July 12, 2017

Dr. Steven Reese, Director
Oregon State University
Radiation Center, A100
Corvallis, OR 99164-1300

SUBJECT: EXAMINATION REPORT NO. 50-243/OL-17-01, OREGON STATE UNIVERSITY NUCLEAR RADIATION CENTER

Dear Dr. Reese:

During the week of June 19, 2017, the U.S. Nuclear Regulatory Commission (NRC) administered an operator licensing examination at your Oregon State University Nuclear Radiation Center 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 Ms. Michele DeSouza at (301) 415-0747 or via internet e-mail Michele.DeSouza@nrc.gov.

Sincerely,

/RA/

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

Docket No. 50-243

Enclosure:
Examination Report No. 50-243/OL-17-01

cc: w/o enclosures: See next page

SUBJECT: EXAMINATION REPORT NO. 50-243/OL-17-01, OREGON STATE UNIVERSITY NUCLEAR RADIATION CENTER DATED JULY 12, 2017

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MBalazik MDeSouza

ADAMS Accession #ML17193A161 Template #NRR-079

OFFICE	NRR/DPR/PROB:CE	NRR/DIRS/IOLB:OLA	NRR/DPR/PROB:BC
NAME	MDeSouza (JNguyen for)	ABaxter	AMendiola
DATE	07/11/2017	07/12/2017	07/12/2017

OFFICIAL RECORD COPY

cc:

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Corvallis, OR 97331

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

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

REPORT NO.: 50-243/OL-17-01

FACILITY DOCKET NO.: 50-243

FACILITY LICENSE NO.: R-106

FACILITY: OSU

EXAMINATION DATES: June 21-24, 2017

SUBMITTED BY: /RA/ 7/11/17
Michele DeSouza, Chief Examiner Date

SUMMARY:
During the week of June 19, 2017, the NRC administered an operator licensing examination to one Senior Reactor Operator (SRO) candidate and four Reactor Operator (RO) candidates. The SRO and ROs passed all applicable portions of the examinations.

REPORT DETAILS

1. Examiner: Michele DeSouza, Chief Examiner, NRC

2. Results:

	RO PASS/FAIL	SRO PASS/FAIL	TOTAL PASS/FAIL
Written	4/0	0/0	4/0
Operating Tests	4/0	1/0	5/0
Overall	4/0	1/0	5/0

3. Exit Meeting:
Michele C. DeSouza, Chief Examiner, NRC
Dr. Steven Reese, Director, OSU Nuclear Radiation Center
Todd Keller, OSU Reactor Administrator
Celia Oney, OSU Reactor Supervisor

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. NRC Examiner discussed with the facility control console key access. NRC Inspectors will evaluate this item. 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: OSU

REACTOR TYPE: TRIGA

DATE ADMINISTERED: 06/22/2017

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 ___ (0.25 each)

A06 a b c d ___

A07 a b c d ___

A08 a ___ b ___ c ___ d ___ (0.25 each)

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 *****)

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 ___ (0.25 each)

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

C01 a ___ b ___ c ___ d ___ (0.25 each)

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 ___ (0.33 each)

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 **********)

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.

Category A: Theory, Thermodynamics & Facility Operating Characteristics

EQUATION SHEET

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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: Theory, Thermodynamics & Facility Operating Characteristics

Question A.01 [1.0 point]
Two common FISSION PRODUCTS that have especially large neutron cross sections and play a significant role in reactor physics are Xe-135 and _____.

a. Nitrogen-16

b. Argon-41

c. Iodine-131

d. Samarium-149

Question A.02 [1.0 point]
The reactor is on a CONSTANT positive period. Which ONE of the following power changes will take the SHORTEST time to complete?

a. From 1 W to 5 W

b. From 10 W to 30 W

c. From 10 kW to 20 kW

d. From 100 kW to 150 kW

Question A.03 [1.0 point]
The first pulse has a reactivity worth of **$1.10** which results in a peak power of **500 MW**. If the second pulse has a peak power of **5000 MW**, the corresponding reactivity worth is:
Given: β_{eff}=0.0075

a. $1.32

b. $1.40

c. $1.62

d. $2.02

Question A.04 [1.0 point]
Which ONE of the reactions below describes a method of production and removal of Xenon?

a. ${}_{52}Te^{134} \rightarrow \gamma + {}_{53}I^{134} \rightarrow p + {}_{54}Xe^{135} \rightarrow \beta^- + {}_{55}Cs^{135} \rightarrow \beta^- + {}_{56}Ba^{135}$

b. ${}_{52}Te^{135} \rightarrow \gamma + {}_{53}I^{135} \rightarrow \beta^- + {}_{54}Xe^{135} \rightarrow {}_{0}n^{1} + {}_{54}Xe^{136} \rightarrow \beta^- + {}_{56}Ba^{135}$

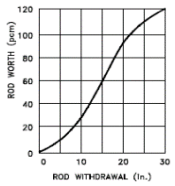
c. ${}_{52}Te^{135} \rightarrow \beta^- + {}_{53}I^{135} \rightarrow \beta^- + {}_{54}Xe^{135} \rightarrow \beta^- + {}_{55}Cs^{135} \rightarrow \beta^- + {}_{56}Ba^{135}$

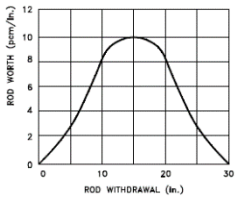
d. ${}_{52}Te^{134} \rightarrow \beta^- + {}_{53}I^{135} \rightarrow \beta^- + {}_{54}Xe^{135} \rightarrow \gamma + {}_{55}Cs^{135} \rightarrow \beta^+ + {}_{56}Ba^{135}$

Category A: Theory, Thermodynamics & Facility Operating Characteristics

Question A.05 [1.0 point, 0.25 points each]
Identify if the descriptions or graphs in Column A describe or depict integral control rod worth or differential rod worth?

Column A	Column B
a. total reactivity worth of the control rod at that height	1. Differential Rod Worth
b. reactivity change per unit movement of a control rod	2. Integral Rod Worth

c. 

d. 

Question A.06 [1.0 point]
Reactor is critical. What would be the corresponding k_{eff} when removing 0.05 $\Delta k/k$ from its criticality?

a. 0.9951

b. 0.9524

c. 0.9750

d. 1.0526

Question A.07 [1.0 point]
A subcritical reactor, k_{eff} is increased from 0.861 to 0.946. Which ONE of the following is the amount of reactivity that was added to the core?

a. 0.086 $\Delta k/k$

b. 0.104 $\Delta k/k$

c. 0.125 $\Delta k/k$

d. 0.220 $\Delta k/k$

Category A: Theory, Thermodynamics & Facility Operating Characteristics

Question A.08 [1.0 point, 0.25 each]
Match the following Neutron term in Column A with the appropriate definition in Column B (each used only once)

Column A	Column B
a. Fast Neutron	1. Neutron born directly from fission
b. Prompt Neutron	2. Neutron in equilibrium with its surroundings
c. Thermal Neutron	3. Neutron born due to decay of a fission product
d. Delayed Neutron	4. Neutron at an energy level greater than its surroundings

Question A.09 [1.0 point]
Which ONE of the following is an example of beta decay?

a. $_{35}Br^{87} = _{33}As^{83}$

b. $_{35}Br^{87} = _{35}Br^{86}$

c. $_{35}Br^{87} = _{34}Se^{86}$

d. $_{35}Br^{87} = _{36}Kr^{87}$

Question A.10 [1.0 point]
Reactor A has a k_{eff} of 0.1 and reactor B has a k_{eff} of 0.8, k_{eff} is increased by 0.1 for each reactor. The amount of reactivity added in reactor A is _____ amount of reactivity in reactor B for the same increment

a. Less than the

b. The same

c. Eight times the

d. Thirty-six times the

Question A.11 [1.0 point]
Assume that the worth's of the Shim rod is $3.50, Safety rod is $4.50, and Reg rod is $2.25. The reactor is critical at 15 W after WITHDRAWING the following control rod worth's: Shim $2.20, Safety $3.40, and Reg $1.50. What is the CORE EXCESS?

a. $2.85

b. $3.15

c. $5.50

d. $7.10

Question A.12 [1.0 point]
Which ONE of the following best describes the difference between reflectors and moderators?

a. Reflectors decrease thermal leakage while moderators decrease fast leakage

b. Reflectors thermalize neutrons while moderators decrease core leakage

c. Reflectors decrease core leakage while moderators thermalize neutrons

d. Reflectors shield against neutrons while moderators decrease core leakage

Question A.13 [1.0 point]
Given a source strength of 150 neutrons per second (N/sec) and a multiplication factor of 0.7, which ONE of the following is the expected stable neutron count rate? CR = S/(1-k)

a. 250 N/sec

b. 350 N/sec

c. 500 N/sec

d. 600 N/sec

Question A.14 [1.0 point]
Which of the following is an example of a FERTILE material?

a. Th-232

b. U-233

c. U-235

d. Pu-239

Category A: Theory, Thermodynamics & Facility Operating Characteristics

Question A.15 [1.0 point]
Which ONE of the following is the number of neutrons in the tritium nucleus ($_1T^3$ or $_1H^3$)?

a. 1

b. 2

c. 3

d. 4

Question A.16 [1.0 point]
What is the effect of additional U-238 on the reactor neutron life cycle when a neutron energy is below 1 MeV?

a. The number of fissions due to U-238 decrease.

b. The number of fissions due to U-238 remains the same.

c. The number of fissions due to U-238 increase.

d. The number of fissions due to U-235 increase.

Question A.17 [1.0 point]
Which ONE of the following conditions describes a critical reactor?

a. $k_{eff} = 1$; $\Delta k/k(\rho) = 1$

b. $k_{eff} = 1$; $\Delta k/k(\rho) = 0$

c. $k_{eff} = 0$; $\Delta k/k(\rho) = 1$

d. $k_{eff} = 0$; $\Delta k/k(\rho) = 0$

Question A.18 [1.0 point]
Which ONE of the following describes the term PROMPT JUMP?

a. Reactor is subcritical at a negative 80 second period

b. Reactor has achieved criticality on prompt neutrons alone

c. Instantaneous change in power level due to inserting a control rod

d. Instantaneous change in power level due to withdrawing a control rod

Category A: Theory, Thermodynamics & Facility Operating Characteristics

Question A.19 [1.0 point]
What is β_{eff}?

a. The fractional change in neutron population per generation

b. The fraction of all delayed neutrons that reach thermal energy

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

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

Question A.20 [1.0 point]
What is the result of the Doppler Effect in the fuel temperature coefficient?

a. Stationary nuclei absorb more neutrons

b. Vibrating nuclei absorb less neutrons

c. Raising the temperature causes the nuclei to vibrate more rapidly effectively unbroadening the energy range of neutrons that may be resonantly absorbed.

d. An apparent broadening of the nuclei's resonances due to a temperature increase.

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

Category B: Normal/Emergency Procedures and Radiological Controls

Question B.01 [1.0 point]
A radioactive source is to be stored in the reactor bay with no shielding. The source reads 2 R/hr at 1 foot. How far from the source does a barrier need to be placed for it to be considered a “Radiation Area”? Note: 1 inch = 2.54 cm

a. 372 m

b. 610 cm

c. 110 cm

d. 30 cm

Question B.02 [1.0 point]
Which ONE of the following are the OSU Technical Specification limits for fuel element storage?

a. k-eff <0.8

b. k-eff <0.85

c. k-eff <0.9

d. k-eff <0.95

Question B.03 [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). Write the correct answer on your answer sheet next to the space given for each example listed below

a. During performance of the daily checklist, you compare the prestart readings of the radiation area monitors to the previous day readings

b. During performance of the daily checklist, you press the scram button to verify a scram on the safety system channel

c. Adjustment of the wide range linear channel in accordance with recent data collected during a reactor power calibration

d. You expose a 2 mCi check source to the stack particulate monitor detector to verify that it alarms at 10,000 cpm

Category B: Normal/Emergency Procedures and Radiological Controls

Question B.04 [1.0 point]
A radioactive source reads 100 mRem/hr on contact. Thirty minutes later, the same source reads 50 mrem/hr. How long is the time for the source to decay from a reading of 100 mrem/hr to 5 mrem/hr?

a. 2.16 hours

b. 3.25 hours

c. 4.48 hours

d. 5.91 hours

Question B.05 [1.0 point]
In accordance with Oregon State University Technical Specifications, how often is the NRC reporting requirements of Argon-41?

a. Every 3 months

b. Twice a year

c. Once a year

d. Every other year

Question B.06 [1.0 point]
Match the appropriate 10CFR part in Column A with the requirements in Column B.

Column A	Column B
a. 10CFR19	1. Individual radiation exposure data
b. 10CFR20	2. Postings of notices to workers
c. 10CFR50	3. Medical examination every two years by a physician
d. 10CFR55	4. Technical information including the proposed maximum power level

Category B: Normal/Emergency Procedures and Radiological Controls

Question B.07 [1.0 point]
Oregon State University Emergency Plan defines the *Emergency Planning Zone* as which ONE of the following?

a. within the walls of the Radiation Center

b. within the walls of the reactor bay

c. within a 100-meter radius of the center of the reactor core

d. within the walls of the Reactor Building

Question B.08 [1.0 point]
What purge must be in service if the reactor will be operated at 120kW?

a. Argon

b. Xenon

c. Radon

d. Nitrogen

Question B.09 [1.0 point]
Which ONE of the following is classified as a Class O Emergency event?

a. Site Area Emergency

b. Alert

c. Notification of Unusual Events

d. Personnel and Operational Events

Question B.10 [1.0 point]
What is the MINIMUM level of management who shall be present at the facility during a recovery from an unplanned or unscheduled shutdown?

a. Reactor Supervisor

b. Reactor Administrator

c. Senior Reactor Operator

d. Radiation Center Director

Category B: Normal/Emergency Procedures and Radiological Controls

Question B.11 [1.0 point]
Which ONE of the following is the definition for "Annual Limit on Intake (ALI)"?

a. 10CFR20 derived limit, based on a Committed Effective Dose Equivalent of 5 Rems whole body or 50 Rems to any individual organ, for the amount of radioactive material inhaled or ingested in a year by an adult worker.

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

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

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

Question B.12 [1.0 point]
Which ONE of the following SCRAM indications would result from a Beam Port three abnormal operation?

a. External

b. Safety

c. Experiment

d. High Voltage

Question B.13 [1.0 point]
Calculate an individual's total whole body dose given the individual received the following doses: 200 mrem of alpha, 100 mrem of gamma, and 350 mrem of neutron (unknown energy)

a. 650 mrem

b. 750 mrem

c. 850 mrem

d. 950 mrem

Category B: Normal/Emergency Procedures and Radiological Controls

Question B.14 [1.0 point]
What is the maximum worth of all experiments in accordance with OSU Technical Specification?

a. $2.30

b. $2.00

c. $1.00

d. $0.50

Question B.15 [1.0 point]
10 CFR 50.59 would require OSU submit a request to the NRC for which ONE of the following modifications?

a. Utilize a new Xenon poisoning method of measurement

b. Change of NLW-1000 with a like model

c. Use new RTDs to perform reactor power calibration

d. Replace the Wide Range Log with an uncompensated ion chamber

Question B.16 [1.0 point]
The OSU Emergency Plan identifies the primary Emergency Support Center as A100. What is the alternate location for more minor emergencies?

a. Room B134

b. Room D302

c. Room D300

d. Room D204

Question B.17 [1.0 point]
Radiation from an unshielded Co-60 source is 600 mrem/hr. What thickness of lead shielding will be needed to lower the radiation level to 5 mrem/hr? Assume: half-value layer of lead is 6.5mm

a. 27 mm

b. 34 mm

c. 39 mm

d. 45 mm

Category B: Normal/Emergency Procedures and Radiological Controls

Question B.18 [1.0 point]
Which ONE of the following reactor primary coolant conditions is a violation of OSU Technical Specification?

a. Bulk water temperature is 110^{o}F

b. Conductivity of the tank water is 4 μmhos/cm

c. Tank water level 12 feet above the top of the core

d. Annual reactor tank water temperature system calibration

Question B.19 [1.0 point]
Which ONE of the following experiments would be listed as a Class C?

a. New experiment placed into a beam tube

b. Experiment containing explosives

c. Experiment that requires movement of reactor shielding

d. Empty containment tube in the Lazy Susan to test new sample containers

Question B.20 [1.0 point]
OSU Emergency Plan allows a one-time MAXIMUM exposure limit of _____ to save a life or protect large populations.

a. 10 Rem

b. 25 Rem

c. 50 Rem

d. 75 Rem

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

Category C: Facility and Radiation Monitoring Systems

Question C.01 [1.0 point, 0.25 each]
Match the purification system conditions listed in Column A with their respective causes listed in Column B (each used only once).

Column A	Column B
a. High Radiation at Demineralizer	1. Fuel element failure
b. High Radiation downstream of Demineralizer	2. Clogged Demineralizer
c. High flow rate through Demineralizer	3. Channeling in Demineralizer
d. High pressure upstream of Demineralizer	4. High temperature in Demineralizer

Question C.02 [1.0 point]
What design feature prevents siphoning of the reactor tank water in the event of a pipe rupture?

a. Vacuum breaker located on the shell side of the heat exchanger

b. Holes in the water pipes, 22 inches below the normal water surface

c. Primary system pipes located six inches below the normal water surface

d. Back-flow preventer on the secondary system

Question C.03 [1.0 point]
Which ONE of the following SCRAMs is required in all effective modes?

a. Preset Timer

b. Power Level

c. High Voltage

d. Fuel Element Temperature

Question C.04 [1.0 point]
Which ONE of the following interlocks will prevents pulsing the reactor while in steady state mode?

a. 1 kW pulse

b. Shim, Safety, and Reg. rod drive circuit

c. Transient Rod Cylinder

d. Wide-Range Log power level channel

Category C: Facility and Radiation Monitoring Systems

Question C.05 [1.0 point]
Which ONE of the following will NOT result in a stack monitor abnormal flow annunciator?

a. Detector failure

b. Pump shut off

c. Incorrect positioning of the throttle valve

d. Clogged sample line due to a foreign object

Question C.06 [1.0 point]
What is the gas does the pneumatic tube system use to transfer samples in and out of the reactor?

a. H

b. CO_2

c. H_2O

d. Air

Question C.07 [1.0 point, 0.33 each]
For irradiations involving quantities of Uranium and Thorium, match the Irradiation Facility in Column A with the associated limit in Column B?

Column A	Column B
a. Rotating Rack	1. 30 MWh
b. Thermal Column	2. 1 MWh
c. Pneumatic Transfer	3. 0.083 MWh

Question C.08 [1.0 point]
Which ONE of the following is NOT a design feature of the Purification System?

a. Reduce corrosion rate due to dissolved ions

b. Reduce radiation levels due to soluble gases

c. Reduce radiation levels due to suspended ions

d. Reduce radiation levels due to dissolved ions

Category C: Facility and Radiation Monitoring Systems

Question C.09 [1.0 point]
Which ONE of the following is NOT normally checked on the CAM during a routine start-up check list?

a. Background reading

b. Filter paper

c. Flow rate

d. Oil level

Question C.10 [1.0 point]
If the reactor tank water level is below the low water level alarm it will cause an increase in production of radiation in the reactor tank. Which ONE of the following is the result of the increased radiation?

a. Ar-41

b. N-16

c. Na-24

d. Fe-59

Question C.11 [1.0 point]
Which ONE of the following channels is grounded in square-wave and pulse mode?

a. Period

b. Safety

c. Linear

d. Log-N

Question C.12 [1.0 point]
Why is the reactor bay maintained at a negative pressure with respect to outside atmosphere?

a. Prevent Ar-41 generation

b. Maintain occupation exposures ALARA

c. Expedite reactor cooling by natural convection

d. Minimize uncontrollable leakage to the unrestricted environment

Category C: Facility and Radiation Monitoring Systems

Question C.13 [1.0 point]
Which ONE of the following standard control rod drive components provides rod position indication?

a. Armature

b. Electromagnet

c. Potentiometer

d. Limit Switches

Question C.14 [1.0 point]
Fuel element temperature must be limited in the TRIGA fuel element in order to avoid fuel element cladding failure due to which of the following mechanisms?

a. Fission product build up

b. Excessive pressure from Ar-41 expansion

c. Excessive pressure from air, fission product gases, and zirconium hydride hydrogen dissociation

d. Distortion of the fuel element due to a phase change of the 304-stainless steel

Question C.15 [1.0 point]
Which ONE of the following detectors is used primarily to measure Ar-41 released to the environment?

a. Air Particulate Monitor

b. Stack Gas Monitor

c. Area Radiation Monitor

d. Environmental TLDs

Question C.16 [1.0 point]
Which ONE of the following is the method used to minimize mechanical shock to the standard control rods on a SCRAM?

a. A small spring located at the bottom of the rod

b. A piston drives water out of a dashpot as the rod nears the bottom of its travel

c. A piston drives air out of a dashpot as the rod nears the bottom of travel

d. An electrical-mechanical brake energizes when the rod down limit switch is energized

Category C: Facility and Radiation Monitoring Systems

Question C.17 [1.0 point]
Which ONE of the following alarm monitors is required by OSU technical specification to shut down the ventilation system upon receipt of a high activity alarm?

a. Exhaust Gas Radiation Monitor

b. Reactor Top Area Radiation Monitor

c. Continuous Air Particulate Radiation Monitor

d. Exhaust Particulate Radiation Monitor

Question C.18 [1.0 point]
Which ONE of the following will result in a reactor SCRAM?

a. Loss of HV to the power measuring channels

b. Simultaneous withdrawal of two control rods

c. Bulk tank water temperature exceeds 40^{o}C

d. Instrumented fuel element temperature exceeds 500^{o}C

Question C.19 [1.0 point]
Which ONE of the following correctly describes the characteristic of the unirradiated 30/20 fuel rods used at the OSTR?

a. The uranium content is a nominal 30 weight%, enriched to less than 20% U-235, and the natural erbium content is homogenously distributed with a nominal 1.1 weight%

b. The hydrogen to zirconium atom ratio (in the ZrHx) shall be between 1.5 to 1.8

c. The uranium content is a nominal 30 weight%, enriched to less than 20% U-235, and no erbium content

d. The uranium content is 30 weight%, enriched to less than 20% U-235, and the natural erbium content is homogenously distributed with a nominal 0.90 weight%

Category C: Facility and Radiation Monitoring Systems

Question C.20 [1.0 point]
Which ONE of the following OSTR Control Rods is equipped with a pneumatic system?

a. Shim Rod

b. Safety Rod

c. Regulating Rod

d. Transient Rod

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

Category A: Theory, Thermodynamics & Facility Operating Characteristics

A.01
Answer: d
Reference: Burn, *Introduction to Nuclear Reactor Operations*, Section 8.1, Page 8-1

A.02
Answer: d
Reference: $P=P_oe^{t/T} \rightarrow t=T*\ln(P/P_o)$ assume constant period=1; The smallest ratio of P/P_o is the shortest time to complete

A.03
Answer: a
$\rho1=(\rho\$1)(\beta_{eff})=(\$1.10)(.0075)=(.00825)$; $[(\rho2-\beta_{eff})^2]/Peak2 = [(\rho1-\beta_{eff})^2]/Peak1$ $Peak2/Peak1*[(\rho1-\beta_{eff})^2]=[(\rho2-\beta_{eff})^2]$; $(5000/500)*[(.00825-.0075)^2]= [(\rho2-\beta_{eff})^2]$; $[(.000005625)^{1/2}]+\beta_{eff} =\rho2=.009872$; $\rho\$2=(\rho2/\beta_{eff})=(.009872/.0075)= \$1.316 \approx \$1.32$
Reference: Burn, R., Introduction to Nuclear Reactor Operations, 1988. § 4.6, p. 4-16

A.04
Answer: c
Reference: DOE Fundamentals Handbook, NRPT, Vol. 2, Module 3, EO 4.1, p.35, KAPL, "Chart of the Nuclides", 17th Ed.

A.05
Answer: a. 2; b. 1; c. 2; d. 1
Reference: DOE Fundamentals Handbook, NPRT, Vol. 2, Mod 3, EO 5.4, 5.5, 5.6, p 51-53

A.06
Answer: b
Reference: $\rho=(k-1)/k-0.05 \rightarrow 1=k-(-0.05k)=k(1+0.05) \rightarrow k=1/1.05 =0.9524$

A.07
Answer: b
Reference: Burn, *Introduction to Nuclear Reactor Operations*, Section 3.3.4, Page 3-20&21
$\Delta\rho=(k_{eff2}-k_{eff1})/(k_{eff1}*k_{eff2})$ = (0.946-0.861)/(0.946*0.861) = 0.104 $\Delta k/k$

A.08
Answer: a. 4, b. 1, c. 2, d. 3
Reference: NRC Standard question

A.09
Answer: d
Reference: Chart of the Nuclides

A.10
Answer: d
Reference: Burn, *Introduction to Nuclear Reactor Operations*, Section 3.3.3, Page 3-21
$\Delta\rho$ reactor A = $(Keff_1-Keff_2)/(Keff_1*Keff_2)$. (0.2-0.1)/(0.2*0.1) = 5 $\Delta k/k$
$\Delta\rho$ reactor B = $(Keff_1-Keff_2)/(Keff_1*Keff_2)$. (0.9-0.8)/(0.9*0.8) = 0.139 $\Delta k/k$
5/0.139 = 36

Category A: Theory, Thermodynamics & Facility Operating Characteristics

A.11
Answer: b
Reference: Total Worth = $3.50+$4.50+$2.25=$10.25; Reactivity at 15=$2.20+$3.40+$1.50 = $7.10; Core Excess = Total Worth – Reactivity@15 W = $10.25-$7.10= $3.15

A.12
Answer: c
Reference: Burn, *Introduction to Nuclear Reactor Operations,* Section 5.4

A.13
Answer: c
Reference: CR=S/(1-k)→150/(1-0.7) = 500 N/sec

A.14
Answer: a
Reference: DOE Fundamentals Handbook, NPRT, Vol. 1, Module 1, EO 4.3, p.52

A.15
Answer: b
Reference: Nuclides and Isotopes; N = A – Z; 3 – 1 = 2

A.16
Answer: a
Reference: DOE Fundamentals Handbook, NPRT, Vol., Module 1, EO 4.7,p. 51

A.17
Answer: b
Reference: Burn, *Introduction to Nuclear Reactor Operations*

A.18
Answer: d
Reference: Burn, *Introduction to Nuclear Reactor Operations,* Page 4-21

A.19
Answer: d
Reference: DOE Fundamentals Handbook *Nuclear Physics and Reactor Theory*, Volume 2, Module 2

A.20
Answer: d
Reference: DOE Fundamentals Handbook, NPRT, Vol. 2, Module 3, EO 2.7,pg. 26

Category B: Normal/Emergency Procedures and Radiological Controls

B.01
Answer: b
Reference: $\frac{DR_1}{x_2^2} = \frac{DR_2}{x_1^2}$; $x_2^2 = \frac{2000\ mrem}{5\ mrem} 1\ ft^2 \left(\frac{(30.48\ cm)^2}{1\ ft^2}\right) = x = 609.6\ cm$

B.02
Answer: c
Reference: Technical Specifications 5.4.a

B.03
Answer: a. check; b. test; c. cal; d. test
Reference: OSU TS Definitions: 1.3, 1.4, 1.5

B.04
Answer: a
Reference: $DR = DR_\circ * e^{-\lambda t}$ = 50 mrem/hr =100 mrem/hr* $e^{-\lambda(0.5hr)}$
Ln(50/100) = -λ*0.5hr = λ=1.3863
Solve for t: Ln(5/100)=-1.3863 (t) = t=2.16 hours or 129.6 mins
Short cut:
100 mrem to 50 mrem : 30 mins; 50 mrem to 25 mrem : 60 mins
25 mrem to 12.5 mrem : 90 mins; 12.5 mrem to 6.25 mrem : 120 mins
6.25 mrem to 3.125: 150 mins Total: slightly >120 mins

B.05
Answer: c
Reference: OSU Technical Specification 6.7.1

B.06
Answer: a. 2, b. 1, c. 4, d. 3
Reference: 10CFR19.11, 10CFR20.1501(2)(i), 10CFR50.34(1)(ii)(A), 10CFR55.21.

B.07
Answer: d
Reference: OSU Emergency Response Plan 6.0

B.08
Answer: d
Reference: OSUTROP 2, V.D., pg. 23

B.09
Answer: d
Reference: OSU Emergency Response Plan 4.1, pg. 4-1

B.10
Answer: a
Reference: OSU Technical Specification 6.1.3.c.4

B.11
Answer: a
Reference: 10CFR20.1003

Category B: Normal/Emergency Procedures and Radiological Controls

B.12
Answer: a
Reference: OSTROP 1, II.A.6, pg. 4, SAR 7.4.1, pg. 11

B.13
Answer: a
Reference: 200 mrem + 100 mrem + 350 mrem = 650 mrem

B.14
Answer: a
Reference: OSU Technical Specification 3.8.1.b

B.15
Answer: d
Reference: 10CFR50.59

B.16
Answer: b
Reference: OSU Emergency Plan 8.0, *Emergency Equipment and Facilities*

B.17
Answer: d
Reference: $DR=DR_o e^{\wedge -ux}$, HVL =6.5mm $1=2e^{\wedge -u*6.5}$ so u=0.10664,
5mrem/hr = 600mrem/hr $e^{\wedge -0.10664*X}$, X = 44.89mm

B.18
Answer: c
Reference: OSU Technical Specification 3.3 and 4.3

B.19
Answer: b
Reference: OSTROP 18, *Procedures for the Approval and Use of Reactor Experiments II*

B.20
Answer: b
Reference: OSU Emergency Plan 7.4.1

Category C: Facility and Radiation Monitoring Systems

C.01
Answer: a. 1, b. 4, c. 3, d. 2
Reference: Standard NRC question

C.02
Answer: b
Reference: OSTROP 7, Operating Procedures for Reactor Water Systems

C.03
Answer: c
Reference: OSU Technical Specification 3.2.3 Table 2

C.04
Answer: c
Reference: OSU Technical Specification 3.2.3, Basis

C.05
Answer: a
Reference: OSTROP 1

C.06
Answer: d
Reference: OSU Training Manual Volume 1

C.07
Answer: a. 2, b. 1, c. 3
Reference: Approved Experiment B.11

C.08
Answer: b
Reference: OSU Training Manual Volume 1

C.09
Answer: d
Reference: OSTROP 2

C.10
Answer: a
Reference: OSTROP 1 & 2

C.11
Answer: a
Reference: OSU Training Manual Volume 2

C.12
Answer: d
Reference: OSU Technical Specification 4.5 & 5.1 Basis

C.13
Answer: c
Reference: OSU SAR 7.3.1

Category C: Facility and Radiation Monitoring Systems

C.14
Answer: c
Reference: OSU Technical Specification 3.2

C.15
Answer: b
Reference: NRC Standard question

C.16
Answer: b
Reference: OSU Training Manual Volume 1

C.17
Answer: d
Reference: OSU Technical Specification 3.5

C.18
Answer: a
Reference: OSU Technical Specification 3.2.3 Table 2, OSU SAR 7.4.1

C.19
Answer: a
Reference: OSU Technical Specification 5.3.3

C.20
Answer: d
Reference: OSU SAR 3.5.1 & 4.2.2 and Training Manual Volume 1