



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

December 27, 2019

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-20-01, THE PENNSYLVANIA STATE  
UNIVERSITY BREAZEAL RESEARCH REACTOR

Dear Dr. Unlu:

During the week of December 2, 2019, the U.S. Nuclear Regulatory Commission (NRC) administered an operator licensing examination at your Pennsylvania State University research reactor. The examinations were conducted according to NUREG-1478, "Operator Licensing Examiner Standards for Research and Test Reactors," Revision 2. Examination questions and preliminary findings were discussed with those members of your staff identified in the enclosed report at the conclusion of the examination.

In accordance with Title 10 of the *Code of Federal Regulations*, Section 2.390, a copy of this letter and the enclosures will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records (PARS) component of NRC's Agencywide Documents Access and Management System (ADAMS). ADAMS is accessible from the NRC Web site at <http://www.nrc.gov/reading-rm/adams.html>. The NRC is forwarding the individual grades to you in a separate letter which will not be released publicly. Should you have any questions concerning this examination, please contact Mr. John T. Nguyen at (301) 415-4007 or via internet e-mail [John.Nguyen@nrc.gov](mailto:John.Nguyen@nrc.gov).

Sincerely,

A handwritten signature in dark ink, appearing to read "J. Mendiola", is written over a horizontal line.

Anthony J. Mendiola, 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-20-01
2. Written examination

cc: Jeffrey Geuther  
cc: w/o enclosures: See next page

Pennsylvania State University

Docket No. 50-005

cc:

Yuanqing Guo  
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Director, Bureau of Radiation Protection  
Department of Environmental Protection  
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Test, Research and Training  
Reactor Newsletter  
Attention: Ms. Amber Johnson  
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Dr. Jeffrey Geuther  
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104 Breazeale Nuclear Reactor Building  
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U.S. NUCLEAR REGULATORY COMMISSION  
OPERATOR LICENSING EXAMINATION REPORT

REPORT NO.: 50-005/OL-20-01

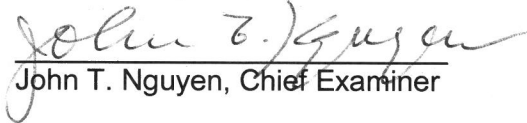
FACILITY DOCKET NO.: 50-005

FACILITY LICENSE NO.: R-2

FACILITY: Pennsylvania State University

EXAMINATION DATES: December 2, 2019

SUBMITTED BY:

  
John T. Nguyen, Chief Examiner

12/16/2019  
Date

**SUMMARY:**

During the week of December 2, 2019, the NRC administered a retake operator licensing examination to one Senior Reactor Operator (SRO) candidate who failed the part B of the written exam on July 30, 2019.

**REPORT DETAILS**

1. Examiner: John T. Nguyen, Chief Examiner, NRC

2. Results:

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

3. Exit Meeting:

There is no exit meeting due to this type of the examination.

ENCLOSURE 1



**THE PENNSYLVANIA STATE  
UNIVERSITY BREAZEAL  
RESEARCH REACTOR**

**Operator Licensing Examination**

**Week of December 2, 2019**

ENCLOSURE 2

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

FACILITY: Pennsylvania State University

REACTOR TYPE: TRIGA

DATE ADMINISTERED: 12/3/2019

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 One (1) hour after the examination starts.

<u>CATEGORY</u>	<u>% OF</u>	<u>CANDIDATE'S</u>	<u>% OF</u>	<u>CATEGORY</u>
<u>VALUE</u>	<u>TOTAL</u>	<u>SCORE</u>	<u>VALUE</u>	<u>CATEGORY</u>
<u>N/A</u>	<u>N/A</u>	_____	_____	A. REACTOR THEORY, THERMODYNAMICS AND FACILITY OPERATING CHARACTERISTICS
<u>20.00</u>	<u>100</u>	_____	_____	B. NORMAL AND EMERGENCY OPERATING PROCEDURES AND RADIOLOGICAL CONTROLS
<u>N/A</u>	<u>N/A</u>	_____	_____	C. FACILITY AND RADIATION MONITORING SYSTEMS
<u>20.00</u>		_____	_____	% TOTALS
		<u>FINAL GRADE</u>		

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

\_\_\_\_\_  
Candidate's Signature

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

**ANSWER SHEET**

Multiple Choice (Circle or X your choice)

If you change your Answer, write your selection in the blank.

N/A

Category B – Normal/Emergency Operating Procedures and Radiological Controls

**ANSWER SHEET**

Multiple Choice (Circle or X your choice)

If you change your Answer, write your selection in the blank.

B01 a \_\_\_ b \_\_\_ c \_\_\_ d \_\_\_ (0.25 each)

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 \_\_\_ (0.25 each)

B07 a b c d \_\_\_

B08 a b c d \_\_\_

B09 a b c d \_\_\_

B10 a \_\_\_ b \_\_\_ c \_\_\_ d \_\_\_ (0.25 each)

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 \_\_\_ (0.25 each)

B16 a b c d \_\_\_

B17 a b c d \_\_\_

B18 a \_\_\_ b \_\_\_ c \_\_\_ d \_\_\_ (0.25 each)

B19 a b c d \_\_\_

B20 a b c d \_\_\_

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

C. PLANT AND RAD MONITORING SYSTEMS

**ANSWER SHEET**

N/A

(\*\*\*\*\* END OF EXAMINATION \*\*\*\*\*)



## NRC RULES AND GUIDELINES FOR LICENSE EXAMINATIONS

During the administration of this examination the following rules apply:

1. Cheating on the examination means an automatic denial of your application and could result in more severe penalties.
2. After the examination has been completed, you must sign the statement on the cover sheet indicating that the work is your own and you have neither received nor given assistance in completing the examination. This must be done after you complete the examination.
3. Restroom trips are to be limited and only one candidate at a time may leave. You must avoid all contacts with anyone outside the examination room to avoid even the appearance or possibility of cheating.
4. Use black ink or dark pencil only to facilitate legible reproductions.
5. Print your name in the blank provided in the upper right-hand corner of the examination cover sheet and each Answer sheet.
6. Mark your Answers on the Answer sheet provided. **USE ONLY THE PAPER PROVIDED AND DO NOT WRITE ON THE BACK SIDE OF THE PAGE.**
7. The point value for each question is indicated in [brackets] after the question.
8. If the intent of a question is unclear, ask questions of the examiner only.
9. When turning in your examination, assemble the completed examination with examination questions, examination aids and Answer sheets. In addition turn in all scrap paper.
10. Ensure all information you wish to have evaluated as part of your Answer is on your Answer sheet. Scrap paper will be disposed of immediately following the examination.
11. To pass the examination you must achieve a grade of 70 percent or greater in each category.
12. There is a time limit of three (3) hours for completion of the examination.

# EQUATION SHEET

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

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

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

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

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

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

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

$$CR_1 \left( \frac{1 - K_{\text{eff}_1}}{1 - K_{\text{eff}_2}} \right) = CR_2 \left( \frac{1 - K_{\text{eff}_2}}{1 - K_{\text{eff}_1}} \right)$$

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

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

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

$$M = \frac{1 - K_{\text{eff}_1}}{1 - K_{\text{eff}_2}}$$

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

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

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

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

$$\Delta \rho = \frac{K_{\text{eff}_2} - K_{\text{eff}_1}}{K_{\text{eff}_1} K_{\text{eff}_2}}$$

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

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

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

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

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

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

**1 Curie = 3.7 x 10<sup>10</sup> dis/sec**

**1 kg = 2.21 lb**

**1 Horsepower = 2.54 x 10<sup>3</sup> BTU/hr**

**1 Mw = 3.41 x 10<sup>6</sup> BTU/hr**

**1 BTU = 778 ft-lb**

**°F = 9/5 °C + 32**

**1 gal (H<sub>2</sub>O) ≈ 8 lb**

**°C = 5/9 (°F - 32)**

**c<sub>p</sub> = 1.0 BTU/hr/lb/°F**

**c<sub>p</sub> = 1 cal/sec/gm/°C**

## Section B: Normal/Emergency Procedures and Radiological Controls

### **QUESTION B.01 [1.0 point, 0.25 each]**

Fill out the blanks with the frequency of the following surveillances required by the PSBR Technical Specifications.

- a. The pulse peak power channel shall be compared to the fuel temperature \_\_\_\_\_ the reactor is pulsed, to ensure proper peak power channel operation. (Each time/ Daily/Weekly/Annually)
- b. A channel test of the detector power supply SCRAM functions for both the wide range and the power range and the watchdog circuit shall be performed \_\_\_\_\_. (Each time/Weekly/Quarterly /Annually)
- c. Channel checks for operability shall be performed \_\_\_\_\_ on fuel element temperature when the reactor is to be operated, or prior to each operation that extends more than one day. (Daily/Weekly/Quarterly /Annually)
- d. The rod drive speed both up and down and the time from SCRAM initiation to the full insertion of any control rod from the full up position shall be measured \_\_\_\_\_. (Daily/Weekly/Quarterly /Annually)

### **QUESTION B.02 [1.0 point]**

80% of the decay of a 2-curie source results in emission of 100 Kev gamma. What is the dose rate at 1 foot?

- a. 0.96 mRem/hr
- b. 960 mRem/hr
- c. 1600 mRem/hr
- d. 9600 mRem/hr

### **QUESTION B.03 [1.0 point]**

An irradiated sample provides a dose rate of 0.7 rem/hr at 5 ft. At 12 feet, the dose rate is approximately \_\_\_\_\_ mrem/hr.

- a. 0.122
- b. 12.2
- c. 122
- d. 1222

## Section B: Normal/Emergency Procedures and Radiological Controls

### **QUESTION B.04 [1.0 point]**

All new experiments shall be reviewed for Technical Specifications compliance, 10 CFR Part 50.59 analysis, and approved in writing by \_\_\_\_\_ management or designated alternate prior to initiation.

- a. level 1
- b. level 2
- c. level 3
- d. level 4

### **QUESTION B.05 [1.0 point]**

Which of the following statements best states the MINIMUM staffing requirements when the reactor is not secured per PSBR Technical Specifications?

- a. 2 ROs in the control room.
- b. 1 SRO + 1 person present at the facility able to carry out prescribed written instructions.
- c. 1 RO in the control room + 1 SRO who can arrive at the facility in 15 minutes.
- d. 1 RO + 1 person present at the facility able to carry out prescribed written instructions.+ 1 SRO who can arrive at the facility in 30 minutes

### **QUESTION B.06 [1.0 point, 0.25 each]**

Fill out the blanks with the Limiting Conditions of Operation (LCO) listed in the PSBR Technical Specifications.

<u>Safety System</u>	<u>LCO</u>
a. The maximum excess reactivity	_____ (\$)
b. The maximum stepped reactivity insertion for pulse operation	_____ (\$)
c. The maximum preset timer	_____ (sec)
d. The maximum rate of reactivity insertion	_____ (\$/sec)

Section B: Normal/Emergency Procedures and Radiological Controls

**QUESTION B.07 [1.0 point]**

Which one of the tag-out color is used for the Administrative tag-out to alert operating staff to temporary administratively imposed limitations on the reactor?

- a. Red
- b. Yellow
- c. White with Danger Insignia
- d. Manila

**QUESTION B.08 [1.0 point]**

You bring a radiation monitor about 1 foot from the demineralizer tank during reactor operation. You measure the radiation reading between close window and the open window of the detector. In comparing to the close window, the reading of the open window would:  
(Assume no piping leaks or contamination.)

- a. increase, because it measures additional beta radiation of Ar-41 decayed.
- b. remain the same, because the Quality Factors for gamma and beta radiation are the same.
- c. increase, because it measures additional radiation of  $N^{16}$  and  $H^3$  betas.
- d. remain the same, because it only measure gamma radiation from the demineralizer tank.

**QUESTION B.09 [1.0 point]**

Which ONE of the following is the definition of Committed Dose Equivalent?

- a. The sum of the deep dose and the committed effective dose equivalent.
- b. The sum of external deep dose equivalent and the organ dose equivalent.
- c. The dose equivalent that the whole body receives from sources outside the body.
- d. The 50 year dose equivalent to an organ or tissue resulting from an intake of radioactive material.

## Section B: Normal/Emergency Procedures and Radiological Controls

### **QUESTION B.10 [1.0 point, 0.25 each]**

Match the 10CFR55 requirements for maintaining an active operator license in column A with the corresponding time period from column B.

	<u>Column A</u>	<u>Column B</u>
a..	Renew License	1 year
b.	Medical Exam	2 years
c.	Pass Requalification Written Examination	4 years
d.	Pass Requalification Operating Test	6 years

### **QUESTION B.11 [1.0 point]**

Which ONE of the following statements correctly describes the relationship between the Safety Limit (SL) and the Limiting Safety System Setting (LSSS)?

- a. The SL is a maximum operationally limiting value that prevents exceeding the LSSS during normal operations.
- b. The SL is a parameter that assures the integrity of the fuel cladding. The LSSS initiates protective actions to preclude reaching the SL.
- c. The SL is a maximum setpoint for instrumentation response. The LSSS is the minimum number of channels required to be operable.
- d. The LSSS is a parameter that assures the integrity of the fuel cladding. The SL initiates protective action to preclude reaching the LSSS.

### **QUESTION B.12 [1.0 point]**

The dose rate from a mixed beta-gamma point source is 100 mrem/hour at one foot and is 0.1 mrem/hour at ten feet. What percentage of the source consists of beta radiation?

- a. 30%
- b. 50%
- c. 70%
- d. 90%

## Section B: Normal/Emergency Procedures and Radiological Controls

### **QUESTION B.13 [1.0 point]**

Per PSBR Standard Operation Procedure, what would you do if the capsule in a pneumatic transfer system fails to return from the reactor core at the proper time?

- a. Keep the RABBIT 1 fan ON
- b. Reduce power and notify the reactor supervisor.
- c. Shutdown the reactor; turn OFF the RABBIT 1 fan and RABBIT 1 Master.
- d. Investigate the cause of the alarm and, if necessary, contact the RPO.

### **QUESTION B.14 [1.0 point]**

Which ONE of the following is the lowest level of permission required to restart the reactor following violation of a Safety Limit?

- a. Senior Reactor Operator
- b. Dean of the Graduate School
- c. Reactor Facility Director
- d. Nuclear Regulatory Commission

### **QUESTION B.15 [1.0 point, 0.25 each]**

Identify each of the following as either a Safety Limit (SL) a Limiting Safety System Setting (LSSS), a Limiting Condition for Operation (LCO), or Design Feature (DF).

- a. The temperature shall not exceed maximum of 650°C as measured with an instrumented fuel element if it is located in a core position representative of the maximum elemental power density (MEPD) in that loading.
- b. The maximum power level shall be no greater than 1.1 megawatt (MW) during steady state operation.
- c. Pulses shall NOT be initiated from power levels above 1 kW. Pulses SHALL NOT be initiated from power levels above 1 kW.
- d. The hydrogen-to-zirconium atom ratio (in the ZrH<sub>x</sub>) of the TRIGA fuel shall be a nominal 1.65 H atoms to 1.0 Zr atom.

Section B: Normal/Emergency Procedures and Radiological Controls

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

If the loss of pool water is expected to use with Fire Hydrant via Fire Company is classified as:

- a. General Emergency
- b. Site Area Emergency
- c. Alert
- d. Unusual Event

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

Which ONE of the following experiments is not allowed to be installed in the reactor or experiment facilities under ANY condition?

- a. Experiment contains any fueled experiment.
- b. Experiment contains any explosive material.
- c. Experiment contains off-gas, sublime, volatilize, or produce aerosols.
- d. The total inventory of iodine isotopes 131 through 135 in the experiment is 2 curies.

**QUESTION B.18 [1.0 point, 0.25 each]**

Match the procedure listed in column A with appropriate its categories listed in column B. Column B can be used once, more than once, or not at all.

<u>Column A</u>	<u>Column B</u>
a. Core loading and fuel handling	1. Emergency Procedure (EP)
b. Fire or explosion	2. Standard Operating Procedure (SOP)
c. Water collection and analysis	3. Special Procedure (SP)
d. Reactor Pool-Water storage tank transfer	4. Auxiliary Operating Procedure (AOP)



Section B: Normal/Emergency Procedures and Radiological Controls

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

While working on an experiment, you receive the following radiation doses: 100 mrem ( $\beta$ ), 25 mrem ( $\gamma$ ), 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

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

During a reactor fuel movement, the Senior Reactor Operator (SRO) becomes ill and taken to the hospital. Only the Reactor Operator (RO) and two experienced trainees remain in the facility. Which of the following statements best describes the reactor operation?

- a. The fuel movement must be discontinued because the PSBR Administrative Procedure requires at least 4 staff members during the operation.
- b. The fuel movement must be discontinued because it required an SRO to be present in the reactor during the fuel movement.
- c. The fuel movement may continue until a replacement SRO can arrive at the facility within 45 minutes.
- d. The fuel movement may continue since the RO can monitor the console while two trainees can move a fuel.

(\*\*\*\*\* END OF CATEGORY B \*\*\*\*\*)  
((\*\*\*\*\* END OF EXAM \*\*\*\*\*))

**B.01**

Answer: a. = Each time      b. = Annually; c. = Daily;      d. = Annually (0.25 each)  
Reference: TS 4.2

**B.02**

Answer: b  
Reference:  $6\text{CEN} = \text{R/hr @ 1 ft.} \rightarrow 6 \times 2 \times 0.8 \times 0.1 = 0.96 \text{ R/hr at 1ft.}$

**B.03**

Answer: c  
Reference:  $\text{DR1} \cdot (\text{D1})^2 = \text{DR2} \cdot (\text{D2})^2$   
 $700 \text{ mRem (5)}^2 = \text{DR} \cdot (12)^2$   
 $\text{DR} = 121.5 \text{ mRem/hr}$

**B.04**

Answer: b  
Reference: TS 6.4

**B.05**

Answer: d  
Reference: TS 6.1.3

**B.06**

Answer: a. = \$7.0;      b. = \$3.50;      c. = 15;      d. = \$0.90 per second (0.25 each)  
Reference: TS 3.2.4

**B.07**

Answer: b  
Reference: PSBR AP 10

**B.08**

Answer: d  
Reference: BASIC Radiological Concept (Betas don't make it through tank)

**B.09**

Answer: d  
Reference: 10CFR20.1003 Definitions

**B.10**

Answer: a. = 6;      b. = 2;      c. = 2;      d. = 1 (0.25 each)  
Reference: 10CFR55.

**B.11**

Answer: b  
Reference: TS 2.1 and 2.2, Objective

**B.12**

Answer: d

Reference: 10CFR20 - At 10 feet, there is no beta radiation.

Calculate gamma at 1 ft.

$$DR_1(D_1)^2 = DR_2(D_2)^2$$

$$0.1(10)^2 = DR_2(1)^2$$

gamma at 1 foot = 10 mrem/hour.

Therefore, beta at 1 foot = 90 mrem/hour or 90%.

**B.13**

Answer: c

Reference: SOP-9.C.2

**B.14**

Answer: d

Reference: NRC Standard Question

**B.15**

Answer: a. = LSSS; b. = LCO; c. = LCO; d. = DF (0.25 each)

Reference: TS 2.1, TS 2.2, TS 3.1, TS 3.2, and TS 5.2

**B.16**

Answer: c

Reference: EP-4

**B.17**

Answer: d

Reference: TS 3.7

**B.18**

Answer: a, 2 b, 1 c, 4 d, 3

Reference: SOP-2; AOP-5, EP-2; SP-2

**B.19**

Answer: d

Reference: Reactor Training Manual - *Ionizing Radiation (already converted to mrem)*

**B.20**

Answer: b

Reference: AP-1

SUBJECT: EXAMINATION REPORT NO. 50-005/OL-20-01, THE PENNSYLVANIA STATE  
UNIVERSITY BREAZEALE RESEARCH REACTOR DATED:  
DECEMBER 27, 2019

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NAME	JNguyen	ZTaru	AMendiola
DATE	12/16/2019	12/19/2019	12/27/2019

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