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

May 7, 2026

Dr. Jason Hou, Director
Nuclear Reactor Program
Department of Nuclear Engineering
North Carolina State University
Campus Box 7909
2500 Stinson Drive
Raleigh, NC 27695-7909

SUBJECT: EXAMINATION REPORT NO. 50-297/OL-26-02, NORTH CAROLINA STATE UNIVERSITY

Dear Dr. Hou:

During the week of April 20, 2026, the U.S. Nuclear Regulatory Commission (NRC) administered an operator licensing examination at your PULSTAR Nuclear 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 Margaret Goodwin at (301) 415-1177, or via email at Margaret.Goodwin@nrc.gov.

Sincerely,

Signed by Brown, Tony
on 05/07/26

Tony Branch, 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. 50-297

Enclosures:
1. Examination Report No. 50-297/OL-26-02
2. Written examination

cc: w/ enclosures to GovDelivery Subscribers

SUBJECT: EXAMINATION REPORT NO. 50-297/OL-26-02 NORTH CAROLINA STATE UNIVERSITY DATED: MAY 7, 2026

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

REPORT NO.: OL-26-02

FACILITY DOCKET NO.: 50-297

FACILITY LICENSE NO.: R-120

FACILITY: PULSTAR Nuclear Research Reactor

EXAMINATION DATE(S): Week of April 20, 2026

SUBMITTED BY: Margaret Goodwin

Margaret N. Goodwin, Chief Examiner

April 29, 2026
Date

SUMMARY:
During the week of April 20, 2026, the NRC administered operator licensing examinations to three Reactor Operator (RO) candidates and one Senior Reactor Operator - Upgrade (SRO-U) candidate. All candidates passed all applicable portions of the examinations and tests.

REPORT DETAILS

1. Examiner: Margaret N. Goodwin, Chief Examiner, NRC

2. Results:

	RO PASS/FAIL	SRO PASS/FAIL	TOTAL PASS/FAIL
Written	3/0	N/A	3/0
Operating Tests	3/0	1/0	4/0
Overall	3/0	1/0	4/0

3. Exit Meeting:
Austin Wells, Manager of Engineering and Operations, North Carolina State University
Zachary Boutlon, Engineer, North Carolina State University
Margaret N. Goodwin, Chief Examiner, NRC

Prior to administration, adjustments to the written exam were accepted based on facility comments. These 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

PULSTAR Nuclear Research Reactor

Operator Licensing Examination

Week of April 20, 2026

Enclosure 2

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

FACILITY: North Carolina State University

REACTOR TYPE: PULSTAR

DATE ADMINISTERED: 04/23/2026

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.

Candidate Name: _____

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

A N S W E R S H E E T

Multiple Choice
(Circle your choice, or write on the line)
If you change your answer, write your selection on the line. Answers written on the line will be taken as the final answer.

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 *****)

Candidate Name: _____

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, or write on the line)
If you change your answer, write your selection on the line. Answers written on the line will be taken as the final answer.

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 *****)

Candidate Name: _____

Category C: Facility and Radiation Monitoring Systems

A N S W E R S H E E T

Multiple Choice
(Circle your choice, or write on the line)
If you change your answer, write your selection on the line. Answers written on the line will be taken as the final answer.

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 ___

C20 a b c d ___

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

EQUATION SHEET

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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]
All of the following are used as artificial or installed neutron sources EXCEPT:

a. Californium-252

b. Antimony-Beryllium

c. Plutonium-239

d. Americium-Beryllium

QUESTION A.02 [1.00 point]
Which ONE of the following statements best describes β_{eff}?

a. The ratio of delayed neutrons to total core neutrons once they have slowed to thermal energies.

b. The ratio of delayed neutrons to total neutrons in the core.

c. The ratio of delayed neutrons that reach thermal energies to the number of prompt neutrons that reach thermal energies.

d. The ratio of delayed neutrons per precursor group to the total number of delayed neutrons in the core.

QUESTION A.03 [1.00 point]
What is the average energy of a neutron produced directly from fission?

a. 0.03 MeV

b. 0.1 MeV

c. 2 MeV

d. 10 MeV

QUESTION A.04 [1.00 point]
If it takes 56 seconds for reactor power to increase from 15 W to 990 kW, what is the reactor period?

a. 0.1s

b. 1.3s

c. 5.0s

d. 12.2s

QUESTION A.05 [1.00 point]
Which ONE of the following characteristics of a nucleus impacts its radius?

a. Its radioactive decay scheme

b. Its atomic mass

c. The amount of energy imparted on it

d. Its half-life

QUESTION A.06 [1.00 point]
Which ONE of the following statements regarding a prompt critical reactor is TRUE?

a. It can only be done with fuel that predominantly fissions with fast neutrons.

b. It occurs when the delayed neutron fraction is essentially zero.

c. It can only be achieved through a rapid insertion of reactivity.

d. It cannot be sustained for longer than a neutron generation lifetime.

QUESTION A.07 [1.00 point]
Which ONE of the following best describes the behavior of Xenon-135 immediately following a reactor shutdown?

a. The concentration of Xenon-135 continues to increase but in such small amounts that it has no impact on the reactor.

b. The concentration of Xenon-135 continues to increase for approximately 7 hours at which point it peaks and starts to decrease.

c. The concentration of Xenon-135 becomes stagnant and remains constant until the next reactor startup.

d. The concentration of Xenon-135 immediately begins to decrease and reaches zero approximately 81 hours after shutdown.

QUESTION A.08 [1.00 point]
Which ONE of the following isotopes would be most effective in a poison control rod?

a. Lithium-6 (σ_a = 945 barns)

b. Boron-10 (σ_a = 3840 barns)

c. Cadium-113 (σ_a = 20,000 barns)

d. Gadolinium-155 (σ_a = 61,000 barns)

QUESTION A.09 [1.00 point]
Which ONE of the following statements regarding stable nuclides is TRUE?

a. The larger the atomic mass of the stable nuclide, the greater the ratio of neutrons to protons.

b. The larger the atomic mass of the stable nuclide, the greater the cross section of thermal neutron activation.

c. Stable nuclides cannot be produced via fission.

d. Stable nuclides cannot enter an excited or high energy state.

QUESTION A.10 [1.00 point]
If K_{eff} is 0.981 with a count rate of 782 cps, what count rate would result in a K_{eff} of 0.997

a. 1436 cps

b. 2649 cps

c. 3781 cps

d. 4953 cps

QUESTION A.11 [1.00 point]
During the lifetime of the reactor, which ONE of the following decreases the overall core excess reactivity?

a. Fuel burnup

b. Control rod burnup

c. Xenon-135 burnup

d. Samarium-149 burnup

QUESTION A.12 [1.00 point]
Which ONE of the following statements BEST describes the difference between the Infinite and Effective Multiplication Factors?

a. The infinite multiplication factor assumes a reactor with no neutron leakage while the effective multiplication factor takes leakage into account.

b. The infinite multiplication factor is not time dependent while the effective multiplication factor is.

c. The infinite multiplication factor tells you what the neutron population will be in a critical reactor while the effective multiplication factor tells you the neutron population in a subcritical reactor.

d. The infinite multiplication factor looks at neutrons of all energies while the effective multiplication factor only considers thermal neutrons.

QUESTION A.13 [1.00 point]
Which ONE of the following BEST describes Doppler Broadening?

a. The average energy of U-235 atoms in the fuel increases thus decreasing the fission cross section.

b. The resonance peaks of U-238 widen resulting in greater rates of neutron absorption.

c. The temperature of the moderator increases leading to a decrease in the scattering cross section.

d. The average neutron energy in the core increases resulting in a larger amount of fast neutron leakage.

QUESTION A.14 [1.00 point]
What reactivity addition is required to increase K_{eff} from 0.794 to 0.966?

a. 0.079

b. 0.088

c. 0.224

d. 1.003

QUESTION A.15 [1.00 point]
Which ONE of the following is an example of beta emission?

a. $_{6}C^{14} \rightarrow {}_{7}N^{14}$

b. $_{6}C^{14} \rightarrow {}_{6}C^{13}$

c. $_{6}C^{14} \rightarrow {}_{4}Be^{10}$

d. $_{6}C^{14} \rightarrow {}_{8}O^{18}$

QUESTION A.16 [1.00 point]
Which ONE of the following BEST describes the integral rod worth along the entire length of a control rod?

a. It follows a parabolic shape with the lowest differential worths at the bottom and top of the control rod.

b. It follows a parabolic shape with the lowest differential worth at the center of the control rod.

c. It follows an “S” shape with the lowest differential worths at the bottom and top of the control rod.

d. It follows an “S” shape with the lowest differential worth at the center of the control rod.

QUESTION A.17 [1.00 point]
Which ONE of the following has the SHORTEST range?

a. Alpha particle

b. Beta particle

c. Gamma

d. Neutron

QUESTION A.18 [1.00 point]
Which ONE of the following is the main source of decay heat following a reactor shutdown?

a. Fissions still occurring in the fuel with the remaining neutrons.

b. An increase in fuel temperature following a decrease in reactivity.

c. The thermalization of all remaining fast neutrons.

d. The continued decay of fission products.

QUESTION A.19 [1.00 point]
What would reactor power be following a prompt jump if a reactivity of 0.0076 were added while the reactor was operating at 100kW with a β_{eff} of 0.0083?

a. 592 kW

b. 1177 kW

c. 1851 kW

d. 2194 kW

QUESTION A.20 [1.00 point]
The energy released from fission comes from:

a. The kinetic energy of the uranium atom and incident neutron.

b. The difference in binding energy between the uranium atom and the daughter products.

c. The energy of the neutron that is transferred to the fission products.

d. The difference in kinetic energy and mass between the uranium atom and incident neutron.

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

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.01 [1.00 point]
Which ONE of the following scenarios would result in a radiation dose exceeding the 10 CFR 20 limits for occupational workers?

a. Handling a freshly irradiated experiment emitting an extremity dose rate of 400 rem/hr for 6 minutes.

b. Accidentally dropping a radioactive powder that gives a radiation dose of 10 rem to the lens of the eye.

c. Inhaling fission product gases during a release resulting in a radiation dose of 55 rem to the lungs.

d. Performing work in a radiation area that takes approximately 3 hours to complete.

QUESTION B.02 [1.00 point]
If a freshly irradiated sample emits a radiation dose of 500 mrem at a distance of 5cm away from the source, how should the storage area be posted?

a. No posting is necessary

b. Radiation Area

c. High Radiation Area

d. Very High Radiation Area

QUESTION B.03 [1.00 point]
Which ONE of the following experiments would NOT be permissible?

a. A doubly encapsulated experiment with a predicted detonation pressure of 250 psi.

b. An experiment that if completely aerosolized, would result in a radiation dose of 500 mrem to anyone within the reactor bay.

c. An experiment designed to be entirely neutron invisible but placed directly between the core and the fission chamber.

d. A movable experiment with a reactivity insertion rate of 50 pcm/s and a total reactivity of 250 pcm.

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.04 [1.00 point]
In accordance with the NCSU Technical Specifications, all of the following surveillances must be completed during an extended reactor shutdown EXCEPT:

a. Channel checks for the Reactor Safety System Channels.

b. Visual inspection of all fuel assemblies.

c. Visual inspection of all magnetically coupled control rods.

d. Channel calibrations of the area radiation monitors.

QUESTION B.05 [1.00 point]
A sample of radioactive Gold-198 is removed from the reactor with a half-life of 2.69 days. What is the decay constant?

a. 0.26 d^{-1}

b. 0.56 d^{-1}

c. 0.76 d^{-1}

d. 0.92 d^{-1}

QUESTION B.06 [1.00 point]
In accordance with NCSU Operating Procedure NRP-OP-103 'Reactor Operation', all of the following must be recorded in the logbook EXCEPT;

a. Reactor power level changes

b. Abnormal facility alarms

c. Equipment bypasses

d. Operation of experimental facilities

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.07 [1.00 point]
In accordance with the NCSU Radiation Protection Program, all of the following are used as High Radiation Area access controls EXCEPT:

a. Locking access points

b. Postings

c. Direct surveillance

d. Radiation minimization and mitigation

QUESTION B.08 [1.00 point]
If an experiment is emitting a dose rate of 25mrem/hr at a distance of 75 cm, what is the dose rate measured at 15 cm?

a. 125 mrem/hr

b. 275 mrem/hr

c. 450 mrem/hr

d. 625 mrem/hr

QUESTION B.09 [1.00 point]
Which ONE of the following statements BEST describes a KNOWN CORE?

a. An arrangement of fuel assemblies in their most reactive position with the control rods fully inserted to ensure sufficient negative reactivity to keep the reactor subcritical.

b. A core configuration including previously measured experiment reactivities that falls within reactivity and shutdown limits while operating at some power above the point of adding heat.

c. A fuel, reflector, and control rod configuration in which the shutdown margin is known and approval has been obtained for full licensed power operations.

d. A core configuration in which the fuel assemblies are located in core positions that differ from their normal locations but the peak flux of each assembly is lower than normal.

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.10 [1.00 point total, 0.25 points each]
In accordance with the NCSU Technical Specifications, identify each of the following as either a CHANNEL CHECK, TEST, or CALIBRATION?

a. Verifying that the water resistivity measurement matches the readings from the previous day.

b. Adjusting the control rod scram time so it falls in 0.5s instead of 1.2s.

c. Ensuring the control rods can't be moved when exposed to a neutron count of less than 2 cps.

d. Adjusting the alarm setpoint of an Area Radiation Monitor so it alarms at 7.5mrem/hr instead of 10mrem/hr.

QUESTION B.11 [1.00 point total, 0.25 points each]
In accordance with the NCSU Technical Specifications, identify each of the following as either a Safety Limit (SL), and Limiting Safety System Setting (LSSS), or a Limiting Condition of Operation (LCO).

a. The true value of reactor coolant inlet temperature shall not be greater than 120^{o}F.

b. The true value of reactor thermal power shall not exceed 1.4 MW_t.

c. The reactor shall not be operated with more than a maximum of 25 fuel assemblies.

d. The reactor shall not be operated above 500 kW without the N-16 Power Measuring Channel.

QUESTION B.12 [1.00 point]
In accordance with the NCSU Reactor Experiment procedure, when removing an irradiated sample, all of the following information is recorded on Appendix B EXCEPT:

a. The name of the operator who removed the sample.

b. The radiation dose rate of the sample at 30 cm.

c. The date that the sample was removed.

d. The time that the sample was removed.

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.13 [1.00 point]
Given the following, calculate the Core Excess of Reactivity and determine if it is within the Technical Specification limit.

Control Rod	Total Reactivity Worth	Excess Reactivity of Rod
Regulating Rod	1340 pcm	370 pcm
Safety Rod #1	1120 pcm	260 pcm
Safety Rod #2	920 pcm	230 pcm
Shim Rod	890 pcm	890 pcm

a. 1750 pcm; the Core Excess is within the Technical Specification Limit

b. 1750; the Core Excess VIOLATES the Technical Specification Limit

c. 4270; the Core Excess is within the Technical Specification Limit

d. 4270; the Core Excess VIOLATES the Technical Specification Limit

QUESTION B.14 [1.00 point]
In accordance with the NCSU Safety Analysis Report, which ONE of the following scenarios would require the use of the Shim Rod?

a. Thermal power calibration

b. Control rod reactivity measurements

c. Reactor core flux mapping

d. Approaching criticality using subcritical multiplication

QUESTION B.15 [1.00 point]
In accordance with the NCSU Technical Specifications, which ONE of the following would result in the automatic actuation of the confinement system?

a. Attempting to move the control rods when the neutron count is less than 2 cps.

b. A radiation field resulting in a dose readout of 150 mrem/hr on the over-the-pool radiation monitor.

c. Opening all facility doors such that the differential pressure of the bay reads less than 0.2" H_2O.

d. An experiment failure causing the primary coolant resistivity to drop below 300 kΩ*cm.

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.16 [1.00 point]
In accordance with the NCSU Emergency Plan, the Operations Boundary is comprised of:

a. The Burlington Engineering Laboratory

b. The Reactor Building and Primary Piping Vault

c. The Reactor Bay, Ventilation Room, and Mechanical Equipment Room

d. The Reactor Bay and Control Room

QUESTION B. 17 [1.00 point]
In accordance with the NCSU Operating Procedure NRP-OP-101 'Reactor Startup and Shutdown', which ONE of the following is done to authorize a reactor startup?

a. The Designated Senior Reactor Operator gives verbal permission to perform a startup.

b. The completion of the startup checklist with no issues indicates the necessary authorization.

c. The Designated Senior Reactor Operator and Reactor Operator verbally agree that the reactor startup can occur.

d. The Designated Senior Reactor Operator signs the startup checklist and the logbook.

QUESTION B.18 [1.00 point]
In accordance with the NCSU Technical Specifications, which ONE of the following surveillances must be performed annually?

a. A calibration of the control room differential pressure gauges.

b. A full core fuel inspection.

c. A channel calibration of the N-16 Channel.

d. A pH and gamma/beta analysis of the primary coolant water.

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.19 [1.00 point]
In accordance with the NCSU Emergency Plan, which ONE of the following scenarios would be classified as an Alert?

a. A plane headed towards the Raleigh Durham Airport malfunctions and crashes into the Reactor Building.

b. A massive anti-nuclear protest breaks out outside of the Burlington Engineering Lab and throw rocks at the building.

c. A fueled experiment fails while in the reactor and causes massive damage to the fuel and fuel cladding leading to the uncontrollable release of radioactive material.

d. A hurricane makes landfall at the facility causing damage to the Reactor Building structure and the loss of the negative pressure differential.

QUESTION B.20 [1.00 point]
In accordance with the NCSU Operating Procedure NRP-OP-105 'Response to SCRAMS, Alarms, and Abnormal Conditions' all of the following require an immediate shutdown EXCEPT:

a. Loss of Reactor Pool Water

b. Loss of Commercial Power

c. Loss of the Safety Channel

d. Loss of Reactor Building Differential Pressure

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

Category C: Facility and Radiation Monitoring Systems

QUESTION C.01 [1.00 point]
In accordance with the NCSU Safety Analysis Report, which ONE of the following statements regarding the fuel is TRUE?

a. The negative temperature coefficient of the fuel is approximately constant from 10 kW to 1 MW.

b. The introduction of Pu-239 via burnup will add positive reactivity over the lifetime of the reactor.

c. The majority of the negative temperature coefficient of the fuel comes from the U-235.

d. The flux distribution of the fuel is constant along its axial length.

QUESTION C.02 [1.00 point]
In accordance with the NCSU Reactor Startup Procedure, which ONE of the following conditions is used to gauge criticality?

a. The power is increasing with a reactor period less (faster) than 15 seconds.

b. All control rods are more than 50% withdrawn from the core.

c. The temperature of the water in the reactor pool begins to increase.

d. The reactor power has doubled at least 5 times since commencing startup.

QUESTION C.03 [1.00 point]
In accordance with the NCSU Safety Analysis Report, which ONE of the following is an Engineered Safety Feature of the NCSU Pulstar Reactor?

a. The control rod scram capability

b. The negative temperature coefficient of the fuel

c. The confinement system

d. The primary cooling system

Category C: Facility and Radiation Monitoring Systems

QUESTION C.04 [1.00 point]
In accordance with the NCSU Safety Analysis Report, which ONE of the following statements BEST describes the difference between natural and forced convection?

a. During forced convection, water flows down through the core and into the outlet plenum where it goes to a plate type heat exchanger. During natural convection, water flows into the outlet plenum and up through the core.

b. The primary coolant follows the same path during forced and natural convection, just at different speeds based on the operation of the primary pump.

c. During forced convection, the water flows up through the core, then out the top of the pool and into a plate type heat exchanger. During natural convection, the water is stagnant and the heat spreads to the top of the pool where it dissipates into the atmosphere.

d. During forced convection, the secondary cooling system runs to remove heat from the primary. During natural convection, the water still flows but no heat is removed because the secondary cooling system remains off.

QUESTION C.05 [1.00 point]
Which ONE of the following experimental facilities allows for the rapid insertion and removal of samples into and out of the reactor?

a. Rotating Exposure Ports

b. Pneumatic Transfer System

c. Thermal Column

d. Beam Ports

QUESTION C.06 [1.00 point]
In accordance with the NCSU Safety Analysis Report, which ONE of the following statements BEST describes the operation of the N-16 Power Measuring Channel?

a. It monitors reactor power by measuring the ratio of oxygen-16 to nitrogen-16.

b. It monitors reactor power by measuring the energies of the gammas produced by the decay of nitrogen-16.

c. It monitors reactor power as a function of the rate at which nitrogen-16 is carried through the core by the flow of water.

d. It monitors reactor power as a function of the decay of nitrogen-16 and the gammas produced.

Category C: Facility and Radiation Monitoring Systems

QUESTION C.07 [1.00 point]
Which ONE of the following BEST describes the radial neutron flux profile of a PULSTAR fuel pin?

a. The neutron flux is equal throughout the radial profile of the fuel pin.

b. The neutron flux is greatest at the center of the fuel pin then decreases towards the surface.

c. The neutron flux is lowest at the center of the fuel pin then increases towards the surface.

d. The neutron flux is greatest at the midpoint between the center and surface of the pin and decreases on either side in a parabolic manner.

QUESTION C.08 [1.00 point]
In accordance with the NCSU Technical Specifications, why must primary coolant resistivity be limited?

a. To ensure optimal conditions for flux profiles.

b. To further aid in ensuring proper cooling for the fuel.

c. To prevent the introduction of contaminants with high reactivity worths.

d. To reduce the potential to activate contaminants in the primary coolant.

QUESTION C.09 [1.00 point]
All of the following are design features of the primary cooling system EXCEPT:

a. It includes an aluminum reactor tank with a capacity of approximately 15,600 gallons.

b. It contains valves necessary to isolate the system as needed.

c. It includes a heat exchanger and pump to continuously move the water throughout the reactor.

d. It is rated to remove up to 4 MW of heat from the system.

QUESTION C.10 [1.00 point]
During steady-state reactor operations at 1 MW, what is the dominant source of radiation dose over the reactor pool?

a. Nitrogen-16

b. Argon-41

c. Cesium-137

d. The fission process

Category C: Facility and Radiation Monitoring Systems

QUESTION C.11 [1.00 point]
In accordance with Section 5 of the NCSU Technical Specifications, which ONE of the following is a required design feature of the Control Rod Blades?

a. They need to all be magnetically coupled and scrammable.

b. They need to be made of silver, indium, cadmium, and have a nickel coating.

c. They need to be able to shut down the reactor with all four control rods fully inserted.

d. The control rod drive mechanisms must be Acme Screw Type Drives.

QUESTION C.12 [1.00 point]
In accordance with the NCSU Technical Specifications, when storing fuel, K_{eff} must be kept below:

a. 0.80

b. 0.85

c. 0.90

d. 0.95

QUESTION C.13 [1.00 point]
In accordance with the NCSU Safety Analysis Report, which ONE of the following is a prerequisite for placing the reactor in Automatic Mode?

a. The regulating rod must be fully inserted.

b. Reactor power must be within ±9% of the demand power.

c. The reactor period must be infinite.

d. All reactor power measuring channels must be on the maximum range.

QUESTION C.14 [1.00 point]
In accordance with the NCSU Safety Analysis, all of the following are Engineered Safety Features EXCEPT:

a. The reactor protection system.

b. The control rod hold down system.

c. The facility confinement system.

d. The natural circulation cooling system.

Category C: Facility and Radiation Monitoring Systems

QUESTION C.15 [1.00 point]
Which ONE of the following is used to mitigate the radiation dose caused by Nitrogen-16 at the facility?

a. Delay Tanks

b. A Diffuser Nozzle

c. A Nitrogen-16 Detector

d. Lead Shielding

QUESTION C.16 [1.00 point]
Which ONE of the following scenarios BEST describes the Maximum Hypothetical Accident?

a. A loss of reactor pool water due to overheating/boiling.

b. A reactivity insertion event due to a failed fueled experiment.

c. A fuel cladding rupture event involving multiple dropped pins.

d. A loss of confinement event due to loss of building integrity.

QUESTION C.17 [1.00 point]
Which ONE of the following is a requirement for all fuel in the core?

a. Fuel assemblies are limited to 20,000 MWD/MTU.

b. All fuel assemblies must be stored in more than 14 ft. of water.

c. All fuel assemblies must allow enough space for sufficient cooling.

d. Fuel assemblies are limited to a maximum of 5 years between visual inspections.

QUESTION C.18 [1.00 point]
Which ONE of the following power monitors has the smallest range of accuracy?

a. Fission Chamber

b. Compensated Ion Chamber

c. Uncompensated Ion Chamber

d. N-16 Detector

Category C: Facility and Radiation Monitoring Systems

QUESTION C.19 [1.00 point]
Which ONE of the following events would cause the confinement dampers to close during reactor operations?

a. A west wall radiation monitor alert at 5 mR/hr.

b. A reactor high power scram at 1.3 MW.

c. A reactor coolant temperature high scram at 117^{o}F.

d. A loss of commercial power to the facility.

QUESTION C.20 [1.00 point]
Which ONE of the following locations experiences the greatest neutron flux?

a. In-reflector Experimental Facilities

b. The East Beam Port

c. The Thermal Column

d. The West Beam Port

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

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

A.01
Answer: c
Reference: DOE Fundamentals Handbook *Nuclear Physics and Reactor Theory* Vo. 1 Module 2, p.3

A.02
Answer: a
Reference: R. R. Burn, *Introduction to Nuclear Reactor Operations*, Vol 2. p. 3-12

A.03
Answer: c
Reference: R. R. Burn, *Introduction to Nuclear Reactor Operations*, Vol 1. p. 2-47

A.04
Answer: c
Reference: $P = P_0 e^{t/T}$

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

$ln\frac{P}{P_0} = \frac{t}{T}$

$T = \frac{t}{ln\frac{P}{P_0}}$

$T = \frac{56}{ln\frac{990000}{15}} = 5.04622 \sim 5.0\ seconds$

A.05
Answer: b
Reference: R. R. Burn, *Introduction to Nuclear Reactor Operations*, Vol 1. p. 2-9

A.06
Answer: b
Reference: R. R. Burn, *Introduction to Nuclear Reactor Operations*, Vol 2. p. 4-1

A.07
Answer: b
Reference: R. R. Burn, *Introduction to Nuclear Reactor Operations*, Vol 4. p. 8-10

A.08
Answer: d
Reference: R. R. Burn, *Introduction to Nuclear Reactor Operations*, Vol 1. p. 2-59

A.09
Answer: a
Reference: DOE Fundamentals Handbook *Nuclear Physics and Reactor Theory* Vo. 1 Module 1, p.14

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

A.10
Answer: d
Reference: $CR1(1-k1) = CR2(1-k2)$

$$CR2 = \frac{CR1 * (1-k1)}{(1-k2)}$$

$$CR2 = \frac{782 * 0.019}{0.003} = 4952.67 \sim 4953$$

A.11
Answer: a
Reference: DOE Fundamentals Handbook *Nuclear Physics and Reactor* Theory Vol. 2 Module 4 p.30

A.12
Answer: a
Reference: DOE Fundamentals Handbook *Nuclear Physics and Reactor* Theory Vol. 2 Module 3 p.2

A.13
Answer: b
Reference: DOE Fundamentals Handbook *Nuclear Physics and Reactor* Theory Vol. 2 Module 3 p.26

A.14
Answer: c
Reference:

$$\Delta\rho = \frac{K_{eff2} - K_{eff1}}{K_{eff1} * K_{eff2}}$$

$$\Delta\rho = \frac{0.966 - 0.794}{0.794 * 0.966} = 0.224$$

A.15
Answer: a
Reference: Chart of the Nuclides

A.16
Answer: c
Reference: R. R. Burn, *Introduction to Nuclear Reactor Operations*, Vol 4. p. 7-5

A.17
Answer: a
Reference: R. R. Burn, *Introduction to Nuclear Reactor Operations*, Vol 1. p. 2-24

A.18
Answer: d
Reference: DOE Fundamentals Handbook *Nuclear Physics and Reactor* Theory Vol. 2 Module 4 p.33

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

A.19

Answer: b

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

$P = \frac{0.0083 * (1 - 0.0076)}{0.0083 - 0.0076} * 100$

P = 1177 kW

A.20

Answer: b

Reference: DOE Fundamentals Handbook *Nuclear Physics and Reactor* Theory Vol. 1 Module 1 p.56

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

Category B: Normal/Emergency Operating Procedures and Radiological Controls

B.01
Answer: c
Reference: 10 CFR 20

B.02
Answer: b
Reference: $DR_1 * d_1^2 = DR_2 d_2^2$
$DR_2 = \frac{DR_1 * d_1^2}{d_2^2}$
$DR_2 = \frac{500 * 5^2}{30^2}$ = 13.8 mrem/hr
10 CFR 20.1003

B.03
Answer: a
Reference: NCSU Technical Specifications 3.7

B.04
Answer: a
Reference: NCSU Technical Specifications 4.3

B.05
Answer: a
Reference: $\lambda = \frac{\ln(2)}{T1/2}$
$\lambda = \frac{\ln(2)}{2.69}$ = 0.257 = 0.26 d^{-1}

B.06
Answer: d
Reference: NCSU Operating Procedure NRP-OP-103 p. 6

B.07
Answer: d
Reference: NCSU Health Physics Procedure 1 p. 16

B.08
Answer: d
Reference: $DR_1 * d_1^2 = DR_2 d_2^2$
$DR_2 = \frac{DR_1 * d_1^2}{d_2^2}$
$DR_2 = \frac{25 * 75^2}{15^2}$ = 625 mrem/hr

B.09
Answer: c
Reference: NCSU Fuel Handling Procedure NRP-OP-301 p. 3

B.10
Answer: a: Check b: Calibration c: Test d: Calibration
Reference: NCSU Technical Specifications 1.2

Category B: Normal/Emergency Operating Procedures and Radiological Controls

B.11
Answer: a: SL b: SL c: LCO d: LCO
Reference: NCSU Technical Specifications

B.12
Answer: a
Reference: NCSU Reactor Experiment Procedure NRP-OP-104 p. 13

B.13
Answer: a
Reference: Core Excess = Excess Reactivity of all Control Rods
CR = 370+260+230+890
CR = 1750 pcm which is with the Technical Specification Limit in 3.2

B.14
Answer: b
Reference: NCSU Safety Analysis Report 4.2.2.2

B.15
Answer: b
Reference: NCSU Technical Specifications 3.3

B.16
Answer: b
Reference: NCSU Emergency Plan p. 7

B.17
Answer: d
Reference: NCSU Operating Procedure NRP-OP-101 p. 39

B.18
Answer: a
Reference: NCSU Technical Specifications 4.5

B.19
Answer: c
Reference: NCSU Emergency Plan 4.2.1

B.20
Answer: d
Reference: NCSU Operating Procedure NRP-OP-105 p. 13

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

Category C: Facility and Radiation Monitoring Systems

C.01
Answer: a
Reference: NCSU Safety Analysis Report 4.5.2.2.3

C.02
Answer: d
Reference: NCSU Operating Procedure NRP-OP-101 p. 5

C.03
Answer: c
Reference: NCSU Safety Analysis Report 6.1

C.04
Answer: a
Reference: NCSU Safety Analysis Report 5.2

C.05
Answer: b
Reference: NCSU Safety Analysis Report 10.2.3

C.06
Answer: d
Reference: NCSU Safety Analysis Report 7.4.3.5

C.07
Answer: c
Reference: NCSU Safety Analysis Report 4.5.2.4

C.08
Answer: d
Reference: NCSU Technical Specifications 3.9

C.09
Answer: d
Reference: NCSU Technical Specifications 5.5

C.10
Answer: d
Reference: NCSU Safety Analysis Report 11.1.1.1

C.11
Answer: b
Reference: NCSU Technical Specifications 5.4

C.12
Answer: c
Reference: NCSU Technical Specifications 5.3

C.13
Answer: b
Reference: NCSU Safety Analysis Report 7.3.2

Category C: Facility and Radiation Monitoring Systems

C.14
Answer: a
Reference: NCSU Safety Analysis Report 6.1

C.15
Answer: a
Reference: NCSU Safety Analysis Report 5.6

C.16
Answer: c
Reference: NCSU Safety Analysis Report 13.1.1

C.17
Answer: a
Reference: NCSU Technical Specifications 5.1

C.18
Answer: d
Reference: NCSU Safety Analysis Report 7.4.3.5

C.19
Answer: d
Reference: NCSU Safety Analysis Report 6.1.1

C.20
Answer: a
Reference: NCSU Safety Analysis Report 10.2.2

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