July 6, 2017

Dr. Donald Wall, Director
Washington State University
Nuclear Radiation Center
50 Roundtop Drive
Pullman, WA 99164-1300

SUBJECT: EXAMINATION REPORT NO. 50-027/OL-17-01, WASHINGTON STATE UNIVERSITY

Dear Dr. Wall:

During the week of June 5, 2017, the U.S. Nuclear Regulatory Commission (NRC) administered an operator licensing examination at your Washington 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 e-mail at 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. 50-027

Enclosures:
1. Examination Report No. 50-027/OL-17-01
2. Written Examination

cc w/o enclosures: See next page

SUBJECT: EXAMINATION REPORT NO. 50-027/OL-17-01, WASHINGTON STATE UNIVERSITY DATED JULY 6, 2017.

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ADAMS ACCESSION #:ML17181A203 **TEMPLATE #:NRR-079**

OFFICE	NRR/DPR/PROB:CE	NRR/DIRS/IOLB:LA	NRR/DPR/PROB:BC
NAME	MDeSouza /JNguyen for/	ABaxter	AMendiola
DATE	06/15/2017	06/30/2017	07/06/2017

OFFICIAL RECORD COPY

cc:

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

REPORT NO.: 50-027/OL-17-01

FACILITY DOCKET NO.: 50-027

FACILITY LICENSE NO.: R-76

FACILITY: WSU NRC

EXAMINATION DATES: June 5-7, 2017

SUBMITTED BY: /RA/ 6/15/2017
Michele DeSouza, Chief Examiner Date

SUMMARY:
During the week of June 5, 2017, the NRC administered an operator licensing examination to one Senior Reactor Operator (SRO) candidate and one Reactor Operator (RO) candidate. The SRO and RO 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	1/0	0/0	1/0
Operating Tests	1/0	1/0	2/0
Overall	1/0	1/0	2/0

3. Exit Meeting:
Michele C. DeSouza, Chief Examiner, NRC
Corey Hines, Assistant Director, WSU Reactor Operations

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: WSU NRC

REACTOR TYPE: TRIGA

DATE ADMINISTERED: 06/07/2017

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 ___ (0.25 each)

A05 a b c d ___

A06 a b c d ___

A07 a b c d ___

A08 a b c d ___

A09 a b c d ___

A10 a b c d ___

A11 a b c d ___

A12 a b c d ___

A13 a b c d ___

A14 a b c d ___

A15 a b c d ___

A16 a b c d ___

A17 a b c d ___

A18 a b c d ___

A19 a b c d ___

A20 a b c d ___

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

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 ___

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 d ___

C08 a b c d ___

C09 a b c d ___

C10 a b c d ___

C11 a b c d ___

C12 a b c d ___

C13 a b c d ___

C14 a b c d ___

C15 a b c d ___

C16 a b c d ___

C17 a b c d ___

C18 a b c d ___

C19 a b c d ___

C20 a b c d ___

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

1 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: Theory, Thermodynamics & Facility Operating Characteristics

Question A.01 [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.02 [1.0 point]
Given a source strength of 200 neutrons per second (N/sec) and a multiplication factor of 0.6, which ONE of the following is the expected stable neutron count rate?

a. 150 N/sec

b. 250 N/sec

c. 400 N/sec

d. 500 N/sec

Question A.03 [1.0 point]
Which ONE of the reactions below describes a method of production and removal of Xenon?

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

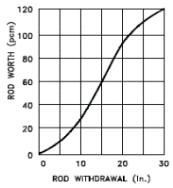
b. $_{52}Te^{135} \rightarrow \gamma + {}_{53}I^{135} \rightarrow \beta^- + {}_{54}Xe^{135} \rightarrow {}_{0}n^{1} + {}_{54}Xe^{136} \rightarrow \beta^- + {}_{56}Ba^{135}$

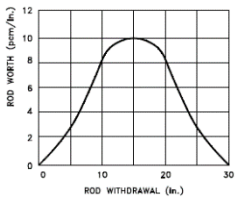
c. $_{52}Te^{135} \rightarrow \beta^- + {}_{53}I^{135} \rightarrow \beta^- + {}_{54}Xe^{135} \rightarrow \beta^- + {}_{55}Cs^{135} \rightarrow \beta^- + {}_{56}Ba^{135}$

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

Question A.04 [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.05 [1.0 point]
A reactor contains a neutron source that produces 15,000 neutrons/second. The reactor has a k_{eff} = 0.88. What is the stable total neutron production rate in the reactor?

a. 100,000 neutrons/sec

b. 115,074 neutrons/sec

c. 125,000 neutrons/sec

d. 135,135 neutrons/sec

Question A.06 [1.0 point]
Reactor period is defined as:

a. The time required for the reactor power to double

b. The time required for a reactor to change by a factor of *e*

c. The time required for the reactor power to be reduced to one-half the initial level

d. The number of factors of ten that reactor power changes in one minute

Category A: Theory, Thermodynamics & Facility Operating Characteristics

Question A.07 [1.0 point]
Which ONE of the following physical characteristics of the TRIGA fuel is the main contributor for the prompt negative temperature coefficient?

a. As the fuel heats up, the resonance absorption peaks broaden and increases the likelihood of absorption in U-238 and/or Pu-240

b. As the fuel heats up, a rapid increase in moderator temperature occurs through conduction and convection heat transfer mechanisms which adds negative reactivity

c. As the fuel heats up, the oscillating hydrogen in the ZrH lattice imparts energy to a thermal neutron, thereby increasing its mean free path and probability of escape

d. As the fuel heats up, fission product poisons (e.g., Xenon) increase in concentration within the fuel matrix and add negative reactivity via neutron absorption

Question A.08 [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

Question A.09 [1.0 point]
The time period in which Xe-135 reaches EQUILIBRIUM in the core is approximately:

a. 7 hours following an up-power transient

b. 18 hours following an up-power transient

c. 48 hours following an up-power transient

d. 72 hours following a reactor shutdown

Category A: Theory, Thermodynamics & Facility Operating Characteristics

Question A.10 [1.0 point]
The reactor is subcritical with the count rate of 100 counts per second (cps) and K_{eff} of 0.950. The control rods are withdrawn until the count rate is doubled. What is the new value of K_{eff}?

a. 1.020

b. 0.998

c. 0.975

d. 0.952

Question A.11 [1.0 point]
Which ONE of the following best describes the alpha decay (α) of a nuclide?

a. The number of protons decreases by 2, and the number of neutrons decreases by 2.

b. The number of protons decreases by 2, and the number of neutrons decrease by 4.

c. The number of protons decreases by 4, and the number of neutrons decrease by 2.

d. The number of protons decreases by 4, and the number of neutrons decreases by 4.

Question A.12 [1.0 point]
Which ONE of the following is the stable reactor period which will result in a power rise from 50% to 100% power in 50 seconds?

a. 14 seconds

b. 36 seconds

c. 72 seconds

d. 144 seconds

Question A.13 [1.0 point]
In a subcritical reactor, K_{eff} is increased from 0.885 to 0.943. Which one of the following is the amount of reactivity that was added to the core?

a. 4.68 %Δk/k

b. 5.58 %Δk/k

c. 6.94 %Δk/k

d. 7.45 %Δk/k

Category A: Theory, Thermodynamics & Facility Operating Characteristics

Question A.14 [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.

Question A.15 [1.0 point]
What is the result between a neutron and a target nucleus in elastic scattering?

a. Energy is transferred into nuclear excitation, and then emitted via a gamma emissions.

b. The target nucleus gains the amount of kinetic energy that the neutron loses.

c. The neutron is absorbed by the target nucleus and then emitted with lower kinetic energy.

d. The neutron conserves its initial kinetic energy if the target nucleus is large.

Question A.16 [1.0 point]
What is the difference between prompt and delayed neutrons?

a. Prompt neutrons are released virtually instantaneously, and delayed neutrons are a very small fraction of the total number of neutrons and do not have an important role in the control of the reactor.

b. Prompt neutrons are released during fast fission while delayed neutrons are released during thermal fissions.

c. Prompt neutrons are released within 10^{-13} seconds, whereas delayed neutrons are emitted following the beta decay of a fission fragment.

d. Prompt neutrons are 99% of the neutron produced in fission and are therefore the dominating factor in determining the reactor period, whereas delayed neutrons account for less than 1% of the neutron population and have little effect on the reactor period

Question A.17 [1.0 point]
What is the effect of 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.18 [1.0 point]
Xenon-135 (Xe^{135}) is produced in the reactor by two methods. One is directly from fission; the other is indirectly from the decay of:

a. Xe^{136}

b. Sm^{136}

c. Cs^{135}

d. I^{135}

Question A.19 [1.0 point]
The reactor is on a CONSTANT positive period. Which ONE of the following power changes will take the LONGEST time to complete?

a. 20%, from 60% to 80%

b. 15%, from 15% to 30%

c. 10%, from 80% to 90%

d. 5%, from 95% to 100%

Question A.20 [1.0 point]
Which ONE of the following is a number of neutrons in the tritium nucleus ($_1T^3$ or $_1H^3$)?

a. 1

b. 2

c. 3

d. 4

(****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”?

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 WSU Technical Specification limits for irradiated fuel storage?

a. k-eff <0.95 Δk/k

b. k-eff <0.90 Δk/k

c. k-eff <0.85 Δk/k

d. k-eff <0.80 Δk/k

Question B.03 [1.0 point]
A radioactive source reads 80 mRem/hr on contact. Thirty minutes later, the same source reads 40 mrem/hr. How long is the time for the source to decay from a reading of 80 mrem/hr to 5 mrem/hr?

a. 1.5 hours

b. 2 hours

c. 3 hours

d. 5 hours

Category B: Normal/Emergency Procedures and Radiological Controls

Question B.04 [1.0 point]
You are performing a periodic radiation survey of an area where general radiation readings are approximately 1 mrem/hr. However, you find an old experimental facility in an accessible area not posted for radiological safety reading reading 25 mrem/hr at 30 cm. How would this area be posted in accordance with the requirements of 10 CFR 20?

a. Radiation Area on contact with the experimental facility

b. Radiation Area @ 30 cm from the experimental facility

c. High Radiation Area on contact with the experimental facility

d. High Radiation Area @ 30 cm from the experimental facility

Question B.05 [1.0 point]
Which ONE of the following is the definition for "Annual Limit on Intake (ALI)"?

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

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. 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.

Question B.06 [1.0 point]
The CURIE content of a radioactive source is a measure of

a. the number of radioactive atoms in the source.

b. the number of nuclear disintegrations per unit time.

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

d. the amount of damage to soft body tissue per unit time.

Category B: Normal/Emergency Procedures and Radiological Controls

Question B.07 [1.0 point]
Which ONE of the following is the correct definition of a CHANNEL CHECK?

a. The combination of sensor, line, amplifier, and output device which are connected for the purpose of measuring the value of a parameter.

b. The introduction of a signal into the channel for verification that it is operable.

c. A qualitative verification of acceptable performance by observation of channel behavior.

d. An adjustment of the channel such that its output corresponds with acceptable accuracy to known values of the parameter which the channel measures.

Question B.08 [1.0 point]
Per WSU Emergency Classification, which ONE of the following is a “failure of an in-core experiment with a minor release of radioactive material”?

a. Alert

b. Unusual Event – (reactor related)

c. Safety Event – (non-reactor related)

d. Normal Operation

Question B.09 [1.0 point]
Which ONE of the following changes requires NRC Approval?

a. Revision of the operator licensing requalification examination

b. Revision of Standard Operating Procedure #1 for Use of the Reactor

c. Major changes in the Administrative Procedure #7

d. Delete an administrative control requirement listed in the WSU Technical Specification 6.0

Question B.10 [1.0 point]
Which ONE of the following is the surveillance reporting requirement of Ar^{41} discharge?

a. Every 3 months

b. Twice a year

c. Once a year

d. Every other year

Category B: Normal/Emergency Procedures and Radiological Controls

Question B.11 [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 Operator

b. Senior Reactor Operator

c. Reactor Facility Director

d. Reactor Operations Committee

Question B.12 [1.0 point]
You use a survey instrument with a window probe to measure the beta-gamma dose rate from an irradiated experiment. The dose rate with the window closed is 160 mrem/hour and 200 mrem/hour with the window open. Which ONE of the following is the gamma dose rate?

a. 40 mrem/hour

b. 140 mrem/hour

c. 160 mrem/hour

d. 360 mrem/hour

Question B.13 [1.0 point]
Which ONE of the following regulations requires submitting NRC Form 396, Certification of Medical Examination by Facility Licensee, as part of an application for an operator license?

a. 10 CFR 19

b. 10 CFR 20

c. 10 CFR 50

d. 10 CFR 55

Category B: Normal/Emergency Procedures and Radiological Controls

Question B.14 [1.0 point]
The Regulating Rod shall be visually inspected _____ while the Transient Rod Drive shall be inspected _____.

a. Monthly, annually

b. Every six months, every year

c. Every year, semiannually

d. Every two years, every six months

Question B.15 [1.0 point]
10 CFR 50.59 would require WSU 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 reactor is operating at 10 mrem/hr at the pool radiation area monitor. You are conducting the facility walk-thru portion of your NRC licensing exam with the NRC examiner. How long can the NRC examiner stay before their 10 CFR 20 total effective dose limit is exceeded?

a. 10 hours

b. 5 hours

c. 2 hours

d. 1 hour

Question B.17 [1.0 point]
WSU Emergency Plan allows a one-time MAXIMUM exposure limit of _____ to save a life or protect large populations.

a. 5 rem

b. 10 rem

c. 25 rem

d. 50 rem

Category B: Normal/Emergency Procedures and Radiological Controls

Question B.18 [1.0 point]
Which ONE of the following radioactive GASES might be an indication of a fuel element leak?

a. N^{16}

b. Ar^{41}

c. I^{131}

d. Cs^{137}

Question B.19 [1.0 point]
Which ONE of the following is the renewal requirement for an existing license?

a. Every six months

b. Every year

c. Biennually

d. Every six years

Question B.20 [1.0 point]
Who may authorize reentry into the Nuclear Radiation Center building after an evacuation of the facility?

a. Reactor Operator

b. Radiation Safety Officer

c. Emergency Coordinator

d. Emergency Director

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

Category C: Facility and Radiation Monitoring Systems

Question C.01 [1.0 point, 0.25 each]
During a WSU Reactor Power Calibration run, indicate which of the following components are to be OFF or ON?

a. Pool mixer

b. Diffuser pump

c. Cooling tower

d. Purification system

Question C.02 [1.0 point]
During the measurement of the traverse bend of a fuel element you find the bend exceeds the original length by 0.13 inches. What, if any, are your actions for this measurement?

a. No action necessary, this measurement is within WSU technical specification, continue with fuel inspection
b. Repeat the measurement at least 5 times and ensure it fails elongation measurement as well, otherwise continue with fuel inspection
c. Stop the fuel inspection and immediately report the result to the U.S. NRC as a reportable incident
d. Stop the fuel inspection and immediately report the results to the supervisor; fuel element is considered damaged

Question C.03 [1.0 point]
Which ONE of the following is the calibration source to be used for the calibration alignment check for the Ar-41 monitor?

a. Carbon - 14

b. Chlorine - 36

c. Cobalt - 60

d. Strontium – 90

Question C.04 [1.0 point]
Which ONE of the following will result in an AUTOMATIC SCRAM?

a. Low pool level = 8 inches

b. 2kW pulse

c. Linear High Flux = 110%

d. Loss of CIC HV

Category C: Facility and Radiation Monitoring Systems

Question C.05 [1.0 point]
Which ONE of the following is initiated by a Beam Port Plug alarm signal?

a. Console board yellow light

b. Red light on its panel only

c. Console board yellow light and panel red light

d. Console annunciator and yellow light as well as a red panel light

Question C.06 [1.0 point]
What is the range of the high temperature SCRAM setpoint in accordance with SOP #13?

a. 440°C – 435°C

b. 461 °C – 475 °C

c. 476 °C – 500 °C

d. 520 °C – 550 °C

Question C.07 [1.0 point]
Which ONE of the following ensures the reactor power level will return to a low level after pulsing?

a. Power level preventer

b. Input transmitter signal

c. Preset timer

d. Coolant temperature flow reducer

Question C.08 [1.0 point]
Which ONE of the following components is used to reduce drive speed on the blade type control rods?

a. Magnetic coupler

b. Mechanical drive clutch

c. Worm gear assembly

d. Nut and ball bearing screw system

Category C: Facility and Radiation Monitoring Systems

Question C.09 [1.0 point]
The Linear Power Channel receives its indication from which kind of detector?

a. GM

b. Scintillator

c. Ion chamber

d. Fission chamber

Question C.10 [1.0 point]
What is the response of the ventilation system upon a high temperature reactor SCRAM?

a. Automatic shutdown

b. Continues to operate normally

c. Switches to dilute mode

d. Switches to isolation mode

Question C.11 [1.0 point]
How much water is required above the top of the core to maintain the radiation shielding requirements of the Reactor Pool Water System?

a. 10 feet

b. 12 feet

c. 14 feet

d. 16 feet

Question C.12 [1.0 point]
Which ONE of the following Area Radiation Monitors (ARM) has a setpoint of 50 mR/hour?

a. Radio Chem Lab Room 101

b. Beam Room 2 South

c. Beam Room 2A Cave

d. Beam Room 2 North

Category C: Facility and Radiation Monitoring Systems

Question C.13 [1.0 point]
Which ONE of the following describes the characteristics of the unirradiated 30/20 fuel?

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

b. Maximum uranium content is 30% by weight uranium, enriched to less than 20% U-235, and erbium content is distributed with a nominal 0.5% weight

c. Maximum uranium content is 30% by weight uranium, enriched to less than 20% U-235, and the erbium content is homogenously distributed with a nominal 0.9% by weight

d. Maximum uranium content is 30% by weight uranium, enriched to less than 20% U-235, and the erbium content is heterogeneously distributed with a nominal 0.6%

Question C.14 [1.0 point]
Which ONE of the following is the main purpose of the interlock preventing withdrawal of more than one control rod at a time?

a. Prevent control rod drive damage

b. Prevention of a pulse while on a positive period

c. Initiate Pulse timer count

d. Prevent inadvertent large reactivity insertion

Question C.15 [1.0 point]
What are your actions while operating the reactor at 100 kW, you receive an Exhaust Gas Monitor (EGM) alarm?

a. Continue with reactor operations and deactivate the EGM alarm

b. Immediately secure reactor and notify the Senior Reactor Operator on duty

c. Isolate ventilation, continue reactor operations, and notify the SRO on duty

d. Immediately notify the Health Physicist on duty for direction

Category C: Facility and Radiation Monitoring Systems

Question C.16 [1.0 point]
What is the MAIN purpose for the small holes at the bottom of the shroud?

a. Prevent control blade corrosion

b. Allow water dispersion to cool blades during shutdown

c. Reduce the effects of viscous damping on the blade fall

d. Increase the blade speed during withdrawal while operating

Question C.17 [1.0 point]
The source interlock signal, that prevents rod withdrawal unless the source level is above a preset level, comes from what channel?

a. Linear

b. Log-N Power

c. Fuel Temperature

d. Percent power #2

Question C.18 [1.0 point]
Which ONE of the following is an indication of a clog in the demineralizer tank?

a. High pressure upstream of demineralizer

b. High flow rate through demineralizer

c. High temperature within demineralizer

d. High radiation level at pool surface

Question C.19 [1.0 point]
A system of limit switches is used to indicate the position of the air cylinder and the transient rod. Which ONE of the following limit switches is actuated when the piston reaches its lower limit of travel?

a. Rod up

b. Rod down

c. Drive up

d. Drive down

Category C: Facility and Radiation Monitoring Systems

Question C.20 [1.0 point]
Which ONE of the following systems receives emergency power in the event of a power loss by the Auxiliary Reactor Emergency Supply (ARIES)?

a. Control rod

b. Pool level alarm

c. Primary coolant pump

d. Pneumatic transfer system

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

Category A: Theory, Thermodynamics & Facility Operating Characteristics

A.01
Answer: a
$\rho 1=(\rho \$1)(\beta_{eff})=(\$1.10)(.0075)=(.00825)$
$[(\rho 2-\beta_{eff})^2]/Peak2 = [(\rho 1-\beta_{eff})^2]/Peak1$
$Peak2/Peak1*[(\rho 1- \beta_{eff})^2]=[(\rho 2-\beta_{eff})^2]$
$(5000/500)*[(.00825-.0075)^2]= [(\rho 2-\beta_{eff})^2]$
$[(.000005625)^{1/2}]+\beta_{eff} =\rho 2=.009872$
$\rho \$2=(\rho 2/\beta_{eff})=(.009872/.0075)= \$1.316 \approx \$1.32$
Reference: Burn, R., Introduction to Nuclear Reactor Operations, 1988. § 4.6, p. 4-16

A.02
Answer: d
Reference: $CR=S/(1-k) \rightarrow 200/(1-0.6) = 500$ N/sec

A.03
Answer: c
Reference: DOE Fundamentals Handbook, NPRT, Vol. 2, Module 3, EO 4.1, p.35
KAPL, "Chart of the Nuclides", 17th Ed.

A.04
Answer: a. 2; b. 1; c. 2; d. 1
Reference: DOE Fundamentals Handbook, NPRT, Vol. 2, Module 3,
EO 5.4, EO 5.5, EO 5.6, pp 51-53

A.05
Answer: c
$N = (S) (M)$
$M = 1 / (1-k_{eff}) = 1 / (1-0.88) = 8.3333$
$N = (15,000)(8.3333) = 125,000$ neutrons/second
Reference: DOE Fundamentals Handbook, NPRT, Vol. 2, Module 4, EO 1.2, p 4

A.06
Answer: b
Reference: DOE Fundamentals Handbook, NPRT, Vol. 2, Module 4, EO 2.1, p.17

A.07
Answer: c
Reference: TRIGA Fuel Design

A.08
Answer: a
Reference: DOE Fundamentals Handbook, NPRT, Vol. 1, Module 1, EO 4.3, p.52

A.09
Answer: c
Reference: Burn, R., Introduction to Nuclear Reactor Operations, Sec 8.4, page 8-12.

Category A: Theory, Thermodynamics & Facility Operating Characteristics

A.10
Answer: c
Reference: Count1*(1-Keff1) = Count2*(1-Keff2) 100*(1-0.950) = 200*(1-Keff2)
100*(1-0.95) = 200(1- Keff2); Keff2 = 0.975

A.11
Answer a
Reference: Chart of the Nuclides, KAPL. Seventeenth Edition.

A.12
Answer: c
Reference: $P = P_0 e^{t/T}$, $T = t / (\ln(P/P_0) = 50 / (\ln(2)) = 72.15$ seconds

A.13
Answer: c
Reference: Burn, R., Introduction to Nuclear Reactor Operations, Section 3.3.4
$\Delta\rho = (Keff1-Keff2)/(Keff1*Keff2) = (0.943-0.885)/((0.943*0.885)$
$0.0694\Delta k/k = 6.94\%\Delta k/k$

A.14
Answer: c
Reference: DOE Fundamentals Handbook, NPRT, Vol. 2, Module 3, EO 2.7,p. 26

A.15
Answer: b
Reference: DOE Fundamentals Handbook, NPRT, Vol., Module 1, EO 3.1, p.43

A.16
Answer: c
Reference: DOE Fundamentals Handbook, NPRT, Vol., Module 2, EO 3.1, p. 29

A.17
Answer: a
Reference: DOE Fundamentals Handbook, NPRT, Vol., Module 1, EO 4.7,p. 51

A.18
Answer: d
Reference: Burn, R., Introduction to Nuclear Reactor Operations, Section 8.1 - 8.4

A.19
Answer: b
Reference: Time is related to ratio of final power to initial power. 2:1 is the largest ratio

A.20
Answer: b
Reference: Nuclides and Isotopes; N = A – Z; 3 – 1 = 2

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: d
Reference: Technical Specifications 5.5

B.03
Answer: b
Reference: DR = DR◦*$e^{-\lambda t}$ = 40 mrem/hr =80 mrem/hr* $e^{-\lambda(0.5hr)}$
Ln(40/80) = -λ*0.5hr = λ=1.3863
Solve for t: Ln(5/80)=-1.3863 (t) = t=2 hours
Short cut:
80 mrem to 40 mrem : 30 mins; 40 mrem to 20 mrem : 60 mins
20 mrem to 10 mrem : 90 mins; 10 mrem to 5 mrem : 120 mins
Total: 120 mins or 2 hrs

B.04
Answer: b
Reference: 10 CFR 20

B.05
Answer: d
Reference: 10CFR20.1003

B.06
Answer: b
Reference: Standard Health Physics Definition.

B.07
Answer: c
Reference: Technical Specifications, Definitions

B.08
Answer: b
Reference: Emergency Plan 4.3

B.09
Answer: d
Reference: WSU Technical Specification 6.4.4, 10 CFR 50.59

B.10
Answer: c
Reference: WSU Technical Specification 4.5.2

B.11
Answer: b
Reference: WSU Technical Specification 6.2.3

Category B: Normal/Emergency Procedures and Radiological Controls

B.12
Answer: c
Reference: NRC Standard Instrumentation Question

B.13
Answer: d
Reference: 10 CFR 55.21

B.14
Answer: d
Reference: WSU Technical Specification Definitions and 4.2.1

B.15
Answer: d
Reference: WSU Administrative Procedure #3 & 10CFR50.59

B.16
Answer: a
Reference: 10 CFR 20 100 mrem limit; TD = DR x T; 100 mrem = 10 mrem/hr x T = 10 hours

B.17
Answer: c
Reference: WSU Emergency Plan Table 3.5

B.18
Answer: c
Reference: Standard NRC question

B.19
Answer: d
Reference: 10 CFR 55.55

B.20
Answer: d
Reference: WSU Emergency Plan 3.4

Category C: Facility and Radiation Monitoring Systems

C.01
Answer: a. ON b. ON c. OFF d. OFF
Reference: WSU Reactor Power Calibration

C.02
Answer: d
Reference: WSU Technical Specification

C.03
Answer: c
Reference: WSU SOP #7

C.04
Answer: d
Reference: WSU Technical Specification 3.2

C.05
Answer: b
Reference: WSU SOP#18

C.06
Answer: b
Reference: WSU SOP#13

C.07
Answer: c
Reference: WSU Technical Specification Table 3.2

C.08
Answer: c
Reference: WSU SAR 4.2.2

C.09
Answer: c
Reference: WSU SAR 7.3.3

C.10
Answer: d
Reference: WSU Technical Specification 3.4(4)

C.11
Answer: d
Reference: WSU Technical Specification 5.8

C.12
Answer: c
Reference: WSU Start-up Checkoff

C.13
Answer: c
Reference: WSU Technical Specification 5.2

Category C: Facility and Radiation Monitoring Systems

C.14
Answer: d
Reference: WSU Technical Specification 3.2

C.15
Answer: c
Reference: WSU SOP#15

C.16
Answer: c
Reference: WSU SAR 4.2.2

C.17
Answer: b
Reference: WSU SAR 7.3

C.18
Answer: a
Reference: Standard NRC question

C.19
Answer: b
Reference: WSU SAR 4.2.2

C.20
Answer: b
Reference: WSU SAR 7.4.6