/16/2010		09/16/2010		09/17/2010	

OFFICIAL RECORD COPY

cc:

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

Dr. Eva J. Pell
Vice President and Dean
of the Graduate School
Pennsylvania State University
304 Old Main
University Park, PA 16802-1504

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

EXAMINATION REPORT NO: 50-05/OL-10-01

FACILITY: Pennsylvania State University

FACILITY DOCKET NO.: 50-05

FACILITY LICENSE NO.: R-75

SUBMITTED BY: _____ _____
Patrick J. Isaac, Chief Examiner Date

SUMMARY:

During the week of August 16, 2010, the NRC administered operator licensing examinations to one Reactor Operator (RO) and two Senior Reactor (SRO) candidates. The candidates passed the examinations.

REPORT DETAILS

1. Examiner: Patrick J. Isaac, Chief Examiner

2. Results:

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

3. Exit Meeting:

Dr. Kenan Unlu, Director, Breazeale Nuclear Reactor
Mark Trump, Associate Director, Breazeale Nuclear Reactor
Patrick Isaac, NRC, Examiner

The NRC Examiner agreed with Mr. Trump's request to correct the answer key for the written examination to reflect that:

Question A.5 – Correct answer is "b"
Question B.20 – Correct answer is "a2; b4; c1; d4"

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

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

FACILITY: Penn State University

REACTOR TYPE: TRIGA

DATE ADMINISTERED: 08/17/10

REGION: 1

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

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.

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 *****)

B. NORMAL/EMERG PROCEDURES & RAD CON

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.

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 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.

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 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

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

$\dot{Q} = \dot{m}\, \Delta h$

$\dot{Q} = UA\, \Delta T$

$$SUR = \frac{26.06\ (\lambda_{eff}\rho)}{(\beta - \rho)}$$

$SUR = 26.06/\tau$

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

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

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

$\tau = (\ell^*/\rho) + [(\bar{\beta}-\rho)/\lambda_{eff}\rho]$

$\rho = (Keff-1)/Keff$

$\rho = \Delta Keff/Keff$

$\bar{\beta} = 0.007$

$DR_1D_1^2 = DR_2D_2^2$

$Cp\ (H20) = 0.146\ \frac{kw}{gpm \cdot {}^\circ F}$

$\lambda_{eff} = 0.1/sec$

$SCR = S/(1-Keff)$

$CR_1\ (1-Keff)_1 = CR_2\ (1-Keff)_2$

$$M = \frac{(1-Keff)_0}{(1-Keff)_1}$$

$M = 1/(1-Keff) = CR_1/CR_0$

$SDM = (1-Keff)/Keff$

$I = I_o\ e^{-ux}$

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

$\tau = \ell^*/(\rho-\bar{\beta})$

$R = 6\ C\ E\ n$

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

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

$P = S / (1 - Keff)$

---

1 Curie = 3.7×10^{10} dps

1 kg = 2.21 lbm

1 hp = 2.54×10^3 BTU/hr

1 Mw = 3.41×10^6 BTU/hr

1 BTU = 778 ft-lbf

$^\circ F = 9/5\,^\circ C + 32$

931 Mev = 1 amu

$^\circ C = 5/9\ (^\circ F - 32)$

QUESTION **A.1** [1.0 point]

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}

QUESTION **A.2** [1.0 point]

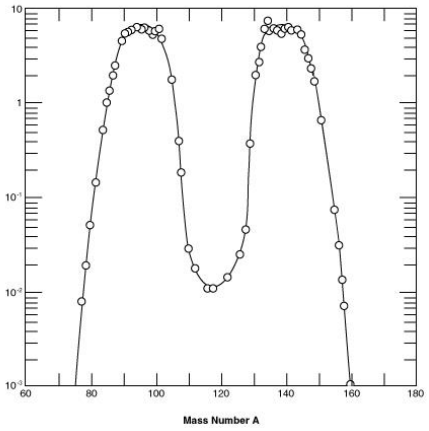
The following graph for U-235 depicts……

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



QUESTION **A.3** [1.0 point]

Which factors of the six factor formula are affected by an **INCREASE** in core temperature and how are they affected?

a. $\downarrow \boldsymbol{Lf}, \downarrow \mathbf{p}, \uparrow \boldsymbol{f}$

b. $\boldsymbol{\varepsilon}, \uparrow \boldsymbol{Lf}, \downarrow \boldsymbol{L_t}, \uparrow \mathbf{p}$

c. $\uparrow \boldsymbol{\varepsilon}, \downarrow \boldsymbol{Lf}, \downarrow \boldsymbol{L_t}, \downarrow \mathbf{p}, \uparrow \boldsymbol{\eta}, \uparrow \boldsymbol{f}$

d. $\uparrow \boldsymbol{\varepsilon}, \uparrow \boldsymbol{Lf}, \downarrow \boldsymbol{L_t}, \uparrow \mathbf{p}, \downarrow \boldsymbol{\eta}, \downarrow \boldsymbol{f}$

Section A Rx Theory, Thermo & Fac. Operating Characteristics

QUESTION **A.4** [1.0 point]

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

QUESTION **A.5** [1.0 point]
What is β_{eff}?

a. The time required for the reactor to change by a power of e

b. The fraction of all fission neutrons that are born as delayed neutrons

c. The fraction of all delayed neutrons which reach thermal energy

d. The fractional change in neutron population per generation

QUESTION **A.6** [1.0 point]

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

Section A Rx Theory, Thermo & Fac. Operating Characteristics

Question **A.7** [1.0 point]

Which of the following types of neutrons has a mean neutron generation lifetime of 12.5 seconds?

a. Prompt

b. Delayed

c. Fast

d. Thermal

Question **A.8** [1.0 point]

Which of the following statements is true about Xenon following a reactor scram?

a. The concentration of ^{135}Xe will decrease due to reduced nuclear flux

b. The concentration of ^{135}Xe will increase due to the decay of the ^{135}I inventory.

c. The concentration of ^{135}Xe will decrease by natural decay into ^{135}I

d. The concentration of ^{135}Xe will remain constant until it is removed via neutron burnout during the subsequent reactor startup.

QUESTION **A.9** [1.0 point]

Which one of the following materials in the reactor causes a "PROMPT" core reactivity addition when reactor power is changed?

a. U-235 and Reactor coolant

b. U-235 and ZrH

c. U-238 and ZrH

d. U-238 and graphite

Section A Rx Theory, Thermo & Fac. Operating Characteristics

QUESTION **A.10** [1.0 point]

An initial count rate of 100 is doubled five times during a startup. Assuming an initial Keff of 0.950, which one of the following is the new Keff?

a. 0.957

b. 0.979

c. 0.985

d. 0.998

QUESTION **A.11** [1.0 point]

During the time following a reactor scram, reactor power decreases on an 80 second period, which corresponds to the half-life of the longest-lived delayed neutron precursors, which is approximately

a. 80 seconds

b. 55 seconds

c. 40 seconds

d. 20 seconds

Section A Rx Theory, Thermo & Fac. Operating Characteristics

QUESTION **A.12** [1.0 point]

Given the following Core Reactivity Data:

Control Rod	Total Worth ($)	Worth Removed ($)
Transient Rod	2.78	1.68
Safety Rod	4.42	2.60
Shim Rod	2.98	1.52
Regulating Rod	2.84	1.60

Which one of the following is the calculated shutdown margin that would satisfy the Technical Specification Minimum Shutdown Margin?

a. 1.17

b. 2.98

c. 3.06

d. 5.62

QUESTION **A.13** [1.0 point]

Which ONE of the following is a correct statement of why delayed neutrons enhance the ability to control reactor power?

a. There are more delayed neutrons than prompt neutrons

b, Delayed neutrons are born at higher energy levels than prompt neutrons

c. Delayed neutrons increase the average neutron lifetime

d. Delayed neutrons readily fission in U-238

QUESTION **A.14** [1.0 point]

Which ONE of the following statements describes the subcritical reactor response as Keff approaches unity?

a. A LARGER change in neutron level results from a given change in Keff and a SHORTER period of time is required to reach the equilibrium neutron level for a given change in Keff.

b. A LARGER change in neutron level results from a given change in Keff and a LONGER period of time is required to reach the equilibrium neutron level for a given change in Keff.

c. A SMALLER change in neutron level results from a given change in Keff and a SHORTER period of time is required to reach the equilibrium neutron level for a given change in Keff.

d. A SMALLER change in neutron level results from a given change in Keff and a LONGER period of time is required to reach the equilibrium neutron level for a given change in Keff.

QUESTION **A.15** [1.0 point]

Immediately after a pulse [approximately 1 millisecond] where is the maximum temperature in a fuel element?

a. in the fuel cladding itself

b. near the fuel-cladding interface.

c. at the middle thermocouple, mid-plane of the fuel region.

d. at the central fuel-zirconium interface

QUESTION **A.16** [1.0 point]

What is the condition of the reactor when $k = \frac{1}{1-\beta}$?

a. subcritical

b. critical

c. prompt critical

d. prompt supercritical

Section A Rx Theory, Thermo & Fac. Operating Characteristics

Question **A.17** [1.0 point]

Inelastic scattering can be described as a process whereby a neutron collides with a nucleus and:

a. recoils with a lower kinetic energy, with the nucleus emitting a gamma ray.

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

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

d. recoils with a higher kinetic energy, with the nucleus absorbing a gamma ray.

Question **A.18** [1.0 point]

Which of the following statements is true regarding a typical reflector?

a. A reflector has a high cross section for absorption which **increases** the peak power to average power ratio.

b. A reflector has a high cross section for scattering, which **increases** the peak to average power ratio

c. Thermal neutrons tend to accumulate in the reflector until they leak back into the core, escape, or become absorbed, which **reduces** the peak to average power ratio.

d. Fast neutrons become absorbed in the reflector fuel, which raises the thermal flux and **reduces** the peak to average power ratio.

Section A Rx Theory, Thermo & Fac. Operating Characteristics

Question **A.19** [1.0 point]

An experiment to be placed in the central thimble has been wrapped in cadmium. Which one of the following types of radiation will be most effectively blocked by the cadmium wrapping?

a. Thermal neutrons

b. Fast neutrons

c. Gamma rays

d. X-rays

Question **A.20** [1.0 point]

The TRIGA reactor is required to pulse from low power levels. Which one of the following is the reason for this limitation on power level prior to the pulse?

a. To prevent exceeding the maximum power level limit

b. To prevent exceeding the fuel element temperature limit

c. To prevent exceeding the pool temperature limit

d. To prevent exceeding the reactivity insertion limits

Section B Normal/Emergency Procedures and Radiological Controls

Question **B.1** [1.0 point]

You are performing a periodic radiation survey when you find a streaming source of radiation from a cabinet which reads 50 mr/hr on contact. How should this area be posted in accordance with the requirements of 10 CFR 20?

a. High Radiation Area @ 30 cm from the source

b. High Radiation Area on contact w/ the cabinet

c. Radiation Area @ 30 cm from the source

d. Radiation Area on contact w/ the cabinet

Question **B.2** [1.0 point]

Which of the following is correct regarding NRC Form 3 “Notice to Employees”?

a. It provides guidance for filing a discrimination report

b. It provides guidance for how to report safety concerns

c. It informs you for how to get a record of your radiation exposure

d. All of the above

Question **B.3** [1.0 point]

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".

Section B Normal/Emergency Procedures and Radiological Controls

Question **B.4** [1.0 point]

The special unit for absorbed dose "Rem" is defined in 10 CFR Part 20 in terms of a dose equivalent. What does the term dose equivalent relate to?

a. It is derived by accounting for the amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in one year

b. It is equal to the absorbed dose (rad) multiplied by the quality factor (Q) of the radiation

c. It is equal to the absorbed dose (rad) divided by the quality factor (Q) of the radiation

d. It is the equivalent dose one would receive during the 50-year period following intake

Question **B.5** [1.0 point]

Which one of the following is the definition for "Annual Limit on Intake" (ALI)?

a. 10 CFR 20 derived limit, based on a Committed Effective Dose Equivalent of 5 rems whole body or 50 rems to any individual organ, for the amount of radioactive material inhaled or ingested in a year by an adult worker.

b. The concentration of a radionuclide in air which, if inhaled by an adult worker for a year, results in a total effective dose equivalent of 100 millirem.

c. The effluent concentration of a radionuclide in air which, if inhaled continuously over a year, would result in a total effective dose equivalent of 50 millirem for noble gases.

d. Projected dose commitment values to individuals that warrant protective action following a release of radioactive material.

Question **B.6** [1.0 point]

In order to ensure the health and safety of the public, 10CFR50 allows the operator to deviate from Technical Specifications. What is the minimum level of authorization needed to deviate from Tech. Specs?

a. USNRC

b. Reactor Supervisor

c. Licensed Senior Reactor Operator

d. Licensed Reactor Operator

Section B Normal/Emergency Procedures and Radiological Controls

Question **B.7** [1.0 point]

Using a calibrated source of 5 curies of Co60, what is the exposure rate at 6 feet from the source? Co60 emits two gamma photons per decay with energies of 1.17 Mev and 1.33 Mev.

a. 750 mR/hr

b. 2.1 R/hr

c. 8.3 R/hr

d. 12.5 R/hr

Question **B.8** [1.0 point]

Which one of the following meets the definition of “Safety Limit”?

a. Setting for a an automatic protective device related to a variable having a significant safety function

b. Limits on important process variables to protect the fuel element cladding

c. Limits imposed on reactor core reactivity for a reference core condition

d. Constraints included in the Technical Specifications that are required for safe operation of the facility

Question **B.9** [1.0 point]

Which one of the following statements describes the basis for the Technical Specifications limit on the maximum power level to initiate a pulse?

a. To prevent power peaking effects.

b. To allow the maximum allowed worth of the pulse rod without exceeding the safety limit.

c. To allow the negative feedback coefficient of the fuel to turn power prior to exceeding the Limiting Safety System Setting.

d. To prevent exceeding the maximum steady state fuel temperature.

Section B Normal/Emergency Procedures and Radiological Controls

Question **B.10** [1.0 point]

The reactor shall not be operated in the PULSE mode unless the following reactor safety system channels are operable, EXCEPT:

a. Detector Power supply

b. Manual Scram Bar

c. Watchdog Circuit

d. Preset Timer

Question **B.11** [1.0 point]

An example of Byproduct Material would be….

a. Pu-239

b. U-233

c. U-235

d. Co-60

Question **B.12** [1.0 point]

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.

Section B Normal/Emergency Procedures and Radiological Controls

Question **B.13** [1.0 point]

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

Question **B.14** [1.0 point]

How many hours per calendar quarter must you perform the functions of an RO or SRO to maintain an active RO or SRO license?

a. 2

b. 4

c. 6

d. 8

Question **B.15** [1.0 point]

The OPERATIONS BOUNDARY is defined as:

a. the reactor building and all connected structures.

b. the chain-link fence surrounding the facility.

c. the reactor bay (room 123) and control room (room 119).

d. the "red" area (radiochemical storage, control room, reactor bay, hot cells).

Section B Normal/Emergency Procedures and Radiological Controls

Question **B.16** [1.0 point]

A release of airborne radioactive material where a person at the reactor site boundary is expected to receive a deep dose equivalent of 15 mrem over a 24 hour period is classified as:

a. Unusual Event

b. Alert

c. Site Area Emergency

d. General Emergency

Question **B.17** [1.0 point]

In the event of an emergency involving an emergency evacuation, the Duty RO is responsible to:

a. be a member of the re-entry team and reporting to the Emergency Director

b. be the acting Emergency Director until relieved by higher levels of facility management

c. admit appropriate emergency support personnel to the facility to mitigate the consequences of the emergency

d. open and take charge of the Emergency Support Center, distributing emergency equipment to appropriate support personnel

Question **B.18** [1.0 point]

During irradiated fuel movement, which one of the following applies to the operation of the facility exhaust system and emergency exhaust system?

a. One facility exhaust fan shall be operating and the emergency exhaust system shall be operable.

b. The facility exhaust system shall be operable with both fans running and the emergency exhaust system shall be operable.

c. One facility exhaust fan shall be operating and, except for periods of time of less than 48 hours during maintenance, the emergency exhaust system shall be operable.

d. The emergency exhaust system shall be operating. The facility exhaust system shall be operable with a minimum of one fan available.

Section B Normal/Emergency Procedures and Radiological Controls

Question **B.19** [1.0 point]

Which one of the following is the main contributor to Ar-41 production at the PBSR?

a. Neutron interaction with the D_2O tank

e. Neutron interaction with the oxygen in the reactor pool water

c. Pool water evaporation

d. Neutron interaction with dissolved air in the reactor pool water

Question **B.20** [1.0 point]

Column A below lists four activities in which a senior operator might participate. Column B lists four categories of procedures in which the activities are described. Match the procedure in Column B to the activity in Column A. Each procedure can be used once, more than once, or not at all.

Column A	Column B
a. Transfer a fuel element from the core to the storage rack.	1. Administrative Policy
b. Add water to the reactor pool (non-emergency).	2. Standard Operating Procedure
c. Issue a Radiation Work Permit.	3. Special Procedure
d. Perform smear survey.	4. Auxiliary Operating Procedure

Section C Facility and Radiation Monitoring Systems

Question **C.1** [1.0 point]

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

Question **C.2** [1.0 point]

Carbon dioxide is used in the pneumatic transfer system instead of compressed air because:

a. it is more compressible

b. it does not retain moisture

c. it minimizes Ar-41 production

d. it minimizes N-16 production

Question **C.3** [1.0 point]

The top grid plate in the reactor:

a. supports the weight of the fuel assemblies

b. aligns and supports the nuclear detectors

c. maintains lateral fuel alignment

d. serves as a reflector over the top of the core

Question **C.4** [1.0 point]

The Wide Range power monitor uses a (an):

a. uncompensated ion chamber

b. compensated ion chamber

c. fission chamber

d. boron-trifluoride detector

Section C Facility and Radiation Monitoring Systems

Question **C.5** [1.0 point]

Which one of the following is a control rod interlock?

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.6** [1.0 point]

All operational interlocks and safety trips required by technical specifications are performed by the:

a. Digital Control Computer (DCC-Z)

b. Digital Control Computer (DCC-X)

c. protection, control and monitoring system (PCMS)

d. reactor safety system (RSS)

Question **C.7** [1.0 point]

In the PSBR Water Handling System, pool water conductivity is measured:

a. at the suction of the purification pump

b. downstream of the skimmer

c. between the filter and purification pump

d. at the inlet of the demineralizer

Section C Facility and Radiation Monitoring Systems

Question **C.8** [1.0 point]

Streaming of radiation from the central thimble is prevented by:

a. a graphite shield box over the top of the tube

b. the tube being filled with water

c. a boral plug inserted into the top of the tube

d. large radius bend in the tube

Question **C.9** [1.0 point]

A reactor stepback is initiated by:

a. east or west bay monitor high radiation

b. east and west facility exhaust fans off

c. high fuel temperature

d. pulse timer timed out

Question **C.10** [1.0 point]

When the Emergency Exhaust System is energized, the most positive indication of flow is by:

a. the red power-on light on the Cobalt-60 lobby control panel.

b. a DCC-X message “Emerg Ventilation Flow On”.

c. the red pilot light on the circuit box on the east wall of the reactor bay.

d. the Absolute Filter pressure gauge reads 0.2 inches H_2O.

Question **C.11** [1.0 point]

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.

Section C Facility and Radiation Monitoring Systems

Question **C.12** [1.0 point]

Which one of the following would be an indication of a leak in the Pool Heat Exchanger?

a. Increased radioactivity in the pond water.

b. Decreased delta T across the Pool Heat Exchanger.

c. Excessive makeup to the pool.

d. Increased pool level.

Question **C.13** [1.0 point]

Which one of the following will initiate a Reactor Scram AND a Reactor Operation Inhibit?

a. High pool temperature.

b. Both East and West Bay Radiation Trips defeated.

c. High Radiation Co-60 Lab Monitor

d. Reactor Bay Truck Door open.

Question **C.14** [1.0 point]

Which one of the following describes an RSS operational interlock function while in the PULSE mode of operation?

a. Prevents manual withdrawal of more than one rod.

b. Prevents application of air to the transient rod if the drive is not fully down.

c. Prevents manual withdrawal of any rod.

d. Prevents movement of all rods except the transient rod.

Question **C.15** [1.0 point]

The DCC-X bulk pool temperature alarms at ~100°F to ensure that:

a. there is an adequate heat sink for the full thermal power of the reactor.

b. the anion bed in the demineralizer is not damaged.

c. the expansion of pool water at higher temperatures does not reduce the moderating capability of the coolant.

d. nucleate boiling does not occur on fuel element surfaces.

Section C Facility and Radiation Monitoring Systems

Question **C.16** [1.0 point]

Which one of the following is true for ALL control rods (i.e., the safety, the shim, the regulating and the transient rods)

a. A stroke of about 15 inches.

b. A length of about 43 inches.

c. A fuel follower of about 15 inches.

d. They contain graphite reflector sections.

Question **C.17** [1.0 point]

Which one of the following is true for the rod drive interlocks?

a. The rod drive interlock logic is fail safe on loss of power since power is not required for the motor controller digital inputs to perform the inhibit function.

b. The rod drive pushbuttons provide normally closed contacts for interlock functions and normally open contacts for inputs to DCC-X.

c. The interlock validation in RSS and the use of redundant software interlocks for the demand velocity signal provide a diverse control rod withdrawal interlock.

d. If more than one “up” pushbutton is pressed at one time, the logic blocks manual withdrawal of the last selected rod or rods and all rods in the automatic mode of control.

Question **C.18** [1.0 point]

Which one of the following initiates a reactor operation inhibit by DCC-X?

a. Emergency exhaust system operating.

b. Reactor pool level below normal.

c. Radiation hazard from the neutron beam ports.

d. Fuel temperature is high.

Section C Facility and Radiation Monitoring Systems

Question **C.19** [1.0 point]

Which one of the following is one of the several sources of water that are available for adding water to the reactor pool by permanently installed piping?

a. Water from the Co-60 pool can be pumped by the primary cooling system pump to the reactor pool.

b. The University water system can supply the pool through the demineralizer.

c. The University water system can supply a high flow rate to the emergency pool flooding system.

d. The heat exchanger secondary side can supply the pool drain lines.

Question **C.20** [1.0 point]

Which one of the following is NOT powered by the main power distribution panel in the control room?

a. East reactor bay exhaust fan

b. Emergency exhaust fan

c. Fire alarm panel

d. N16 pump

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

Section A Rx Theory, Thermo & Fac. Operating Characteristics

A.1
Answer: c
Sm^{149} (41,000 b); U^{235} (687 b); Xe^{135} (2.65 x 10^6 b); B^{10} (3840 b)
Reference: Lamarsh, J. "Introduction to Nuclear Engineering" p. 738

A.2
Answer: d
Reference: DOE Manual Vol. 1, pg. 57

A.3
Answer: a
Reference:
As reactor core temperature increases, the moderator to fuel ratio will decrease due to the decrease in density of the water. Therefore, due to this fact:

↓*Lf (Fast Non-Leakage Factor):* is the probability that neutrons will not leak out while still fast. Therefore, with less moderator in the core, the probability that they will not leak out decreases.

↓p*(Resonance Escape Probability)*: is the probability that a neutron will be reduced to thermal energy levels without being absorbed by U-238. Due to the increase in temperature and Doppler Broadening effects, the probability of escape decreases.

↑***f*** *(Thermal Utilization Factor)*: is the ratio of absorption in fuel to the amount absorbed in the core (e.g., fuel, moderator, control rods, etc.). When the temperature rises, the water moderator expands, and a significant amount of it will be forced out of the reactor core. This means that N_m, the number of moderator atoms per cm^3, will be reduced, making it less likely for a neutron to be absorbed by a moderator atom. This reduction in N_m results in an increase in thermal utilization as moderator temperature increases because a neutron now has a better chance of hitting a fuel atom.

DOE Manual Vol. 2, Section 1.0

A.4
Answer: b
Reference:
$\frac{CR_1}{CR_2} = \frac{1}{M}$, Where CR_1= reference count rate (i.e., 55 cps) and CR_2= current count rate.

A.5
Answer: b
Reference: DOE Handbook, Vol. 2, Section 2.0

A.6
Answer: b
Reference:
Reactivity added = \$0.18 x .007 = 0.00126
$\tau = (\beta-\rho)/\lambda_{eff}\rho = \frac{.007 - .00126}{(.1)(.00126)} = 45.6$ seconds

A.7
Answer: b
Reference: DOE Handbook Vol. 1 Section 3.0

Section A Rx Theory, Thermo & Fac. Operating Characteristics

A.8
Answer: b
Reference: Following a reactor shutdown, xenon-135 concentration will increase due to the decay of the iodine inventory of the core.
DOE Handbook, Vol. 2, Section 4

A.9
Answer: c
Reference: PSTR Training Manual, Section 2.23.3

A.10
Answer: d
Reference:
CR1 (1-Keff1) = CR2 (1 - Keff2) or M1 (1-Keff1) = M2 (1 - Keff2)
CR2/CR1 = 32 → CR1 (1-Keff1)/CR2 = 1 - Keff2) → 100 (1-0.950)/3200 = 1 - Keff2
Keff2 = 1 - .0015625 = .998

A.11
Answer: b
Reference: Group 1 is the longest-lived delayed neutron precursor for thermal fission in U-235, with a half-life of 55.72 sec.
Lamarsh, J. "Introduction to Nuclear Engineering" p. 88

A.12
Answer: b
Reference:
SDM = $\sum$(B) - Max. (A) = \$7.40 - \$4.42 = \$2.98

A.13
Answer: c
Reference: DOE Manual, Section 3

A.14
Answer: b
Reference: PSTR Training Manual, Section 2.18

A.15
Answer: b
Reference: PSTR SAR chapter IX, Sect. B

A.16
Answer: c
Reference: The multiplication factor (k) is proportional to the total number of neutrons, prompt and delayed, emitted per fission. However, since only the fraction (1-β) of the fission neutrons are prompt, the fraction of prompt neutrons from with regards to the multiplication factor is (1-β)k. Therefore, when (1-β)k=1, the reactor is critical on prompt neutrons alone, and the reactor is said to be prompt critical. If you rearrange (1-β)k=1 it will read $k = \frac{1}{1-\beta}$.
Lamarsh, J. 2001. Introduction to Nuclear Engineering 3rd Ed.. pp.340-341

A.17
Answer: a
Reference: DOE Handbook Vol I, pg. 45

Section A Rx Theory, Thermo & Fac. Operating Characteristics

A.18
Answer: c
Reference: The thermalized neutrons are not absorbed as quickly in the reflector as neutrons thermalized in the core since the reflector, being unfueled, has a much smaller absorption cross-section. The thermal neutrons tend to accumulate in the reflector until they leak back into the core, escape from the outer surface of the reflector, or are absorbed.
Lamarsh, J. 2001. Introduction to Nuclear Engineering 3rd Ed.. p. 305.

A.19
Answer: a
Reference: PSTR Training Manual, Chapter 7 pg. 31

A.20
Answer: b
Reference: PSTR Tech. Specs. 3.1.4

Section B Normal/Emergency Procedures and Radiological Controls

B.1
Answer: c
Reference: 10 CFR 20

B.2
Answer: d
Reference: NRC Form 3. http://www.nrc.gov/reading-rm/doc-collections/forms/form3_us.pdf

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

B.4
Answer: b
Reference: 10CFR20.1003 and NRC Training Material

B.5
Answer: a.
Reference: PSBR Training Manual, Chapter 7, pg. 4; 10CFR20.1003

B.6
Answer: c.
Reference: 10CFR50.54(y)

B.7
Answer: b
Reference: PSBR Training Manual, Chapter 7, pg. 31
$R/hr = 6CE/r^2 = 6 \times 5 \times 2.5 / 6^2 = 2.08$ R/hr

B.8
Answer: b
Reference: PSBR Tech. Specs. Section 1.0

B.9
Answer: b
Reference: PSBR Tech. Specs 3.1.4 Bases

B.10
Answer: a
Reference: PSBR Tech. Specs. 3.2.4

B.11
Answer: d
Reference: Byproduct material is radioactive material made radioactive by the process of using special nuclear material; 10 CFR Part 20.1003

B.12
Answer: c
Reference: SOP-9.C.2

B.13
Answer: a
Reference: AP-1

Section B Normal/Emergency Procedures and Radiological Controls

B.14
Answer: b
Reference: 10CFR55.53(e)

B.15
Answer: a
Reference: Emergency Procedure EP-1

B.16
Answer: a
Reference: EP-5 Section V (G)

B.17
Answer: a
Reference: EP-1.B.4

B.18
Answer: a
Reference: Tech. Specs. 3.5

B.19
Answer: d
Reference: PSBR SAR Chapter 11

B.20
Answer: a, 2 b, 4 c, 1 d, 4
Reference: SOP-3; AP-17; SP-2; AOP-4

Section C Facility and Radiation Monitoring Systems

C.01
Answer: b
Reference: PSBR Training Manual, Page 4-30

C.02
Answer: c
Reference: PSBR Training Manual, Section 3.20.

C.03
Answer: c
Reference: PSBR Training Manual, Section 3.2

C.04
Answer: c
Reference: PSBR Training Manual, Section 4.9

C.05
Answer: a
Reference: CCP-4

C.06
Answer: d
Reference: PSBR Training Manual, Section 4.20.1

C.07
Answer: d
Reference: PSBR Training Manual, Figure 3.8, Page 3-13.

C.08
Answer: b
Reference: PSBR Training Manual, Section 3.25

C.09
Answer: c
Reference: PSBR Training Manual, Section 4.20.6.1b

C.10
Answer: b
Reference: PSBR Training Manual, Section 3.17

C.11
Answer: b
Reference: PSBR Training Manual, Section 3.14.

C.12
Answer: d
Reference: PSBR Training Manual, Section 3.11

C.13
Answer: d
Reference: PSBR Training Manual, Section 4.20.6.1b

Section C Facility and Radiation Monitoring Systems

C.14
Answer: d
Reference: PSBR Training Manual, Section 4.20.4.2

C.15
Answer: b
Reference: PSBR Training Manual, Section 3.9

C.16
Answer: a
Reference: PSBR Training Manual, Section 3.5

C.17
Answer: b
Reference: PSBR Training Manual, Section 4.20.7.2c

C.18
Answer: c
Reference: PSBR Training Manual, page 4-29

C.19
Answer: b
Reference: PSBR Training Manual, Section 3.8

C.20
Answer d
Reference: EP-3; Figure 1, Control System Power Distribution