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

July 30, 2019

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

SUBJECT: EXAMINATION REPORT NO. 50-027/OL-19-01, WASHINGTON STATE UNIVERSITY

Dear Dr. Wall:

During the week of June 17, 2019, the U.S. Nuclear Regulatory Commission (NRC) administered an operator licensing examination at your Washington State University 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,

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-19-01
2. Written Examination
cc: w/o enclosures: See next page

Washington State University

Docket No. 50-027

cc:

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Mr. Corey Hines, Associate Director
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Test, Research and Training
Reactor Newsletter
Attention: Amber Johnson
Dept of Materials Science and Engineering
University of Maryland
4418 Stadium Drive
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U.S. NUCLEAR REGULATORY COMMISSION
OPERATOR LICENSING INITIAL EXAMINATION REPORT

REPORT NO.: 50-027/OL-19-01

FACILITY DOCKET NO.: 50-027

FACILITY LICENSE NO.: R-76

FACILITY: TRIGA

EXAMINATION DATES: June 17-20, 2019

SUBMITTED BY: Michele DeSouza — 06/28/2019
Michele DeSouza, Chief Examiner — Date

SUMMARY:
During the week of June 17, 2019, the NRC administered an operator licensing examination to six Reactor Operator (RO) and one Senior Reactor Operator Instant (SROI). The six RO and one SROI candidates passed all applicable portions of the examination(s).

REPORT DETAILS

1. Examiner: Michele DeSouza, Chief Examiner, NRC

2. Results:

	RO PASS/FAIL	SRO PASS/FAIL	TOTAL PASS/FAIL
Written	6/0	1/0	7/0
Operating Tests	6/0	1/0	7/0
Overall	6/0	1/0	7/0

3. Exit Meeting:
Michele C. DeSouza, Chief Examiner, NRC
Corey Hines, Interim Director, Washington State University Nuclear Radiation Center Reactor
Hillary Bennett, Reactor Supervisor, Washington State University Nuclear Radiation Center Reactor

Facility comments were accepted prior to the administration of the written examination. Upon completion of the examination, the NRC Examiner met with facility staff representatives to discuss the results. Two Inspector Follow Up Items (IFI) were identified. On the control panel, log channel indicator is sticking and needs to be tapped on the plastic for the real indication. Rod Position Indicator #4 appears to be slipping down on the control panel indicator. At the conclusion of the meeting, the NRC examiner thanked the facility for their support in the administration of the examination.

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

FACILITY: Washington State University

REACTOR TYPE: TRIGA

DATE ADMINISTERED: 06/17/2019

CANDIDATE: _____

INSTRUCTIONS TO CANDIDATE:
Answers are to be written on the Answer sheet provided. Attach all Answer sheets to the examination. Point values are indicated in parentheses for each question. A 70% in each category is required to pass the examination. Examinations will be picked up 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

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.

13. When you have completed and turned in your examination, leave the examination area. If you are observed in this area while the examination is still in progress, your license may be denied or revoked.

EQUATION SHEET

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$\Delta\rho = \frac{K_{eff_2} - K_{eff_1}}{K_{eff_1} K_{eff_2}}$$

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

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 – Reactor Theory, Thermodynamics, & Facility Operating Characteristics

ANSWER SHEET

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

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 ___

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

ANSWER SHEET

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

B01 a b c d ___

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 _____ (0.25 each)

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

ANSWER SHEET

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 ___ (0.50 each)

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

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

QUESTION A.01 [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? CR = S/(1-k)

a. 250 N/sec

b. 350 N/sec

c. 500 N/sec

d. 600 N/sec

QUESTION A.02 [1.0 point]
Which type of neutron interaction (light nuclei) is most important in moderating fast neutrons to thermal energies?

a. Radiative capture

b. Elastic scattering

c. Inelastic scattering

d. Charged particle reaction

QUESTION A.03 [1.0 point, 0.25 each]
Match the term listed in Column A with its corresponding unit listed in Column B.
Answers may be used once, more than once, or not at all.

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

QUESTION A.04 [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.05 [1.0 point]
What is the meaning that any point on a differential rod worth curve represents?

a. The negative reactivity added as the rod is inserted.

b. The cumulative area under the differential curve starting from the bottom of the core.

c. The amount of reactivity that one inch of rod motion would insert at that position in the core.

d. The zero reactivity when the rod is on the bottom and the positive reactivity being added as the rod is withdrawn.

QUESTION A.06 [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. $_{52}Te^{134} \rightarrow \beta^- + {}_{53}I^{135} \rightarrow \beta^- + {}_{54}Xe^{135} \rightarrow \gamma + {}_{55}Cs^{135} \rightarrow \beta^+ + {}_{56}Ba^{135}$

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

QUESTION A.07 [1.0 point]
Which ONE of the following most accurately describes the reason that fission products such as Xenon-135 and Samarium-149 have the most substantial impact in reactor design and operation?

a. Xenon-135 and Samarium-149 cause excess positive reactivity in the core.

b. Xenon-135 and Samarium-149 burn up causes an increase in the thermal flux.

c. Xenon-135 and Samarium-149 have large absorption cross sections resulting in a large removal of neutrons from the reactor.

d. Xenon-135 and Samarium-149 produce fast fission neutrons, resulting in the net increase in the fast neutron population of the reactor core.

QUESTION A.08 [1.0 point]
Which ONE of the following is the principal source of heat in the reactor after a shutdown from an extended 100 kW operation?

a. Spontaneous fission of Uranium - 238

b. Production of delated neutrons

c. Subcritical reaction of photo neutrons

d. Decay of fission fragments

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

QUESTION A.09 [1.0 point]
Reactor power is 0.1 watt. Reactor Operator inserts a sample with a worth of 0.06% Δk/k into the reactor core. Which ONE of the following best describes the reactor kinetics? The reactor is:

a. Critical

b. Subcritical

c. Supercritical

d. Prompt Critical

QUESTION A.10 [1.0 point]
A subcritical reactor, k_{eff} is increased from 0.861 to 0.966. Which ONE of the following is the amount of reactivity that was added to the core?

a. 0.076 Δk/k

b. 0.085 Δk/k

c. 0.126 Δk/k

d. 0.203 Δk/k

QUESTION A.11 [1.0 point]
Which ONE of the following defines the term EFFECTIVE MULTIPLICATION FACTOR?

a. Change in the number of neutrons per second that causes a fission event.

b. Number of neutrons by which neutron population changes per generation.

c. Rate of change of reactor power in neutron per second.

d. Fractional change in neutron population per generation.

QUESTION A.12 [1.0 point]
Which ONE of the following is the mechanism by which a nucleus can gain stability by converting a neutron to a proton or vice versa?

a. Alpha Decay

b. Beta Decay

c. Gamma Decay

d. Photoelectric Effect

QUESTION A.13 [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.14 [1.0 point]
Which ONE of the following changes does not require a movement of control rods in order to maintain constant reactor power?

a. Nitrogen-16 formation

b. Xenon-135 buildup

c. Uranium-235 burnup

d. Pool water temperature decreases

QUESTION A.15 [1.0 point]
The reactor is critical at 100 watts, a control rod is moved that results in a positive reactivity insertion of 0.126% $\Delta k/k$. Which ONE of the following will be the stable reactor period as a result of this reactivity insertion? Given $B_{eff} = 0.0078$

a. 21 seconds

b. 34 seconds

c. 45 seconds

d. 52 seconds

QUESTION A.16 [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.17 [1.0 point]
Which ONE of the following types of neutrons has a mean generation lifetime of about 12 seconds?

a. Fast

b. Prompt

c. Thermal

d. Delayed

QUESTION A.18 [1.0 point]
What is the amount of reactivity added if the multiplication factor, k, is increased from 0.800 to 0.950?

a. 0.083 $\Delta k/k$

b. 0.197 $\Delta k/k$

c. 0.211 $\Delta k/k$

d. 0.364 $\Delta k/k$

QUESTION A.19 [1.0 point]
How is the term k_{eff} defined?

a. production / (absorption + leakage)

b. (absorption + leakage) / production

c. absorption / (production + leakage)

d. (production + leakage) / absorption

QUESTION A.20 [1.0 point]
Which ONE of the following is the stable reactor period which will result in a power rise from 10% to 100% power in 10 seconds?

a. 4 seconds

b. 8 seconds

c. 11 seconds

d. 15 seconds

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

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.01 [1.0 point]
Which are the emergency response ACTIONS required in response to general emergencies?

a. Assessment, Corrective and Protective

b. Awareness, Mitigating and Preventive

c. Responsive, Calculative and Deterrent

d. Reactive, Limiting and Resultant

QUESTION B.02 [1.0 point]
An area in which radiation levels could result in an individual receiving a dose equivalent of 120 mrem/hr at 30 cm is defined as:

a. Radiation Area

b. High Radiation Area

c. Very High Radiation Area

d. Unrestricted Area

QUESTION B.03 [1.0 point]
Which ONE of the following is **NOT** a requirement in accordance with Washington State University (WSU) Emergency Plan *accident scenarios tested over a two year period?*

a. Active shooter scenario within the reactor facility

b. Medical emergency involving a simulated contaminated individual.

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

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

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.04 [1.0 point]
What is the maximum worth of all MOVABLE experiments in accordance with WSU Technical Specification?

a. $2.30

b. $2.00

c. $1.00

d. $0.50

QUESTION B.05 [1.0 point]
Which ONE of the following will violate 10 CFR 55.53, 'conditions of licenses', if you are currently a licensed operator?

a. Requalification written examination was 20 months ago

b. Last license renewal was 48 months ago

c. Previous quarter you were the licensed operator for 8 hours

d. Requalification operating test was 16 months ago

QUESTION B.06 [1.0 point]
How long will it take a 2-Curie source to decay to 0.02 Curie? Half-life = 2 years

a. 3 years

b. 9 years

c. 13 years

d. 17 years

QUESTION B.07 [1.0 point]
How frequent are operators required to receive emergency training and drills, per the Emergency Plan?

a. Quarterly

b. Biennial

c. Semi-Annual

d. Annually

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.08 [1.0 point]
Which ONE of following types of radiation has the LOWEST Quality Factor specified in 10 CFR 20?

a. Gamma/X-ray/Beta

b. Thermal Neutrons

c. Fast Neutrons/Protons

d. Alpha Particles

QUESTION B.09 [1.0 point]
Which ONE of the following is NOT required to be audited on an annual basis by the Reactor Safeguards Committee?

a. Emergency Plan

b. Technical Specification

c. Physical Security Plan

d. Reactor Operator Requalification Plan

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 is the definition for "Deep Dose Equivalent"?

a. The portion of the dose equivalent received from radiation sources outside the body.

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

c. The dose equivalent at a tissue depth of 1cm.

d. The portion of the dose equivalent received from radiative material taken into the body.

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.12 [1.0 point]
Which ONE of the following describes the actions 'in case of a fire unrelated to the reactor, determine the location and extent of the fire'?

a. Awareness

b. Assessment

c. Deterrent

d. Protective

QUESTION B.13 [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. Nuclear Science Center Director

QUESTION B.14 [1.0 point, 0.25 each]
List the appropriate reference: 10CFR19, 10CFR20, 10CFR50, 10CFR55 corresponding to the below statements.

a. Individual radiation exposure data

b. Postings of notices to workers

c. Medical examination every two years by a physician

d. Technical information including the proposed maximum power level

QUESTION B. 15 [1.0 point]
Which ONE of the following radioactive GASES might be an indication of a fuel element leak?

a. Cs^{137}

b. Xe^{135}

c. Ar^{41}

d. N^{16}

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.16 [1.0 point]
The dose rate from a mixed beta-gamma point source is 100 mrem/hr at one foot and is 0.1 mrem/hr at ten feet. What percentage of the source consists of beta radiation?

a. 25%

b. 45%

c. 70%

d. 90%

QUESTION B.17 [1.0 point]
Which ONE of the following, according to WSU Technical Specifications, is an example of a record to be retained for the lifetime of the reactor facility?

a. Reactor log book

b. Drawings of the reactor facility

c. Experiments performed with the reactor

d. Records of meeting and audit reports of the Reactor Safety Committee

QUESTION B.18 [2.0 points, 0.5 each]
Match the Technical Specification Limits in Column A with the corresponding value in Column B (Answers used only once).

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

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.19 [1.0 point]
Which ONE of the following changes requires NRC approval prior to being implemented?

a. Deletion of an administrative control requirement listed in the Washington State Technical Specification

b. Deletion of a check listed in Startup Checklist

c. Change to the individual appointed to the Washington State Level-2 position

d. Replace the primary cooling pump with an identical pump

(***** 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 is one of the correct sources to be used to perform calibration alignment of the Argon-41 monitor?

a. Cesium-137

b. Carbon-14

c. Chlorine-36

d. Strontium-90

QUESTION C.03 [1.0 point]
During 100kW stable reactor operation, you receive an Exhaust Gas Monitor alarm, what are the required actions?

a. Immediately secure reactor and notify the Health Physicist on duty

b. Continue with reactor operations and deactivate the EGM alarm

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

d. Continue reactor operations after isolation of the ventilation and also notify the Senior Reactor Operator on duty

QUESTION C.04 [1.0 point]
What indication does the NPP-1000 provide in STEADY STATE mode?

a. Energy (MW-sec) and Low Count Rate

b. Percent Power ONLY

c. Percent Power and 1kW Interlock

d. Peak power and Energy (MW-sec)

Category C: Facility and Radiation Monitoring Systems

QUESTION C.05 [1.0 point]
Which ONE of the following is an indication of a clogged demineralizer?

a. High radiation downstream of demineralizer

b. High radiation at the demineralizer

c. High pressure upstream of demineralizer

d. High flow rate through the demineralizer

QUESTION C.06 [1.0 point]
What is the MAIN purpose of the interlock to prevent withdrawal of more than one control rod at a time?

a. prevent inadvertent large reactivity insertion

b. prevent damage of control rod drive system

c. prevent initiation of a pulse while on a positive period

d. prevent initiation of a pulse during a reactor startup

QUESTION C.07 [1.0 point]
Which ONE of the following limit switches actuates when the piston reaches its lower limit of travel?

a. Rod Up

b. Rod Down

c. Drive Up

d. Drive Down

QUESTION C.08 [1.0 point]
What is the MAIN purpose for the small flow holes at the bottom of the shroud?

a. prevent corrosion on the control blade

b. allow water to cool the blade during shutdown

c. increase the blade speed during withdrawal

d. reduce the effects of viscous damping on the blade fall time

Category C: Facility and Radiation Monitoring Systems

QUESTION C.09 [1.0 point]
What are your actions if, while operating the reactor at 1 MW, you receive a Continuous Air Monitor (CAM) HIGH alarm?

a. Immediately notify the Health Physicist on duty for direction

b. Continue with reactor operations and deactivate the CAM 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 is the MAIN function performed by the discriminator in the log count rate of the Wide Range Log Channel?

a. To convert the signal from a fission counter to LINEAR output over a range of 10^{-8} to 150 percent of full power.

b. To filter out small pulses due to gamma interactions, passing only pulses due to neutron events within the log count rate.

c. To generate a current signal equal and of opposite polarity as the signal due to gamma generated within the log count rate.

d. To convert the signal logarithmic output of the metering circuit to a delta time output for period metering purposes.

QUESTION C.11 [1.0 point]
Which ONE of the following is an indication of a fuel element failure?

a. High radiation at the demineralizer

b. High flow rate through demineralizer

c. High radiation downstream the demineralizer

d. High pressure upstream of the demineralizer

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]
During reactor operation, a leak develops in the SECONDARY to PRIMARY heat exchanger. Which ONE of the following conditions correctly indicates a leak in the heat exchanger?

a. Pool water conductivity will increase and Pool water level will increase

b. Pool water conductivity will decrease and Pool water level will decrease

c. Pool water conductivity will increase and Pool water level will decrease

d. Pool water conductivity will decrease and Pool water level will increase

QUESTION C.14 [1.0 point]
Per WSU Technical Specifications, which ONE of the following can cause a control rod interlock when the PULSE mode is selected?

a. Standard rod drive DOWN and control rod DOWN

b. Power level at 2 kW and Pneumatic cylinder UP

c. Preset timer sets at 10 sec and Pneumatic cylinder UP

d. Pneumatic cylinder DOWN and Transient rod DOWN

QUESTION C.15 [1.0 point]
The reactor building is equipped with a ventilation system designed to exhaust from a stack, at what height from the ground level in front of the Dodgen Research Facility?

a. 25 +/- 2 feet

b. 46 +/- 2 feet

c. 72 +/- 2 feet

d. 100 +/- 2 feet

Category C: Facility and Radiation Monitoring Systems

QUESTION C.16 [1.0 point]
Which ONE of the statements below describes the operation of the three-way solenoid valve of the Transient rod air system?

a. When the solenoid valve de-energized; the vent port is closed. Air flows from pneumatic cylinder back to the accumulator.

b. When the solenoid valve energized, the supply port is opened and the actual port is closed. Air from the accumulator is vented through the vent port.

c. When the solenoid valve is de-energized, the vent (exhaust) port is closed, the supply port is opened and the actual port (to the cylinder) is opened. Air from the accumulator is continuously supplied to the pneumatic cylinder of the Transient rod.

d. When the solenoid valve is energized, the vent (exhaust) port is closed, the supply port is opened and the actual port (to the cylinder) is opened. Air from the accumulator is continuously supplied to the pneumatic cylinder of the Transient rod.

QUESTION C.17 [1.0 point]
Which ONE of the following best describes on how the Uncompensated Ion Chamber (UIC) and Compensated Ion Chamber (CIC) operate?

a. The CIC has two chambers, one is coated with U-235 for fission reaction and the other is coated with boron-10 for (n,α) reaction; whereas the UIC has only one chamber coated with U-235 for fission reaction.

b. The CIC has two chambers, both can sense gamma rays but only one is coated with boron-10 for (n,α) reaction; whereas the UIC has only one chamber coated with boron-10 for (n,α) reaction.

c. The CIC has only one chamber coated with boron-10 for (n,α) reaction; whereas the UIC has two chambers, one is coated with U-235 for fission reaction and the other is coated with boron-10 for (n,α) reaction.

d. The CIC has only one chamber coated with U-235 for fission reaction, whereas the UIC has two chambers, both can sense gamma rays but only one is coated with boron-10 for (n,α) reaction.

Category C: Facility and Radiation Monitoring Systems

QUESTION C.18 [2.0 points, 0.25 each]

Match the inputs listed in column A with their responses listed in column B. (Items in column B may be used more than once or not at all). Assume the reactor is in operation.

Column A	Column B
a. Preset timer = 10 sec	1. Indicate only
b. Low pulse air pressure	2. Interlocks
c. Pool water conductivity = 1 micomho/cm	3. Reactor automatically scrams
d. H.V. failure in Safety Channel #2	
e. Seismic Switch relay actuates	
f. Withdrawal of blade #1 while in the Pulse mode	
g. Pool water temperature = 40 °C	
h. Linear Power = 125 % full power	

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

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

A.01
Answer: c
Reference: CR=S/(1-k)→200/(1-0.6) = 500 N/sec

A.02
Answer: b
Reference: LaMarsh, 3rd edition, Section 3.6, Page 68-71

A.03
Answer: a. 2; b. 3; c. 4; d. 1
Reference: Burn, *Introduction to Nuclear Reactor Operations*, Section

A.04
Answer: b
Reference: Burn, *Introduction to Nuclear Reactor Operations*

A.05
Answer: c
Reference: Burn, *Introduction to Nuclear Reactor Operations,* Example 7.2b, Page 7-4

A.06
Answer: d
Reference: DOE Fundamentals Handbook, NRPT, Vol. 2, Module 3, EO 4.1, p.35, KAPL, "Chart of the Nuclides", 17th Ed.

A.07
Answer: c
Reference: DOE Fundamentals Handbook, NPRT, Vol. 2, Module 3, Page 34

A.08
Answer: d
Reference: DOE Fundamentals Handbook, NPRT, Vol. 1, Module 1, EO 4.9, p.61

A.09
Answer: c
Reference: Burn, *Introduction to Nuclear Reactor Operations,* Section 4.2

A.10
Answer: c
Reference: Burn, *Introduction to Nuclear Reactor Operations*, Section 3.3.4, Page 3-20&21
$\Delta\rho=(k_{eff2}-k_{eff1})/(k_{eff1}*k_{eff2})$ = (0.966-0.861)/(0.966*0.861)

A.11
Answer: d
Reference: Burn, *Introduction to Nuclear Reactor Operations,* Section 1.3.1, Page 1-5

A.12
Answer: b
Reference: NRC Standard question

A.13
Answer: b
Reference: Nuclides and Isotopes; N = A – Z; 3 – 1 = 2

A.14
Answer: a
Reference: Burn, *Introduction to Nuclear Reactor Operations,* Problem 7.7.4, Page 7-17

A.15
Answer: d
Reference: $0.126\%\Delta k/k = 0.00126\Delta k/k$; $T = (\beta - \rho) / \lambda_{eff} \rho$; $(0.0078 - 0.00126) / (0.1)(0.00126) = 51.9$ seconds

A.16
Answer: a
Reference: DOE Fundamentals Handbook, NPRT, Vol. 1, Module 1, EO 4.3, p.52

A.17
Answer: d
Reference: DOE Fundamentals Handbook, NPRT, Vol. 1, NP-02, Page 31

A.18
Answer: b
Reference: Burn, *Introduction to Nuclear Reactor Operations*, Section 3.3.3, Page 3-21
$(keff_1-keff_2)/(keff_1*keff_2)$. $(0.95 - 0.8)/(0.95*0.8) = 0.197$

A.19
Answer: a
Reference: Burn, *Introduction to Nuclear Reactor Operations*

A.20
Answer: a
Reference: $P=P_o e^{t/T} \rightarrow t=T*\ln(P/P_o)$ T = 10/Ln(100/10), T = 4.34 seconds

Category B: Normal/Emergency Operating Procedures and Radiological Controls

B.1
Answer: a
Reference: WSU E-Plan 7.2

B.2
Answer: b
Reference: 10CFR20

B.3
Answer: a
Reference: WSU E-Plan 10.2

B.4
Answer: c
Reference: WSU TS 4.6

B.5
Answer: d
Reference: 10CFR55.53(i), 10CFR55.53(h), 10CFR55.53(e), 10CFR55.53(h), 10CFR55.59(c) and 10CFR55.59(c)(1)

B.6
Answer: c
Reference: $A=A_o*e^{-\lambda t}$; 0.02Ci = 2Ci* $e^{-\lambda t}$; λ = 0.963/2years = 0.3465; ln(0.02/2) = -0.3465*(t); -4.60/-0.3465 = t = 13.2 years

B.7
Answer: b
Reference: WSU E-Plan, 10.1

B.8
Answer: a
Reference: 10 CFR 20.1004

B.9
Answer: b
Reference: WSU

B.10
Answer: b
Reference: WSU TS 3.5.1

B.11
Answer: c
Reference: 10CFR20.1003, Definitions

B.12
Answer: b
Reference: WSU E-Plan, 7.2

B.13
Answer: c
Reference: WSU TS 6.2.3(5)

Category B: Normal/Emergency Operating Procedures and Radiological Controls

B.14
Answer: a. 10CFR19 b. 10CFR19 c. 10CFR55 d. 10CFR50
Reference: 10CFR19.13, 10CFR19.11, 10CFR55.21 and 10CFR50.36

B.15
Answer: b
Reference: WSU TS 5.6Recommend further emphasis and training to ensure proficiency.

B.16
Answer: d
Reference: $(DR_1)(d_1)^2 = (DR_2)(d_2)^2$; 10CFR20, no Beta radiation at ten ft;
Calculate gamma at one ft: $(0.1)(10)^2 = (DR_2)(1)^2 = 10$ mrem/hr
100 mrem/hr – 10 mrem/hr = 90 mrem/hr or 90%

B.17
Answer: b
Reference: WSU TS 6.9.2

B.18
Answer: a. 2, b. 1, c. 4, d. 3
Reference: WSU TS, 3.1 and 3.6

B.19
Answer: a
Reference: 10CFR50.59

Category C: Facility and Radiation Monitoring Systems

C.01
Answer: a. 1, b. 2, c. 1, d. 3
Reference: WSU TS Table 3.2 and 3.3

C.02
Answer: a
Reference: WSU SOP#7, B.4

C.03
Answer: d
Reference: WSU SOP-15, Section C.e. Exhaust Gas Monitor

C.04
Answer: b
Reference: WSU

C.05
Answer: c
Reference: NRC Standard Question

C.06
Answer: a
Reference: WSU TS 3.2.3

C.07
Answer: b
Reference: WSU SAR 4.2.2

C.08
Answer: d
Reference: WSU SAR 4.2.2

C.09
Answer: d
Reference: WSU SOP 15.C.2.d.2

C.10
Answer: b
Reference: WSU SAR Figure 7-4

C.11
Answer: a
Reference: NRC Standard Question

C.12
Answer: b
Reference: WSU TS 3.2

Category C: Facility and Radiation Monitoring Systems

C.13
Answer: a
Reference: WSU SAR Table 5.3-1

C.14
Answer: b
Reference: WSU TS Table 3.3

C.15
Answer: b
Reference: WSU TS 5.7(2)

C.16
Answer: d
Reference: WSU SAR 4.2.2, Figure 4-16

C.17
Answer: b
Reference: WSU Training Manual, Section 5.1

C.18
Answer: a. 3, b. 1 c. 1, d. 3, e. 3, f. 2, g. 1, h. 3
Reference: WSU TS 3.2 SAR 7.4

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