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

June 13, 2023

Dr. Wei Ji, Director
Rensselaer Walthousen Reactor Critical Facility
Rensselaer Polytechnic Institute
JEC 5040, MANE Department
Troy, NY 12180

SUBJECT: EXAMINATION REPORT NO. 50-225/OL-23-01, RENSSELAER POLYTECHNIC INSTITUTE

Dear Dr. Ji:

During the week of May 31, 2023, the U.S. Nuclear Regulatory Commission (NRC) administered an operator licensing examination at your Rensselaer Polytechnic University Critical Experiments Facility. 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 component of NRC's Agencywide Documents Access and Management System (ADAMS). ADAMS is accessible from the NRC website 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 Dan Hoang at (301) 415-3052 or via email at Dan.Hoang@nrc.gov.

Sincerely,

Signed by Tate, Travis
on 06/13/23

Travis L. Tate, Chief
Non-Power Production and Utilization Facility
Oversight Branch
Division of Advanced Reactors and Non-Power
Production and Utilization Facilities
Office of Nuclear Reactor Regulation

Docket No. 50-225

Enclosures:
1. Examination Report No. 50-225/OL-23-01
2. Written examination

cc: GovDelivery Subscribers

SUBJECT: EXAMINATION REPORT NO. 50-225/OL-23-01, RENSSELAER POLYTECHNIC INSTITUTE DATED: JUNE 13, 2023

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| OFFICE | NRR/DANU/UNPO/CE | NRR/DANU/UNPO/OLA | NRR/DANU/UNPO/BC |
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**OFFICIAL RECORD COPY**

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

REPORT NO.: 50-225/OL-23-01

FACILITY DOCKET NO.: 50-225

FACILITY LICENSE NO.: CX-22

FACILITY: Critical

EXAMINATION DATES: May 31 – June 1, 2023

SUBMITTED BY Danvhoang 6/04/2023
Dan V. Hoang, Chief Examiner Date

SUMMARY:
During the weeks of May 31, 2023, the NRC administered operator licensing examinations to one Senior Reactor Operator-Instant (SRO-I) candidate. The candidate passed all applicable portions of the examinations.

REPORT DETAILS

1. Examiner: Dan V. Hoang, Chief Examiner, NRC

2. Results:

| | RO PASS/FAIL | SRO PASS/FAIL | TOTAL PASS/FAIL |
|---|---|---|---|
| Written | N/A | 1/0 | 1/0 |
| Operating Tests | N/A | 1/0 | 1/0 |
| Overall | N/A | 1/0 | 1/0 |

3. Exit Meeting:
Peter Kowal, Reactor Supervisor, RCF
Katelyn Cook, Senior Reactor Operator, RCF
Dan V. Hoang, Chief Examiner, NRC

Facility comments were accepted prior to the administration of the written examination. Upon completion of an operator licensing 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.

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

FACILITY: Rensselaer Polytechnic Institute

REACTOR TYPE: Critical Facility.

DATE ADMINISTERED: 06/01/2023.

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 |
|---|---|---|---|---|---|
| **18.00** | **33.3** | _____ | _____ | **A.** | **REACTOR THEORY, THERMODYNAMICS AND FACILITY OPERATING CHARACTERISTICS** |
| **18.00** | **33.3** | _____ | _____ | **B.** | **NORMAL AND EMERGENCY OPERATING PROCEDURES AND RADIOLOGICAL CONTROLS** |
| **18.00** | **33.3** | _____ | _____ | **C.** | **FACILITY AND RADIATION MONITORING SYSTEMS** |
| **54.00** | | _____ **FINAL GRADE** | _____ | **%** | **TOTALS** |

All work done on this examination is my own. I have neither given nor received aid.

_____
Candidate's Signature

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

**A N S W E R  S H E E T**

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

A01 a b c d ___

A02 a b c d ___

A03 a b c d ___

A04 a b c d ___

A05 a b c d ___

A06 a b c d ___

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 ___

(***** 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 ___

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

Category C: Plant 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 ___

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 ___

(***** 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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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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 the major source of energy released during fission?

a. Kinetic energy of prompt and delayed neutrons.

b. Kinetic energy of fission fragments.

c. Alpha and beta radiation.

d. Gamma radiation decay.

**QUESTION A.02 [1.0 point]**
Xenon-135 is formed from _____ decay of _____.

a. Alpha, Cesium-135

b. Beta, Iodine-135

c. Alpha, Tellurium-135

d. Beta, Barium-135

**QUESTION A.03 [1.0 point]**
The FAST FISSION FACTOR is defined as a ratio of:

a. the number of neutrons that reach thermal energy over the number of fast neutrons that start to slow down.

b. the number of fast neutrons produced from fission in a generation over the number of fast neutrons produced from fission in the previous generation.

c. the number of fast neutrons produced from U-238 over the number of thermal neutrons produced from U-235.

d. the number of fast neutrons produced from all fission over the number of fast neutrons produced from thermal fission.

**QUESTION A.04 [1.0 point]**
How long will it take power to triple, given a reactor period of 32 seconds?

a. 62 seconds.

b. 54 seconds.

c. 41 seconds.

d. 35 seconds.

**QUESTION A.05 [1.0 point]**
Which ONE of the following is the stable reactor period which will result in a power rise from 1% to 100% power in 2 minutes?

a. 0.5 second.

b. 13 seconds.

c. 26 seconds.

d. 43 seconds

**QUESTION A.06 [1.0 point]**
Which ONE of the following is the MAIN reason for operating reactor with thermal neutrons instead of fast neutrons?

a. The neutron lifetime of thermal neutrons is longer than fast neutrons, so the fuel has enough time to capture thermal neutrons.

b. The fission cross section of the fuel is much higher for thermal energy neutrons than fast neutrons, so thermal neutrons are easier to cause fission.

c. The atomic weight of thermal neutrons is larger than fast neutrons, so thermal neutrons are easily to slow down and be captured by the fuel.

d. The fission cross section of the fuel is much higher for fast neutrons than thermal energy neutrons. Since fast neutrons are easier to cause fission, a reactor cannot control with fast neutrons.

**QUESTION A.07 [1.0 point]**
Which ONE of the following is the meaning of "*any point on a differential rod worth curve"*?

a. The amount of reactivity that one unit (e.g., one inch, one percent) of rod motion would insert at that position in the core.

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

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

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

**QUESTION A.08 [1.0 point]**
Which ONE of the following changes will increase the core excess?

a. Insertion of an experiment containing cadmium.

b. Adding of a fuel experiment (U-235) into the core.

c. Pool water temperature increase.

d. Buildup of xenon in the core.

**QUESTION A.09 [1.0 point]**
Which term is described by the following?
"The increase in neutron population by providing a positive additional reactivity while the reactor is subcritical."

a. Subcritical Multiplication.

b. Inverse Multiplication.

c. Neutron Production.

d. Source Strength.

**QUESTION A.10 [1.00 point]**
What is β?

a. The fractional change in neutron population per generation.

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

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

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

**QUESTION A.11 [1.00 point]**
Which ONE of the following types of neutrons has a mean neutron generation lifetime of 12.5 seconds?

a. Prompt.

b. Delayed.

c. Fast.

d. Thermal.

**QUESTION A.12 [1.00 point]**
The reactor is critical and increasing in power. Power has increased from 10 W to 800 W in 90 seconds. How long at this rate will it take power to increase from 4 kW to 10 kW?
Note: neglect the negative temperature coefficient.

a. 8 seconds.

b. 19 seconds.

c. 35 seconds.

d. 67 seconds.

**QUESTION A.13 [1.00 point]**
Which ONE of the following best describes the relationship between reactor power and neutron flux?

a. Reactor power is two times greater than the fission rate of the fuel.

b. Reactor power increases exponentially as the fission rate increases.

c. The rate of energy produced by the reactor is linearly proportional to the fission rate in the core.

d. Thermal power can be calculated by multiplying the neutron flux by the total volume of the core.

**QUESTION A.14 [1.00 point]**
Which ONE is true about “subcritical multiplication”? As the reactor approaches criticality, the parameter

a. $k_{eff}$ approaches zero.

b. ρ approaches infinity.

c. M approaches one.

d. 1/M approaches zero.

**QUESTION A.15 [1.00 point]**
During Regulating Rod calibration, doubling time was recorded to be 68 seconds. What was reactor period?

a. 47 seconds.

b. 98 seconds.

c. 116 seconds.

d. 133 seconds.

**QUESTION A.16 [1.0 point]**
Some neutrons do not come directly from fission, but from fission product decay. These neutrons are called:

a. Thermal neutrons.

b. Delayed neutrons.

c. Neutron Production.

d. Fission neutrons.

**QUESTION A.17 [1.0 point]**
Excess reactivity is the amount of reactivity _____.

a. associated with burnable poisons.

b. needed to achieve prompt criticality.

c. available below that which is required to make the reactor subcritical.

d. available above that which is required to keep the reactor critical.

**QUESTION A.18 [1.00 point]**
What is the kinetic energy range of a thermal neutron?

a. > 1 MeV

b. 100 KeV – 1 MeV

c. 1 eV – 100 KeV

d. < 1 eV

(***** END OF SECTION A *****)

Category B: Normal/Emergency Operating Procedures and Radiological Controls

**QUESTION B.01 [1.00 point]**
Which ONE of the following correctly describes the limitations of experiment? The experiment with _____ shall NOT be placed inside the reactor experimental facilities.

a. Total unsecured experiment worth < $0.60

b. Total secured reactivity worth exceeding $0.35

c. Explosive materials.

d. Fissionable materials.

**QUESTION B.02 [1.00 point]**
An annual test of the nuclear instrument was performed. Which ONE of the following is the latest the test that must be performed AGAIN without violation of the Technical Specifications?

a. Not to exceed 13 months.

b. Not to exceed 14 months.

c. Not to exceed 15 months.

d. Not to exceed 16 months.

**QUESTION B.03 [1.00 point]**
The minimum shutdown reactivity with all four control rods bottomed shall be _____.

a. Equally to $1.00

b. Greater than $1.00

c. Equally to $0.90

d. Lesser than $0.90

Category B: Normal/Emergency Operating Procedures and Radiological Controls

**QUESTION B.04 [1.00 point]**
Which ONE of the following is the radiation dose rate limit for the public in an unrestricted area?

a. 1 rem in a year.

b. 100 mrem per quarter.

c. 5 mrem in any one hour.

d. 2 mrem in any one hour.

**QUESTION B.05 [1.00 point]**
A radioactive source reads 5 Rem/hr on contact. Five hours later, the same source reads 1.25 Rem/hr. How long is the time for the source to decay from a reading of 5 Rem/hr to 625 mRem/hr?

a. 6.5 hours.

b. 7.5 hours.

c. 8.5 hours.

d. 9.5 hours.

**QUESTION B.06 [1.00 point]**
The requalification program must be conducted for a continuous period not to exceed 24 months in duration, in accordance with _____.

a. 10 CFR 19

b. 10 CFR 20

c. 10 CFR 50

d. 10 CFR 55

Category B: Normal/Emergency Operating Procedures and Radiological Controls

**QUESTION B.07 [1.0 point]**
Which ONE of the following surveillances is a channel check?

a. During a startup, you depress a scram button to verify a manual scram.

b. You turn the console key OFF to verify the reactor scram.

c. You adjust Linear channel in accordance with recent data collected from a thermal power calibration.

d. During a steady state power, you compare the readings of the Linear channel and the Log-N channel.

**QUESTION B.08 [1.0 point]**
The reactor operator licensing candidates require submitting an NRC Form 398, Personal Qualification Statement-License, as part of their applications. This requirement could be found in:

a. 10 CFR Part 19.

b. 10 CFR Part 20.

c. 10 CFR Part 50.

d. 10 CFR Part 55.

**QUESTION B.09 [1.0 point]**
A radioactive material is decayed 30% after one hour. Determine its half-life?

a. 2 hours.

b. 3 hours.

c. 4 hours.

d. 5 hours.

Category B: Normal/Emergency Operating Procedures and Radiological Controls

**QUESTION B.10 [1.0 point]**
Per 10 CFR 20, what is the annual limit of radiation exposure for a visitor?

a. 2 mRem/hr.

b. 100 mRem/hr.

c. 100 mRem.

d. No limit defined, just need to meet an ALARA program.

**QUESTION B.11 [1.00 point]**
Which ONE of following types of radiation is the **HIGHEST** Quality Factor specified in 10 CFR 20?

a. Alpha.

b. Beta.

c. Gamma.

d. Neutron (unknown energy).

**QUESTION B.12 [1.0 point]**
Which ONE of the following changes must be submitted to NRC for approval prior to implementation?

a. Replace a cooling pump with an identical one.

b. Add additional item in the reactor pre-startup checklist.

c. Add additional requirement to bypass the Water Dump Valve SCRAM in the RCF Operating Procedure.

d. Delete Section 5, Design Features, listed in the RCF Technical Specifications because you think this Section is no longer needed.

Category B: Normal/Emergency Operating Procedures and Radiological Controls

**QUESTION B.13 [1.0 point]**
What is the exposure rate at a distance of 4 meters, if the initial exposure rate for a point source is 400 mR/hr at a distance of 2 meters?

a. 75 mR/hr.

b. 100 mR/hr.

c. 125 mR/hr.

d. 45 mR/hr.

**QUESTION B.14 [1.0 point]**
The OPERATIONS BOUNDARY is defined as:

a. The area, that consists of the control room, the reactor bay, and Counting Room.

b. The area, that extends 500 feet in every direction from center of the reactor.

c. The area for which offsite emergency planning is performed to assure that prompt and effective actions can be taken to protect public in the event of an accident.

d. The area within the site boundary such as the reactor building (or the nearest physical personnel barrier in cases where the reactor building is not a principal physical personnel barrier) where the reactor chief administrator (Facility Director for the RCF) has direct authority over all activities.

**QUESTION B.15 [1.00 point]**
Per RCF Technical Specifications, which ONE of the following is the specification of the Safety Limit (SL)?

a. The steady state reactor power level shall not exceed 100 W.

b. The maximum fuel pellet temperature shall not exceed 1000 °C.

c. The minimum reactor period shall not less than 5 seconds.

d. The maximum available excess reactivity based on the reference core condition shall not exceed $0.60.

Category B: Normal/Emergency Operating Procedures and Radiological Controls

**QUESTION B.16 [1.0 point]**
Which ONE of the following emergencies is categorized as an ALERT?

a. Loss of off-site electrical power.

b. Detection of smoke or flames within the RCF Building or Boiler House.

c. Area Monitor exceeds Alarm Levels when the reactor is shutdown or secured.

d. Phone or other message threatening damage to the facility with an explosive device.

**QUESTION B.17 [1.0 point]**
The Quality Factor is used to convert:

a. External dose to internal dose.

b. Dose in rems to dose equivalent in rads.

c. Dose in rads to dose equivalent in rems.

d. Derived air concentration (DAC) to Annual limit on Intake (ALI).

**QUESTION B.18 [1.00 point]**
A channel _____of the safety system channels, and visual inspection of the reactor shall be performed daily prior to reactor startup.

a. Test.

b. Check.

c. Calibration.

d. Maintenance.

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

Category C:  Facility and Radiation Monitoring Systems

**QUESTION C.01 [1.0 point]**
The Uncompensated Ion Chambers is powered from:

a. 120 volt AC outlets.

b. 120 volt DC power supply.

c. 300 volt DC battery.

d. 480 volt, three-phase power from the utility grid.

**QUESTION C.02 [1.0 point]**
Which ONE of the following types of detector is utilized in the area gamma radiation monitoring system?

a. Geiger-Mueller tube.

b. Scintillation detector.

c. Ionization chamber.

d. Proportional counter.

**QUESTION C.03 [1.0 point]**
One of the amplifier functions in the Startup channel is to:

a. Count a total number of neutron and gamma pulses.

b. Separate gamma pulses from neutron pulses.

c. Convert a number of pulses to a current in amps.

d. Convert a number of pulses to a reactor period in seconds.

Category C: Facility and Radiation Monitoring Systems

**QUESTION C.04 [1.0 point]**
Which of the following scrams have bypass provisions?

a. Door scram and the Water Dump Valve scram.

b. Log-N period scram and the Water Dump Valve scram.

c. Door scram and the Linear Power high level scram.

d. Log-N scram and the Linear Power high level scram.

**QUESTION C.05 [1.0 point]**
Which ONE of the following converts the 480 VAC to 120 VAC in the RCF electrical distribution system?

a. Line Transfer Switch.

b. The utility power grid.

c. Motor Control Centers.

d. A 30 kva Transformer.

**QUESTION C.06 [1.0 point]**
Which ONE of the following is TRUE about the facility ventilation system?

a. In normal mode, all the air is exhausted through a series of charcoal and CWS filters before going out through the stack.

b. In normal mode, the off-gas system blowers are secured.

c. Air circulation occurs via natural circulation.

d. Ventilation system is not required.

Category C: Facility and Radiation Monitoring Systems

**QUESTION C.07 [1.0 point]**
Per RCF Lab Manual, the facility will use ____ foils for the absolute power measurement.

a. copper

b. nickel

c. gold

d. aluminum

**QUESTION C.08 [1.0 point]**
Which ONE of the following materials is the control rods absorbers?

a. Aluminum.

b. Boron.

c. Cadmium.

d. Stainless Steel.

**QUESTION C.09 [1.0 point]**
The basis for limiting of maximum water level not greater than 10 inches above the top grid of the core is based on:

a. Providing adequate neutron shielding during operation.

b. Avoiding hydraulic restrictions to control rod insertion during a scram.

c. Limiting moderator mass to maximize negative temperature coefficient effects during transients.

d. Ensuring that negative reactivity will be added within 1 minute of activation of the water dump.

Category C: Facility and Radiation Monitoring Systems

**QUESTION C.10 [1.0 point]**
Following a loss of building electrical power, which ONE of the following best describes on how the reactor tank water is quickly drained to the storage tank?

a. The filled drain valve and the quick dump valve will fail OPEN, allowing water flow from reactor tank to the storage tank.

b. Reactor tank water can be quickly drained through the fill line by deenergizing of the air-operated drain valve.

c. Reactor tank water can be quickly drained by energizing of the quick drain valve that are operated by motor control.

d. The 50 GPM pump will turn “ON” and pumping water from the reactor tank to the storage tank.

**QUESTION C.11 [1.0 point]**
Which ONE of the following is a correct alarm set point for the area gamma monitor located in the control room?

a. 10 mrem/hr.

b. 20 mrem/hr.

c. 40 mrem/hr.

d. 50 mrem/hr.

**QUESTION C.12 [1.0 point]**
Which ONE of the following is the RCF neutron startup source?

a. Americium-Beryllium (Am-Be).

b. Uranium-Beryllium (U-Be).

c. Radon-Beryllium (Ra-Be).

d. Plutonium-Beryllium (Pu-Be).

Category C: Facility and Radiation Monitoring Systems

**QUESTION C.13 [1.0 point]**
A signal to indicate the control rod position comes from:

a. Optical encoders.

b. A rack and pinion drive are indicated in percentage of total travel.

c. Three limit switches determine the relative movement of the control rod.

d. A radio-frequency detector measures the height of the control rod extension tube above the piston.

**QUESTION C.14 [1.0 point]**
When a failure of fuel pins occurs, the Continuous Air Monitor (CAM) alarms due to the release of:

a. N-16.

b. Ar-41.

c. Na-24.

d. I-135.

**QUESTION C.15 [1.0 point]**
The SPERT Fuel Pin Active Fuel Length is _____.

a. 16.00 in.

b. 20.00 in.

c. 36.00 in.

d. 46.00 in.

Category C: Facility and Radiation Monitoring Systems

**QUESTION C.16 [1.0 point]**
Which ONE of the following conditions will cause the reactor interlock?

a. Reactor period exceeds 25 seconds.

b. Source range reading is 10 cps.

c. Fill pump “ON.”

d. Chart recorder power “ON.”

**QUESTION C.17 [1.0 point]**
The _____ should be energized when the immersion heaters are energized.

a. Agitator

b. Impeller

c. Neutron source

d. Heating elements

**QUESTION C.18 [1.0 point]**
When not in use, the SPERT (F-1) fuel shall be stored within the storage vault located in the reactor room. The fuel shall be stored in cadmium clad steel tubes with a minimum center-to-center separation of _____ and with no more than ___ SPERT (F-1) fuel pins per tube mounted on a steel wall rack.

a. 8.5 inches, 15.

b. 8.0 inches, 15.

c. 8.5 inches, 10.

d. 8.0 inches, 10.

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

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

**A.01**
Answer: b
Reference: Glasstone, Nuclear Reactor Engineering, Section 1.47 & Burns, Section 3.2.1, page 3-5.

**A.02**
Answer: b
Reference: LaMarsh 3rd ed., Section 7.5, pg. 377 & Burns, Figure 8.1, page. 8-6.

**A.03**
Answer: d
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, Sec 3.3.1, page 3-16.

**A.04**
Answer: d
Reference: $P = P_0 e^{t/T}$ $3 = 1 \cdot e^{t/32}$ ; $t = 32 \cdot \ln(3)$ ; $t = 35.2$ sec.

**A.05**
Answer: c
Reference: $P = P\ e^{t/T}$ —> $T = t/\text{Ln}(P/P_0)$; $T = 120/\text{Ln}(100)$; $T = 26$ sec.

**A.06**
Answer: b
Reference: Burn, R., *Introduction to Nuclear Reactor Operations*, Figure 2.6, Page 2-39.

**A.07**
Answer: a
Reference: Burns, Example 7.2 (b), page 7-4.

**A.08**
Answer b
Reference: NRC Standard Question.

**A.09**
Answer: a
Reference: Burn, R., *Introduction to Nuclear Reactor Operations*, Section 5.1, Subcritical Multiplication.

**A.10**
Answer: b
Reference: DOE Handbook Vol. 2 Module 4.

**A.11**
Answer: b
Reference: DOE Handbook Vol. 1 Module 2, Section 3.0.

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

**A.12**
Answer: b
Reference: $P = P_o^{et}/T$
$800 = 10*e^{(90\ sec/T)}$
$T = 20.54sec$
$10\ kW = 4\ kW*e^{(t/20.54)}$
$t = 19\ sec.$

**A.13**
Answer: c
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* Section 2.8.13, page 2-64.

**A.14**
Answer: d
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* Table 5.5, page 5-15.

**A.15**
Answer: b
Reference: $T = DT/\ln(2) = 68\ seconds/0.693 = 98.124 \approx 98\ seconds.$

**A.16**
Answer: b
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* Section 3.2.2.

**A.17**
Answer: d
Reference: DOE Fundamentals of Nuclear Engineering, Chapter 3, page 61.

**A.18**
Answer: d
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* Section 2.5.1, page 2-36.

Category B: Normal/Emergency Operating Procedures and Radiological Controls

**B.01**
Answer: c
Reference: RCF TS 3.8.8, page 12.

**B.02**
Answer: c
Reference: RCF TS Definition 1.3, page 4.

**B.03**
Answer: b
Reference: RCF TS 3.2.2, page 7.

**B.04**
Answer: d
Reference: 10 CFR 20.1301(a)(2).

**B.05**
Answer: b
Reference: $DR = DR_0 * e^{-\lambda t}$
$1.25 \text{ rem/hr} = 5 \text{ rem/hr} * e^{-\lambda(5hr)}$
$\ln(1.25/5) = -\lambda * 5 \rightarrow \lambda = 0.277$; solve for t: $\ln(.625/5) = -0.277 * t$ 5 or t = 7.5 hours.

**B.06**
Answer: d
Reference: 10 CFR 55.59(a)(1).

**B.07**
Answer: d
Reference: RCF TS 1.3, page 1.

**B.08**
Answer: d
Reference: 10 CFR 55.31(a)(1).

**B.09**
Answer: a
Reference: $DR = DR_0 * e^{-\lambda t}$
30% is decayed, so 70% is still there $70\% = 100\% * e^{-\lambda(1hrs)}$
$\ln(70/100) = -\lambda * 1 \rightarrow \lambda = 0.357$ $t_{1/2} = \ln(2)/\lambda \rightarrow .693/.357$ or t=1.94 hours.

**B.10**
Answer: c
Reference: 10 CFR 20.1301(1).

**B.11**
Answer: a
Reference: 10 CFR 20.1004.

Category B: Normal/Emergency Operating Procedures and Radiological Controls

**B.12**
Answer: d
Reference: 10 CFR 50.59.

**B.13**
Answer: b
Reference: $I_2 = I_1 D_1^2 / d_2^2$; $I_2 = (400\ mR/hr)(2m)^2 / (4m)^2$; $I_2 = 100\ mR/hr$.

**B.14**
Answer: d
Reference: RCF Emergency Plant Section 2, page 6.

**B.15**
Answer: b
Reference: RCF TS 2.1, page 5.

**B.16**
Answer: c
Reference: RCF Emergency Plant Section 5, page 8.

**B.17**
Answer: c
Reference: 10 CFR 20.1004, Table 1004(b).1

**B.18**
Answer: a
Reference: RCF TS 4.2.4, page 15.

**C.01**
Answer: c
Reference: RCF SAR 7.2.3, page 7-2.

**C.02**
Answer: a
Reference: RCF SAR 7.7, page 7-7.

**C.03**
Answer: b
Reference: RCF SAR 7.2.3, page 7-1.

**C.04**
Answer: a
Reference: RCF Operating Procedure, Section D.

**C.05**
Answer: d
Reference: RCF SAR 8.1, page 8-1.

**C.06**
Answer: c
Reference: RCF SAR 9.1, page 9-1.

**C.07**
Answer: c
Reference: RCF Lab Manual, Section 11.1, page 67.

**C.08**
Answer: b
Reference: RCF SAR 4.2.2, page 4-10.

**C.09**
Answer: d
Reference: RCF TS 3.2, Bases, page 9.

**C.10**
Answer: a
Reference: RCF SAR Figure 5.1, page 5-1.

**C.11**
Answer: a
Reference: RCF SAR 7.7, page 7-7.

**C.12**
Answer: d
Reference: RCF SAR 4.1, page 4-1.

**C.13**
Answer: a
Reference: RCF SAR 7.3, page 7-3.

Category B: Normal/Emergency Operating Procedures and Radiological Controls

**C.14**
Answer: d
Reference: NRC Standard Question.

**C.15**
Answer: c
Reference: RCF SAR Figure 4.5, page 4-9.

**C.16**
Answer: c
Reference: RCF SAR 7.3, page 7-3.

**C.17**
Answer: a
Reference: RCF Operating procedure, Section C.2.a.

**C.18**
Answer: a
Reference: RCF TS 5.4, page 20.