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

June 28, 2018

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

SUBJECT: EXAMINATION REPORT NO. 50-027/OL-18-01, WASHINGTON STATE UNIVERSITY NUCLEAR RADIATION CENTER

Dear Dr. Wall:

During the week of May 29, 2018, 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 e-mail Michele.DeSouza@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. 50-027

Enclosures: 1. Examination Report No. 50-027/OL-18-01
2. Written Examination, WSU 18-01

cc: w/o enclosures: See next page

SUBJECT: EXAMINATION REPORT NO. 50-027/OL-18-01, WASHINGTON STATE UNVERSITY NUCLEAR RADIATION CENTER DATED JUNE 28, 2018

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**ADAMS Accession No.: ML18179A493** **NRR-079**

| OFFICE | NRR/DLP/PROB/CE | NRR/DLP/PROB/OLA | NRR/DLP/PROB/BC |
|---|---|---|---|
| NAME | MDeSouza | CJRandiki | AMendiola |
| DATE | 06/06/2018 | 06/26/2018 | 06/28/2018 |

**OFFICIAL RECORD COPY**

cc:

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

REPORT NO.: 50-027/OL-18-01

FACILITY DOCKET NO.: 50-027

FACILITY LICENSE NO.: R-76

FACILITY: WSU NRC

EXAMINATION DATES: May 29-31, 2018

SUBMITTED BY: ***/RA/*** ***06/05/2018***
Michele DeSouza, Chief Examiner Date

SUMMARY:
During the week of May 29, 2018, the NRC administered an operator licensing examination to one Senior Reactor Operator Upgrade (SRO-U) candidate and three Reactor Operator (RO) candidates. The SRO-U and three 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 | 3/0 | 1/0 | 3/0 |
| Operating Tests | 3/0 | 1/0 | 4/0 |
| Overall | 3/0 | 1/0 | 4/0 |

3. Exit Meeting:

Michele C. DeSouza, Chief Examiner, NRC
Corey Hines, Assistant Director, WSU Reactor Operations
Tyler LaVoie, WSU 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. 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: 05/29/2018

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 | | _____ | _____ % | TOTALS |
| | | FINAL GRADE | | |

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 ___ (0.25 each)

A04 a b c d ___

A05 a b c d ___

A06 a b c d ___

A07 a b c d ___

A08 a b c d ___

A09 a b c d ___

A10 a b c d ___

A11 a b c d ___

A12 a b c d ___

A13 a b c d ___

A14 a b c d ___

A15 a b c d ___

A16 a b c d ___

A17 a ___ b ___ c ___ d ___ (0.50 each)

A18 a b c d ___

A19 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 ___ (0.50 each)

B19 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 ___ (0.50 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 ___ e ___ f ___ g ___ h ___ (0.25 each)

(***** 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: Reactor Theory, Thermodynamics, and Facility Operating Characteristics

**QUESTION A.01 [1.0 point]**
What is $\beta_{eff}$?

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

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 fractional change in neutron population per generation

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

a. 5% power – from 1% to 6% power

b. 10% power – from 10% to 20% power

c. 15% power – from 20% to 35% power

d. 20% power – from 40% to 60% power

**QUESTION A.03 [1.0 point, 0.25 each]**
Match the term in Column A with its correct definition in Column B.

| Column A | Column B |
|---|---|
| a. Prompt Neutron | 1. Neutron in equilibrium with its surroundings |
| b. Fast Neutron | 2. Neutron born directly from fission |
| 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.04 [1.0 point]**
Which ONE of the following identifies how prompt neutrons are produced?

a. High energy photon pair production

b. Fission fragment decay

c. Directly from fission

d. Installed source

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

**QUESTION A.05 [1.0 point]**
Which term below matches the definition, *the number of neutrons passing through one $cm^2$ of target material per second*?

a. Neutron flux

b. Neutron density

c. Neutron population

d. Neutron impact potential

**QUESTION A.06 [1.0 point]**
What is the average number of neutrons produced from every fission of Uranium-235 with thermal neutrons?

a. 2.42 neutrons

b. 2.66 neutrons

c. 2.81 neutrons

d. 2.93 neutrons

**QUESTION A.07 [1.0 point]**
Which ONE of the following is the direct source of DELAYED neutrons in the fission process?

a. Fission of U-235

b. Absorption of U-235

c. Spontaneous fission of the fission products

d. Decay of the fission product daughters

**QUESTION A.08 [1.0 point]**
What is the half-life of a material with an original activity of 2400 cps, after 10 minutes an activity of 1757 cps?

a. 8 minutes

b. 22 minutes

c. 35 minutes

d. 41 minutes

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

**QUESTION A.09 [1.0 point]**
Which ONE of the following best describes the difference between reflectors and moderators?

a. Reflectors decrease core leakage while moderators thermalize neutrons

b. Reflectors thermalize neutrons while moderators decrease core leakage

c. Reflectors decrease thermal leakage while moderators decrease fast leakage

d. Reflectors shield against neutrons while moderators decrease core leakage

**QUESTION A.10 [1.0 point]**
Which ONE of the following is the new $k_{eff}$ of the reactor if initially the reactor is subcritical with a shutdown margin of $0.526\Delta k/k$ and the addition of a reactor experiment increases the indicated count rate from 10 cps to 20 cps?

a. 0.639

b. 0.828

c. 0.975

d. 1.014

**QUESTION A.11 [1.0 point]**
Which ONE of the following determines $k_{eff}$? $k_{eff}$ is $k_\infty$ times_____.

a. Fast fission factor

b. Reproduction factor

c. Resonance escape probability

d. Total non-leakage probability

**QUESTION A.12 [1.0 point]**
Which one of the following terms describes the total amount of reactivity added by inserting or withdrawing a control rod from a reference height to any other rod height?

a. Integral Rod Worth

b. Differential Rod Worth

c. Shutdown Reactivity

d. Reference Margin Reactivity

**QUESTION A.13 [1.0 point]**
Which ONE of the following conditions describes a critical reactor?

a. $k = 1; \Delta k/k = 1$

b. $k = 0; \Delta k/k = 0$

c. $k = 0; \Delta k/k = 1$

d. $k = 1; \Delta k/k = 0$

**QUESTION A.14 [1.0 point]**
Two common FISSION PRODUCTS that have especially large neutron cross sections and play a significant role in reactor physics are Sm-149 and _____.

a. Nitrogen-16

b. Argon-41

c. Iodine-131

d. Xenon-135

**QUESTION A.15 [1.0 point]**
Which ONE of the following is the definition of k-eff, effective neutron multiplication factor?

a. absorption / (production + leakage)

b. (production + leakage) / absorption

c. production / (absorption + leakage)

d. (absorption + leakage) / production

**QUESTION A.16 [1.0 point]**
Which factor, in the six-factor formula, is represented by the following ratio?

$$\frac{\text{\# of neutrons that reach thermal energy}}{\text{total \# of neutrons before thermalization}}$$

a. Fast fission factor

b. Reproduction factor

c. Thermal utilization factor

d. Resonance escape probability

**QUESTION A.17 [2.0 points, 0.5 each]**
Given a mother isotope of $_{35}Br^{87}$ identify each of the daughter isotopes as a result of: α, $\beta^+$, $\beta^-$, γ, or n? (Answers may be used once, more than once or not at all).

a. $_{33}As^{83}$

b. $_{34}Se^{87}$

c. $_{35}Br^{86}$

d. $_{36}Kr^{87}$

**QUESTION A.18 [1.0 point]**
A reactor is critical at 0.1 mW, you are raising reactor power, and doubling time is 30 seconds. What is the reactor power 1 minute later?

a. 0.4 mW

b. 0.6 mW

c. 0.8 mW

d. 1.2 mW

**QUESTION A.19 [1.0 point]**
Which of the following statements illustrates a characteristic of Subcritical Multiplication?

a. The number of source neutrons decreases for each generation

b. The number of fission neutrons remains constant for each generation

c. As k-eff approaches unity (1), for the same increase in k-eff, a greater increase in neutron population occurs

d. Number of neutrons gained per generation gets larger for each succeeding generation

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

Category B: Normal/Emergency Operating Procedures and Radiological Controls

**QUESTION B.01 [1.0 point]**
Which ONE of the following is the Limiting Condition for Operation objective?

a. To define the maximum fuel temperature that can be permitted with confidence that a fuel cladding failure will not occur.

b. To prevent the safety limits from being reached or exceeded.

c. To assure that the reactor can startup at all times.

d. To ensure that the fuel rod temperature safety limit will not be exceeded during steady-state operation.

**QUESTION B.02 [1.0 point]**
Which ONE of the following items will ALLOW a Reactor Operator to continue to operate the reactor? (Assume today is the three year anniversary of receiving your RO license)

a. Performed one startup over the past year

b. Last physical examination was three years ago

c. Two hours of console operation performed in the last quarter

d. Written exam administered by Reactor Supervisor was 10 months ago

**QUESTION B.03 [1.0 point]**
Washington State University (WSU) Emergency Plan requires *accident scenarios are varied such that, over a two year period, the following emergency response elements are tested*.
Which ONE of the following is NOT a requirement?

a. Communication tests designed to ensure reliability of the system(s) and correct transmission and receipt of messages

b. Medical emergency involving a simulated contaminated individual.

c. Active shooter scenario within the reactor facility

d. Radiological monitoring including contamination control methods, dose rate measurements, nonessential personnel evacuation and record keeping

**QUESTION B.04 [1.0 point]**
What is the MINIMUM staffing requirement to be present at the facility for fuel accountability?

a. One Senior Reactor Operator

b. Reactor Facility Director only

c. One Reactor Operator and One Senior Reactor Operator

d. One Senior Reactor Operator and a non-licensed individual

Category B: Normal/Emergency Operating Procedures and Radiological Controls

**QUESTION B.05 [1.0 point]**
What type of radiation detector is preferred for finding area contamination?

a. Ionization Chamber

b. Proportional Counter

c. Geiger-Mueller

d. Scintillation detector

**QUESTION B.06 [1.0 point]**
An area of radiation reads 460 mRem/hr. How long can you stay before exceeding your annual federal limit?

a. 10.87 hours

b. 14.64 hours

c. 15.23 hours

d. 16.11 hours

**QUESTION B.07 [1.0 point]**
Per the WSU Emergency Plan, how frequent are operators required to receive emergency training and drills?

a. Quarterly

b. Semi-Annual

c. Annually

d. Biennial

**QUESTION B.08 [1.0 point]**
Which ONE of the following satisfies 10 CFR 20 and would be considered the most correct WSU method for environmental monitoring?

a. Surveillance monitoring of personnel operatin around exposure beam ports

b. Continuous air monitoring fro Nitrogen-16 in the Exhaust Gas Monitoring System

c. Performing periodic pool water samples with a high purity germanium detector

d. Processing highly sensitive thermoluminescent dosimeters placed in unrestricted areas adjacent to the facility

Category B: Normal/Emergency Operating Procedures and Radiological Controls

**QUESTION B.09 [1.0 point]**
Which ONE of the following surveillances is classified as a Channel Test?

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 detector to a check source to verify that it responds

**QUESTION B.10 [1.0 point]**
Which ONE of the following surveillance requirements is the frequency for the calibration of the radiation monitoring instrumentation?

a. Monthly

b. Annually

c. Every two years

d. Prior to start-up

**QUESTION B.11 [1.0 point]**
Which ONE of the following experiments listed below requires Double Encapsulation per Washington State University Technical Specifications?

a. An experiment containing liquid fissionable material

b. An experiment containing 22 grams of explosive material

c. An experiment containing corrosive material to reactor components

d. An experiment, calculated upon failure to release an approximate total dose equivalent of 0.02 mSv for a period of two hours stating at the time, as a result of any airborne pathway

**QUESTION B.12 [1.0 point]**
Which ONE of the following locations is NOT an area where the Emergency Notification Rosters are required to be posted?

a. Reactor Laboratory

b. Reactor Control Room

c. Whitcom Dispatch Communications Center

d. Nuclear Radiation Center Main Office

Category B: Normal/Emergency Operating Procedures and Radiological Controls

**QUESTION B.13 [1.0 point]**
What is your dose rate at 1 foot away from the source, if you are receiving 250 mR/hr at 3 feet away from the source?

a. 2.25 R/hr

b. 2.85 R/hr

c. 3.05 R/hr

d. 3.25 R/hr

**QUESTION B.14 [1.0 point]**
Which ONE of the following are the WSU Technical Specification limits for irradiated fuel storage?

a. k-eff <0.80 $\Delta$k/k

b. k-eff <0.85 $\Delta$k/k

c. k-eff <0.90 $\Delta$k/k

d. k-eff <0.95 $\Delta$k/k

**QUESTION B. 15 [1.0 point]**
Which ONE of the following federal regulations establish procedures and criteria for the issuance of licenses to Reactor Operators and Senior Reactor Operators?

a. 10 CFR 19

b. 10 CFR 20

c. 10 CFR 50

d. 10 CFR 55

**QUESTION B.16 [1.0 point]**
Per WSU Technical Specification, which ONE of the following is NOT a requirement for records to be maintained for the life of the facility?

a. Rod worth measurements and other reactivity measurements

b. Radiation exposures for all personnel monitored

c. Gaseous and liquid radioactive effluents released to the environs

d. Fuel inventories, receipts, and shipments

Category B: Normal/Emergency Operating Procedures and Radiological Controls

**QUESTION B.17 [1.0 point]**
During WSU emergency recovery operations to restore the facility to a safe status, who must assess the existing radiation and contamination levels?

a. Emergency Director

b. Reactor Operator

c. Radiation Safety Coordinator

d. Any two individuals on the team

**QUESTION B.18 [2.0 points, 0.50 each]**
Match the Technical Specification Limits in Column A with the corresponding value in Column B (Each limit in Column A has only one answer. Answers in Column B may be used once, more than once, or not at all).

| Column A | Column B |
|---|---|
| a. Secured Experiment | 1. $0.50 |
| b. Movable Experiment | 2. $1.00 |
| c. Sum of all individual experiments | 3. $2.00 |
| d. Maximum Excess Reactivity | 4. $5.00 |
| | 5. $6.56 |
| | 6. $7.46 |

**QUESTION B.19 [1.0 point]**
A radiation survey of an area reveals a general radiation reading of 10 mRem/hr. However, a small section of pipe (point source) reads 100 mRem/hr at one foot. Which ONE of the following is the posting requirement for the area, in accordance with 10CFR20? (2.54cm=1inch)

a. CAUTION - RADIATION AREA

b. CAUTION – HIGH RADIATION AREA

c. CAUTION – RADIOACTIVE MATERIAL

d. CAUTION – AIRBORNE RADIOACTIVITY AREA

(***** End of Category B *****)

Category C: Facility and Radiation Monitoring Systems

**QUESTION C.01 [2.0 points, 0.50 each]**
Match the input signals in Column A with their AUTOMATIC responses listed in Column B. (Assume the reactor is in operation. Items in Column B may be used once, more than once or not at all).

| Column A | Column B |
|---|---|
| a. Low Pool Level = 8 inches | 1. Alarm Only |
| b. Perform Pulse at 2kW | 2. Interlock |
| c. Linear High Flux = 110% | 3. Scram |
| d. Loss of CIC High Voltages | |

**QUESTION C.02 [1.0 point]**
Which ONE of the following supplies the Period information?

a. Safety Channel #1

b. Safety Channel #2

c. Log Power Channel

d. Wide Range Channel

**QUESTION C.03 [1.0 point]**
Which ONE of the following channels provides the 1 kW pulse interlock information?

a. NLP 1000

b. NPP 1000

c. NMP 1000

d. NLW 1000

**QUESTION C.04 [1.0 point]**
Which ONE of the following requires the ion exchange resin be changed?

a. pH of the PRIMARY coolant is 8.0

b. pH of the SECONDARY coolant is 8.0

c. Ion Exchanger INLET conductivity is 0.6 micromho/cm

d. Ion Exchanger OUTLET conductivity is 0.6 micromho/cm

Category C: Facility and Radiation Monitoring Systems

**QUESTION C.05 [1.0 point]**
WSU Technical Specifications requires fuel elements be stored in a safe array where the $k_{eff}$ is less than _____.

a. 0.6

b. 0.7

c. 0.8

d. 0.9

**QUESTION C.06 [1.0 point]**
Which ONE of the following is the main reason for the requirement that the fuel temperature, as measured by the Instrumented Fuel Rod, shall not be more than 10°C above the pool temperature during the fuel movement?

a. Ensure the reactivity measurement to be made at low power, without having to correct for negative temperature coefficient contributions

b. Ensure the fuel temperature increase will not cause any damage to the fuel measurement tool

c. Ensure a lateral bending and an elongation of a fuel element are correctly measured

d. Maintain the integrity of the fuel element cladding

**QUESTION C.07 [1.0 point]**
Which ONE of the following is the alarm setpoint for the Beam Room 2A Cave?

a. 10 mR/hr

b. 35 mR/hr

c. 50 mR/hr

d. 60 mR/hr

**QUESTION C.08 [1.0 point]**
Which ONE of the following initiates a rod withdrawal prohibit unless the source level is above a preset limit?

a. Linear Channel

b. Log-N Channel

c. Fuel Temperature Channel

d. Percent Power Channel

Category C: Facility and Radiation Monitoring Systems

**QUESTION C.09 [1.0 point]**
What are your actions if, while operating the reactor at 100 kW, you receive an Exhaust Gas Monitor alarm?

a. Immediately notify the Health Physicist on duty for direction

b. Continue with reactor operations and deactivate the EGM alarm

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

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

**QUESTION C.10 [1.0 point]**
Which ONE of the following components is used to reduce drive speed on the blade type control rods?

a. Worm Gear Assembly

b. Magnetic Coupler

c. Mechanical Drive Clutch

d. Nut and Ball Bearing Screw System

**QUESTION C.11 [1.0 point]**
Which ONE of the following ensures the reactor power level will return to a low level after pulsing?

a. Preset Timer

b. Power Level Preventer

c. Input Transmitter Signal

d. Coolant Temperature Flow Reducer

**QUESTION C.12 [1.0 point]**
Which ONE of the following will result in an AUTOMATIC SCRAM?

a. 2 kW Pulse

b. Loss of CIC HV

c. Linear High Flux = 110%

d. Low Pool Level = 8 inches

Category C: Facility and Radiation Monitoring Systems

**QUESTION C.13 [1.0 point]**
Which ONE of the following is an indication of a clog in the demineralizer tank?

a. High Radiation level at the pool surface

b. High Flow Rate through Demineralizer

c. High Temperature within Demineralizer

d. High pressure Upstream of Demineralizer

**QUESTION C.14 [1.0 point]**
Which ONE of the following is the frequency requirement for changing the CAM filter?

a. Daily

b. Weekly

c. Monthly

d. Quarterly

**QUESTION C.15 [1.0 point]**
Which ONE of the following is the MAIN purpose of the prohibit of withdrawal of more than one control rod at a time?

a. Damage of Control Rod Drive system

b. Initiation of a pulse during a reactor startup

c. Inadvertently large reactivity insertion

d. Initiation of a pulse while on a positive period

**QUESTION C.16 [1.0 point]**
Which ONE of the following correctly describes the characteristic of the Standard Fuel Rod used at the WSU reactor?

a. Maximum Uranium content is 30% by weight Uranium, enriched to less than 20% U-235, and the Erbium content is homogeneously distributed with a nominal 0.9% by weight

b. Maximum Uranium content is 9% by weight Uranium, enriched to less than 20% U-235 and NO Erbium content

c. Maximum Uranium content is 20% by weight Uranium, enriched to less than 30% 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 homogenously distributed with a nominal 0.5% by weight

Category C: Facility and Radiation Monitoring Systems

**QUESTION C.17 [1.0 point]**
Which ONE of the following systems obtains emergency power in the event of a power loss by the Auxiliary Reactor Emergency Supply (ARIES)?

a. Control Rods

b. Pool Level Alarm

c. Primary Coolant Pump

d. Pneumatic Transfer System

**QUESTION C.18 [2.0 points, 0.25 each]**
The WSU ventilation system is in the DILUTE mode. Provide a correct status for FANS (ON/OFF) and AUTO-DAMPER (OPEN/CLOSED). See Table Below

a. F1

b. F3

c. F4

d. D1

e. D2

f. D3

g. D4

h. D5

| CONTROL MODE | FAN STATUS | | | AUTO DAMPER STATUS | | | | |
|---|---|---|---|---|---|---|---|---|
| | F1 | F3 | F4 | D1 | D2 | D3 | D4 | D5 |
| | | | | | | | | |
| DILUTE | | | | | | | | |
| | | | | | | | | |

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

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

**A.01**
Answer: a
Reference: DOE Fundamentals Handbook *Nuclear Physics and Reactor Theory*, Volume 2, Module 2

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

**A.03**
Answer: a. 2 b. 4 c. 1 d. 3
Reference: Standard NRC Question

**A.04**
Answer: c
Reference: Burn, *Introduction to Nuclear Reactor Operations*, Section 3.2

**A.05**
Answer: a
Reference: DOE Fundamentals Handbook, *Nuclear Physics and Reactor Theory*, Volume 3, Section 2.2

**A.06**
Answer: a
Reference: DOE Fundamentals Handbook, *Nuclear Physics and Reactor Theory*, Volume 2

**A.07**
Answer: d
Reference: Lamarsh, Introduction to Nuclear Engineering, 3rd Edition, page 87

**A.08**
Answer: b
Reference: DOE Fundamentals Handbook *Nuclear Physics and Reactor Theory*, Volume 1, Module 1; $A=A_o e^{-\lambda T}$

**A.09**
Answer: a
Reference: Burn, *Introduction to Nuclear Reactor Operations,* Section 5.4

**A.10**
Answer: b
Reference: SDM= $1 - k_{eff}/k_{eff}$, $k_{eff} = 1/1+0.526$; $k_{eff} = 0.6553$; $CR_1 / CR_2 = (1- k_{eff2}) / (1 - k_{eff1})$ $10/20 = (1 - k_{eff2}) / (1 - 0.653)$, $(0.5) \times (0.05) = (1 - k_{eff2})$, $k_{eff2} = 1 - (0.5)(0.05) = 0.82765$

**A.11**
Answer: d
Reference: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, Volume 2, page 9

**A.12**
Answer: b
Reference: Standard NRC question

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

**A.13**
Answer: d
Reference: LaMarsh, *Introduction to Nuclear Engineering*, 3rd Edition, Section 4.3

**A.14**
Answer: d
Reference: Burn, *Introduction to Nuclear Reactor Operations*, Section 8.1, Page 8-1

**A.15**
Answer: c
Reference: DOE Fundamentals Handbook, *Nuclear Physics and Reactor Theory*, Volume 2, Module 3

**A.16**
Answer: d
Reference: LaMarsh, *Introduction to Nuclear Engineering*, 3rd Edition, Section 6.5, page 287

**A.17**
Answer: a. $\alpha$ b. $\beta^+$ c. n d. $\beta^-$
Reference: Standard NRC question

**A.18**
Answer: a
Reference: $P=P_o e^{t/T}$

**A.19**
Answer: c
Reference: Standard NRC Reactor Theory Question

Category B: Normal/Emergency Operating Procedures and Radiological Controls

**B.1**
Answer: d
Reference: WSU TS 3.1.1

**B.2**
Answer: d
Reference: 10CFR55.53

**B.3**
Answer: c
Reference: WSU Emergency Plan 10.2

**B.4**
Answer: c
Reference: WSU Administrative Procedure #9, Section E

**B.5**
Answer: c
Reference: NRC standard question

**B.6**
Answer: a
Reference: 5000 mRem / 460 mRem/hr = 10.87 hours

**B.7**
Answer: d
Reference: WSU Emergency Plan, 10.1

**B.8**
Answer: d
Reference: WSU SOP #17

**B.9**
Answer: b
Reference: WSU TS 1.0 Definitions

**B.10**
Answer: b
Reference: WSU Technical Specification 3.5.1

**B.11**
Answer: c
Reference: WSU Technical Specification 3.6(9)

**B.12**
Answer: a
Reference: WSU Emergency Plan, Appendix E

**B.13**
Answer: a
Reference: $I_1D_1^2=I_2D_2^2 \rightarrow$ 250mR/hr@$(3ft)^2=I_2@(1ft)^2 \rightarrow$2250 mR/hr or 2.25 R/hr

Category B: Normal/Emergency Operating Procedures and Radiological Controls

**B.14**
Answer: a
Reference: WSU TS 5.5

**B.15**
Answer: d
Reference: 10CFR55.1(a)

**B.16**
Answer: a
Reference: WSU TS 6.9.2

**B.17**
Answer: a
Reference: WSU Emergency Plan 9.0

**B.18**
Answer: a. 3, b. 2, c. 4, d. 6
Reference: WSU Technical Specification, 3.1 and 3.6

**B.19**
Answer: b
Reference: 10 CFR 20.1003; $S=S_o(r_o/r)^2$, therefore for a point source, 100 mrem/hr at 1 ft = 103.23mrem/hr at 30 cm

Category C: Facility and Radiation Monitoring Systems

**C.01**
Answer: a. 1, b. 2, c. 1, d. 3
Reference: WSU TS 3.2

**C.02**
Answer: c
Reference: WSU SAR 7.3.2 and Figure 7-5

**C.03**
Answer: d
Reference: WSU SOP #4, Section D

**C.04**
Answer: d
Reference: WSU SOP #4, Section D

**C.05**
Answer: c
Reference: WSU TS 5.5

**C.06**
Answer: a
Reference: WSU SOP #7, Section B.9

**C.07**
Answer: c
Reference: WSU Startup Checklist

**C.08**
Answer: b
Reference: WSU SAR 7.3

**C.09**
Answer: c
Reference: WSU SOP #15

**C.10**
Answer: a
Reference: WSU SAR 4.2.2

**C.11**
Answer: a
Reference: WSU Technical Specification Table 3.2

**C.12**
Answer: b
Reference: WSU Technical Specification 3.2

**C.13**
Answer: d
Reference: Standard NRC question

Category C: Facility and Radiation Monitoring Systems

**C.14**
Answer: b
Reference: WSU SOP-8

**C.15**
Answer: c
Reference: WSU Technical Specification 3.2.3

**C.16**
Answer: b
Reference: WSU Technical Specification 5.2, SAR Section 4 and 10, Core 35A diagram

**C.17**
Answer: b
Reference: WSU SAR 7.4.6

**C.18**
Answer: a. OFF, b. ON c. OFF, d. CLOSED, e. OPEN, f. OPEN, g. CLOSED, h. OPEN
Reference: WSU SAR 9.1, Table 9-1