UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

September 18, 2025

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

SUBJECT: EXAMINATION REPORT NO. 50-005/OL-25-01, THE PENNSYLVANIA STATE UNIVERSITY

Dear Dr. Unlu:

During the week of August 18, 2025, the U.S. Nuclear Regulatory Commission (NRC) administered an operator licensing examination at The 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. 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 component of NRC's Agencywide Documents Access and Management System (ADAMS). ADAMS is accessible from the NRC website 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 Margaret Goodwin at (301) 415-1177 or via email at Margaret.Goodwin@nrc.gov.

Sincerely,

Signed by Brown, Tony
on 09/18/25

Tony Brown, Chief
Non-Power Production and Utilization Facility
Oversight Branch
Division of Advanced Reactors and Non-Power
Production and Utilization Facilities
Office of Nuclear Reactor Regulation

Docket No. 50-005

Enclosures:
1. Examination Report No. 50-005/OL-25-01
2. Facility Comments with NRC Resolution
3. Written examination

cc: w/enclosures to GovDelivery Subscribers

SUBJECT: EXAMINATION REPORT NO. 50-005/OL-25-01, THE PENNSYLVANIA STATE UNIVERSITY DATED: SEPTEMBER 18, 2025

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

REPORT NO.: 50-005/OL-25-01

FACILITY DOCKET NO.: 50-005

FACILITY LICENSE NO.: R-2

FACILITY: Pennsylvania State University

EXAMINATION DATES: Week of August 18, 2025

SUBMITTED BY: Margaret N. Goodwin — 9/4/2025
Name, Chief Examiner — Date

SUMMARY:
During the week of August 18, 2025, the NRC administered operator licensing examinations to two Reactor Operator (RO) and three Senior Reactor Operator – Upgrade (SRO-U) candidates. All candidates passed all applicable portions of the examinations and tests.

REPORT DETAILS

1. Examiner: Margaret N. Goodwin, 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	3/0	5/0
Overall	2/0	3/0	5/0

3. Exit Meeting:
Jeffrey Geuther, Associate Director of Operations, Pennsylvania State University
Sean Herrmann, Operations Coordinator, Pennsylvania State University
Margaret N. Goodwin, Chief Examiner, NRC

Prior to administration of the written examination, based on facility comments, adjustments were accepted. Comments provided corrections and additional clarity to questions/answers and identified where changes were appropriate based on current facility conditions. Upon completion of all operator licensing examinations, the NRC examiner met with facility staff representatives to discuss the results. At the conclusion of the meeting, the NRC examiner thanked the facility for their support in the administration of the examination.

FACILITY COMMENTS AND NRC RESOLUTION

QUESTION B.09 [1.0 point]
In accordance with PSBR Emergency Procedure 3, Power Failure, which ONE of the following actions must be taken upon loss of facility power?

a. Turn off console power.

b. Review the Industrial Sabotage procedure.

c. Place a Do Not Operate tag on the console key switch.

d. Secure the primary cooling system.

Answer: a
Reference: PSBR Emergency Procedure 3, Power Failure p. 10

Facility Comment B.9
In Section E of procedure EP-3, it specifies that console power down (answer A) is followed by placing a DNO tag on the console (answer C). It's possible that the intent of the question was to ask whether the key switch must be turned to the OFF position vs. powering down the console. If so, this should be clarified.

If you look at EP-3 VII.A.1 (momentary outage), you are directed to section VII.B, which gives a list of equipment operability checks. After these are complete, the procedure moves back to section VII.A. Step VII.A.4 states that "IF it is necessary to power down the console (e.g., secure the UPS due to low runtime, bypass/unbypass UPS, etc.), THEN go to VII.E below"

This set of steps set up specific conditions when the power to the console would need to be shut off, and allows for conditions when, for example, we can keep operating if there is a "blip" in power but the UPS has sufficient capacity to carry the console load.

NRC Resolution B.9
The NRC determined the justification for two correct answers is supported and the NRC accepts this change. Future questions will be worded to reflect the clarification.

QUESTION C.02 [1.0 point]
In accordance with the PSBR Safety Analysis Report, which ONE of the following scenarios would result in a reactor stepback?

a. High pool temperature alarm.

b. Initiation of the emergency evacuation system.

c. Low pool level alarm.

d. Fuel temperature high alarm.

Answer: d
Reference: PSBR SAR 7.3.1.2

Facility Comment C.2
It is correct that a stepback is caused by high fuel temperature, but it is also caused by reactor operation inhibit. High pool temperature is an inhibit condition and would therefore cause a stepback.

NRC Resolution C.2
The NRC determined the justification for two correct answers is supported and the NRC accepts this change.

Pennsylvania State Breazeale Reactor

Operator Licensing Examination

Week of August 18, 2025

Enclosure 3

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

FACILITY: Pennsylvania State University
Breazeale Reactor

REACTOR TYPE: TRIGA

DATE ADMINISTERED: August 20, 2025

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 and a 70% overall are 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	33.0	_____	_____	A. REACTOR THEORY, THERMODYNAMICS, AND FACILITY OPERATING CHARACTERISTICS
20.00	33.0	_____	_____	B. NORMAL AND EMERGENCY OPERATING PROCEDURES AND RADIOLOGICAL CONTROLS
20.00	33.0	_____	_____	C. FACILITY AND RADIATION MONITORING SYSTEMS
60.00		_____	_____%	TOTALS
		FINAL GRADE		

All 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. As well as a grade of 70 percent or greater overall.

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

Category A: Reactor Theory, Thermodynamics, & Facility Operating Characteristics

A N S W E R S H E E T

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

A01 a b c d ___

A02 a b c d ___

A03 a b c d ___

A04 a b c d ___

A05 a b c d ___

A06 a b c d ___

A07 a b c d ___

A08 a b c d ___

A09 a b c d ___

A10 a b c d ___

A11 a b c d ___

A12 a b c d ___

A13 a b c d ___

A14 a b c d ___

A15 a b c d ___

A16 a b c d ___

A17 a b c d ___

A18 a b c d ___

A19 a b c d ___

A20 a b c d ___

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

A N S W E R S H E E T

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

B01 a b c d ___

B02 a b c d ___

B03 a b c d ___

B04 a b c d ___

B05 a b c d ___

B06 a b c d ___

B07 a b c d ___

B08 a b c d ___

B09 a b c d ___

B10 a b c d ___

B11 a b c d ___

B12 a b c d ___

B13 a b c d ___

B14 a b c d ___

B15 a b c d ___

B16 a b c d ___

B17 a b c d ___

B18 a b c d ___

B19 a b c d ___

B20 a b c d ___

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

Category C: Facility and Radiation Monitoring Systems

A N S W E R S H E E T

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

C01 a b c d ___

C02 a b c d ___

C03 a b c d ___

C04 a b c d ___

C05 a b c d ___

C06 a b c d ___

C07 a b c d ___

C08 a b c d ___

C09 a b c d ___

C10 a b c d ___

C11 a b c d ___

C12 a b c d ___

C13 a b c d ___

C14 a b c d ___

C15 a b c d ___

C16 a b c d ___

C17 a b c d ___

C18 a b c d ___

C19 a b c d ___

C20 a b c d ___

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

EQUATION SHEET

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

1 Horsepower = 2.54 x 10^3 BTU/hr

1 BTU = 778 ft-lb

1 gal (H_2O) ≈ 8 lb

c_P = 1.0 BTU/hr/lb/°F

1 kg = 2.21 lb

1 Mw = 3.41 x 10^6 BTU/hr

°F = 9/5 °C + 32

°C = 5/9 (°F - 32)

c_p = 1 cal/sec/gm/°C

Category A: Reactor Theory, Thermodynamics, and Facility Operating Characteristics

QUESTION A.01 [1.0 point]
Which ONE of the following statements best describes a fissile isotope?

a. An isotope that ordinarily generates a greater than average number of neutrons per fission.

b. An isotope that can generate other similarly fissile isotopes.

c. An isotope that requires a high energy neutron to fission.

d. An isotope that can fission with a zero-energy neutron.

QUESTION A.02 [1.0 point]
Which ONE of the following equations best represents the effective multiplication factor?

a. $\frac{neutron\ production + removal\ from\ the\ current\ generation}{neutron\ production + removal\ from\ the\ preceding\ generation}$

b. $\frac{neutron\ production\ from\ one\ generation}{neutron\ removal\ in\ the\ preceding\ generation}$

c. $\frac{neutron\ production\ in\ the\ current\ generation}{neutron\ production\ in\ the\ first\ generation}$

d. $\frac{neutron\ production\ in\ the\ first\ generation}{neutron\ removal\ in\ the\ current\ generation}$

QUESTION A.03 [1.0 point]
Xenon-135 in an operating reactor is predominantly produced from _____ and removed through _____.

a. Decay of I-135; Burnup

b. Decay of I-135; Decay of Xe-135

c. Direct Fission; Burnup

d. Direct Fission; Decay of Xe-135

QUESTION A.04 [1.0 point]
Which ONE of the following actions would result in a DECREASE in the reactivity worth of a control rod?

a. Placing another control rod in an adjacent grid position.

b. Replacing an adjacent water filled location with a graphite reflector.

c. Replacing the surrounding low enriched fuel with highly enriched fuel.

d. Replacing an adjacent graphite reflector element with a fuel experiment.

QUESTION A.05 [1.0 point]
Which ONE of the following best describes the purpose of a burnable poison?

a. To prevent an unexpected prompt criticality upon first startup.

b. To maintain a constant critical rod position in the beginning of the core lifetime.

c. To ensure that the fuel does not burn up quickly, prolonging the life of the reactor.

d. To ensure there is sufficient negative reactivity that only two control rods are needed to shutdown the reactor.

QUESTION A.06 [1.0 point]
Which ONE of the following best describes the Binding Energy of an atom?

a. The energy difference between and atom and the sum of its protons, neutrons, and electrons.

b. The minimum amount of excitation required for fission to occur.

c. The amount of energy required for an incident neutron to cause fission.

d. The amount of energy required for an incident neutron to be absorbed by an atom.

QUESTION A.07 [1.0 point]
If the K_{inf} of the reactor is 1.088, what is K_{eff} with a Fast Non-Leakage Probability of 0.928 and a Thermal Non-Leakage Probability of 1.013?

a. 0.786

b. 0.997

c. 1.017

d. 1.023

QUESTION A.08 [1.0 point]
With respect to the nuclear force, all of the following are TRUE EXCEPT:

a. It has an extremely short range of force on the order of 10^{-13} cm.

b. The number of atoms it can attract is only limited by their proximity to each other.

c. It is stronger than the electrostatic repulsive forces of the nucleus.

d. The force between two neutrons in a nucleus is equal to the force between a neutron and a proton in the same nucleus at the same distance.

QUESTION A.09 [1.0 point]
Which ONE of the following BEST describes the primary function of the control rods?

a. Provide the ability to pulse through the use of pneumatically powered control rods.

b. Provide sufficient core excess to perform in-core experiments.

c. Maintain the temperature of the fuel below the safety limit.

d. Performing reactor startups, power changes, and shutdowns.

QUESTION A.10 [1.0 point]
What would be the new reactor power immediately after a reactivity of 0.006 were added while operating at 50 kW with $\beta = 0.007$?

a. 348 kW

b. 516 kW

c. 724 kW

d. 892 kW

QUESTION A.11 [1.0 point]
Which ONE of the following BEST describes Compton scattering?

a. An alpha particle hits the nucleus of an atom and imparts a significant amount of energy into it.

b. An electron is ejected from an atom when a high energy beta particle hits it.

c. A neutron is absorbed by an atom and imparts some energy which is released when another neutron is ejected from the nucleus.

d. A gamma ray hits an orbital electron depositing some amount of energy into the electron.

QUESTION A.12 [1.0 point]
What is the reactor period if it takes 40 seconds for reactor power to increase from 100kW to 750 kW?

a. 10 seconds

b. 20 seconds

c. 40 seconds

d. 60 seconds

QUESTION A.13 [1.00 point]
Which ONE of the following conditions will require the withdrawal of control rods to maintain reactor power?

a. An increase in temperature of the ZrH in the fuel.

b. An increase in pool water temperature from 30^{o} C to 45^{o} C.

c. Moving the core closer to the D_2O tank.

d. Moving the nuclear instruments closer to the core.

QUESTION A.14 [1.0 point]
Which ONE of the following BEST describes the neutron transport equation?

a. It is the number of neutrons leaking out of the core at all energies.

b. It is the number of fission neutrons that exit the fuel at any given moment.

c. It is the number of neutrons of all energies in a given volume.

d. The number of neutrons added and removed from a given volume is dependent on energy and direction.

QUESTION A.15 [1.0 point]
Which ONE of the following isotopes is a fission product poison?

a. Bromine-87

b. Samarium-149

c. Erbium-166

d. Tellurium-135

QUESTION A.16 [1.0 point]
If the reactor is operating with a K_{eff} of 1.00 and a β_{eff} = 0.007, what will the new K_{eff} be if $0.50 of negative reactivity is added to the reactor?

a. 0.872

b. 0.981

c. 0.986

d. 0.997

QUESTION A.17 [1.0 point]
If K_{eff} = 0.87 with a count rate of 672 cps, what count rate correlates to a K_{eff} of 0.96?

a. 207 cps

b. 1097 cps

c. 1547 cps

d. 2184 cps

QUESTION A.18 [1.0 point]
Which ONE of the following fission products has the GREATEST kinetic energy?

a. Fission fragments

b. Fission neutrons

c. Fission gammas

d. Fission X-rays

QUESTION A.19 [1.0 point]
In which ONE of the following scenarios is Fick's Law of Diffusion VALID?

a. In a strong neutron absorbing medium.

b. Within approximately 3 mean free paths of another neutron source.

c. When the scattering of neutrons varies greatly in all directions.

d. When the medium has an exceedingly low atomic mass.

QUESTION A.20 [1.0 point]
Which ONE of the following best describes the neutron flux of TRIGA fuel along the length of the element?

a. It is highest at the center then decreases towards the graphite end fittings.

b. It is highest at the top of the fuel element and decreases linearly along the length of the fuel.

c. It is highest at the center with spikes at both of the graphite end fittings.

d. It is highest where the fuel meets the graphite end fittings and is otherwise uniform along the length of the fuel.

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

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.01 [1.0 point]
In accordance with the PSBR Technical Specifications, which ONE of the following surveillances shall be completed daily?

a. Measurement of the core excess reactivity.

b. A measurement of the reactivity insertion rate times for control rods.

c. A channel check of the rod interlock preventing the withdrawal of multiple control rods.

d. Measurement of the pool water conductivity.

QUESTION B.02 [1.0 point]
In accordance with the PSBR Standard Operating Procedure 11, Reactor Operations at the Beam Port, why should the beam port plugs remain in place for 10 hours after reactor shutdown?

a. To allow for the decay of Ar-41.

b. To ensure sufficient shielding of the core before it can be moved.

c. To provide adequate decay time for any experiments in place.

d. To allow time to verify that there are no leaks present in the beam ports.

QUESTION B.03 [1.0 point]
In accordance with PSBR Standard Operating Procedure 2, Daily Checkout Procedure, which ONE of the following conditions would prohibit reactor operations?

a. Failure of the intrusion alarm to actuate when tested.

b. Failure of the low source level interlock to actuate upon removal of the source.

c. Discovery that the purification system conductivity cell reading is out of service.

d. Discovery that the Gamma Ionization Chamber High Power SCRAM will only actuate at power levels above 112%.

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.04 [1.0 point]
In accordance with PSBR Standard Operation Procedure 3, Core Loading and Fuel Handling, which ONE of the following TRIGA Fuel Elements may be placed in the B-ring?

a. A new 8.5 wgt% element

b. A 12 wgt% element with 12 Mega Watt Days of burnup

c. A fresh 12 wgt% element

d. An instrumented 12 wgt% element

QUESTION B.05 [1.0 point]
In accordance with PSBR Standard Operating Procedure 7, Qualification of Reactor Pool Reactor Operating Positions, when qualifying a new core position, all of the following are done EXCEPT:

a. A background radiation survey in the Reactor Bay.

b. Determination of scram times for all control rods.

c. Determination of control rod withdrawal speeds.

d. Determination of critical rod positions at 50 watts while in a known core position.

QUESTION B.06 [1.0 point]
In accordance with the PSBR Technical Specifications, all of the following would prohibit reactor operations EXCEPT:

a. Loss of the emergency exhaust system for a period exceeding 48 hours.

b. Discovery that the Reactor Bay Heating, Ventilation and Exhaust System is inoperable.

c. Sporadic loss of negative differential pressure lasting less than 30 minutes.

d. Loss of negative differential pressure causing the reactor bay heating ventilation and exhaust system indicator lamp to go out for greater than 1 hour.

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.07 [1.0 point]
In accordance with PSBR Standard Operating Procedure 6, Experiment Encapsulation and Irradiation, what should be done prior to using experiment encapsulation materials for the first time?

a. Encapsulation materials must be studied to determine their behavior during Loss of Coolant Accidents.

b. Encapsulation materials must undergo high temperature testing to determine their melting point.

c. Encapsulation materials must undergo Neutron Activation Analysis to determine any potential activation concerns.

d. Encapsulation materials cannot be used in the vertical tube system without studying their response to off-gassing methods.

QUESTION B.08 [1.0 point]
Which ONE of the following events would result in an occupational worker exceeding their federal radiation dose limits?

a. Handling an irradiated experiment for 10 minutes emitting an extremity dose rate of 600mrem/hr.

b. An accidental exposure of radioactive powder to the eye emitting a dose rate of 200 rem/hr that takes 6 minutes to clean.

c. Working in a radiation area for a total of 20 hours over the course of a year.

d. Handling irradiated material emitting a dose rate of 60 rem/hr for 2 minutes.

QUESTION B.09 [1.0 point]In accordance with PSBR Emergency Procedure 3, Power Failure, which ONE of the following actions must be taken upon loss of facility power?

a. Turn off console power.

b. Review the Industrial Sabotage procedure.

c. Place a Do Not Operate tag on the console key switch.

d. Secure the primary cooling system.

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.10 [1.0 point]
In accordance with PSBR Checks and Calibrations Procedure 11, Core Reactivity Evaluation, which ONE of the following conditions MUST be met when calculating core excess reactivity?

a. The reactor must be in the R1 position.

b. The reactor must be xenon free.

c. The reactor must have the source installed.

d. The reactor tank water must be less than 30 °C.

QUESTION B.11 [1.0 point]
In accordance with PSBR Special Procedure 3, Pool Cooling System, which ONE of the following actions must be taken in the event of a leak between the primary and secondary cooling systems within the heat exchanger?

a. The water in the reactor tank must be sampled to check pH and conductivity are within operational limits to determine if operations may continue.

b. Monitor reactor pool water level and add water as necessary.

c. The reactor pool cooling system must be secured and the primary pump must be shut off prior to the secondary pump.

d. The reactor operator must immediately SCRAM and secure the reactor.

QUESTION B.12 [1.0 point]
In accordance with PSBR Auxiliary Operating Procedure 11, Handling of Potentially Contaminated Material in a Radioactive Materials Laboratory, what should be done with used gloves that indicate 900cpm on a pancake Geiger-Mueller

a. Gloves indicating less than 1000 cpm can be disposed of in a used glove container.

b. The gloves should be disposed of in a marked radioactive waste container with no further analysis.

c. The SRO should be notified and the entire lab should be marked ‘Contaminated DO NOT ENTER’ until a full radioactive contamination survey can be performed.

d. The gloves should be bagged and a gamma analysis performed to determine the isotopes present.

QUESTION B.13 [1.0 point]
A 0.25 Ci source is generating 2 MeV gammas at a distance of 3 feet. What is the dose rate produced by the source?

a. 0.33 rem/s

b. 1.00 rem/s

c. 1.50 rem/s

d. 1.67 rem/s

QUESTION B.14 [1.0 point]
If an irradiated experiment is emitting a dose rate of 45 mrem/hr when measured 10 cm away, what is the dose rate 50 cm away?

a. 0.01 mrem/hr

b. 1.80 mrem/hr

c. 4.50 mrem/hr

d. 9.00 mrem/hr

QUESTION B.15 [1.0 point]
In accordance with PSBR Standard Operating Procedure 9, Pneumatic Transfer System Operation, which ONE of the following events would require a reactor shutdown?

a. A sample container returning to the terminus visibly broken and missing pieces.

b. A High Alarm on the Room 2B Vent Hood Radiation Monitor.

c. A sample returning to the terminus emitting a higher than expected dose with no associated alarms.

d. A Rabbit 1 Low Pressure Alarm.

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.16 [1.0 point]
In accordance with PSBR Standard Operating Procedure 8, Disposition of Irradiated Materials, when removing irradiated samples from the pool while the reactor is shutdown, all of the following items are required EXCEPT:

a. Full body and extremity dosimetry.

b. Personal PPE such as a lab coat and disposable gloves.

c. A Radiation Work Permit verifying the material irradiated and required decay time.

d. A Ludlum 9-3 or equivalent detector that is working properly and within the calibration period.

QUESTION B.17 [1.0 point]
In accordance with PBSR Emergency Procedure 4, Loss of Reactor Pool Water, all of the following actions should be taken EXCEPT:

a. SCRAM the reactor and notify the SRO.

b. Investigate the source of the leak.

c. Determine the leakage rate.

d. Move the core and install the divider gate prior to finding the source of the leak.

QUESTION B.18 [1.0 point]
In accordance with the PSBR Emergency Preparedness Plan, which ONE of the following conditions/events would be classified as an Alert?

a. A radioactive release resulting in a deep dose equivalent of 10 mrem in 24 hours at the site boundary.

b. Damage to the fuel resulting in the release of radionuclides into the reactor bay.

c. A leak in the reactor tank resulting in a water loss of 500 gpm.

d. A bomb threat to the facility.

QUESTION B.19 [1.0 point]
What is the half-life of a radioactive sample if the decay constant is 0.003 sec^{-1}?

a. 112 seconds

b. 231 seconds

c. 770 seconds

d. 982 seconds

QUESTION B.20 [1.0 point]
In accordance with PSBR Standard Operating Procedure 2, Daily Checkout Procedure, which ONE of the following is a CHANNEL TEST?

a. Recording the radiation monitor readings from the units on the auxiliary equipment rack.

b. Verifying the EVACUATION INITIATE console pushbutton activates the Emergency Exhaust System.

c. Calculating the amount of water lost overnight to determine if a tank leak is present.

d. Shortening the time for the preset timer scram after discovering it took 16 seconds to initiate.

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

Category C: Facility and Radiation Monitoring Systems

QUESTION C.01 [1.0 point]
In accordance with the PSBR Safety Analysis Report, all of the following are a part of the Reactor Safety System EXCEPT:

a. The Fission Chamber

b. The Instrumented Fuel Element

c. The Control Rods

d. The Gamma Ion Chamber

QUESTION C.02 [1.0 point]
In accordance with the PSBR Safety Analysis Report, which ONE of the following scenarios would result in a reactor stepback?

a. High pool temperature alarm.

b. Initiation of the emergency evacuation system.

c. Low pool level alarm.

d. Fuel temperature high alarm.

QUESTION C.03 [1.0 point]
In accordance with the PSBR SAR, all of the following Radiation Monitor Alarms will initiate a scram EXCEPT:

a. Reactor Bridge West High Monitor

b. Co-60 Lab Monitor

c. South Bay Monitor

d. Neutron Beam Lab Monitor

Category C: Facility and Radiation Monitoring Systems

QUESTION C.04 [1.0 point]
In accordance with the PSBR SAR, which ONE of the following statements BEST describes what happens as fuel temperature INCREASES?

a. The temperature of the Zr-H moderator increases resulting in a decrease in the efficiency of the moderator.

b. The pressure in the fission gas between the fuel and cladding decreases resulting in a reactivity decrease.

c. The average neutron energy increases resulting in an increase in reactor power.

d. The thermal conductivity of the cladding decreases resulting in a further increase in fuel temperature.

QUESTION C.05 [1.0 point]
In accordance with the PSBR SAR, which ONE of the following conditions would indicate the large air compressor has failed?

a. A loss of differential pressure between the reactor bay and the outside.

b. A loss of air to the pneumatic transfer system.

c. A loss of air pressure in the transient rod.

d. A loss of air flow through the East and West Air Monitors.

QUESTION C.06 [1.0 point]
In accordance with the PSBR SAR, during a loss of facility power, all of the following equipment will continue to function without interruption EXCEPT:

a. East and West Wall Radiation Monitors.

b. PA System and Evacuation alarm.

c. Control Rod Drives and Motors

d. Facility Lighting System.

Category C: Facility and Radiation Monitoring Systems

QUESTION C.07 [1.0 point]
In accordance with the PSBR SAR, which ONE of the following conditions would indicate that the D_2O tank is leaking into the core while the reactor is operating in the D_2O position?

a. Core excess reactivity would decrease.

b. The fuel temperature would decrease.

c. Bulk pool temperature would decrease.

d. Primary coolant outlet conductivity would decrease.

QUESTION C.08 [1.0 point]
In accordance with the PSBR SAR, which ONE of the following would increase the peak fuel temperature during a reactor pulse?

a. Increasing the total reactivity worth of the transient rod.

b. Increasing the amount of reactivity used to pulse.

c. Increasing the preset timer scram from 15 seconds to 20 seconds.

d. Increasing the number of control rods in the core from 4 to 5 rods.

QUESTION C.09 [1.0 point]
In accordance with the PSBR Technical Specifications, all of the following are bases for the Technical Specification limit on pool level EXCEPT:

a. It provides sufficient shielding to protect personnel.

b. It provides sufficient cooling through natural circulation.

c. It provides sufficient moderation to maintain a shutdown condition.

d. It provides sufficient time to shut the reactor down during a Loss of Coolant Accident.

Category C: Facility and Radiation Monitoring Systems

QUESTION C.10 [1.0 point]
In accordance with the PSBR SAR, which ONE of the following maintains the negative differential pressure when the Emergency Exhaust System is actuated?

a. The filter bank.

b. Closing the air inlet system dampers.

c. Closing the rooftop exhaust stacks and opening the emergency exhaust stack.

d. Increasing the flow of air through the air monitors and out through the rooftop exhaust system.

QUESTION C.11 [1.0 point]
In accordance with the PSBR SAR, all of the following conditions prevent control rod movement prior to and during reactor operations EXCEPT:

a. A source count rate below 2cps.

b. Pushing more than one “down” pushbutton

c. A reactor period faster than 3 seconds.

d. Operating in pulse mode

QUESTION C.12 [1.0 point]
In accordance with the PSBR Safety Analysis Report, which ONE of the following experimental facilities has the GREATEST neutron flux?

a. The D_2O tank.

b. The Fast Neutron Irradiator

c. The Central Thimble

d. The Fast Flux Tube

Category C: Facility and Radiation Monitoring Systems

QUESTION C.13 [1.0 point]
In accordance with the PSBR SAR, which ONE of the following systems is utilized to conserve reactor pool water when the tank needs to be drained?

a. Transferring the pool water into the Thompson pool.

b. Pumping the pool water into the university water system through the floor drains for reuse.

c. The pool storage tank.

d. There is no system in place to conserve water when draining the tank.

QUESTION C.14 [1.0 point]
In accordance with PSBR SAR 6.1, which ONE of the following features are used at the PSBR to limit the exchange or release of effluents to the outside environment?

a. The Reactor Tank Bioshield

b. The Fuel Cladding.

c. Facility Containment

d. Facility Confinement

QUESTION C.15 [1.0 point]
In accordance with the PSBR SAR, which ONE of the following statements regarding the watchdog trip is TRUE?

a. The watchdog trip can be reset by refreshing the watchdog.

b. The watchdog trip has a single relay contact to ensure all initiating conditions result in a scram.

c. The watchdog trip only utilizes computer software and no hardware to initiate a reactor scram.

d. The watchdog trip employs latching logic so the tripped state is maintained even after the initiating condition is cleared.

QUESTION C.16 [1.0 point]
In accordance with the PSBR SAR, what water pH range is considered optimal for the stainless steel and aluminum components in the reactor pool?

a. 4-5

b. 5-6

c. 6-7

d. 7-8

Category C: Facility and Radiation Monitoring Systems

QUESTION C.17 [1.0 point]
In accordance with the PSBR SAR, which ONE of the following BEST describes how Nitrogen-16 is mitigated at this facility?

a. The height and volume of water in the tank mitigates Nitrogen-16.

b. The flow of water from the primary cooling system mitigates Nitrogen-16.

c. The demineralizer system is utilized to mitigate Nitrogen-16 by maintaining water cleanliness.

d. The diffuser pump near the core mitigates Nitrogen-16 by increasing the amount of time it takes to reach the pool surface.

QUESTION C.18 [1.0 point]
Which ONE of the following design features minimizes the thermal neutron flux in the Fast Flux Tube and Fast Neutron Irradiator?

a. Shield plugs above each of the tubes.

b. Boron shielding around both of the tubes.

c. Ensuring that both tubes are filled with water.

d. Administratively preventing the reactor from being placed within two feet of either tube.

QUESTION C.19 [1.0 point]
In accordance with PSBR SAR 5.4, the primary coolant cleanup system is responsible for all of the following EXCEPT:

a. Preventing the growth of algae within the reactor tank.

b. Minimizing the corrosion of core components.

c. Limiting the concentration of contaminants in the reactor pool.

d. Maintaining high water clarity.

Category C: Facility and Radiation Monitoring Systems

QUESTION C.20 [1.0 point]
Which ONE of the following actions would increase the amount of Ar-41 produced at the facility?

a. Replacing all fuel elements with new 8.5 wgt% TRIGA fuel elements.

b. Increasing the flow rate through the facility exhaust system.

c. Increasing the flow rate through the primary coolant system.

d. Increasing the amount of time spent at full power over the year.

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

Category A: Reactor Theory, Thermodynamics, and Facility Operating Characteristics

A.01
Answer: d
Reference: R. R. Burn, *Introduction to Nuclear Reactor Operations*, Vol 2. p. 3-2

A.02
Answer: b
Reference: DOE Fundamentals Handbook *Nuclear Physics and Reactor Theory* Vol. 2 Module 3 p.8

A.03
Answer: a
Reference: DOE Fundamentals Handbook *Nuclear Physics and Reactor* Theory Vol. 2 Module 3 p.36

A.04
Answer: a
Reference: R. R. Burn, *Introduction to Nuclear Reactor Operations*, Vol 4. p. 7-18

A.05
Answer: b
Reference: DOE Fundamentals Handbook *Nuclear Physics and Reactor* Theory Vol. 2 Module 4 p.30

A.06
Answer: a
Reference: DOE Fundamentals Handbook *Nuclear Physics and Reactor* Theory Vol. 1 Module 1 p. 18

A.07
Answer: d
Reference: $K_{eff} = K_{inf} * P_{FNL} * P_{TNL}$
$K_{eff} = 1.088 * 0.928 * 1.013 = 1.023$

A.08
Answer: b
Reference: DOE Fundamentals Handbook *Nuclear Physics and Reactor* Theory Vol. 1 Module 1 p. 49

A.09
Answer: d
Reference: R. R. Burn, *Introduction to Nuclear Reactor Operations*, Vol 4. p. 7-1

A.10
Answer: a
Reference: $P = \frac{\beta * (1-\rho)}{\beta - \rho} * P_0$
$P = \frac{0.007 * (1 - 0.006)}{0.007 - 0.006} * 50$
$P = \frac{0.007 * (0.994)}{0.001} * 50 = 347.9 = 348kW$

A.11
Answer: d
Reference: DOE Fundamentals Handbook *Nuclear Physics and Reactor Theory* Vol. 1 Module 1 p. 66

A.12
Answer: b
Reference: $P = P_0 e^{t/T}$

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

$$\frac{t}{T} = \ln\left(\frac{P}{P_0}\right)$$

$$T = \frac{t}{\ln\left(\frac{P}{P0}\right)}$$

$$T = \frac{40}{\ln(7.5)} = 19.85 = 20$$

A.13
Answer: a
Reference: R. R. Burn, *Introduction to Nuclear Reactor Operations*, Vol 3. p. 6-2

A.14
Answer: d
Reference: Duderstadt & Hamilton, *Nuclear Reactor Analysis*, p 111-112

A.15
Answer: b
Reference: R. R. Burn, *Introduction to Nuclear Reactor Operations*, Vol 4. p. 8-15

A.16
Answer: d
Reference: $\frac{K2 - K1}{K1 * K2} = \Delta\rho$

$$K2 - K1 = \rho(K1 * K2)$$

$$1 - \frac{K1}{K2} = \rho * K1$$

$$1 - \rho * K1 = \frac{K1}{K2}$$

$$K2 = \frac{K1}{1 - \rho * K1}$$

$$\$ = \frac{\rho}{\beta}$$

$$\rho = \$ * \beta =).50 * 0.007 = -0.0035$$

$$K2 = \frac{1.00}{1 - (-0.0035 * 1.00)} = \frac{1.00}{1.0035} = 0.997$$

A.17
Answer: d
Reference: $CR1(1 - k1) = CR2(1 - k2)$

$$CR2 = \frac{CR1 * (1 - k1)}{(1 - k2)}$$

$$CR2 = \frac{672 * 0.13}{0.04} = 2184$$

Category A: Reactor Theory, Thermodynamics, and Facility Operating Characteristics

A.18
Answer: a
Reference: R. R. Burn, *Introduction to Nuclear Reactor Operations*, Vol 2. p. 3-5

A.19
Answer: d
Reference: LaMarsh, *Introduction to Nuclear Engineering*, p. 194

A.20
Answer: a
Reference: NRC Standard Question + PSU MCNP Modeling

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

Category B: Normal/Emergency Operating Procedures and Radiological Controls

B.01
Answer: d
Reference: PSBR Technical Specifications 4.3.3

B.02
Answer: a
Reference: PSBR Standard Operating Procedure 11, Reactor Operation at the Beam Ports, pg. 9

B.03
Answer: d
Reference: PSBR Standard Operating Procedure 2, Daily Checkout Procedure, pgs. 3-10

B.04
Answer: a
Reference: PSBR Standard Operating Procedure 3, Core Loading and Fuel Handling p. 3

B.05
Answer: c
Reference: PSBR Standard Operating Procedure 7, Qualification of Reactor Pool Reactor Operating Positions pgs. 2-3.

B.06
Answer: c
Reference: PSBR Technical Specifications 3.5

B.07
Answer: c
Reference: PSBR Standard Operating Procedure 6, Experiment Encapsulation and Irradiation p. 2

B.08
Answer: b
Reference: $\frac{200\ rem}{hr} * \frac{1\ hr}{60\ min} * \frac{6min}{1} =$ 20 rem dose 10CFR20.1201

B.09
Answer: a or c NRC accepted per facility comment and justification
Reference: PSBR Emergency Procedure 3, Power Failure p. 10

B.10
Answer: b
Reference: PSBR Checks and Calibrations Procedure 11, Core Reactivity Evaluation p. 1

B.11
Answer: c
Reference: PSBR Special Procedure 3, Pool Cooling System p. 3

Category B: Normal/Emergency Operating Procedures and Radiological Controls

B.12
Answer: d
Reference: PSBR Auxiliary Operating Procedure 11, Handling of Potentially Contaminated Material in a Radioactive Materials Laboratory p. 2

B.13
Answer: a
Reference: $DR = \frac{6 * Ci * E(n)}{R^2}$
DR = $\frac{6 * 0.25 * 2}{3^2}$
DR = 0.333 rem/s

B.14
Answer: b
Reference: $DR_1 d_1^2 = DR_2 d_2^2$
$DR_2 = \frac{DR_1 d_1^2}{d_2^2}$
$DR_2 = \frac{45 * 10^2}{50^2}$
$DR_2 = 1.80$

B.15
Answer: a
Reference: PSBR Standard Operating Procedure 9, Pneumatic Transfer System Operation p. 5

B.16
Answer: c
Reference: PSBR Standard Operating Procedure 8, Disposition of Irradiated Materials p. 6

B.17
Answer: d
Reference: PSBR Emergency Procedure 4, Loss of Reactor Pool Water p. 3

B.18
Answer: c
Reference: PSBR Emergency Preparedness Plan 4.1 and 4.2

B.19
Answer: b
Reference: $T_{1/2} = \frac{\ln(2)}{Decay\ Constant}$
$T_{1/2} = \frac{\ln(2)}{0.003} = 231\ seconds$

B.20
Answer: b
Reference: PSBR Standard Operating Procedure 2, Daily Checkout Procedure p. 7

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

Category C: Facility and Radiation Monitoring Systems

C.01
Answer: b
Reference: PSBR SAR 7.2.3 and 4.2.2

C.02
Answer: a or d NRC accepted based on facility comment and justification
Reference: PSBR SAR 7.3.1.2

C.03
Answer: a
Reference: PSBR SAR 7.3.1.3

C.04
Answer: a
Reference: PSBR SAR 4.2.3

C.05
Answer: c
Reference: PSBR SAR 9.7.1

C.06
Answer: d
Reference: PSBR SAR 8.1

C.07
Answer: a
Reference: PSBR SAR 10.2.2

C.08
Answer: b
Reference: PSBR SAR 4.5.1

C.09
Answer: c
Reference: PSBR Technical Specifications 3.3.1

C.10
Answer: c
Reference: PSBR SAR 6.1

C.11
Answer: b
Reference: PSBR SAR 7.4.4

C.12
Answer: c
Reference: PSBR SAR 10.2.5

Category C: Facility and Radiation Monitoring Systems

C.13
Answer: c
Reference: PSBR SAR 5.2.1

C.14
Answer: d
Reference: PSBR SAR 6.1

C.15
Answer: d
Reference: PSBR SAR 7.4.2

C.16
Answer: b
Reference: PSBR SAR 5.4

C.17
Answer: d
Reference: PSBR SAR 5.6

C.18
Answer: b
Reference: PSBR SAR 10.2.4

C.19
Answer: a
Reference: PSBR SAR 5.4

C.20
Answer: d
Reference: PSBR SAR 11.1.1.1

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