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

June 4, 2025

Dr. Mary Lou Dunzik-Gougar
Reactor Administrator and Supervisor
Idaho State University
Professor of Nuclear Engineering
921 South 8th Avenue, MS 8065
Pocatello, ID 83209-8060

SUBJECT: EXAMINATION REPORT NO. 50-284/OL-25-01, IDAHO STATE UNIVERSITY

Dear Dr. Dunzik-Gougar:

During the week of April 28, 2025, the U.S. Nuclear Regulatory Commission (NRC) administered an operator licensing examination at your Idaho State University research reactor. The examination was 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 Michele DeSouza at (301) 415-0747 or via email at Michele.DeSouza@nrc.gov.

Sincerely,

Signed by Brown, Tony
on 06/04/25

Tony Brown, 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. 50-284

Enclosures:
1. Examination Report No. 50-284/OL-25-01
2. Written examination

cc: w/enclosures to GovDelivery Subscribers

SUBJECT: EXAMINATION REPORT NO. 50-284/OL-25-01, IDAHO STATE UNIVERSITY
DATED: JUNE 4, 2025

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DATE	6/4/2025	6/4/2025	6/4/2025

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

REPORT NO.: 50-284/25-01

FACILITY DOCKET NO.: 50-284

FACILITY LICENSE NO.: R-110

FACILITY: Idaho State University

EXAMINATION DATES: Week of April 28, 2025

SUBMITTED BY: *Michele DeSouza* 5/27/2025
Michele C. DeSouza, Chief Examiner Date

SUMMARY:
During the week of April 28, 2025, the NRC administered operator licensing examinations to ten Reactor Operator (RO) candidates. All RO candidates passed all applicable portions of the examinations and tests.

REPORT DETAILS

1. Examiner: Michele C. DeSouza, Chief Examiner, NRC

2. Results:

	RO PASS/FAIL	SRO PASS/FAIL	TOTAL PASS/FAIL
Written	10/0	0/0	10/0
Operating Tests	10/0	0/0	10/0
Overall	10/0	0/0	10/0

3. Exit Meeting:
Michele C. DeSouza, Chief Examiner, NRC
Mary Lou Dunzik-Gougar, Facility Administrator, ISU
Larry Foulkrod, Reactor Supervisor, ISU
Mackenzie Gorham, Lead Instructor, ISU

Prior to administration of the written examination, based on facility comments, adjustments were accepted. Comments provided corrections and additional clarity to questions/answers and identified where changes were appropriate based on current facility conditions.

Upon completion of all operator licensing examinations, 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.NRC

UNITED STATES NUCLEAR REGULATORY COMMISSION

Protecting People and the Environment

Idaho State University

Operator Licensing Examination

Week of April 28, 2025

Enclosure 2

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

FACILITY: Idaho State University

REACTOR TYPE: AGN-201

DATE ADMINISTERED: May 1, 2025

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 and a 70% overall are 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	33.0	_____	_____	A. REACTOR THEORY, THERMODYNAMICS, AND FACILITY OPERATING CHARACTERISTICS
20.00	33.0	_____	_____	B. NORMAL AND EMERGENCY OPERATING PROCEDURES AND RADIOLOGICAL CONTROLS
20.00	33.0	_____	_____	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

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 and a 70 percent or greater overall.

12. There is a time limit of three (3) hours for completion of the examination.

A N S W E R S H E E T

Multiple Choice (Circle 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 ____

A19 a b c d ____

A20 a b c d ____

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

Category B: Normal/Emergency Operating Procedures and Radiological Controls

A N S W E R S H E E T

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

B01 a b c d ____

B02 a b c d ____

B03 a b c d ____

B04 a b c d ____

B05 a b c d ____

B06 a b c d ____

B07 a b c d ____

B08 a b c d ____

B09 a b c d ____

B10 a b c d ____

B11 a b c d ____

B12 a b c d ____

B13 a b c d ____

B14 a b c d ____

B15 a _____ b _____ c _____ d _____

B16 a b c d ____

B17 a _____ b _____ c _____ d _____

B18 a b c d ____

B19 a b c d ____

B20 a b c d ____

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

Category C: Facility and Radiation Monitoring Systems

A N S W E R S H E E T

Multiple Choice (Circle 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 ____

C19 a _____ b _____ c _____ d _____

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

EQUATION SHEET

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

1 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, and Facility Operating Characteristics

QUESTION A.01 [1.00 point]
What happens to the mass number and the atomic number of an element, when an element undergoes negative beta decay (β-)?

a. The mass number decreases by 4 and the atomic number decreases by 2.

b. The mass number does not change and the atomic number decreases by 2.

c. The mass number increases by 2 and the atomic number increases by 1.

d. The mass number does not change and the atomic number increases by 1.

QUESTION A.02 [1.00 point, 0.25 each]
Match the neutron interaction type in Column A with the neutron result in Column B. Answers in Column B may be used once, more than once, or not at all.

Column A	**Column B**
a. Inelastic Scattering	1. Net Neutron Producing
b. Fission	2. Net Neutron Absorbing
c. Radiative Capture	3. Neutrons are neither produced or absorbed, but conserved
d. Charged-Particle Reactions	

QUESTION A.03 [1.00 point]
Which ONE of the following is the approximate energy release from each Uranium-235 fission?

a. 100 MeV

b. 200 MeV

c. 300 MeV

d. 400 MeV

QUESTION A.04 [1.00 point]
If k_{eff} is 1.0065 and $\beta_{eff} = \rho = 0.0065$, what is the status of the reactor?

a. The reactor is supercritical on delayed and prompt neutrons.

b. The reactor is supercritical on prompt neutrons alone.

c. The reactor is subcritical but approaching criticality.

d. The reactor is critical on delayed and prompt neutrons.

QUESTION A.05 [1.00 point]
Which ONE of the following answers lists the factors from the 'Six Factor Formula' that are MOST affected during short transients of reactor operation?

a. Reproduction Factor

b. Resonance Escape Probability Factor

c. Fast Non-Leakage Factor

d. Thermal Non-Leakage Factor

QUESTION A.06 [1.00 point]
The effective multiplication factor, k-effective, can be determined by dividing the number of neutrons produced from fission in the third generation by the number of neutrons produced from fission in the _____ generation.

a. First

b. Second

c. Third

d. Fourth

QUESTION A.07 [1.00 point]
Which ONE of the following statements correctly describes 'shutdown margin'?

a. The amount of reactivity available above what is required to keep the reactor critical.

b. A measure of excess reactivity available to overcome fission product buildup, fuel burnup, and power defect.

c. The negative reactivity inserted by an increase in moderator temperature within the core when the reactor is brought from zero to full power.

d. The instantaneous amount of reactivity by which a reactor is subcritical or would be subcritical from its present condition assuming all control rods are fully inserted except for the single rod with the highest integral worth, that is assumed to be fully withdrawn.

QUESTION A.08 [1.00 point]
Which ONE of the following is a characteristic of an effective core reflector?

a. A low resistance to radiation damage.

b. A low thermal conductivity.

c. A high scattering to absorption cross section ratio.

d. A small crystal expansion structure.

QUESTION A.09 [1.00 point]
Which ONE of the following does NOT affect control rod worths?

a. Core age

b. Adjacent rods

c. Moderator temperature

d. Installed neutron source position

QUESTION A.10 [1.00 point]
Which ONE of the following is the number of neutrons in the Boron-10 nucleus ($_5B^{10}$)?

a. 1

b. 3

c. 4

d. 5

QUESTION A.11 [1.00 point]
The rate at which power decreases after a scram is limited by _____:

a. the peak fuel temperature.

b. the presence of a graphite reflector.

c. the time spent at power above the point of adding heat.

d. the fission product decay of the longest-lived delayed neutron precursor.

QUESTION A.12 [1.00 point]
Of all the energy released during a fission event, the LARGEST energy amount appears in the form of _____.

a. gamma radiation.

b. alpha and beta radiation.

c. kinetic energy of fission fragments.

d. kinetic energy of prompt and delayed neutrons.

QUESTION A.13 [1.00 point]
Which ONE of the following defines Thermal Utilization Factor? It is a ratio of _____.

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

b. fast neutrons produced by thermal fission over thermal neutrons absorbed in the fuel.

c. Thermal neutrons absorbed in fuel over thermal neutrons absorbed in the fuel and core materials.

d. Thermal neutrons absorbed in fuel and core materials over neutrons that reach thermal energy.

QUESTION A.14 [1.00 point]
Which ONE of the following changes does NOT require movement of control rods to maintain constant reactor power?

a. Uranium-235 burnup

b. Xenon-135 buildup

c. Nitrogen-16 formation

d. Samarium buildup

QUESTION A.15 [1.00 point]
During the initial rise to power, the nuclear instruments show that when K_{eff} is 0.85, the count rate is 1280 cps. Once reactivity has been added, what count rate would correspond with a K_{eff} of 0.95?

a. 2270 cps

b. 3310 cps

c. 3840 cps

d. 4530 cps

QUESTION A.16 [1.00 point]
Which ONE of the following is a good moderator and what are the properties of a good moderator?

a. Water (H2O), because it has a relatively low absorption and high scattering cross section.

b. Carbon, because it has a relatively high absorption and low scattering cross section.

c. Beryllium, because it has a relatively low absorption and low scattering cross section.

d. Deuterium (D2O), because it has a relatively high absorption and high cross section.

QUESTION A.17 [1.00 point]
If beta (β) for U-235 is 0.0065 and beta effective (β_{eff}) for the ISU AGN fuel is approximately 0.0074, how does this difference affect reactor period in the reactor period equation, T=(β-p)/λp? This difference produces a _____ for a given addition of reactivity with beta effective (β_{eff}).

a. Longer period

b. Shorter period

c. Stable period

d. Decay constant (λ) increase

QUESTION A.18 [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.19 [1.00 point]
Which ONE of the following is defined as the balance between production of neutrons and their absorption in the core when leakage is neglected?

a. Utilization Factor

b. Reproduction Factor

c. Infinite Multiplication Factor

d. Effective Multiplication Factor

QUESTION A.20 [1.00 point]
Which ONE of the following changes in reactor power would take the LONGEST time? Assume the reactor is on a constant period.

a. 100 mW to 400 mW

b. 400 mW to 500 mW

c. 1 W to 3.5 W

d. 3.5 W to 4.5 W

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

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.01 [1.00 point]
In accordance with ISU Emergency Plan, Rev.8, which ONE of the following is NOT in the line of succession for the Dose Assessment Coordinator (DAC)?

a. Reactor Supervisor.

b. ISU Radiation Safety Officer

c. ISU Assistant Radiation Safety Officer

d. Reactor Administrator

QUESTION B.02 [1.00 point]
In accordance with the ISU Technical Specifications, which ONE of the following is NOT a requirement to meet the terms of the definition of 'reactor shutdown'?

a. Reactor console key 'off' and the key under the control of a licensed operator.

b. Core fuse melts resulting in separation of the core.

c. Moving a single experiment worth one dollar.

d. All safety and control rods are fully withdrawn from the core.

QUESTION B.03 [1.00 point]
An irradiated sample (point source) reads 10 mrem/hr at 1 meter. Which ONE of the following is the required posting for the area, in accordance with 10 CFR 20?

a. "Caution – Radiation Area"

b. "Caution – High Radiation Area"

c. "Grave Danger – Very High Radiation Area"

d. "Caution – Airborne Radioactivity Area"

QUESTION B.04 [1.00 point]
In accordance with ISU Maintenance Procedure 1, '*Rod Drive Maintenance and Rod Worth* M*easurements'* are required to be conducted _____ and require the direct supervision of a _____.

a. quarterly; Certified Observer

b. semiannually; Reactor Operator

c. annually; Senior Reactor Operator

d. biennially; Reactor Supervisor

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.05 [1.00 point]
Which ONE of the following would NOT be a reportable occurrence in accordance with ISU Technical Specifications?

a. Manual scram bar only causes the safety control rod #2 to scram.

b. Excess reactivity limits with the most reactive rod and fine control rod fully inserted is \$0.67/0.5%Δk/k.

c. Shutdown margin with the most reactive rod and the fine control rod fully inserted is \$1.45/1.0073%Δk/k.

d. No licensed operator in the control room with the key in the control panel console.

QUESTION B.06 [1.00 point]
In accordance with ISU Emergency Plan, Rev. 8, which ONE of the following individuals, by position title, has the authority to declare a Notification of Unusual Event (NOUE)?

a. Reactor Safety and Recovery Operations Coordinator (ROC).

b. Emergency Preparedness Coordinator (EPC).

c. Pocatello City Fire Department (PFD) Chief.

d. Director of Emergency Operations (DEO).

QUESTION B.07 [1.00 point]
An experiment reading 8.5 rem/hr was removed from the reactor. Five hours later it reads 600 mrem/hr. What is the half-life of the experiment?

a. 1.00 hours

b. 1.3 hours

c. 1.9 hours

d. 2.2 hours

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.08 [1.00 point]
In accordance with ISU Technical Specification, the Reactor Safety Committee will review and approve all the following EXCEPT which one of the following?

a. Audit reports.

b. Reportable occurrences.

c. Proposed changes in Technical Specifications or other license documents.

d. Proposed equipment change that does not change the original intent or use and results in a more conservative approach.

QUESTION B.09 [1.00 point]
Which ONE of the following is the 10 CFR 20 definition of Total Effective Dose Equivalent (TEDE)?

a. It is the sum of the external deep dose and the organ dose.

b. It is the dose that your whole body receives from sources outside the body.

c. It is the dose to a specific organ or tissue resulting from an intake of radioactive material.

d. It is the sum of the effective dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures).

QUESTION B.10 [1.00 point]
In accordance with ISU Technical Specification, the following records will be retained for the lifetime of the reactor facility EXCEPT:

a. Facility radiation and contamination surveys.

b. Fuel inventories and fuel transfers.

c. Radiation exposures for all personnel.

d. Gaseous and liquid radioactive effluents released to the environs.

QUESTION B.11 [1.00 point]
Which ONE of the following is the definition of the term ‘Curie’?

a. A measure of the number of radioactive atoms in the source.

b. A measure of nuclear disintegrations per unit time.

c. A measure of the amount of reactivity per unit length in the source.

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

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.12 [1.00 point]
In accordance with 10 CFR 20, which ONE of the following scenarios would NOT be allowed?

a. Personnel working in an area where the radiation dose exceeds 5 mrem per hour.

b. Allowing a visiting researcher to receive a radiation dose of 50 mrem over a 6-month period.

c. A 17-year-old Reactor Operator trainee received a dose of 400 mrem in the 9 months before turning 18.

d. Giving an hour-long tour to a State Senator in an area where the dose received in an hour is greater than 5 mrem.

QUESTION B.13 [1.00 point]
Which ONE of the following actions would NOT be considered in keeping with As Low as Reasonably Achievable (ALARA)?

a. Leaving samples in a lead protected cave until they need to be removed either according to the irradiation request or due to other experiments needing the facility.

b. Setting a radioactive source down in a secure location to answer questions before continuing to move the source.

c. Handling the installed neutron source with only one hand to ensure a portable radiation meter can be used for dose monitoring.

d. Using tongs to move radioactive material in a fume hood.

QUESTION B.14 [1.00 point]
In accordance with the ISU Emergency Plan, Rev. 8, which ONE of the following action terms is associated with '*the type of actions that could mitigate or correct the problems for each emergency class*'?

a. Assessment actions

b. Protective actions

c. Corrective actions

d. Regulatory actions

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.15 [1.00 point, 0.25 each]
Match the surveillance in Column A with the associated surveillance interval in Column B. Options in Column B may be used once, more than once, or not at all.

Column A	Column B
a. Channel Calibration of Seismic Displacement Safety Channel	1. Daily
b. Channel Test of the Seismic Displacement Interlock	2. Quarterly
c. Channel Check of the Nuclear Safety Channels 1, 2, and 3	3. Annually
d. Channel Calibration of the Portable Radiation Survey Instruments	4. Semi-annually

QUESTION B.16 [1.00 point]
In accordance with ISU Technical Specifications, which ONE of the following experiments would NOT be allowed in the reactor core?

a. An experiment with a potential particulate release of 5mrem Total Effective Dose Equivalent (TEDE).

b. The available excess reactivity with all rods fully inserted and the worth of the experiment is $0.75.

c. An experiment using 5 mg of TNT in a container rated to a detonation pressure of up to 8 mg.

d. A secured doubly encapsulated experiment containing hydrochloric acid.

QUESTION B. 17 [1.00 point, 0.25 each]
For each of the following activities, categorize them as either a Channel Check, Test, or Calibration.

a. Adjusting Safety Channel 3 to initiate a high-power scram based on the gold foil calculated values.

b. Moving the Channel #2 MODE selector switch to TEST 10^{-11} position and following OP-1 steps for evaluation.

c. Depressing the 0.5 cps button on Channel #1 to verify the trip indication light illuminates at or before 0.5 cps on the meter.

d. Looking at the Radiation Area Monitors to see if the readouts match previous dose rates at full power.

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.18 [1.00 point]
As a licensed operator at ISU, you were unable to perform the functions of an operator for the minimum number of hours required during the previous calendar quarter. In accordance with 10 CFR part 55, what are the minimum number of hours you must complete before resumption of functions authorized by your license?

a. 4

b. 6

c. 8

d. 12

QUESTION B.19 [1.00 point]
What is the dose rate at 1 foot, given 85% of the decay of an 6 Curie point source results in emission of a 200 keV gamma?

a. 0.61 R/hr

b. 1.008 R/hr

c. 6.12 R/hr

d. 9.17 R/hr

QUESTION B.20 [1.00 point]
In accordance with ISU Technical Specification, which ONE of the following is the maximum average reactivity addition rate per second?

a. 0.065% $\Delta k/k$

b. 0.032% $\Delta k/k$

c. 0.145% $\Delta k/k$

d. 0.625% $\Delta k/k$

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

Category C: Facility and Radiation Monitoring Systems

QUESTION C.01 [1.00 point]
In accordance with ISU Technical Specification, which ONE of the following is the maximum average reactivity addition rate per second?

a. 5.057%

b. 1.121%

c. 0.652%

d. 0.065%

QUESTION C.02 [1.00 point]
Which ONE of the following describes Nuclear Safety Instrumentation Channel 1?

a. BF_3 proportional counter, thru a pre-amplifier, and provides the startup indication.

b. BF_3 ion chamber, thru the HV supply, and provides the logarithmic indications.

c. BF_3 proportional counter, thru the cambelling unit, and provides the linear indications.

d. Dual chamber, Boron-lined Geiger-Mueller detector, thru an amplifier to provide a period indication.

QUESTION C.03 [1.00 point]
Which ONE of the following is NOT a characteristic/function of the ISU thermal fuse?

a. Designed to soften at 100ºC

b. Located near the center of the core

c. Provides a space for core expansion and gas accumulation

d. Permits the bottom core section to drop 5 cm (2inches) to the bottom of the core tank.

Category C: Facility and Radiation Monitoring Systems

QUESTION C.04 [1.00 point]
Which ONE of the following is the installed ISU reactor startup source?

a. AmBe

b. PuBe

c. Cf-252

d. RaBe

QUESTION C.05 [1.00 point]
Which ONE of the following describes the relationship between the amount of reactivity in each rod to the amount of fuel material contained in the rod?

a. Proportional

b. Exponential correlation

c. Gaussian correlation

d. Linear relationship

QUESTION C.06 [1.00 point]
Which ONE of the following lists the level of reactivity loss that the reactor will shut down if the thermal fuse melts and the core separates?

a. 0.5% Δk/k

b. 1.00% Δk/k

c. 3.5% Δk/k

d. 5.0% Δk/k

QUESTION C.07 [1.00 point]
Which ONE of the following actions will result in an increase in excess reactivity?

a. Replacement of lead from beam port #4 with aluminum

b. Inserting the cadmium plug into the glory hole

c. Changing core temperature from 20 °C to 18 °C

d. Changing thermal column from graphite to water

Category C: Facility and Radiation Monitoring Systems

QUESTION C.08 [1.00 point]
Which ONE of the following nuclear safety channels provides the high power scram at or before 3.0×10^{-7} amps?

a. Channel 1

b. Channel 2

c. Channel 3

d. Radiation Monitor

QUESTION C.09 [1.00 point]
While conducting ISU OP-2, *AGN-201 Operating Procedure #2*, which ONE of the following pre-operational checks or tests do NOT need to be performed?

a. Radiation Area Monitor Alarm Test.

b. Rod Drop Test.

c. Channel #2 Period Test.

d. Channels 'ON' and Operating Check.

QUESTION C.10 [1.00 point]
Which ONE of the following best describes the fine control rod?

a. Contains 14.4g U-235 in polyethylene, magnetically coupled to a carriage.

b. Contains 3.65g U-235 in polyethylene, mechanically coupled to a carriage.

c. Contains 14.5g U-235 in polyethylene, magnetically coupled to a pull device.

d. Contains 5.91g U-235 in polyethylene, mechanically coupled to a push rod.

QUESTION C.11 [1.00 point]
Which ONE of the following is the type of sensor used for the shield tank water level signal?

a. Float switch

b. Pressure switch

c. Differential pressure switch

d. Plunger push level sensor

Category C: Facility and Radiation Monitoring Systems

QUESTION C.12 [1.00 point]
Which ONE of the following will NOT result in an automatic reactor scram?

a. Water level

b. Reactor period

c. Radiation level

d. Loss of facility power

QUESTION C.13 [1.00 point]
Which ONE of the following statements best describes the basis for the shield water temperature limit?

a. Ensures the integrity of all experiments conducted at the facility.

b. Prevents reactivity additions associated with core temperature.

c. Ensures the thermal fuse material will not degrade due to extreme low operating temperatures.

d. Prevents thermal stress on reactor tank and core components due to large temperature fluctuations during operation.

QUESTION C.14 [1.00 point]
Which ONE of the following is the MAIN function of the high-density graphite surrounding the core?

a. Increase neutron leakage

b. Decrease neutron leakage

c. Absorb thermal neutrons

d. Absorb fission product gases

Category C: Facility and Radiation Monitoring Systems

QUESTION C.15 [1.00 point]
Which ONE of the following areas has increased radiation fields when the reactor is operating at 5 watts?

a. Counting laboratory, room 22

b. Subcritical laboratory, room 23

c. Reactor Supervisor's office, room 15

d. Observation/conference room, room 19

QUESTION C.16 [1.00 point]
In accordance with ISU Technical Specification Limiting Conditions for Operation (LCOs), which ONE of the following is NOT an interlock associated with the control rods?

a. Scram not reset/cleared.

b. Only one safety rod can be inserted at a time.

c. Coarse control rod cannot be inserted unless both safety rods are fully inserted.

d. Reactor startup cannot commence unless both safety rods and coarse control rods are fully withdrawn from the core.

QUESTION C.17 [1.00 point]
Which ONE of the following control rod drive components is used to decelerate each scrammable rod during the last 10 cm of travel?

a. Dashpot

b. Electromagnet

c. Synchro generator

d. Double lead screw drivetrain

QUESTION C.18 [1.00 point]
Which ONE of the following would add the most positive reactivity to the reactor when placed in the '*glory hole*'?

a. Gold

b. Boron

c. Cadmium

d. Polyethylene

Category C: Facility and Radiation Monitoring Systems

QUESTION C.19 [2.0 point, 0.50 each]
Match the reactor item in Column A with its material make-up in Column B. Options in Column B may be used once, more than once, or not at all.

Column A	Column B
a. Reflector	1. 10 cm of Lead
b. Reactor Tank	2. 55 cm of Water
c. Gamma Shield	3. 80 mm of Steel
d. Fast Neutron Shield	4. Heavy Density Graphite

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

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

A.01
Answer: d
Reference: DOE Fundamentals Handbook, Volume 1, Module 2, page 24

A.02
Answer: a. 3; b. 1; c. 2; d. 1 or 2
Reference: Burn, *Introduction to Nuclear Reactor Operations,* Section 2.4.5

A.03
Answer: b
Reference: Burn, *Introduction to Nuclear Reactor Operations,* Section 3.2.1, page 3-4

A.04
Answer: b
Reference: Glasstone & Sesonske, *Nuclear Reactor Engineering*, page 248

A.05
Answer: a
Reference: Burn, *Introduction to Nuclear Reactor Operations,* Section 3.3.1, page 3-16

A.06
Answer: b
Reference: Burn, *Introduction to Nuclear Reactor Operations*, page 8-1

A.07
Answer: d
Reference: DOE Fundamentals Handbook, Volume 2, Module 4, page 34

A.08
Answer: c
Reference: DOE Fundamentals Handbook, Volume 2, Module 4, page 25

A.09
Answer: d
Reference: Burn, *Introduction to Nuclear Reactor Operations*, Section 7.7.12(b), page 7-19

A.10
Answer: d
Reference: Chart of Nuclides; N = A – Z or 10-5 = 5

A.11
Answer: d
Reference: Burn, *Introduction to Nuclear Reactor Operations*, page 4-13

A.12
Answer: c
Reference: Burn, *Introduction to Nuclear Reactor Operations,* Section 2.4.4, page 2-26

A.13
Answer: c
Reference: Burn, *Introduction to Nuclear Reactor Operations*, Section 3.3.1, page 3-16

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

A.14
Answer: c
Reference: Burn*, Introduction to Nuclear Reactor Operations,* Section 7.7.4, page 7-17

A.15
Answer: c
Reference: $CR_1*(1-K_{eff1}) = CR_2*(1-K_{eff2})$

$$CR2 = \frac{CR1 * (1 - k_{eff1})}{(1 - K_{eff2})}$$

$$CR2 = \frac{1280 * 0.15}{0.05}$$

$$CR_2 = 3840$$

A.16
Answer: a
Reference: Burn, *Introduction to Nuclear Reactor Operations*, Section 2.8.6, page 2-62

A.17
Answer: a
Reference: Burn, *Introduction to Nuclear Reactor Operations*, Example 3.4.3, page 3-32, 3-33. In the reactor period equation, T=(β-p)/λp, if Beta effective is used instead of Beta for U-235, the term (β_{eff}-p) is larger giving a longer period.

A.18
Answer: c
Reference: Burn, *Introduction to Nuclear Reactor Operations*, Problem 2.8.12, page 2-64

A.19
Answer: c
Reference: DOE Fundamentals Handbook, Volume 2, Module 3, page 2

A.20
Answer: a
Reference: $P = P_0 e^{t/T}$, $P/P_0 = e^{t/T}$, $Ln (P/P_0) = t/T$. Ln(400/100) = t/T, Ln (4) = t/T = 1.386, answer (a) power manipulations would take the longest time to complete

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

Category B: Normal/Emergency Operating Procedures and Radiological Controls

B.01
Answer: d
Reference: ISU Emergency Plan 3.3

B.02
Answer: c
Reference: ISU Technical Specifications 1.22

B.03
Answer: b
Reference: 10 CFR 20.1003, 10 CR 20.1902
$(DR_1)(D_1)^2 = (DR_2)(D_2)^2$
$(10\ mRem/hr)(100\ cm)^2 / (30\ cm)^2 = 111\ mRem/hr$

B.04
Answer: c
Reference: ISU Maintenance Procedure 1

B.05
Answer: c
Reference: ISU Technical Specification 3.1 and 6.9.2

B.06
Answer: d
Reference: ISU Emergency Plan 3.2.1

B.07
Answer: b
Reference: $DR = DR_0 \cdot e\text{-}\lambda t$; $T_{1/2} = 0.693/\lambda$

$DR = DR_0 \cdot e^{-0.693/T1/2}$

$0.600 = 8.50 \cdot e^{(-0.693)(5)/T1/2}$

$0.070 = e^{-3.465/T1/2}$

$\ln(0.070) = \ln(e^{-3.465/T1/2})$

$-2.65 = -3.465/T_{1/2}$

$T_{1/2} = -3.465/-2.65$

$T_{1/2} = 1.307\ hr = 1.3\ hours$

B.08
Answer: d
Reference: ISU Technical Specification 6.4.2

B.09
Answer: d
Reference: 10 CFR 20.1003, Definitions

Category B: Normal/Emergency Operating Procedures and Radiological Controls

B.10
Answer: a
Reference: ISU Technical Specification 6.10.1 and 6.10.2

B.11
Answer: b
Reference: Standard Health Physics Definition

B.12
Answer: d
Reference: 10 CFR 20.1301 and 10 CFR 20.1207

B.13
Answer: c
Reference: Standard Health Physics Question

B.14
Answer: c
Reference: ISU Emergency Plan 7.4

B.15
Answer: a. 3, b. 3, c. 1, d. 3
Reference: ISU Technical Specification 4.2 and 4.4

B.16
Answer: c
Reference: ISU Technical Specifications 3.3.1

B.17
Answer: a. Calibration; b. Check; c. Test; d. Check
Reference: ISU Technical Specifications 4.2 and OP-1

B.18
Answer: b
Reference: 10 CFR 55.53(f)

B.19
Answer: c
Reference: 6 Cen = R/hr at 1 ft

(6 * 6 Ci) x (0.85 * 0.2)

6.12 R/hr at 1 ft

B.20
Answer: a
Reference: ISU Technical Specification 3.2(b)

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

Category C: Facility and Radiation Monitoring Systems

C.01
Answer: d
Reference: ISU Technical Specifications 3.2

C.02
Answer: a
Reference: ISU SAR 4.4.2

C.03
Answer: c
Reference: ISU SAR 4.2

C.04
Answer: c
Reference: ISU SAR Table 4.2-1

C.05
Answer: a
Reference: ISU SAR 4.4.1

C.06
Answer: d
Reference: ISU Technical Specification 2.2b

C.07
Answer: c
Reference: Standard NRC question

C.08
Answer: b
Reference: ISU Technical Specification 3.1

C.09
Answer: c
Reference: ISU MP-1, *Rod Drive Maintenance and Rod Worth Measurements*, Section II.11

C.10
Answer: b
Reference: ISU SAR Table 4.2-1

C.11
Answer: a
Reference: ISU SAR 4.3.4

C.12
Answer: c
Reference: ISU Technical Specification 3

C.13
Answer: b
Reference: ISU Technical Specification 3.2

Category C: Facility and Radiation Monitoring Systems

C.14
Answer: b
Reference: Standard NRC question

C.15
Answer: d
Reference: ISU SAR 3.2.4

C.16
Answer: a
Reference: ISU Technical Specification 3.2.c

C.17
Answer: a
Reference: ISU SAR 4.3.1

C.18
Answer: d
Reference: Standard NRC question

C.19
Answer: a. 4; b. 3; c. 1; d. 2
Reference: ISU SAR Table 4.2-1

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