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

December 20, 2018

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

SUBJECT: EXAMINATION REPORT NO. 50-005/OL-19-01, PENNSYLVANIA STATE UNIVERSITY BREAZEALE RESEARCH REACTOR

Dear Dr. Unlu:

During the week of November 26, 2018, 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.

Sincerely,

/RA/

Anthony J. Mendiola, Chief
Research and Test Reactors Oversight Branch
Division of Licensing Projects
Office of Nuclear Reactor Regulation

Docket No. 50-005

Enclosures:
1. Examination Report No. 50-005/OL-19-01
2. Written examination

cc: Jeffrey Geuther

cc: w/o enclosures: See next page

SUBJECT: EXAMINATION REPORT NO. 50-005/OL-19-01, PENNSYLVANIA STATE UNIVERSITY BREAZEALE RESEARCH REACTOR DATED DECEMBER 20, 2018

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OFFICE	NRR/DLP/PROB/CE	NRR/DLP/IOLB/OLA	NRR/DLP/PROB/BC
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DATE	12/17/2018	12/20/2018	12/20/2018

OFFICIAL RECORD COPY

cc:

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U.S. NUCLEAR REGULATORY COMMISSION
OPERATOR LICENSING EXAMINATION REPORT

REPORT NO.: 50-005/OL-19-01

FACILITY DOCKET NO.: 50-005

FACILITY LICENSE NO.: R-2

FACILITY: Pennsylvania State University

EXAMINATION DATES: November 27 - 28, 2018

SUBMITTED BY: ***/RA by Paulette Torres for*** **12/19/2018**
John T. Nguyen, Chief Examiner Date

SUMMARY:
During the week of November 26, 2018, the NRC administered an operator licensing examination to one Reactor Operator (RO), one Senior Reactor Operator Instant (SROI), and one Senior Reactor Operator Upgrade (SROU) candidates. All candidates passed all applicable portions of the examination.

REPORT DETAILS

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

2. Results:

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

3. Exit Meeting:
John T. Nguyen, Chief Examiner, NRC
Mary Jane Ross-Lee, Deputy Director, NRC
Jeffrey Geuther, Associate Director, PSBR

Per discussion with the facility, prior to administration of the examination, adjustments were accepted. Upon completion of the examination, 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.

ENCLOSURE 1

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

FACILITY:	Pennsylvania State University
REACTOR TYPE:	TRIGA
DATE ADMINISTERED:	11/28/2018
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

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

A N S W E R S H E E T

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

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 ___ (0.25 each)

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 ___ (0.25 each)

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

Category B – Normal/Emergency Operating Procedures and Radiological Controls

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.

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 ___ (0.25 each)

B07 a b c d ___

B08 a ___ b ___ c ___ d ___ (0.25 each)

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 ___ (0.25 each)

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 *****)

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.

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 ___ (0.5 each)

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 ___ (0.25 each)

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 ___

(***** 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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$T_{\frac{1}{2}} = \frac{0.693}{\lambda} \frac{K_{eff_2} - K_{eff_1}}{K_{eff_1} K_{eff_2}}$$

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

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

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

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

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

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

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

1 kg = 2.21 lb

1 Horsepower = 2.54 x 10^3 BTU/hr

1 Mw = 3.41 x 10^6 BTU/hr

1 BTU = 778 ft-lb

°F = 9/5 °C + 32

1 gal (H_2O) ≈ 8 lb

°C = 5/9 (°F - 32)

c_P = 1.0 BTU/hr/lb/°F

c_p = 1 cal/sec/gm/°C

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

QUESTION A.01 [1.0 point]
The reactor is critical and increasing in power. Power has increased from 200 W to 800 W in 60 seconds. How long will it take at this rate for power to increase from 8 kW to 16 kW?

a. 3 seconds

b. 13 seconds

c. 30 seconds

d. 63 seconds

QUESTION A.02 [1.0 point]
Which ONE of the following conditions will require the control rod withdrawal to maintain constant power level after the following change?

a. Adding of a fuel experiment such as U-235 into the core.

b. Removal of an experiment containing borated graphite.

c. Increase of pool water temperature.

d. Burnout of Xenon in the core.

QUESTION A.03 [1.0 point]
The reactor is critical at 100 watts. A control rod is withdrawn to insert a positive reactivity of 0.126% $\Delta k/k$. Which ONE of the following will be the stable reactor period as a result of this reactivity insertion? Given beta effective = 0.0078

a. 13 seconds

b. 46 seconds

c. 52 seconds

d. 80 seconds

QUESTION A.04 [1.0 point]
For the $^{0}\beta_{-1}$ decay of a nuclide, the number of protons will _____ and its atomic mass number will _____.

a. increase by 1 / be the same

b. decrease by 1 / be the same

c. decrease by 1 / decrease by 1

d. increase by 1 / increase by 1

QUESTION A.05 [1.0 point]
Which ONE of the following best describes the likelihood of fission occurring in U-235 and U-238?

a. Neutrons at low energy levels (eV) are more likely to cause fission with U-235 than neutrons at higher energy levels (MeV).

b. Neutron cross section of U-235 increases with increasing neutron energy, whereas neutron cross section of U-238 decreases with increasing neutron energy.

c. Neutrons at low energy levels (eV) are more likely to cause fission with U-238 than neutrons at higher energy levels (MeV).

d. Neutron cross sections of U-235 and U-238 are independent from the neutron energy levels.

QUESTION A.06 [1.0 point]
Match the term listed in Column A with its corresponding unit listed in column B.

	Column A	Column B
a.	1 barn	1. cm^{-1}
b.	Macroscopic Cross Section	2. $10^{-24}\ cm^{2}$
c.	Neutron Flux	3. Neutrons / cm^{2} /sec
d.	Reaction Rate	4. Fissions / cm^{3} sec

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

QUESTION A.07 [1.0 point]
Reactor power is 100 watts. Reactor Operator inserts a sample worth of 0.008 ∆k/k into the reactor core. Which ONE of the following best describes the reactor kinetic? The reactor is:

a. subcritical

b. critical

c. supercritical

d. prompt supper critical

QUESTION A.08 [1.0 point]
Reactor power is rising on a 10 second period. Approximately how long will it take for power to quadruple?

a. 14 seconds

b. 29 seconds

c. 55 seconds

d. 72 seconds

QUESTION A.09 [1.0 point]
Several processes occur that may increase or decrease the available number of neutrons. SELECT ONE of the following six-factor formula term that describes an INCREASE in the number of neutrons during the cycle.

a. Reproduction Factor.

b. Thermal Utilization Factor.

c. Resonance Escape Probability.

d. Thermal Non-leakage Probability.

QUESTION A.10 [1.0 point]
Given a source strength of 1000 neutrons per second (N/sec) and a multiplication factor of 0.8, which ONE of the following is the expected stable neutron count rate?

a. 700 N/sec

b. 5000 N/sec

c. 10000 N/sec

d. 20000 N/sec

QUESTION A.11 [1.0 point]
If the multiplication factor, k, is increased from 0.800 to 0.950, the amount of reactivity added is:

a. 0.150 $\Delta k/k$

b. 0.197 $\Delta k/k$

c. 0.250 $\Delta k/k$

d. 0.297 $\Delta k/k$

QUESTION A.12 [1.0 point]
The following data was obtained during a reactor fuel load.

Step	No. of Elements	Detector A (count/sec)
1	0	100
2	4	120
3	8	140
4	12	200
5	15	400

The estimated total number of elements required to achieve criticality is between:

a. 16 to 18

b. 19 to 21

c. 22 to 24

d. 25 to 27

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

QUESTION A.13 [1.0 point]
Which one of the following is the principal source of heat in the reactor after a shutdown from extended operation at 100 KW?

a. Production of delayed neutrons

b. Subcritical reaction of photoneutrons

c. Spontaneous fission of U^{238}

d. Decay of fission fragments

QUESTION A.14 [1.0 point]
Select following isotopes from the largest to smallest microscopic absorption cross-section for thermal neutrons?

a. Sm^{149} B^{10} Xe^{135} U^{235}

b. B^{10} Sm^{149} Xe^{135} U^{235}

c. Xe^{135} Sm^{149} B^{10} U^{235}

d. Xe^{135} U^{235} Sm^{149} B^{10}

QUESTION A.15 [1.0 point]
The K_{eff} for the reactor is 0.955. The reactivity needed to bring the reactor to the criticality is:

a. +0.0471

b. +0.0450

c. -0.0471

d. -0.0450

QUESTION A.16 [1.0 point]
Which one of the following factors in the "six factor" formula is the most affected by the control rod?

a. Fast fission factor (ε).

b. Thermal utilization factor (f).

c. Reproduction factor (η).

d. Resonance escape probability (p).

QUESTION A.17 [1.0 point]
Which ONE of the following is the stable reactor period which will result in a power rise from 10% to 100% power in 10 seconds?

a. 4 seconds

b. 10 seconds

c. 24 seconds

d. 43 seconds

QUESTION A.18 [1.0 point]
An initial count rate is 100 cps. It is doubled five times during a startup. Assuming an initial Keff of 0.950, which one of the following is the new Keff?

a. 0.963

b. 0.974

c. 0.985

d. 0.998

QUESTION A.19 [1.0 point]
The term K_{eff} is defined as …

a. absorption/(production + leakage)

b. (production + leakage)/absorption

c. (absorption + leakage)/production

d. production/(absorption + leakage)

QUESTION A.20 [1.0 point, 0.25 each]
A fissile material is one that will be fission upon absorption of a thermal neutron. A fertile material is one that absorbs a neutron and becomes a fissile material. Identify each of the listed isotopes as either fissile or fertile.

a. Th-232 _____

b. U-235 _____

c. U-238 _____

d. Pu-239 _____

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

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.01 [1.0 point]
An irradiated sample provides a dose rate of 0.5 rem/hr at 3 ft. Approximately how far from the sample reads 10 mrem/hr?

a. 6 ft.

b. 9 ft.

c. 17 ft.

d. 21 ft.

QUESTION B.02 [1.0 point]
How long will it take a 2-Curie source, with a half-life of 2 years, to decay to 0.02 Curie?

a. 4 years

b. 7 years

c. 13 years

d. 17 years

QUESTION B.03 [1.0 point]
The CURIE content of a radioactive source is a measure of:

a. number of radioactive atoms in the source.

b. number of nuclear disintegrations per unit time.

c. amount of damage to soft body tissue per unit time.

d. amount of energy emitted per unit time by the source.

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.04 [1.0 point]
Per PSBR Technical Specifications, substantive changes to experiments previously reviewed by the PSRSC shall be made only after review and approval in writing by _____ or designated alternate.

a. Dean, College of Engineering

b. Manager of Radiation Protection

c. PSBR Director

d. Senior Reactor Operator

QUESTION B.05 [1.0 point]
Per PSBR Technical Specifications, when reactor bay Area Radiation monitor (ARM) is inoperable, the reactor operations:

a. may continue only if Co-60 bay is still operable.

b. may continue only if Continuous Air Monitor is still operable.

c. shall not be operated and the licensed operator shall report to the supervisor.

d. may continue if portable gamma sensitive instruments having their own alarm are substituted.

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.

	Safety System	LCO
a.	Fuel Temperature (maximum)	_____ ˚C
b.	Steady State High Power	_____ % of maximum power
c.	Preset timer (maximum)	_____ sec
d.	Pulse Mode Inhibit (Minimum)	_____ kW

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.07 [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 reactor ventilation system.

b. reduce power and notify the reactor supervisor.

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

d. shutdown the reactor; turn off the RABBIT 1 fan and RABBIT 1 Master.

QUESTION B.08 [1.0 point, 0.25 each)]
Column A below lists four activities in which the licensed 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.	Conduct a daily checkout procedure.	1. Administrative Policy
b.	Add water to the reactor pool (non-emergency).	2. Standard Operating Procedure
c.	Issue a Tag Out.	3. Special Procedure
d.	Transfer water between the reactor pool and the Pool Water Storage Tank	4. Auxiliary Operating Procedure

QUESTION B.09 [1.0 point]
The dose rate from a mixed beta-gamma point source is 100 mrem/hour at a distance of one (1) foot, and is 0.1 mrem/hour at a distance of ten (10) feet. What percentage of the source consists of beta radiation?

a. 30%

b. 50%

c. 70%

d. 90%

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.10 [1.0 point, 0.25 each]
Identify each of the following surveillances as a channel check (**CHECK)**, a channel test (**TEST)**, or a channel calibration (**CAL)**.

a. During the startup, you verify a Manual Scram.

b. During the startup, you verify the reactor interlock system by performing simultaneous manual withdrawal of two control rods.

c. During reactor operation, you compare readings of water pool temperature.

d. Adjust the scram set point on the Reactor Bay ARM with recent data collected on the calibration.

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]
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

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.13 [1.0 point, 0.25 each]
Identify each of the following as either a Safety Limit (SL) a Limiting Safety System Setting (LSSS) or a Limiting Condition for Operation (LCO).

a. The temperature in a water-cooled TRIGA fuel element shall not exceed 1150°C under any conditions of operation.

b. The maximum power level shall be no greater than 1.1 megawatt (MW) during steady state operation.

c. The fuel temperature shall not exceed 650°C as measured in an instrumented fuel element (IFE).

d. The time from SCRAM initiation to the full insertion of any control rod from a full up position shall be less than 1 second.

QUESTION B.14 [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 Technical Specifications?

a. Director of Reactor Operations

b. PSBR Safeguards Committee

c. Licensed Senior Reactor Operator.

d. Licensed Reactor Operator.

QUESTION B.15 [1.0 point]
Which ONE of the following experiments is not allowed to be installed in the reactor or experiment facilities under ANY condition? The experiment:

a. contains any fissile material.

b. contains any explosive material.

c. has an secured experiment worth of $3.0.

d. has a single, movable experiment worth of $2.0.

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.16 [1.0 point]
A two-curie source, emitted 80% of 100 Kev gamma, is to be stored in the reactor building. How far from the source will it read 100 mrem/hr?

a. 3 feet

b. 10 feet

c. 13 feet

d. 100 feet

QUESTION B.17 [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.18 [1.0 point]
According to the Emergency Procedure (EP-1), abnormal continual loss of reactor pool water at a rate that exceeds the combined makeup capacity of all available refill systems is defined as:

a. Operational Event

b. Notification of Unusual Event

c. Alert

d. Site Area Emergency

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.19 [1.0 point]
Per PSBR Technical Specifications, the primary coolant temperature channel shall be calibrated:

a. monthly.

b. quarterly.

c. semiannually.

d. annually.

QUESTION B.20 [1.0 point]
A fueled experiment with significant fission product inventory is being moved to the storage area. 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.

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

Category C: Facility and Radiation Monitoring Systems

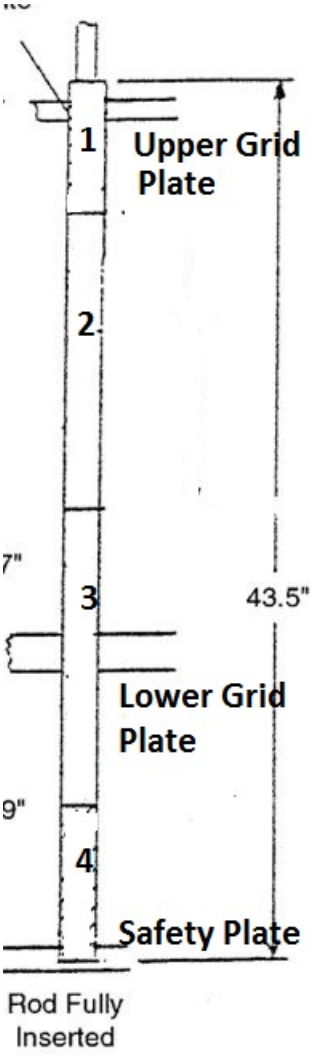
QUESTION C.01 [1.0 point]
The following diagram depicts the control rod with fueled follower (rod fully inserted). Which ONE of the following numbers listed on the diagram correctly describes the fuel section?

a. 1

b. 2

c. 3

d. 4



Category C: Facility and Radiation Monitoring Systems

QUESTION C.02 [1.0 point]
Which ONE of the following describes an RSS operational interlock while in the PULSE mode of operation?

a. Prevents manual withdrawal of any rod.

b. Prevents manual withdrawal of more than one rod.

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

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

QUESTION C.03 [1.0 point]
If a presence of ____ is found in the secondary side of the heat exchanger, a possible fueled leak occurs from the primary system to the secondary system.

a. Cs-135

b. Ca-40

c. Ar-41

d. N-16

QUESTION C.04 [1.0 point]
The following diagram depicts the building compressed air diagram. If valve 33 is turned OFF, which one of the following is a source of the compressed air that will supply air to the Transient rod?

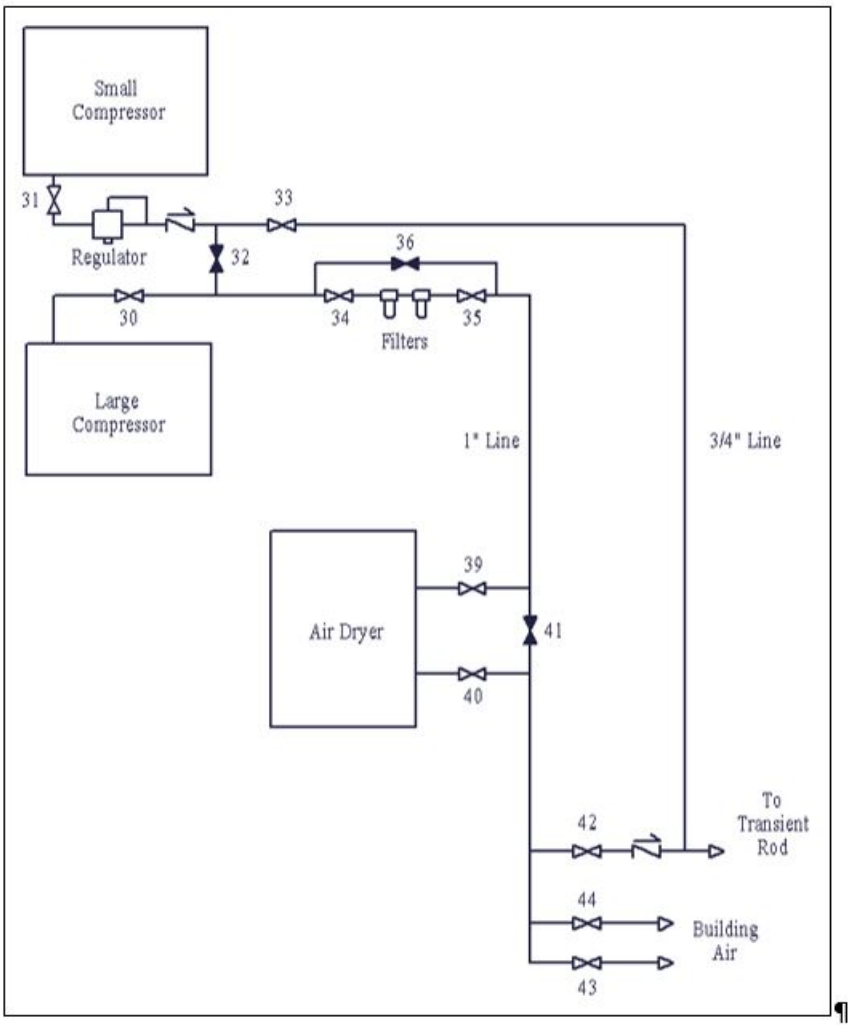
a. The large compressor.

b. There is no air supply to the Transient rod.

c. The backup building air system that comes from valves 44 and 43.

d. The small compressor because valve 32 is automatically turned ON.

Category C: Facility and Radiation Monitoring Systems



Figure·3-12A:·Building·compressed·air·block·diagram.¶

Category C: Facility and Radiation Monitoring Systems

QUESTION C.05 [2.0 points, 0.5 each]
Identify whether each of the following Reactor Safety Channels shall be effective in the Steady State (SS) mode, the Pulse mode (PULSE), the Square Wave (SW), ALL modes (ALL) or any combinations (for example: SS + SW)

a. Watchdog Circuit

b. High Power Level

c. Preset Timer

d. Fuel Element Temperature

QUESTION C.06 [1.0 point]
The main purpose of the fuel followers installed in the control rods is to:

a. decrease the fast neutron flux in the core.

b. decrease the thermal neutron flux in the core.

c. increase the effectiveness for reactor pulsing.

d. increase the core excess reactivity in the reactor core.

QUESTION C.07 [1.0 point]
Reactor power is 1 KW in the steady state mode. If you accidently press the “Square Wave” button, the reactor will:

a. scram.

b. alarm only.

c. run down.

d. be in the steady sate mode.

Category C: Facility and Radiation Monitoring Systems

QUESTION C.08 [1.0 point]
All operational interlocks and safety trips required by technical specifications are performed by the:

a. Reactor safety system (RSS)

b. Digital Control Computer –Z (DCC-Z)

c. Digital Control Computer – X (DCC-X)

d. Protection, control and monitoring system (PCMS)

QUESTION C.09 [1.0 point]
Which ONE of the following detectors will NOT activate the emergency evacuation alarm upon receipt of a high radiation alarm?

a. Reactor Bay Air East

b. Reactor Pump Room

c. Neutron Beam Laboratory

d. Co-60 Laboratory

QUESTION C.10 [1.0 point]
A three-way solenoid valve controls the air supplied to the pneumatic cylinder of the Transient rod. De-energizing the solenoid causes the valve to shift to:

a. open, admitting air to the cylinder.

b. close, admitting air to the cylinder.

c. open, removing air from the cylinder.

d. close, removing air from the cylinder.

Category C: Facility and Radiation Monitoring Systems

QUESTION C.11 [1.0 point, 0.25 each]
Use the following diagram of the reactor control system; match the components listed in Column A to the appropriate position locator listed in the diagram.

Column A

a. DCC-X _____

b. I/O _____

c. RSS & Interlock _____

d. DCC-Z _____

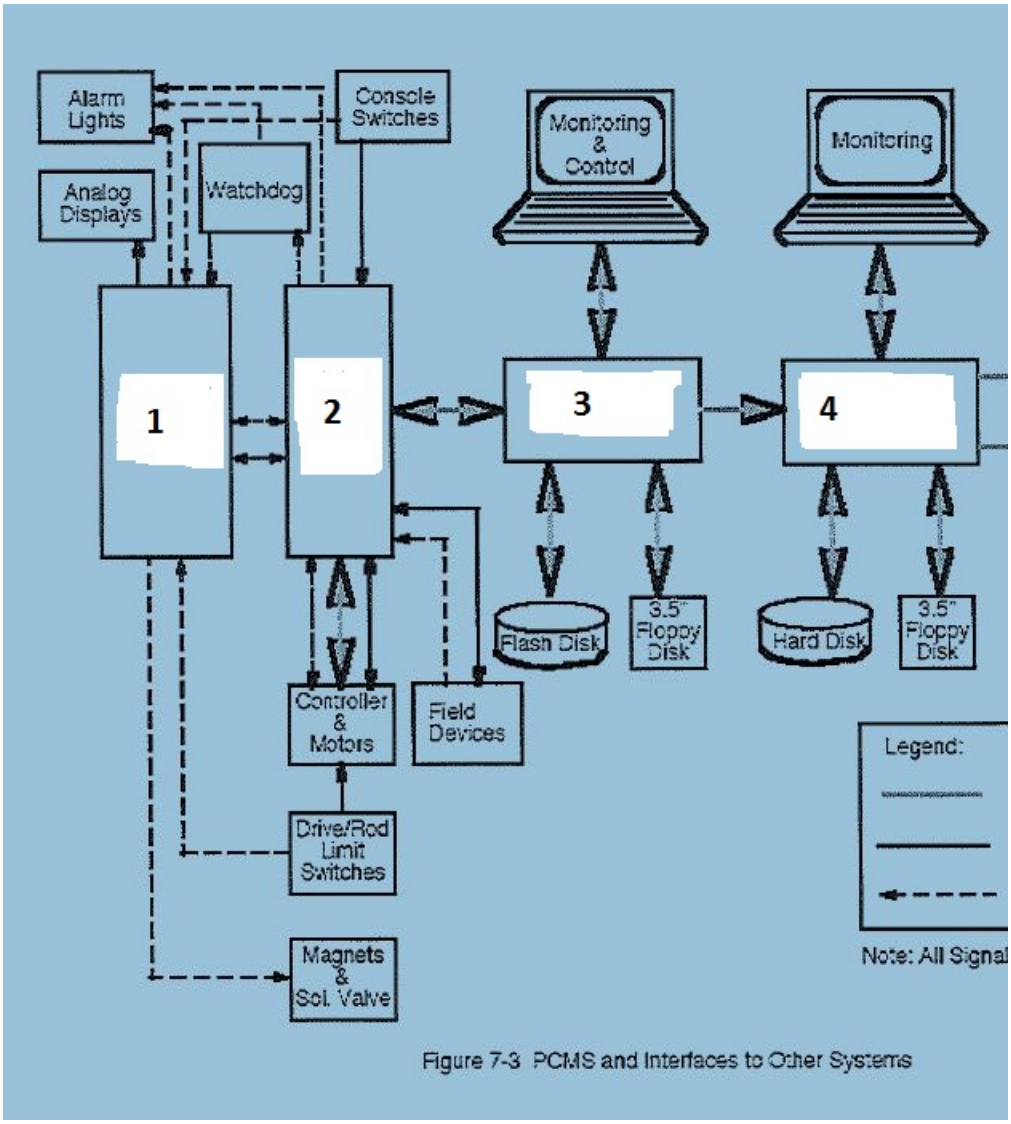


Figure 7-3 PCMS and Interfaces to Other Systems

Category C: Facility and Radiation Monitoring Systems

QUESTION C.12 [1.0 point]
Which ONE of the following is NOT true regarding the configuration of PSBR TRIGA fuel elements?

a. The total uranium content shall be either 8.5 wt% or 12.0 wt% nominal and enriched to less than 20% uranium-235.

b. The hydrogen-to-zirconium atom ratio (in the ZrHx) shall be a nominal 1.0 H atoms to 1.65 Zr atom.

c. The hydrogen-to-zirconium atom ratio (in the ZrHx) shall be a nominal 1.65 H atoms to 1.0 Zr atom.

d. Cladding: 304 stainless steel.

QUESTION C.13 [1.0 point]
Reactor is subcritical with the following conditions:
The SHIM rod and drive are "UP"
The Carriage of the Transient rod is UP
Reactor is in the Steady State Mode
If you apply "AIR" to the Transient rod system, the reactor will:

a. scram.

b. inhibit (interlock).

c. SHIM rod runs down.

d. increase to critical.

QUESTION C.14 [1.0 point]
Reactor Operator completely sets up a $1.50 pulse. Which ONE of the following statements is true while the reactor is in the Pulse mode?

a. Reactor Operator can withdraw the Shim rod.

b. Reactor Operator can "fire" a pulse when a reactor power level is at 1.5 kW.

c. Reactor Operator can move the Transient rod drive in any direction after setting up its position.

d. Reactor Operator cannot change back to a Manual mode from a Pulse mode without firing a pulse.

Category C: Facility and Radiation Monitoring Systems

QUESTION C.15 [1.0 point]
Which ONE of the following is the MAIN purpose to have a neutrons source in the reactor core?

a. Ensure the reactor change from subcritical to critical by using neutron source ONLY.

b. Provide a reference point where all instruments undergo a check before the reactor is brought to a critical position.

c. Provide enough neutrons to assure proper nuclear instrumentation response during reactor startup.

d. Prevent the reactor changing from a Steady State mode to a Pulse mode if a period exceeds 10 seconds.

QUESTION C.16 [1.0 point]
When the OUTLET conductivity of the demineralizer reads 0.5 μS/cm (μSiemens) and the INLET resistivity reads 1 μS/cm, it indicates that:

a. the resin bed has been depleted and it needs to be changed.

b. the outlet leg of the demineralizer has been logged.

c. the inlet leg of the demineralizer has been logged.

d. The demineralizer is operable and no need to change the resin bed.

QUESTION C.17 [1.0 point]
Which ONE of the following is the correct statement for the operation of the pneumatically operated valves 80 A and 82 A in the Primary coolant system?

a. When the Primary pump starter switch is actuated, the pump starts after a delay of ~10 seconds to allow the pneumatic valves 80A and 82A to fully open. The time delay protects the pump from dead head when starting the system.

b. When the Primary pump starter switch is actuated, the pump starts after a delay of ~1 minute to allow the pneumatic valves 80A and 82A to fully open. The time delay allows to warm-up the primary pump.

c. When primary pump is turned off, the valves 80A and 82A are completely closed within 10 seconds to prevent water hammer damage to the valves.

d. If adequate pressure is not present in the Primary pump, the pneumatic valves 80A and 82A are automatically turned off.

Category C: Facility and Radiation Monitoring Systems

QUESTION C.18 [1.0 point]
If any significant buildup of radioactivity from the reactor pool, the conductivity of the pool water will be:

a. increase.

b. decrease.

c. the same.

d. no relationship between radioactivity and conductivity in the pool water.

QUESTION C.19 [1.0 point]
Reactor Operator performs a fuel element inspection. In measuring the transverse bend, he finds the bend of one fuel element exceeds the original bend by 0.10 inches. For this measurement, he will:

a. continue the fuel inspection because this bend is within TS limit.

b. continue the fuel inspection because the Technical Specifications require the elongation measurement only.

c. stop the fuel inspection; you immediately report the result to the supervisor because it is considered a damaged fuel element.

d stop the fuel inspection, you immediately report the result to the U.S. NRC since it is a reportable occurrence.

(***** END OF CATEGORY C *****)
((***** END OF EXAM *****))

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

A.01
Answer: c
Reference:
$P = Poet/T \quad 800 = 200*e^{(60\ sec/T)} \quad T = 43.28$ sec
$16\ kW = 8\ kW*e^{(t/43.28)}$
t = 30 sec

A.02
Answer: c
Reference: Burn, R., Introduction of Nuclear Reactor Operations, © 1988, Sec 3.3.1

A.03
Answer: c
Reference: Reactivity added = 0.126 % $\Delta k/k$ = 0.00126 Δ k/k
$\tau = (\beta-\rho)/\lambda eff\rho = \frac{0.0078 - 0.00126}{(0.1)\ (0.00126)} = 51.9$ seconds

A.04
Answer: a
Reference: Chart of the Nuclides

A.05
Answer: a
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, Section 3.2

A.06
Answer: a(2) b(1) c(3) d(4) (0.25 each)
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, Sec 2.6

A.07
Answer: d
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Sec 4.2
When the insertion of 0.008 $\Delta k/k$ > Keff, reactor is prompt critical.

A.08
Answer: a
Reference: $P = P_0\ e^{t/T}$ —> ln(4) = time ÷ 10 seconds –> time = ln (4) x 10 sec. 1.386 x 10 ≈ 13.8 sec.

A.09
Answer: a
Reference: Burn, R., Introduction to Nuclear Reactor Operations, ©3.3, 1988

A.10
Answer: b
Reference: CR = S/(1-K) → CR = 1000/(1 - 0.8) = 5000 N/sec

A.11
Answer: b
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1982, Sec 3.3.3, page 3-21.
$\Delta\rho$ = keff1-keff2/(keff1 x keff2) = 0.95-0.8 /(0.8*0.95)=0.197 $\Delta k/k$

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

A.12
Answer: a
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1982, Sec 5.5, page 5-18-5-25.

A.13
Answer d
Reference: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory Volume 1, Module 1, Enabling Objective 4.9, p. 61.

A.14
Answer: c
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Sec 8.1

A.15
Answer: a
Reference: $\Delta\rho = (K_{eff1} - K_{eff2}) \div (K_{eff1} * K_{eff2})$
$\Delta\rho = (1.0000-0.9550) \div (0.9550 * 1.0000)$
$\Delta\rho = 0.0450 \div 0.9550 = 0.0471$

A.16
Answer: b
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, § 3.13

A.17
Answer: a
Reference: $P = P_0 e^{t/T}$ —> $T = t/Ln(P/P_0)$
$T = 10/Ln(100/10)$; T = 4.34 sec.

A.18
Answer: d
Reference:
CR1 *(1-Keff1) = CR2 *(1- Keff2)
100 (1- 0.950) = 500 *(1 - Keff2)
Keff2 = 0.998

A.19
Answer: d
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988

A.20
Answer: a. = fertile; b. = fissile; c. = fertile; d. = fissile (0.25 each)
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Sec 3.2

Category B: Normal/Emergency Operating Procedures and Radiological Controls

B.01
Answer: d
Reference: DR1*(D1) 2= DR2*(D2) 2 ;
500 mrem (3) 2 = 10 mrem (d) 2
D = 21 ft

B.02
Answer: c
Reference: $A = A_{\circ} * e^{-\lambda t}$
$0.02Ci = 2\ Ci * e^{-\lambda(t)}$
$\lambda = \ln(2) / (\text{half-life})$
$\lambda = 0.693 / 2\ \text{year} = 0.3465$
$\ln(0.02/2) = -0.3465*(t) \rightarrow -4.60/-0.3465$
t =13.2 years

B.03
Answer: b
Reference: Standard Health Physics Definition

B.04
Answer: c
Reference: TS 6.4

B.05
Answer: c
Reference: TS 3.6.1

B.06
Answer: a. = 650; b. = 110; c. = 15; d. = 1 (0.25 each)
Reference: TS 3.2.4

B.07
Answer: d
Reference: SOP-9.C.2

B.08
Answer: a, 2 b, 4 c, 1 d, 3
Reference: SOP-2; AOP-8, AP-10; SP-2

B.09
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%.

Category B: Normal/Emergency Operating Procedures and Radiological Controls

B.10
Answer: a. = TEST; b. = TEST; c. = CHECK; d. = CAL (0.25 each)
Reference: TS Definitions

B.11
Answer: b
Reference: TS 2.1 and 2.2, Objective

B.12
Answer: a
Reference: EP-5 Section V (G)

B.13
Answer: a. = SL; b. = LCO; c. = LSSS; d. = LCO (0.25 each)
Reference: TS 2.1, TS 2.2, TS 3.1, TS 3.2

B.14
Answer: c
Reference: 10CFR50.54(y)

B.15
Answer: d
Reference: TS 3.7

B.16
Answer: a
Reference: 6CEN = R/hr @ 1 ft. -> 6 x 2 x 0.8 x 0.1 = 0.96 R/hr at 1ft.
I0D02 = I2*D2
0.96 R/hr*(1 ft) 2 = 0.1 R/hr *D 2
D= sqrt(0.96/0.1) = 3 ft.

B.17
Answer: b
Reference: 10CFR20.1003 and NRC Training Material

B.18
Answer: c
Reference: EP-1, Alert

B.19
Answer: d
Reference: TS 4.3.2

B.20
Answer: a
Reference: TS 3.5

Category C: Facility and Radiation Monitoring Systems

C.01
Answer: c
Reference: Training Manual, Figure 5.10

C.02
Answer: c
Reference: Training Manual, Interlock Functions

C.03
Answer: a
Reference: Chart of Nuclides
Cs-135 is a fission product

C.04
Answer: a
Reference: Training Manual, Building Compressed Air

C.05
Answer: a. =ALL; b. = SS and SW; c. = PULSE; d. = ALL (0.5 each)
Reference: TS 3.2

C.06
Answer: d
Reference: NRC Standard Questions

C.07
Answer: d
Reference: SAR 7.3.1

C.08
Answer: a
Reference: Training Manual, Reactor Safety, Protection, Control and Monitoring System

C.09
Answer: b
Reference: SAR 7.3.1.3 C.10

C10
Answer: d
Reference: NRC Standard Question

C.11
Answer: a(3) b(2) c(1) d(4) (0.25 each)
Reference: SAR 7.3

C.12
Answer: b
Reference: TS 5.1

Category C: Facility and Radiation Monitoring Systems

C.13
Answer: b
Reference: SAR 7.3

C.14
Answer: c
Reference: NRC Standard Question

C.15
Answer: c
Reference: Training Manual, Neutron Source

C.16
Answer: d
Reference: Training Manual, Conductivity Measurement

C.17
Answer: a
Reference: Training Manual, Primary Pump and Associated Piping

C.18
Answer: a
Reference: NRC Standard Questions

C.19
Answer: a
Reference: TS 3.1.6