June 27, 2017

Dr. Ayman I. Hawari, 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-17-02, NORTH CAROLINA STATE UNIVERSITY

Dear Dr. Hawari:

During the week of May 8, 2017, the U.S. Nuclear Regulatory Commission (NRC) administered an operator licensing examination at your North Carolina State University reactor. The examinations were conducted according to NUREG-1478, "Operator Licensing Examiner Standards for Research and Test Reactors," Revision 2. Examination questions and preliminary findings were discussed with those members of your staff identified in the enclosed report at the conclusion of the examination.

In accordance with Title 10 of the *Code of Federal Regulations,* Section 2.390, a copy of this letter and the enclosures will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records (PARS) component of NRC's Agencywide Documents Access and Management System (ADAMS). ADAMS is accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html. The NRC is forwarding the individual grades to you in a separate letter which will not be released publicly. Should you have any questions concerning this examination, please contact Ms. Michele DeSouza at (301) 415-0747 or via e-mail at Michele.DeSouza@nrc.gov.

Sincerely,

/RA/

Anthony J. Mendiola, Chief
Research and Test Reactors Oversight Branch
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Docket No. 50-297

Enclosures:
1. Examination Report No. 50-297/OL-17-02
2. Written Examination

cc w/o encls: See next page

SUBJECT: EXAMINATION REPORT NO. 50-297/OL-17-02, NORTH CAROLINA STATE UNIVERSITY DATED JUNE 27, 2017.

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DATE	06/22/2017	06/22/2017	06/27/2017

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

REPORT NO.: 50-297/OL-17-02

FACILITY DOCKET NO.: 50-073

FACILITY LICENSE NO.: R-120

FACILITY: NCSU Pulstar

EXAMINATION DATES: May 9-10, 2017

SUBMITTED BY: ____________________________ __________
Michele DeSouza, Chief Examiner Date

SUMMARY:
During the week of May 8, 2017, the NRC administered an operator licensing examination to four Reactor Operator (RO) candidates. The four RO candidates passed all applicable portions of the examinations.

REPORT DETAILS

1. Examiner: Michele DeSouza, Chief Examiner, NRC

2. Results:

	RO PASS/FAIL	SRO PASS/FAIL	TOTAL PASS/FAIL
Written	4/0	0/0	0/0
Operating Tests	4/0	0/0	0/0
Overall	4/0	0/0	0/0

3. Exit Meeting:
Michele C. DeSouza, Chief Examiner, NRC
Andrew T. Cook, NCSU, Manager of Engineering and Operations
Gregory Gibson, NCSU, Training Coordinator

Per discussion with the facility, prior to administration of the examination, adjustments were accepted. Upon completion of the examination, the NRC Examiner met with facility staff representatives to discuss the results. Additionally, the NRC Examiner questioned the facility on the security of the control panel key. 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: NCSU

REACTOR TYPE: PULSTAR

DATE ADMINISTERED: 05/11/2017

CANDIDATE: ________________________

INSTRUCTIONS TO CANDIDATE:
Answers are to be written on the Answer sheet provided. Attach all Answer sheets to the examination. Point values are indicated in parentheses for each question. A 70% in each category is required to pass the examination. Examinations will be picked up three (3) hours after the examination starts.

CATEGORY VALUE	% OF TOTAL	CANDIDATE'S SCORE	% OF CATEGORY VALUE		CATEGORY
20.00	**33.3**	____________	_____	**A.**	**REACTOR THEORY, THERMODYNAMICS AND FACILITY OPERATING CHARACTERISTICS**
20.00	**33.3**	____________	_____	**B.**	**NORMAL AND EMERGENCY OPERATING PROCEDURES AND RADIOLOGICAL CONTROLS**
20.00	**33.3**	____________	_____	**C.**	**FACILITY AND RADIATION MONITORING SYSTEMS**
60.00		____________ **FINAL GRADE**	_____ %		**TOTALS**

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

____
Candidate's Signature

Enclosure 2

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 ___ (0.25 each)

A02   a   b   c   d   ___

A03   a   b   c   d   ___

A04   a   b   c   d   ___

A05   a ___ b ___ c ___ d ___ e ___ (0.20 each)

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 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 ___ (0.25 each)

B03 a b c d ___

B04 a b c d ___

B05 a b c d ___

B06 a ___ b ___ c ___ (0.33 each)

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 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 ___ (0.25 each)

C07   a ___   b ___ (0.50 each)

C08   a ___   b ___   c ___   d ___ (0.25 each)

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 **********)

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 <u>only</u> to facilitate legible reproductions.

5. Print your name in the blank provided in the upper right-hand corner of the examination cover sheet and each Answer sheet.

6. Mark your Answers on the Answer sheet provided. USE ONLY THE PAPER PROVIDED AND DO NOT WRITE ON THE BACK SIDE OF THE PAGE.

7. The point value for each question is indicated in [brackets] after the question.

8. If the intent of a question is unclear, ask questions of the examiner only.

9. When turning in your examination, assemble the completed examination with examination questions, examination aids and Answer sheets. In addition turn in all scrap paper.

10. Ensure all information you wish to have evaluated as part of your Answer is on your Answer sheet. Scrap paper will be disposed of immediately following the examination.

11. To pass the examination you must achieve a grade of 70 percent or greater in each category.

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

EQUATION SHEET

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

---

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

1 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 & Facility Operating Characteristics

Question A.01 [1.0 point, 0.25 each]
A fissile material is one which will fission upon the absorption of a THERMAL neutron. A fertile material is one which upon absorption of a neutron becomes a fissile material. Identify each of the listed isotopes as either fissile or fertile.

a. Th^{232}

b. U^{235}

c. U^{238}

d. Pu^{239}

Question A.02 [1.0 point]
The reactor supervisor tells you that the K_{eff} for the reactor is 0.955. How much reactivity must you add to the reactor to reach criticality?

a. +0.0471

b. +0.0450

c. -0.0471

d. -0.0450

Question A.03 [1.0 point]
When performing rod calibrations, many facilities pull the rod out a given increment, then measure the time for reactor power to double (doubling time), then calculate the reactor period. If the doubling time is 42 seconds, what is the reactor period?

a. 29 sec

b. 42 sec

c. 61 sec

d. 84 sec

Question A.04 [1.0 point]
A reactor has a shutdown margin of 0.0526 ΔK/K. Adding a reactor experiment increases the indicated count rate from 10 cps to 20 cps. Which one of the following is the new K_{eff} of the reactor?

a. 0.53

b. 0.90

c. 0.975

d. 1.001

Question A.05 [1.0 point, 0.20 each]
Given a mother isotope of $({}_{35}Br^{87})^{*}$, identify each of the daughter isotopes as a result of α, β⁺, β⁻, γ, or n, decay.

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

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

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

d. ${}_{35}Br^{87}$

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

Question A.06 [1.0 point]
WHICH ONE of the following describes the MAJOR contributions to the production and depletion of xenon in the reactor?

a. Produced directly from fission and depletes by neutron absorption only.

b. Produced from radioactive decay of iodine and depletes by neutron absorption only.

c. Produced directly from fission and depletes by radioactive decay and neutron absorption.

d. Produced from radioactive decay of iodine and depletes by radioactive decay and neutron absorption.

Question A.07 [1.0 point]
The probability of neutron interaction per cm of travel in a material is defined as:

a. a neutron flux.

b. a mean free path.

c. a microscopic cross section.

d. a macroscopic cross section.

Question A.08 [1.0 point]
Which ONE of the following conditions would INCREASE the shutdown margin of a reactor?

a. Lowering moderator temperature if the moderator temperature coefficient is negative.

b. Inserting an experiment adding positive reactivity.

c. Depletion of a burnable poison.

d. Depletion of uranium fuel.

Question A.09 [1.0 point]
Which one of the following is the PRIMARY reason that delayed neutrons are so effective at controlling reactor power?

a. Delayed neutrons make up a very large fraction of the fission neutrons in the core.

b. Delayed neutrons have a much longer mean lifetime than prompt neutrons.

c. Delayed neutrons are born at lower energies than prompt neutrons.

d. Delayed neutrons are born at thermal energies.

Question A.10 [1.0 point]
Which one of the following is a correct statement concerning the factors affecting control rod worth?

a. As reactor power increases rod worth increases.

b. Fuel burn up causes the rod worth for periphery rods to decrease.

c. Fuel burn up causes the rod worth to increase in the center of the core.

d. The withdrawal of a rod causes the rod worth of the remaining inserted rods to increase.

Question A.11 [1.0 point]
Pool temperature increases by 20°F. Given αT moderator = -0.0005 ΔK/K/°F and an average regulating rod worth of 0.004 ΔK/K/inch. By how much and in what direction did the regulating rod move to compensate for the temperature change?

a. 0.25 inches in

b. 0.25 inches out

c. 2.5 inches in

d. 2.5 inches out

Question A.12 [1.0 point]
You perform two startups with exactly the same core characteristics. During the first startup you proceed straight to criticality. During the second startup you receive a phone call after starting to pull rods, but before reaching criticality. How will this increase in time before reaching criticality affect reactor critical conditions? For the second startup

a. rod height will be the same, reactor power will be the same.

b. rod height will be the same, reactor power will be higher.

c. rod height will be higher, reactor power will be higher.

d. rod height will be lower, reactor power will be lower.

Question A.13 [1.0 point]
A reactor is subcritical with a K_{eff} of 0.955. Which ONE of the following is the MINIMUM reactivity (K/K) that must be added to produce prompt criticality? Given βeff=0.007

a. 0.007

b. 0.047

c. 0.054

d. 0.064

Question A.14 [1.0 point]
The ratio of the number of neutrons in one generation to the number of neutrons in the previous generation defines the:

a. fast fission factor.

b. neutron non-leakage factor.

c. neutron reproduction factor.

d. effective multiplication factor.

Question A.15 [1.0 point]
Which ONE of the following does NOT affect the Effective Multiplication Factor K_{eff}?

a. The moderator-to-fuel ratio.

b. The moderator temperature.

c. The physical dimensions of the core.

d. The strength of an installed neutron souce.

Question A.16 [1.0 point]
With the reactor on a constant period, which of the following changes in reactor power would take the **LONGEST** time?

a. 5% — from 1% to 6%

b. 15% — from 20% to 35%

c. 20% — from 40% to 60%

d. 25% — from 75% to 100%

Question A.17 [1.0 point]
You've just increased power at a research reactor. As a result fuel temperature increased from 100°C to 120°C. For this reactor the fuel temperature coefficient (α_{tf}) is -0.01% k/k/°C, and the average rod worth for the regulating rod is 0.05%)k/k/inch. How far and in what direction must you move the regulating rod to compensate? (Assume all other factors which could affect reactivity remain unchanged.)

a. 2 inches inward

b. 2 inches outward

c. 4 inches inward

d. 4 inches outward

Question A.18 [1.0 point]
Several processes occur that may increase or decrease the available number of neutrons. SELECT from the following the six-factor formula term that describes an ***INCREASE*** in the number of neutrons during the cycle.

a. Thermal utilization factor (f).

b. Resonance escape probability (p).

c. Thermal non-leakage probability ($_{th}$).

d. Reproduction factor (η).

Question A.19 [1.0 point]
Which of the following atoms will cause a neutron to lose the most energy during an elastic scattering reaction?

a. O^{16}

b. C^{12}

c. U^{235}

d. H^1

Question A.20 [1.0 point]
A reactor is operating at a constant power level with equilibrium xenon. Reactor power is then doubled. The equilibrium xenon level at the higher power level will be:

a. higher than its value at the lower power level, but not twice as high.

b. twice as high.

c. more than twice as high.

d. the same as at the lower power level.

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

Category B: Normal/Emergency Operating Procedures and Radiological Controls

Question B.01 [1.0 point]
Per NCSU Emergency Classification, the reactor failing to scram is an example of:

a. Normal Operations

b. Notification of Unusual Event

c. Alert

d. Site Area Emergency

Question B.02 [1.0 point, 0.25 each]
Match each of the Limiting Safety System Settings for Forced Convection Flow in Column A with the correct value in Column B. (Answers in column B may be used once, more than once, or not at all)

Column A	Column B
a. Reactor Thermal Power	1. 117°F
b. Pool Water Temperature	2. 1.4 MWt
c. Height of water above the top of the core	3. 450 gpm
d. Coolant Flow Rate	4. 115°F
	5. 14 feet, 4 inches
	6. 400 gpm
	7. 1.3 MWt
	8. 14 feet, 2 inches

Question B.03 [1.0 point]
Which ONE of the following is the definition for "Annual Limit on Intake (ALI)"?

a. Projected dose commitment values to individuals that warrant protective action following a release of radioactive material.

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

c. The effluent concentration of a radio-nuclide in air which, if inhaled continuously over a year, would result in a total effective dose equivalent of 50 millirem for noble gases

d. 10CFR20 derived limit, based on a Committed Effective Dose Equivalent of 5 Rems whole body or 50 Rems to any individual organ, for the amount of radioactive material inhaled or ingested in a year by an adult worker.

Question B.04 [1.0 point]
Which of the following is the reactivity limit for a non-secured experiment?

a. 1590 pcm

b. 1000 pcm

c. 500 pcm

d. 300 pcm

Question B.05 [1.0 point]
During which one of the following operations may the Over-the-Pool radiation monitor be bypassed for up to two (2) minutes?

a. Removal of experiments from the reactor pool.

b. Calibration response checks.

c. During return of pneumatic rabbit capsule from the core.

d. Immediately after starting the pneumatic blower system.

Question B.06 (1.0 point, 0.33 each)
What is the minimum required operating crew with the reactor at 100 kW, steady state conditions? Indicate whether each individual must be AT THE FACILITY or MAY BE ON CALL.

a.	RHP	1.	AT THE FACILITY
b.	RO	2.	MAY BE ON CALL
c.	DSRO		

Question B.07 [1.0 point]
Which of the following describes the requirement for the Reactor Operator Assistant (ROA) to be available when the reactor is not secured?

a. Only needs to be present for startup and shutdown

b. Always present in the control room

c. Can be at the reactor facility within five (5) minutes

d. Available on call (e.g. within thirty (30) minutes)

Question B.08 [1.0 point]
The CURIE content of a radioactive source is a measure of

a. the number of radioactive atoms in the source.

b. the number of nuclear disintegrations per unit time.

c. the amount of energy emitted per unit time by the source

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

Question B.09 [1.0 point]
Which one of the following are the Technical Specification limits for irradiated fuel storage?

a. K_{eff} <0.95 Δk/k

b. K_{eff} <0.90 Δk/k

c. K_{eff} <0.85 Δk/k

d. K_{eff} <0.80 Δk/k

Question B.10 [1.0 point]
Technical Specifications allow continued reactor operation on a loss of reactor building differential pressure during investigation of the cause for a period of time not to exceed....

a. Not at all; commence reactor shutdown immediately

b. 5 minutes

c. 30 Minutes

d. 1 hour

Question B.11 [1.0 point]
A radioactive source reads 2 Rem/hr on contact. Four hours later, the same source reads 1.0 Rem/hr. How long is the time for the source to decay from a reading of 2 Rem/hr to 250 mRem/hr?

a. 8 hours

b. 12 hours

c. 16 hours

d. 20 hours

Question B.12 [1.0 point]
The radiation from an unshielded source is 600 mrem/hr. When you insert 40 mm thickness of lead sheet, the radiation level reduces to 150 mrem/hr. What is the half-value-layer of lead? (HVL: thickness of lead required so that the original intensity will be reduced by half)?

a. 10 mm

b. 20 mm

c. 30 mm

d. 40 mm

Question B.13 [1.0 point]
You hear the fire alarm sound and see the strobe lights indicating the activation of a fire detector or pull station. Which ONE of the following actions with respect to reactor operations must you perform?

a. Determine if reactor operations may continue.

b. Attempt to determine if the source of the alarm is in the reactor bay.

c. SCRAM the Reactor.

d. Ensure the Main H&V System Fans are OFF.

Question B.14 [1.0 point]
You are performing a periodic radiation survey of an area where general radiation readings are approximately 1 mrem/hr. However, you find an old experimental facility in an accessible area not posted for radiological safety reading reading 25 mrem/hr at 30 cm. How would this area be posted in accordance with the requirements of 10 CFR 20?

a. Radiation Area on contact with the experimental facility

b. Radiation Area @ 30 cm from the experimental facility

c. High Radiation Area on contact with the experimental facility

d. High Radiation Area @ 30 cm from the experimental facility

Question B.15 [1.0 point]
The OPERATIONS BOUNDARY for the facility is …

a. The border that includes the Burlington Engineering Laboratories (BEL), the area between Lampe and Broughton Drive and the Area between Stinson Drive and the North face of BEL.
b. The border that outlines the Reactor Building.
c. The border within a 50 m circle with the reactor core at the center.
d. The border within a 50 m circle with the stack at the center.

Question B.16 [1.0 point]
Per the Emergency Plan, the maximum TEDE which may be authorized for taking corrective actions to protect valuable property if a lower dose is not practicable and only by volunteers who are fully aware of the risks involved...

a. >25 rem
b. Up to 25 rem
c. Up to 10 rem
d. Up to 5 rem

Question B.17 [1.0 point]
Which ONE of the following is the correct definition of a CHANNEL TEST?

a. A qualitative verification of acceptable performance by observation of channel behavior. This verification, where possible, shall include comparison of the channel with other independent channels or systems measuring the same variable.
b. The combination of sensor, line, amplifier, and output devices which are connected for the purposes of measuring the value of a parameter.
c. The introduction of a signal into the channel for verification that it is operable.
d. An adjustment of the channel such that its output corresponds with acceptable accuracy to known values of the parameter which the channel measures.

Question B.18 [1.0 point]
Which ONE of the following modifications would be considered a "50.59" in which the NCSU Reactor Facility must file a request to NRC for change? The facility plans to:

a. Revise the Reactor Startup Procedure

b. Change the membership of the Radiation Safety Committee from five to four members.

c. Replace the differential pressure gauge used to provide the pressure difference between the Reactor Bay and the outside ambient with a new, identical gauge

d. Perform a reactor power calibration with the new resistance temperature detector (RTD) probe

Question B.19 [1.0 point]
"The reactor fuel shall be UO_2 with a nominal enrichment of 4% or 6% in U-235, zircaloy clad, with fabrication details as described in the Safety Analysis Report." This is an example of _______ section listed in the Technical Specifications.

a. Limiting Conditions for Operation (LCO)

b. Surveillance Requirements

c. Design Features

d. Administrative Controls

Question B.20 [1.0 point]
Which ONE of the following conditions is a violation of your requalification plan?

a. You last took a requalification written examination 17 months ago.

b. Last quarter you operated the reactor for six hours.

c. You last took a requalification operating test 13 months ago.

d. Your last medical examination was 26 months ago.

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

Cateory C: Facility and Radiation Monitoring Systems

Question C.01 [1.0 point]
Which ONE of the following materials or elements are used as a neutron absorber in the control rods?

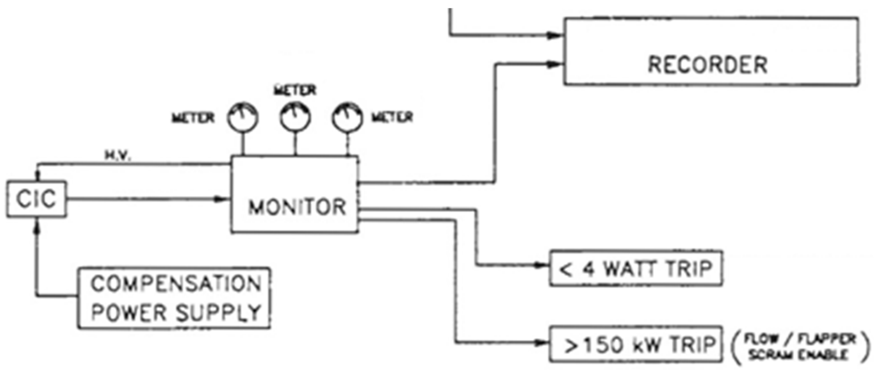
a. Boron

b. Borated graphite

c. Cadmium

d. Zircaloy

Question C.02 [1.0 point]
The following block diagram depicts:



a. Source Range Channel

b. Log and Linear Channel

c. Linear Power Channel

d. Safety Channel

Question C.03 [1.0 point]
A Nitrogen-16 Channel (N-16) provides:

a. a DIRECT measurement of neutron flux in the core by monitoring neutrons produced by the activation O-16 (n,p) → N-16

b. an INDIRECT measurement of neutron flux in the core by monitoring decay gamma radiation produced by the activation O-16 (n,p) → N-16

c. a DIRECT measurement of N-16 released to the reactor bay

d. an INDIRECT measurement of neutron flux in the core by monitoring decay gamma radiation produced by the activation N-15 (n,ɣ) → N-16

Question C.04 [1.0 point]
Which one of the following describes the purpose of the >$9x10^4$ cps inhibit on the source range channel?

a. Ensures the channel is not saturated by an excessively high count rate

b. Ensures on a loss of power to the channel, a source range inhibit will be generated

c. Ensures that there is sufficient subcritical multiplication taking place

d. Ensures automatic withdrawal of the fission detector from the core

Question C.05 [1.0 point]
Following a loss of commercial power, the auxiliary generator automatically starts and supplies power to the auxiliary generator distribution panel via the automatic transfer switch. After an hour of the auxiliary generator running, power is lost again. Upon investigation, you notice the auxiliary generator has stopped and the emergency latch relay indicator light is lit. Which ONE of the following describes a potential cause for what happened?

a. The latch relay opened the generator run circuitry when oil pressure was too high

b. The latch relay opened the generator run circuitry when oil temperature was too low

c. The latch relay opened the generator run circuitry when water pressure was too low

d. The latch relay opened the generator run circuitry when water temperature was too high

Cateory C: Facility and Radiation Monitoring Systems

Question C.06 [1.0 point, 0.25 each]
The following figure depicts the reactor core support structure. Match the devices listed in column A with their current locations on the next page in Figure 4-6.

Column A

1. Fission Chamber
2. Control Rod
3. Startup Source Holder
4. Neutron Detector

Cateory C: Facility and Radiation Monitoring Systems

Question C.07 [1.0 point, 0.5 each]
Match Column A with the correct pH value or range in Column B. (Answers in column B may be used once, more than once, or not at all)

Column A	Column B
a. Primary Coolant Cleanup System Outlet (value)	1. 5.5 – 7.0
b. Bulk Pool Water (range)	2. 6.8
	3. 6.5 – 7.5
	4. 7.0
	5. 5.5 – 7.0
	6. 7.2
	7. 5.5 – 7.5
	8. 7.5

Question C.08 [1.0 point, 0.25 each]
Match the temperature measuring channel sensing points Column A with the correct temperature set points in Column B. (Answers in column B may be used once, more than once, or not at all)

Column A	Column B
a. Hot Leg RTD Abnormal Pool Temperature Alarm	1. 95 F
b. Cold Leg RTD Abnormal Pool Temperature Alarm	2. 100 F
c. Pool Water High Temperature Switch Alarm	3. 105 F
d. Pool Temperature SCRAM	4. 110 F
	5. 112 F
	6. 114 F
	7. 116 F
	8. 117 F

Question C.09 [1.0 point]
Which one of the following is the largest contributor to Argon 41 production at the NCSU?

a. Beam Tubes and Thermal Column

b. Pneumatic Transfer System

c. Air dissolved in pool water

d. Rotating and Dry Exposure Ports

Cateory C: Facility and Radiation Monitoring Systems

Question C.10 [1.0 point]
Pulsing is no longer a permitted function of the Shim Rod. Which ONE of the following BEST mitigates the possibility of accidental pulse rod ejection?

a. Pulsing is specifically prohibited by procedure

b. Pulsing is no longer allowed by the NRC license

c. The shim rod is fully inserted during normal operations

d. The airlines and all associated equipment required for pulsing have been removed

Question C.11 [1.0 point]
The primary function of the discriminator in the Source Range Channel is to:

a. convert pulses created by neutron-induced fissions into a DC current

b. amplify pulses produced by alpha particles resulting from the natural decay of fission fragment

c. distinguish the pulses created by neutron-induced fissions from pulses produced by the gamma rays for the true signal

d. filter out ALL pulses created by neutron-induced fissions and select ONLY pulses produced by the gamma rays for the true signal

Question C.12 [1.0 point]
Which one of the following monitors, when in an ALARM condition, DOES NOT cause an evacuation?

a. Control Room Area Monitor

b. Stack Gas Monitor

c. Demineralizer Resin Monitor

d. Auxiliary GM

<u>Cateory C: Facility and Radiation Monitoring Systems</u>

Question C.13 [1.0 point]
Which one of the following correctly describes how a Resistance Temperature Detector (RTD) failure would be indicated? If an RTD should fail,

a. in the open position, the temperature indication will go to the midpoint of the temperature scale.
b. because of a short, the temperature indication will go to the midpoint of the temperature scale.
c. in the open position, the temperature indication will go offscale in the low value direction.
d. because of a short, the temperature indication will go offscale in the low value direction.

Question C.14 [1.0 point]
Which ONE of the following reactions describes the operation of the installed neutron source?

a. Pu -> U + alpha; B + alpha -> N + neutron
b. Pu -> Am + beta; Be + beta -> Li + neutron
c. Pu -> U + alpha; Be + alpha -> C + neutron
d. Pu -> Am + beta; B + beta -> Be + neutron

Question C.15 [1.0 point]
The power supply for the control rod magnets is capable of supplying an adjustable current to each magnet. Select the control rod magnet current required to be used prior to fuel movements.

a. 0 mA
b. 45 mA
c. 60 mA
d. 125 mA

Question C.16 [1.0 point]
Which ONE of the following is the purpose of the Nitrogen Purge System?

a. It acts as a backup motive force in the Pneumatic Transfer system should the air/vacuum supply blower fail.
b. It provides a nitrogen purge gas to the Pneumatic Transfer System to reduce the formation of Ar-41.
c. It acts with the BT&TC exhaust system to supply a continuous nitrogen gas blanket to the Beam Tubes to minimize Ar-41 formation.
d. It is used as a source of nitrogen gas for moisture removal and humidity control within the Dry Exposure Ports.

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

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

Cateory C: Facility and Radiation Monitoring Systems

Question C.18 [1.0 point]
Following extended reactor operation at 1 MWt, multiple leaks from the pool to the reactor bay were developed that led to a complete loss of pool water. Which of the following would be the primary hazard or concern?

a. Clean up of the highly radioactive coolant water.

b. High radiation levels from the uncovered core.

c. Keeping the reactor shutdown.

d. Failure or breach of the cladding on multiple fuel pins

Question C.19 [1.0 point]
The primary coolant heat exchanger is a __________ flow, __________ pass, plate-type heat exchanger.

a. parallel, single

b. counter, multi

c. cross, multi

d. counter, single

Question C.20 [1.0 point]
After reactor startup, reactor power is raised to 1 MWt. Prior to sample loading, you know it is preferred to place the reactor in automatic. Which ONE of the following describes the conditions that must be met before the rod control system will go into Automatic control?

a. Regulating rod withdrawn beyond 10.5 inches, FC ABS DEV is within ±4%, and Gang Drive switch is in the neutral position

b. Regulating rod withdrawn beyond 13.5 inches, FC ABS DEV is within ±9%, and Gang Drive switch is in the neutral position

c. Regulating rod withdrawn beyond 15.5 inches, FC ABS DEV is within ±7%, and Gang Drive switch is in the neutral position

d. Regulating rod withdrawn beyond 9.5 inches, FC ABS DEV is within ±13%, and Gang Drive switch is in the neutral position

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

Category A: Reactor Theory, Thermodynamics & Facility Operating Characteristics

A.01
Answer: a. = fertile; b. = fissile; c. = fertile; d. = fissile
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, § 3.2 Example 3.2(a)

A.02
Answer: a
Reference: $\Delta\rho = (K_{eff1} - K_{eff2}) \div (K_{eff1} * K_{eff2})$
$\Delta\rho = (1.000 - 0.9550) \div (1.0000*0.9550)$
$\Delta\rho = 0.0450 \div 0.9550 = 0.0471$

A.03
Answer: c
Reference: ln (2) = -time/τ = time/(ln(2)) = 60.59 = 61 seconds

A.04
Answer: c
Reference: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory Volume 2, Module 4, Enabling Objective 3.6, p. 28.
$SDM = 1\text{-}K_{eff}/K_{eff} \rightarrow K_{eff} = 1/SDM + 1 \rightarrow K_{eff} = 1/0.0526 + 1 \rightarrow K_{eff} = .95$
$CR_1/CR_2 = (1 - K_{eff2}) / (1 - K_{eff1}) \rightarrow 10/20 = (1 - K_{eff2}) / (1 - 0.95)$
$(0.5) \times (0.05) = (1 - K_{eff2}) \rightarrow K_{eff2} = 1 - (0.5)(0.05) = 0.975$

A.05
Answer: a. = α; b. = β^+; c. = n; d. = γ; e. = β^-
Reference: STD NRC question.

A.06
Answer: d
Reference: Burn, R., Introduction of Nuclear Reactor Operations, © 1988, §

A.07
Answer: d
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1982, Section 2.5.2, page 2-44.

A.08
Answer: d
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 6.2.3, p. 6-4.

A.09
Answer: b
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1982, §§ 3.2.2 — 3.2.3

A.10
Answer: d
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1982, § 7.2 & 7.3, pp. 7-1 — 7-10.

Category A: Reactor Theory, Thermodynamics & Facility Operating Characteristics

A.11
Answer: d
Reference: +20°F × -0.0005 ΔK/K/°F = - 0.01 ΔK/K. To compensate the rod must add +0.01 ΔK/K. +0.01ΔK/K ÷ +0.004 ΔK/K/inch = +2.5 inches

A.12
Answer: b
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 5.3

A.13
Answer: c
Reference: From k=0.995 to criticality (k=1), Δ = (k-1)/k = -0.047)k/k or 0.047)k/k needs to be added to reach criticality. From criticality to JUST prompt, Δ = βeff is required, so minimum reactivity = 0.047+0.007= 0.054

A.14
Answer: d
Reference: Introduction to Nuclear Operation, Reed Burn, 1982, Sec 3.3

A.15
Answer: d
Reference: DOE Fundamentals Handbook, Module 3, pages 2-9.

A.16
Answer: a
Reference: $P = P_0 e^{t/\tau}$ $\ln(P/P_0) = t/\tau$ Since you are looking for which would take the longest time it is obvious to the most casual of observers that the ratio P/P_0 must be the largest.

A.17
Answer: d
Reference: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory
-0.0001)k/k/°C H +20°C = -0.002)k/k. To compensate must add +0.002)k/k.
(0.002)k/k)) (0.0005%)k/k/inch) = 4 inches in the positive (outward) direction.

A.18
Answer: d
Reference: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory

A.19
Answer: d
Reference: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory

A.20
Answer: a
Reference: DOE Reference, Module 3, Xenon, page 37

Category B: Normal/Emergency Operating Procedures and Radiological Controls

B.01
Answer: b
Reference: PULSTAR Emergency Procedure 4, Revision 6, Attachment 1

B.02
Answer: a. = 7; b. = 1; c. = 8; d. = 3
Reference: Technical Specifications, Section 2.2.1

B.03
Answer: d
Reference: 10CFR20.1003

B.04
Answer: b
Reference: Technical Specifications, Section 3.2

B.05
Answer: c
Reference: Technical Specifications Section 3.5

B.06
Answer: a. = 2; b. = 1; c. = 2;
Reference: Technical Specification 6.1.3

B.07
Answer: c
Reference: Technical Specification 6.1.3

B.08
Answer: b
Reference: Standard Health Physics Definition

B.09
Answer: b
Reference: Technical Specifications 5.3

B.10
Answer: c
Reference: Technical Specifications 3.6, Note 3 (<30 mins).
NRP-OP-105, Section 4.4 (S/D @ 25 mins if D/P not restored)

B.11
Answer: b
Reference: $DR = DR_o * e^{-\lambda t}$; 1 rem/hr =2 rem/hr* $e^{-\lambda(4hr)}$; Ln(1.0/2) = -λ*4 --> λ=0.1733; solve for t: Ln(.25/2)=-0.1733 (t) → t=12 hours; Short cut: 2 Rem to 1 Rem : 4 hrs, 1 Rem to 0.50Rem : 8 hrs; 0.50 rem to 0.25 Rem : 12 hrs Total: 12 hrs

Category B: Normal/Emergency Operating Procedures and Radiological Controls

B.12
Answer: b
Reference: $DR = DR_{\circ} * e^{-\mu X}$; Find μ : $250 = 1000 * e^{-\mu * 60}$; $\mu = 0.0231$
If insertion of an HVL (thickness of lead), the original intensity will be reduced by half.
Find X: $1 = 2 * e^{-0.0231 * X}$; X= 30 mm
Find HVL by shortcut: 1000mR- 500 mR is the 1st HVL
500 mR – 250 mR is the 2nd HVL, So HVL=60mm/2 = 30 mm

B.13
Answer: c
Reference: NRP-OP-105, Response to SCRAMS, Alarms and Abnormal Conditions

B.14
Answer: b
Reference: 10CFR20

B.15
Answer: b
Reference: Emergency Plan, Definitions & Figure 4, Reactor Site Map

B.16
Answer: c
Reference: Emergency Plan

B.17
Answer: c
Reference: Technical Specifications, Definitions

B.18
Answer: b
Reference: 10 CFR 50.59

B.19
Answer: c
Reference: Technical Specifications, Section 5.1

B.20
Answer: d
Reference: Operator Requalification Program and 10 CFR 55.59

Category C: Facility and Radiation Monitoring Systems

C.01
Answer: c
Reference: Updated SAR PULSTAR Reactor. Draft March 24, 2015. Page 1-14

C.02
Answer: b
Reference: Updated SAR PULSTAR Reactor. Draft March 24, 2015. Figure 7.2

C.03
Answer: b
Reference: Updated SAR PULSTAR Reactor. Draft March 24, 2015. Section 7.4.3.5

C.04
Answer: a
Reference: Updated SAR PULSTAR Reactor. Draft March 24, 2015. Section 7.4.3.1

C.05
Answer: d
Reference: Updated SAR PULSTAR Reactor. Draft March 24, 2015. Section 8.2

C.06
Answer: a. 4; b. 1; c. 2; d. 3 or a. B; b. C; c. D; d. A
Reference: Updated SAR PULSTAR Reactor. Draft March 24, 2015. Figure 4.6

C.07
Answer: a. 4; b. 7
Reference: Updated SAR PULSTAR Reactor. Draft March 24, 2015, Section 5.4
Technical Specifications 3.9.b

C.08
Answer: a. 4; b. 2; c. 6; d. 7
Reference: Updated SAR PULSTAR Reactor. Draft March 24, 2015, Section 7.4.4.4 & Section 7.4.4.5

C.09
Answer: b
Reference: Updated SAR PULSTAR Reactor. Draft March 24, 2015, Section 11.1.1.1

C.10
Answer: d
Reference: Updated SAR PULSTAR Reactor. Draft March 24, 2015, Section 4.2.2.2

C.11
Answer: c
Reference: NRC Standard Question
Updated SAR PULSTAR Reactor. Draft March 24, 2015, Section 7.4.3.1

C.12
Answer: c
Reference: Updated SAR PULSTAR Reactor. Draft March 24, 2015, Section 6.2.1

Category C: Facility and Radiation Monitoring Systems

C.13
Answer: d
Reference: Generic Instrumentation Question

C.14
Answer: c
Reference: Updated SAR PULSTAR Reactor. Draft March 24, 2015, Section 4.2.4
NCSU SNM Inventory Record

C.15
Answer: c
Reference: Updated SAR PULSTAR Reactor. Draft March 24, 2015, Section 7.4.2
NRP-OP-301 - Reactor Fuel Handling; APPENDIX A.

C.16
Answer: b
Reference: Updated SAR PULSTAR Reactor. Draft March 24, 2015, Section 11.2

C.17
Answer: a
Reference: NRC Standard Question

C.18
Answer: b
Reference: Updated SAR PULSTAR Reactor. Draft March 24, 2015, Section 13.2.3

C.19
Answer: d
Reference: Updated SAR PULSTAR Reactor. Draft March 24, 2015. Section 5.2

C.20
Answer: b
Reference: Updated SAR PULSTAR Reactor. Draft March 24, 2015. Section 7.3.2