June 4, 2015

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-15-01, NORTH CAROLINA STATE UNIVERSITY

Dear Dr. Hawari:

During the week of April 27, 2015, the U.S. Nuclear Regulatory Commission (NRC) administered operator licensing examinations at your North Carolina State University Research 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 at the conclusion of the examinations with Mr. Andrew Cook, Reactor Operations Manager, as identified in the enclosed report.

In accordance with Section 2.390 of Title 10 of the *Code of Federal Regulations*, 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 Web site at http://www.nrc.gov/reading-rm/adams.html (the Public Electronic Reading Room). The NRC is forwarding the individual grades to you in a separate letter which will not be released publicly.

If you have any questions concerning the examinations, please contact Mr. John T. Nguyen at (301) 415-4007 or via email John.Nguyen@nrc.gov.

Sincerely,

/RA/
Kevin Hsueh, 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-15-01
2. Written Examination

cc: w/o enclosures: See next page

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DISTRIBUTION w/ encls:
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ADAMS Accession No: ML15133A261

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DATE	05/30/2015	05/ 21 /2015	06/04/2015

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Test, Research, and Training Reactor Newsletter
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U. S. NUCLEAR REGULATORY COMMISSION

OPERATOR LICENSING INITIAL EXAMINATION REPORT

REPORT NO.: 50-297/OL-15-01

FACILITY DOCKET NO.: 50-297

FACILITY LICENSE NO.: R-120

FACILITY: North Carolina State University Pulstar Reactor

EXAMINATION DATES: April 27 – April 29, 2015

SUBMITTED BY: **/RA Patrick Isaac for/** 06/04/2015
John T. Nguyen, Chief Examiner Date

SUMMARY:

During the week of April 27, 2015, the NRC administered operator licensing examinations to three Reactor Operator (RO) license candidates. All candidates passed the examinations and will be issued a license to operate the North Carolina State University reactor.

REPORT DETAILS

1. Examiner: John T. Nguyen, Chief Examiner, NRC

2. Results:

	RO PASS/FAIL	SRO PASS/FAIL	TOTAL PASS/FAIL
Written	3/0	0/0	3/0
Operating Tests	3/0	0/0	3/0
Overall	3/0	0/0	3/0

3. Exit Meeting:

Andrew Cook, Reactor Operations Manager
John Nguyen, NRC, Chief Examiner

The NRC examiner thanked the facility for their support in the administration of the examinations.

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

FACILITY: NORTH CAROLINA STATE UNIVERSITY

REACTOR TYPE: PULSTAR

DATE ADMINISTERED: April 27, 2015

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

1 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-lbf

°F = 9/5 °C + 32

1 gal (H_2O) ≈ 8 lbm

°C = 5/9 (°F - 32)

c_P = 1.0 BTU/hr/lbm/°F

c_p = 1 cal/sec/gm/°C

U.S.NRC
UNITED STATES NUCLEAR REGULATORY COMMISSION
Protecting People and the Environment

North Carolina State University

Operator Licensing Examination

Week of April 27, 2015

Section A – Reactor Theory, Thermodynamics and Facility Operating Characteristics.

QUESTION A.01 [1.0 point]
Which ONE of the following correctly describes the SIX- FACTOR FORMULA?

a. $K_\infty = K_{eff}$ * the reproduction factor

b. $K_\infty = K_{eff}$ * the total leakage probability

c. $K_{eff} = K_\infty$ * the total non-leakage probability

d. $K_{eff} = K_\infty$ * (the resonance escape probability * the reproduction factor)

QUESTION A.02 [1.0 point]
A reactor with K_{eff} = 0.7 contributes 1000 neutrons in the first generation. Changing from the first generation to the SECOND generation, how many **total neutrons** are there after the second generation?

a. 700

b. 1300

c. 1700

d. 2100

QUESTION A.03 [1.0 point]
Few minutes following a reactor scram of 500 kW, the reactor period has stabilized and the power level is decreasing at a **CONSTANT** rate. What is the power level one minute later from 1 kW?

a. 0.2 kW

b. 0.5 kW

c. 0.8 kW

d. 2.1 kW

QUESTION A.04 [1.0 point]
Reactor is increasing power from 100 W to 10 kW in steady state mode. Which ONE of the following best describes the values of K_{eff} and ρ during the power increment?

a. $K_{eff} = 1$ and $\rho = 0$

b. $K_{eff} = 1$ and $\rho = 1$

c. $K_{eff} > 1$ and $0 < \rho < \beta\text{-eff}$

d. $K_{eff} > 1$ and $\beta\text{-eff} < \rho < 1$

QUESTION A.05 [1.0 point]
Given a reactor period of 32 seconds, approximately how long will it take for power to triple?

a. 22 seconds

b. 35 seconds

c. 46 seconds

d. 64 seconds

QUESTION A.06 [1.0 point]
Reactor is at 10 W. The reactor operator immediately inserts an experiment of 500 pcm reactivity worth into the core. This insertion will cause:
Given:
T: reactor period, ℓ*: Prompt neutron lifetime; ρ: reactivity insertion; β: beta fraction; λ-eff: delayed neutron precursor constant

a. A sudden drop in delayed neutrons

b. A number of prompt neutrons is twice as much as a number of delayed neutrons

c. The resultant period is a function of the prompt neutron lifetime ($T=\ell^*/\rho$)

d. The resultant period is a function of the delayed neutron precursors $T = \left[\frac{\bar{\beta} - \rho}{\lambda_{eff}\rho}\right]$

QUESTION A.07 [1.0 point]
Which ONE of the following describes the term **PROMPT JUMP**?

a. A reactor is increasing power at a constant rate of 80 second period

b. The instantaneous change in power level due to inserting control rods

c. The instantaneous change in power level due to inserting negative worth, - 300 pcm, of experiment

d. The instantaneous change in power level due to removing negative worth,- 300 pcm, of experiment

QUESTION A.08 [1.0 point]
Which ONE of the following is the MAIN reason for operating reactor with thermal neutrons instead of fast neutrons?

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

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

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

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

QUESTION A.09 [1.0 point]
Which ONE of the following is a number of neutrons in the Uranium-235 nucleus ($_{92}U^{235}$)?

a. 92

b. 143

c. 235

d. The U-235 doesn’t have a constant number of neutrons, it fluctuates between 95 and 140.

QUESTION A.10 [1.0 point]
A reactor is slightly supercritical with the following values for each of the factors in the six-factor formula:

Fast fission factor	1.03
Fast non-leakage probability	0.84
Resonance escape probability	0.96
Thermal non-leakage probability	0.88
Thermal utilization factor	0.70
Reproduction factor	1.96

A control rod is inserted to bring the reactor back to critical. Assuming all other factors remain unchanged, the new value for the thermal utilization factor is:

a. 0.698

b. 0.702

c. 0.074

d. 0.076

QUESTION A.11 [1.0 point]
Two common FISSION PRODUCTS that have especially large neutron capture cross sections and play a significant role in reactor physics. One is Sm-149 and the other is:

a. I-131

b. Ar-41

c. Xe-135

d. B-10

QUESTION A.12 [1.0 point]
Delayed neutrons are produced by:

a. decay of N-16

b. Photoelectric Effect

c. decay of fission fragments

d. directly from the fission process

QUESTION A.13 [1.0 point]
The effective target area in cm^2 presented by a single nucleus to an incident neutron beam is defined as:

a. a macroscopic cross section

b. a microscopic cross section

c. a mean free path

d. a neutron flux

QUESTION A.14 [1.0 point]
A reactor is subcritical with K_{eff} of 0.955. Which ONE of the following is the MINIMUM reactivity (ρK/K) that must be added to produce PROMPT criticality? Given βeff=0.0073

a. 0.0050

b. 0.0073

c. 0.0543

d. 0.9623

QUESTION A.15 [1.0 point]
Given a source strength of 100 neutrons per second (N/sec) and a multiplication factor (k) of 0.9, which ONE of the following is the expected stable neutron count rate?

a. 900 N/sec

b. 1000 N/sec

c. 1500 N/sec

d. 2000 N/sec

QUESTION A.16 [1.0 point]
Which ONE of the following nuclides will cause a fast neutron to lose its most energy per collision?

a. H_1

b. B_{10}

c. C_{12}

d. U_{238}

QUESTION A.17 [1.0 point]
Which ONE of the following conditions will INCREASE the core excess of a reactor?

a. Higher moderator temperature (assume negative temperature coefficient).

b. Insertion of a negative reactivity worth experiment.

c. Burnout of a burnable poison.

d. Fuel depletion.

QUESTION A.18 [1.0 point]
Given the following Core Reactivity Data during startup:

Control Rod	Total Rod Worth (pcm)	Rod Worth removed at 5 watts critical (pcm)
Rod # 1	2000	1500
Rod # 2	3000	2000
Rod # 3	4000	3500
Total	9000	7000

Assuming that all control rods are scrammable, the **TECHNICAL SPECIFICATION MINIMUM** Shutdown Margin for this core is:

a. 2000 pcm

b. 3000 pcm

c. 4000 pcm

d. 7000 pcm

QUESTION A.19 [1.0 point]
Which ONE of the following is the correct amount of reactivity added if the multiplication factor, k, is increased from 0.800 to 0.950?

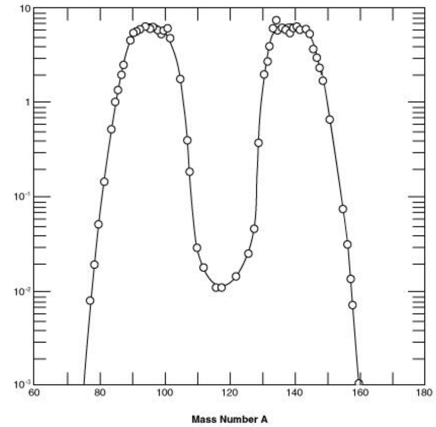
a. 1500 pcm

b. 1970 pcm

c. 15000 pcm

d. 19700 pcm

QUESTION A.20 [1.0 point]
The following graph for U-235 depicts……



a. axial flux distribution in the core

b. fission product yield distribution

c. radial flux distribution in the core

d. neutron energy distribution in the moderator

***************** End of Section A *****************

Section B - Normal/Emergency Procedures and Radiological Controls

QUESTION B.01 [1.0 point]
Per NCSU Emergency Classification, fuel damage indicated by high coolant, fission product activity at 5 % of FSAR values is an example of:

a. Normal Operations

b. Notification of Unusual Events

c. Alert

d. Site Area Emergency

QUESTION B.02 [1.0 point]
The radiation from an unshielded source is 1 rem/hr. When you insert 60 mm thickness of lead sheet, the radiation level reduces to 250 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.03 [1.0 point, 0.25 each]
Match each of the Technical Specification Limits in column A with its corresponding value in column B. (Each limit has only one answer, values in Column B can be used once, more than once or not at all.)

Column A	Column B (limit shall not exceed)
a. Maximum Excess Reactivity	1. 301 pcm
b. Maximum Secured Experiments	2. 401 pcm
c. Minimum Shutdown Margin	3. 1001 pcm
d. Maximum Movable Experiment	4. 1591
	5. 2891 pcm
	6. 3971 pcm

QUESTION B.04 [1.0 point]
Which ONE of the following conditions is a violation of Limiting Condition for Operations?

a. Reactor operator conducted a fuel inspection and found a total of twenty-five fuel assemblies in the reactor core

b. Reactor was at full power. The pumps failed, causing the primary coolant temperature exceeded 98 °F

c. The minimum shutdown margin was found to be 800 pcm in the reference core condition

d. N-16 Power Measuring Channel was NOT operable during reactor operation of 600 kW

QUESTION B.05 [1.0 point]
Which ONE of the following requires the NRC APPROVAL for changes?

a. Revise the Reactor Startup and Shutdown Procedure

b Change a frequency of the requalification written examination from once per year to twice per year

c Delete one of the procedures listed in the NCSU Test and Maintenance Procedures

d Reduce a minimum of the Reactor Safety and Audit Committee from five to three members

QUESTION B.06 [1.0 point]
A radioactive source reads 2 Rem/hr on contact. Five 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. 5 hours

b. 10 hours

c. 15 hours

d. 20 hours

QUESTION B.07 [1.0 point]
During the Startup Checklist, you verify the Safety Flapper Not Closed Scram Test by pressing the LOG N Channel 0.1 mA pushbutton. This verification is considered to be: ________________________.

a. a channel calibration

b. a channel check

c. a channel test

d. a channel measurement

QUESTION B.08 [1.0 point]
Assume an individual has received whole body occupational exposures of:

- 1 mrads of gamma
- 1 mrads of alpha
- 1 mrads of neutrons with **unknown** energy

What would be the cumulative dose equivalent (H_T) in **mrem** for this individual?

a. 3 mrem

b. 12 mrem

c. 21 mrem

d. 31 mrem

QUESTION B.09 [1.0 point]
Which ONE of the following is considered a Special Nuclear Material?

a. U-238

b. N-16

c. Ar-41

d. Pu-239

QUESTION B.10 [1 point]
Which ONE of the following is a **MINIMUM** staffing requirement when the reactor is NOT secured?

a. 1 Reactor Facility Director in the control room + 1 SRO on call

b. 1 RO in the control room + 1 staff member + 1 RO on call

c. 1 RO in the control room +1 staff member + 1 SRO on call

d. 1 SRO in the control room + 1 RO in the control room + 1 staff member

QUESTION B.11 [1.0 point]
You perform a fueled experiment in experimental facilies. Half-way through a 6-hour operation, you discover the reactor ventilation system is OFF with dampers OPEN. Which ONE of the following actions should you take?

a. Immediately secure reactor operations. This event is a Technical Specification (TS) violation.

b. Immediately secure reactor, but this event is NOT a TS violation because the dampers are still in the containment mode.

c. Continue with reactor operation. Up to 24 hours is allowed to run reactor before repairing the ventilation system.

d. Continue with reactor operations. The NCSU Technical Specifications requires the ventilation system turn OFF during fueled experiment.

QUESTION B.12 [1.0 point]
Which ONE of the following correctly describes the limitations of experiment? The experiment with _____ shall not be irradiated in the reactor.

a. any corrosive material

b. any pressure buildup

c. any flammable material

d. cause of a shadowing of nuclear instrumentations

QUESTION B.13 [1.0 point]
A system or component is defined as "OPERATING" by Technical Specifications when:

a. a system is operational when reactor is in the unsecured condition

b. a system is operational when reactor is in the shutdown condition

c. it is capable of performing its intended function

d. a system is recently calibrated

QUESTION B.14 [1.0 point]
During a reactor operation, a small fire occurs in the reactor console. Which ONE of the following classes of extinguisher would most likely be used with this type of fire?

a. Class A: Fires in ordinary combustibles, such as wood, paper, plastic, etc.

b. Class B: Fires in flammable or combustible liquids, flammable gases, greases, etc.

c. Class C: Fires in live electrical equipment.

d. Class D: Fires involving combustible metals such as magnesium

QUESTION B.15 [1.0 point]
You perform a tour for the President Obama. Per 10 CFR 20, what is the annual limit of radiation exposure for the President?

a. 5 Rem

b. 100 mrem/hr

c. 100 mrem

d. 50 mrem

QUESTION B.16 [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. Replace an identical Linear Channel

b. Measure a control rod worth with new method

c. Replace a fission chamber with a compensated ion chamber for the Source Range Channel

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

QUESTION B.17 [1.0 point]
An unshielded source reads 300 mr/hr at 100 cm. You store it in a lead pig and perform a survey. It reads 200 mr/hr on contact, and 10 mr/hr at 100 cm. If a shielded source is stored in a lead pig, how do you post this area with your justification?

a. Very High Radiation Area because an unshielded source reads 3333 mr/hr at 30 cm

b. High Radiation Area because a shielded source reads 200 mr/hr on contact

c. High Radiation Area because a shielded source reads 111 mr/hr at 30 cm from the lead pig

d. Radiation Area because a shielded source reads 10 mr/hr at 100 cm from the lead pig

QUESTION B.18 [1.0 point]
The reactor operator licensing candidate requires submitting an NRC Form 396, Medical Requirements, as part of his or her application. This requirement can be found in:

a. 10 CFR Part 20

b. 10 CFR Part 50.59

c. 10 CFR Part 55

d. 10 CFR Part 73

QUESTION B.19 [1.0 point]
"The fuel inventory and transfer records shall be retained for the life of the facility". This is an example of _______ section listed in the Technical Specifications.

a. Design Features

b. Surveillance Requirements

c. Limiting Conditions for Operation (LCO)

d. Administrative Controls

QUESTION B.20 [1.0 point]
In the event of a suspected fuel leak, which ONE of the following nuclides would most likely be found in a Continuous Air Monitor?

a. Ar-41

b. Kr-85

c. N-16

d. Co-60

****************************** End of Section B ********************************

Section C: Plant and Rad Monitoring Systems

QUESTION C.01 [1.0 point]
During the Startup in Forced Convection Mode, you find the Actual Critical Position (ACP) is 250 pcm above the Estimated Critical Position (ECP). For this calculation, you will:

a. continue the startup because this ACP is within the limit

b. drive rods to sub critical, and then drive back to critical for verification

c. shutdown reactor and immediately notify the result to the Designated Senior Reactor Operator

d shutdown reactor and immediately report to the U.S. NRC for TS violation

QUESTION C.02 [1.0 point]
A Nitrogen-16 Channel (N-16) provides:

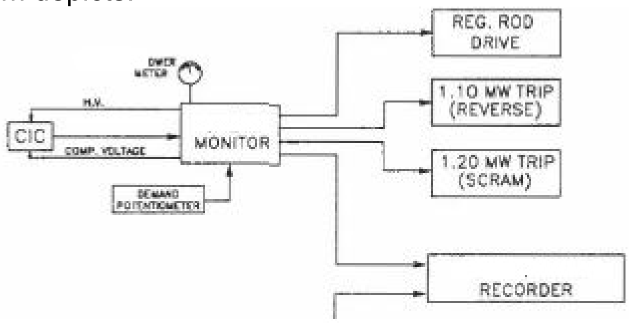
a. a DIRECTION measurement of N-16 released to the reactor bay

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

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

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

QUESTION C.03 [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.04 [1.0 point]**~~ Question deleted during administration of the exam
~~The primary water heat exchanger consists of shell and tube type heat exchanger. The primary water makes ______ pass(es) through the stainless steel tube(s) and the secondary water make ________ pass(es) in the carbon steel shell section.~~

a. 2/1

b. 4/1

c. 2/ 2

d. 1/4

QUESTION C.05 [1.0 point]
You receive an “Abnormal Pool Level” alarm. It means:

a. the pool water level exceeds + 6 inches from zero inch reference

b. the pool water level exceeds -4 inches from zero inch reference

c. the Primary Coolant Flow drops to 480 gpm

d. the pool temperature exceeds 117 °F

QUESTION C.06 [1.0 point]
Which **ONE** of the following elements is MAINLY used as the neutron absorber in the NCSU control rods?

a. boron

b. aluminum-silver-indium

c. silver-indium-cadmium

d. gold-indium-cadmium

QUESTION C.07 [1.0 point]
The source interlock system will prevent rod withdrawal unless source level is above a preset level. This source interlock signal comes from:

a. Source Range Channel

b. Log and Linear Channel

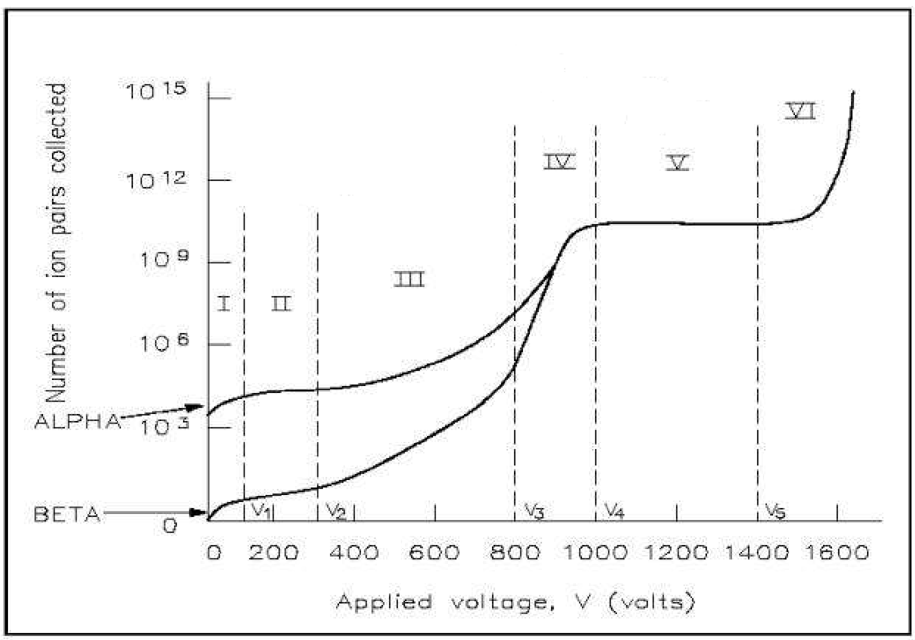
c. Linear Power Channel

d. Safety Channel

QUESTION C.08 [1.0 point, 0.25 each]
Reactor is in operation. Match the input signals listed in column A with their AUTOMATICALLY responses listed in column B. (Items in column B may be used more than once or not at all.)

Column A	Column B
a. Temperature recorder (T2) = 85 °F	1. Normal Operation
b. Log N OPER energized and SHIM rod at 12'' withdrawn	2. Alarm ONLY
c. Linear Channel = 120% power	3. Interlock
d. Ground Fault Detection	4. Scram (with or without Alarm)

QUESTION C.09 [1 point]
The figure below is an example of the gas ionization curve for gas-filled detectors. Which of the following ROMAN NUMERALS corresponds to the GEIGER-MUELLER REGION?



a. Region II

b. Region III

c. Region IV

d. Region V

QUESTION C.10 [1.0 point]
A neutron flux will activate isotopes in air. The primary isotope we worry about in the pneumatic transfer system is:

a. N^{16} (O^{16} (n,p) N^{16})

b. Kr^{80} (Kr^{79} (n, γ) kr^{80})

c. Ar^{41} (Ar^{40} (n, γ) Ar^{41})

d. H^{2} (H^{1} (n, γ) H^{2})

QUESTION C.11 [1.0 point]
Which **ONE** of the following best depicts the series of boundaries preventing fission product release to the environment?

a. Core shroud, pool water, Reactor building with negative pressure

b. Pool water, reactor tank wall, HEPA filters

c. Fuel element cladding, pool water, Reactor building with negative pressure, HEPA filters

d. Fuel element cladding, Demineralizer system, HEPA filters

QUESTION C.12 [1.0 point]
Reactor is at 300 kW. You receive a LOW Coolant Temperature T2 alarm. Per NRP-OP-105 , you should:

a. Immediately increasing cooling. If the Secondary is OFF, turn it ON

b. Immediately decreasing cooling. If the Secondary is OFF, turn it ON

c. Immediately increasing cooling. If the Secondary is ON, turn it OFF

d. Immediately decreasing cooling. If the Secondary is OFF, leave it OFF

Section C: Plant and Rad Monitoring Systems

QUESTION C.13 [1.0 point]
Which ONE of the following is the correct parameter used for the calibration of control rods by positive period method at NCSU? The operator will determine:

a. count rate vs. K-effective

b. temperature vs. period

c. pool level vs. coolant flow

d. reactivity vs. rod height

QUESTION C.14 [1.0 point]
The Temperature Measuring Channel measures the water temperature in the Primary and Secondary Coolant. The NCSU Measuring Temperature Channel consists of:

a. a precision wound resistor which changes resistance proportional to the change in temperature.

b. a bi-metallic junction which changes voltage proportional to the change in temperature.

c. a sphere containing a liquid which changes volume with temperature. Expansion and contraction cause an arm in an inductor to move changing inductance proportional to the change in temperature.

d. a mercury filled balloon inside an inductor, the expansion and contraction of the mercury causes a variation in the circuit inductance proportional to the change in temperature.

QUESTION C.15 [1.0 point]
The primary function of the discriminator in the Source Range Channel is to:

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

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

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

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

Section C: Plant and Rad Monitoring Systems

QUESTION C.16 [1.0 point]
Which ONE of the following is the acceptable range for the primary coolant pH?

a. 6.0 – 7.0

b. 5.0 – 6.0

c. 4.0 – 5.0

d. 3.0 – 4.0

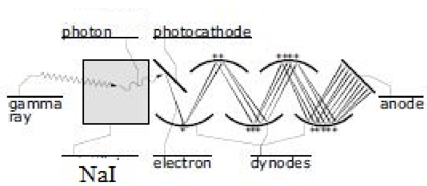
QUESTION C.17 [1.0 point]
The figure attached is a basic design of :

a. Thermoluminescent Dosimeter (TLD)

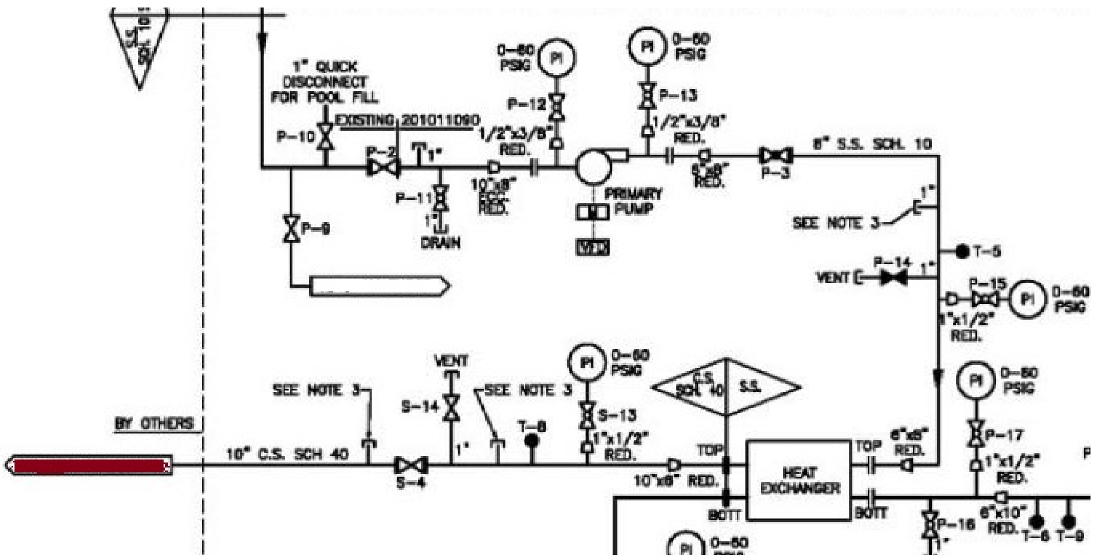
b. Film badge

c. Pocket ionization chamber

d. Scintillation detector



QUESTION C.18 [1.0 point]
The figure below is a part of the primary coolant system. Which ONE of the following is a next location that the coolant flow (indicated by the RED arrow) will go through?



a. Cooling Tower

b. Beam tubes

c. Reactor Pool

d. Demineralizer Tank

QUESTION C.19 [1.0 points, 0.25 each]
The Figure 4.6 depicts the reactor core support structure. Match the devices listed in column A with their correct locations.

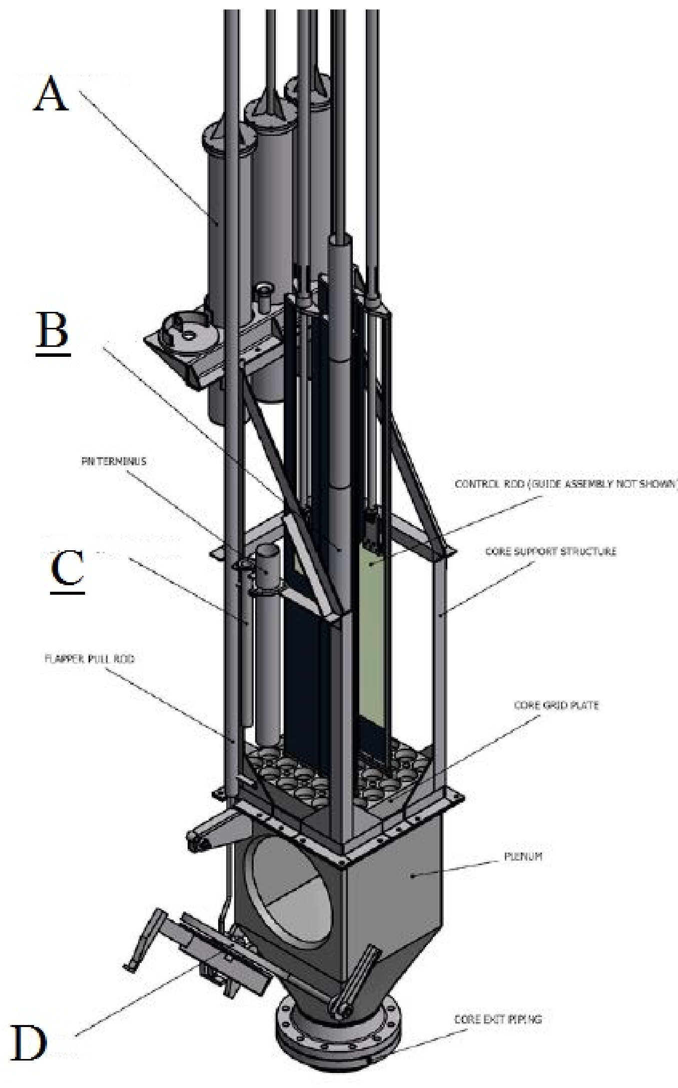
Column A

a. Flapper

b. Neutron Detector

c. Fission Chamber

d. Startup Source Holder



QUESTION C.20 [1.0 point]
Which ONE of the following best describes on how an automatic transfer switch in the Auxiliary Distribution Panel works?

a. This switch is spring loaded to remain in the open position. As the generator comes up to speed and voltage, the generator output voltage works against the spring tension to close the switch and apply power to the Auxiliary Distribution Panel.

b. This switch is controlled by computer system. As the generator comes up to speed and voltage, the computer will sense the power and then switch from OFF to ON, so the power is distributed to the Auxiliary Distribution Panel.

c. This switch is operated by a hydraulic system in the open position. As the generator comes up to speed and voltage, the system will change phase and close the switch, so the power is distributed to the Auxiliary Distribution Panel.

d. This switch is operated by a motor control system in the stand-by position. As the generator comes up to speed and voltage, a motor control system will start and close the switch, so the power is distributed to the Auxiliary Distribution Panel.

******************* End of Section C ****************************
****************** End of the Exam ***************************

A.01
Answer: c
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Sec 3.3

A.02
Answer: c
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1982, § 5.3, p. 5.6
2-nd generation=n + K*n=1000+700=1700 neutrons

A.03
Answer: b
Reference: $P = P_0\ e^{-t/T} = 1\ kW \mid e^{(60sec/-80sec)} = 1\ kW * e^{-0.75} = 0.472 \mid 1\ kW = 0.47\ kW$

A.04
Answer: c
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Sec 4.2

A.05
Answer: b
Reference: $P=P_oe^{t/\tau}$ $3=1* e^{t/32}$ $t = 32\ sec*\ln(3) = 35.2\ sec$

A.06
Answer d
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, Sec 4.6, page 4-17.

A.07
Answer: d
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1982, Page 4-21.

A.08
Answer: c
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1982, Figure 2.6, page 2-39

A.09
Answer: b
Reference: Nuclides and Isotopes
N = A – Z 235-92 = 143

A.10
Answer: a
Reference: K eff = 1.03*0.84*0.96*0.88*1.96*x
X= 1/1.4326 = 0.698

A.11
Answer c
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, Sec 8.1

A.12
Answer: c
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1982, Sec 3.2.

A.13
Answer: b
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, Section 8.2

A.14
Answer: c
Reference: from k=0.955 to criticality (k=1), ρρ = (k-1)/k = -0.047 ρk/k or ρρ = 0.047 ρk/k needed to reach criticality. From criticality to JUST prompt, ρk/k = βeff required, so minimum reactivity added to produce prompt criticality will be: 0.047+0.0073= 0.0543

A.15
Answer: b
Reference: CR = S/(1-K) → CR = 100/(1 - .9) = 1000 N/sec

A.16
Answer: a
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Sec 2.4.5

A.17
Answer c
Reference: Standard NRC question

A.18
Answer: b
Reference: Tech Spec Minimum SDM = SDM – highest control rod worth
7000 pcm – 4000 pcm = 3000 pcm

Or
Total rod worth – excess reactivity – highest control rod worth
9000 pcm – 2000 pcm – 4000 pcm = 3000 pcm

A.19
Answer: d
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1982, Sec 3.3.3, page 3-21.
$\Delta\rho$ = keff1-keff2/(keff1 x keff2) =0.197 ΔK/K = 19700 pcm

A.20
Answer: b
Reference: DOE Manual Vol. 1, pg. 57

B.01
Answer: b
Reference: Emergency Plan 5.1

B.02
Answer: c
Reference: $DR = DR_o * e^{-\mu X}$
Find μ : $250 = 1000 * e^{-\mu * 60}$; μ = 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.03
Answer: a(6) b(4) c(2) d(1)
Reference: TS 3.2

B.04
Answer: d
Reference: TS 3.4

B.05
Answer: d
Reference: 10 CFR 50.59 (TS changes required an amendment)

B.06
Answer: c
Reference: $DR = DR_o * e^{-\lambda t}$
1 rem/hr =2 rem/hr* $e^{-\lambda(5hr)}$
Ln(1.0/2) = -λ*5 --> λ=0.1386; solve for t: Ln(.25/2)=-0.1386 (t) → t=15 hours
Short cut:
2 Rem to 1 Rem : 5 hrs
1 Rem to 0.50Rem : 5 hrs
0.50 rem to 0.25 Rem : 5 hrs
Total: 15 hrs

B.07
Answer: c
Reference: TS, Definition 1.2

B.08
Answer: d
Qualify factor(Q) - adjusts absorbed dose to dose equivalent
Q = 1 for x, gamma or beta
Q = 20 for alphas and other heavy particles
Q = 10 for neutrons of unknown energy; table 1004(b).2. is for known energies
Q = 10 for high-energy protons

Reference: 10 CFR 20

B.09
Answer: d
Reference: 10 CFR 20 “Definitions”

B.10
Answer: c
Reference: TS 6.1.3

B.11
Answer: a
Reference: TS 3.8.b

B.12
Answer: d
Reference: TS 3.7

B.13
Answer: c
Reference: Technical Specifications, Section 1.2.15

B.14
Answer: c
Reference: NRC standard question

B.15
Answer: c
Reference: 10 CFR 20

B.16
Answer: c
Reference: 10 CFR 50.59

B.17
Answer: c
Reference: 10 CFR 20. 10 mR/hr $(100 \text{ cm})^2 = X * (30 \text{ cm})^2$
X = 111 mR/hr at 30 cm

B.18
Answer: c
Reference: 10 CFR 55

B.19
Answer: d
Reference: TS 6.8

B.20
Answer: b
Reference: SAR 6.3.2.2

Section C Facility and Radiation Monitoring Systems

C.01
Answer: c
Reference: NCSU Training Manual, Section **NRP-OP-101 "Reactor Startup and Shutdown"**

C.02
Answer: d
Reference: NCSU Training Manual 7.2

C.03
Answer: c
Reference: NCSU Training Manual, Figure 7-1

~~**C.04**~~ Deleted
~~Answer: b~~
~~Reference: NCSU Training Manual 4.2.1~~

C.05
Answer: a
Reference: NRP-OP-105, Section 3, Response to Reactor Alarms

C.06
Answer: c
Reference: NCSU Training Manual 3.2.3.5

C.07
Answer: a
Reference: NCSU Training Manual 7.2.1

C.08
Answer: a(2) b(1) c(4) d(4)
Reference: NRP-OP-105

C.09
Answer: d
Reference: Bevelacqua, J. Basic Health Physics

C.10
Answer: c
Reference: NCSU Training Manual 10.3.2

C.11
Answer: c
Reference: NRC Standard Question

C.12
Answer: d
Reference: NRP-OP-105

C.13
Answer: d
Reference: NCSU Training Manual Figure 3-32 Gang Integral Rod Worth

C.14
Answer: a
Reference: NCSU Training Manual 7.3.4

C.15
Answer: b
Reference: NRC Standard Question

C.16
Answer: a
Reference: TS 3.9

C.17
Answer: d
Reference: Basic knowledge of radiation detector

C.18
Answer: a
Reference: NCSU Training Manual Figure 5-1, Reactor Coolant System P&ID

C.19
Answer: a(D) b(A) c(B) d(C)
Reference: NCSU Training Manual Figure 4-6

C.20
Answer: a
Reference: NCSU Training Manual 8.3.4