May 11, 2016

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-16-02, NORTH CAROLINA STATE UNIVERSITY

Dear Dr. Hawari:

During the week of April 18, 2016, 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 examination with Greg Gibson, NCSU Senior Reactor Operator, 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 this examination, please contact Mr. John T. Nguyen at (301) 415-4007 or via email at John.Nguyen@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-16-02
2. Written examination

cc: w/o enclosures: See next page

cc:

Office of Intergovernmental Relations
116 West Jones Street
Raleigh, NC 27603

Dr. Kostadin Ivanov, Head
Department of Nuclear Engineering
North Carolina State University
Campus Box 7909
Raleigh, NC 27695-7909

W. Lee Cox, Section Chief
Department of Health and Human Services
Division of Health Service Regulation
Radiation Protection Section
1645 Mail Service Center
Raleigh, NC 27699-1645

Dr. Louis Martin-Vega, Dean
College of Engineering
North Carolina State University
113 Page Hall
Campus Box 7901
Raleigh, NC 27695-7901

Test, Research, and Training
Reactor Newsletter
University of Florida
202 Nuclear Sciences Center
Gainesville, FL 32611

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Docket No. 50-297

Enclosures:
1. Examination Report No. 50-297/OL-16-01
2. Written examination

cc: w/o enclosures: See next page

DISTRIBUTION w/ encls:
PUBLIC Anthony Mendiola Johnny Eads Alexander Adams Duane Hardesty

ADAMS Accession No: ML

OFFICE	NRR/DPR/PROB/CE		NRR/DPR/PROB/OLA		NRR/DPR/PROB/BC
NAME	JNguyen		CRevelle		AMendiola
DATE	04/27/2016		05/09/2016		05/11/2016

OFFICIAL RECORD COPY

ENCLOSURE 1
U. S. NUCLEAR REGULATORY COMMISSION
OPERATOR LICENSING INITIAL EXAMINATION REPORT

REPORT NO.: 50-297/OL-16-01

FACILITY DOCKET NO.: 50-297

FACILITY LICENSE NO.: R-120

FACILITY: North Carolina State University Pulstar Reactor

EXAMINATION DATES: April 18 – April 20, 2016

SUBMITTED BY: **/RA/** **4/27/2016**
John T. Nguyen, Chief Examiner Date

SUMMARY:

During the week of April 18, 2016, the NRC administered operator licensing examination to two Reactor Operator (RO) license candidates. The entire license candidates passed all applicable portions of the examinations.

REPORT DETAILS

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

2. Results:

	RO PASS/FAIL	SRO PASS/FAIL	TOTAL PASS/FAIL
Written	2/0	0/0	2/0
Operating Tests	2/0	0/0	2/0
Overall	2/0	0/0	2/0

3. Exit Meeting:
John Nguyen, NRC, Chief Examiner
Greg Gibson, NCSU, Senior Reactor Operator

The examiner thanked the facility for their assistance during the exam administration.

ENCLOSURE 2
U. S. NUCLEAR REGULATORY COMMISSION
NON-POWER REACTOR LICENSE EXAMINATION

FACILITY: NORTH CAROLINA STATE UNIVERSITY

REACTOR TYPE: PULSTAR

DATE ADMINISTERED: April 19, 2016

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

A. RX THEORY, THERMO & FAC OP CHARS

A N S W E R S H E E T

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

A01 a b c d ___

A02 a b c d ___

A03 a b c d ___

A04 a b c d ___

A05 a b c d ___

A06 a b c d ___

A07 a b c d ___

A08 a b c d ___

A09 a b c d ___

A10 a b c d ___

A11 a b c d ___

A12 a b c d ___

A13 a b c d ___

A14 a ___ b ___ c ___ (0.33 each)

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 *****)

B. NORMAL/EMERG PROCEDURES & RAD CON

A N S W E R S H E E T

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

B01 a b c d ___

B02 a b c d ___

B03 a ___ b ___ c ___ d ___ (0.25 each)

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 *****)

C. PLANT AND RAD 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 ___ (0.25 each)

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 ___ (0.25 each)

C09 a b c d ___

C10 a b c d ___

C11 a ___ b ___ c ___ d ___ (0.50 each)

C12 a b c d ___

C13 a b c d ___

C14 a b c d ___

C15 a b c d ___

C16 a b c d ___

C17 a b c d ___

C18 a b c d ___

C19 a b c d ___

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

NRC RULES AND GUIDELINES FOR LICENSE EXAMINATIONS

During the administration of this examination the following rules apply:

1. Cheating on the examination means an automatic denial of your application and could result in more severe penalties.

2. After the examination has been completed, you must sign the statement on the cover sheet indicating that the work is your own and you have neither received nor given assistance in completing the examination. This must be done after you complete the examination.

3. Restroom trips are to be limited and only one candidate at a time may leave. You must avoid all contacts with anyone outside the examination room to avoid even the appearance or possibility of cheating.

4. Use black ink or dark pencil only to facilitate legible reproductions.

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

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

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

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

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

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

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

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

EQUATION SHEET

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

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

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

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

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

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

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

$$CR_1 (1 - K_{eff_1}) = CR_2 (1 - K_{eff_2}) \quad CR_1 (-\rho_1) = CR_2 (-\rho_2)$$

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

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

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

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

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

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

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

$$T_{\frac{1}{2}} = \frac{0.693}{\lambda} \quad \Delta\rho = \frac{K_{eff_2} - K_{eff_1}}{K_{eff_1} K_{eff_2}}$$

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

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

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

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

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

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-lbf

1 gal (H_2O) ≈ 8 lbm

c_P = 1.0 BTU/hr/lbm/°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

North Carolina State University

Operator Licensing Examination

Week of April 18, 2016

ENCLOSURE 2

QUESTION A.01 [1.0 point]
In a comparison between a delayed neutron and a prompt neutron born from the same fission event, the delayed neutron is more likely to:

a. leak out of the core.

b. be absorbed in the moderator.

c. cause fission of a U-238 nucleus.

d. cause fission of a U-235 nucleus.

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 THIRD generation, how many **total neutrons** are there after the third generation?

a. 1400

b. 1700

c. 2190

d. 2800

QUESTION A.03 [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	1.05
Fast non-leakage probability	0.80
Resonance escape probability	0.90
Thermal non-leakage probability	0.92
Thermal utilization factor	0.80
Reproduction factor	1.86

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. 0.682

b. 0.712

c. 0.773

d. 0.873

QUESTION A.04 [1.0 point]
The reactor is SHUTDOWN by 5% Δk/k with the count rate of 1000 counts per second (cps). The control rods are withdrawn until the count rate is quadrupled. What is the value of K_{eff} ?

a. 0.952

b. 0.976

c. 0.988

d. 1.002

QUESTION A.05 [1.0 point]
The product of number density and microscopic cross section of an element is defined as:

a. Macroscopic Cross Section.

b. Maximum Cross Section.

c. Thermal Cross Section.

d. Decay Constant.

QUESTION A.06 [1.0 point]
While a reactor is at 5 W, the reactor operator is withdrawing a control rod to insert a positive reactivity of 156 pcm. Which ONE of the following will be the stable reactor period as a result of this withdrawal? Given beta-effective = 0.0073 and λ_{eff}= 0.1.

a. 17 seconds

b. 27 seconds

c. 37 seconds

d. 47 seconds

QUESTION A.07 [1.0 point]
Which term is described by the following?
“The fractional change of the effective multiplication factor from criticality.”

a. 1/M

b. K-effective

c. Reactor period

d. Reactivity

QUESTION A.08 [1.0 point]
Which ONE of the following most correctly describes the SIX- FACTOR FORMULA?

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

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

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

d. $K_{\infty} = K_{eff}$ * the utilization factor

QUESTION A.09 [1.0 point]
A reactor is subcritical with a K_{eff} of 0.927. If you add 7.875% $\Delta k/k$ into the core, the reactor will be:

a. subcritical.

b. just critical.

c. supercritical.

d. prompt critical.

QUESTION A.10 [1.0 point]
The NCSU reactor is critical at 5 W. A reactor operator accidentally inserts a fuel element worth 1000 pcm into the core. With this insertion, a reactor will be:

a. subcritical

b. critical

c. supercritical

d. prompt critical

QUESTION A.11 [1.0 point]
A mechanism by which a nucleus can gain stability by converting a neutron to a proton or vice versa is called:

a. gamma decay

b. beta decay

c. alpha decay

d. photoelectric effect

QUESTION A.12 [1.0 point]
The MAIN reason for operating a reactor with thermal neutrons instead of fast neutrons is:

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.13 [1.0 point]
Why are burnable poisons added to a reactor core during initial core loading? The main reason is to:

a. Increase the availability of usable nuclear fuel with the existing control rod design.

b. Shape the fast neutron flux for maximum specimen irradiation capability.

c. Reduce the secondary isotopic radiation effects from irradiated control rods.

d. Shape the thermal neutron flux for maximum specimen irradiation capability.

QUESTION A.14 [1.0 point, 0.33 each]
Match the term listed in Column A with its corresponding units listed in column B. Answer in Column B can be used once, more than once, or not at all.

Column A	Column B
a. Microscopic Cross Section	1. 1/cm
b. Macroscopic Cross Section	2. 10^{-24} cm^2
c. Neutron Flux	3. Neutrons / cm^2 /sec
.	4. Neutrons / cm^3 /sec
	5. 10^{-24} cm^3

QUESTION A.15 [1.0 point]
Following a positive reactivity addition to a shutdown reactor, the neutron power will increase even though k-effective is less than 1. The MAIN reason is due to:

a. Production of fast neutrons

b. Neutron moderation in the fuel

c. Subcritical multiplication process

d. Void temperature coefficient in the moderator

QUESTION A.16 [1.0 point]
On the average, how many neutrons are produced for each fission of U-235?

a. 2.00 neutrons

b. 2.09 neutrons

c. 2.43 neutrons

d. 2.93 neutrons

QUESTION A.17 [1.0 point]
Given the following Core Reactivity Data during startup:

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

The **Core Excess Reactivity** is:

a. 2000 pcm

b. 3000 pcm

c. 4000 pcm

d. 7000 pcm

QUESTION A.18 [1.0 point]
Reactor is at full power. The following graph shows the reactor time behavior following a reactor scram. Which ONE of the following best describes the transition of power between point A and B after the initial insertion? .

a. An **immediate** decrease in the **prompt neutron fraction** due to leakage, absorption, and a reduction in the fission rate.

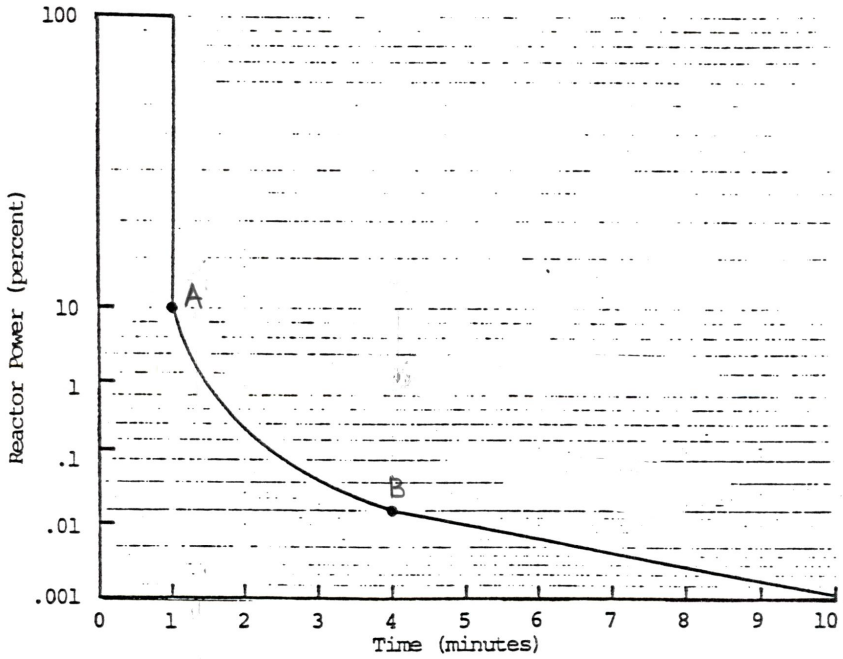
b. Fission product gases such as xenon begin to buildup causing the expansion of fuel density.

c. Neutron level in the core is sustained by prompt neutrons.

d. Delayed neutron precursors would begin to effect.

INTRODUCTION TO NUCLEAR REACTOR OPERATIONS
Reactor Kinetics
Reed Robert Burn
December 1988

Figure 4.3 Reactor Time Behavior Following a Reactor Scram



QUESTION A.19 [1.0 point]
If the mean generation time for neutrons in a reactor is 0.1 sec and k = 1.001, what is the reactor period?

a. 1 seconds

b. 10 seconds

c. 100 seconds

d. 180 seconds

QUESTION A.20 [1.0 point]
The reactor is on a **CONSTANT** positive period. Which ONE of the following power changes will take the **longest time** to complete?

a. 5%, from 95% to 100%

b. 10%, from 80% to 90%

c. 15%, from 15% to 30%

d. 20%, from 60% to 80%

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

QUESTION B.01 [1.0 point]
Radiation Work Permit (RWP) provides specific radiological precautions and practices while performing work activities outside of normal conditions for the purpose of limiting personnel radiation dose and spread of contamination. The below items are listed as conditions for obtaining a RWP, EXCEPT:

a. Entry into potential Radiation Area.

b. Entry into potential Contaminated Area.

c. Entry into potential Airborne Radioactivity Area.

d. Remove the control rod out of the reactor core for repairing.

QUESTION B.02 [1.0 point]
What is the maximum allowable dose that the Emergency Director can authorize for a volunteer in order to make a corrective action to protect valuable property?

a. 5 Rem

b. 10 Rem

c. 25 Rem

d. 50 Rem

QUESTION B.03 [1.0 point, 0.25 each]
Match type of radiation listed in column A with their quality factor listed in column B. Items in column B can be used once, more than once or not at all.

Column A	Column B
a. X-ray	1. 1
b. Gamma	2. 5
c. Alpha particles	3. 10
d. High-energy photons	4. 20

QUESTION B.04 [1.0 point]
A radioactive source reads 5 Rem/hr on contact. Five hours later, the same source reads 1.25 Rem/hr. How long is the time for the source to decay from a reading of 5 Rem/hr to 625 mRem/hr?

a. 5.5 hours

b. 7.5 hours

c. 9.5 hours

d. 11.5 hours

QUESTION B.05 [1.0 point]
A reactor has been operated at full power with an experiment in the core. Which ONE of the following is NOT a Tech Spec violation?

a. The Stack Gas Monitor pump has been turned OFF during the reactor operation.

b. The N-16 Channel has not been operable during the reactor operation.

c. The Stack Particulate Monitor has not been operable during reactor operation.

d. You review the irradiation request form and find that the total of the reactivity worths of all experiment is 2.0 % Δk/k.

QUESTION B.06 [1.0 point]
Per NCSU Technical Specifications, the MAXIMUM excess reactivity shall be:

a. 1000 pcm

b. 1590 pcm

c. 3970 pcm

d 4970 pcm

QUESTION B.07 [1.0 point]
Per NCSU Emergency Plan, the boundary that includes BEL, the area between Lampe and Broughton Drive and the area between Stinson Drive and the north face of BEL, is defined as:

a. Site Boundary.

b. Offsite Boundary.

c. Operations Boundary.

d. Containment Boundary.

QUESTION B.08 [1.0 point]
A five-curie source (Co-60), emits 100% of a 1.17 Mev and 1.33 Mev gamma, is to be stored in the reactor building. What is the exposure rate at 6 feet from the source?

a. 1.3 R/hr

b. 2.1 R/hr

c. 8.3 R/hr

d. 208 R/hr

QUESTION B.09 [1.0 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 + 1 HP on-call

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

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

d. 1 SRO in the control room + 1 RO on call + 1 HP on call

QUESTION B.10 [1 point]
During a reactor operation, the reactor operator observes that the pool water temperature exceeds 120 °F. For this temperature, which ONE of the following is the best action?

a. The operator may increase power level to verify that at what temperature a reactor scram will be actuated.

b. The operator may continue an operation because the temperature is within TS limit.

c. The operator shall secure the reactor, and immediately report the result to the supervisor because the reactor safety system did not activate a scram.

d. The operator shall secure the reactor, and immediately report the result to the supervisor because the reactor safety system did not activate a Rod Withdraw Prohibit.

QUESTION B.11 [1.0 point]
Which ONE of the following is NOT a By-product Material?

a. Pu-239

b. Cobalt-57

c. Carbon-14

d. Tritium

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. Rate of reactivity exceeding 50 pcm/sec

b. Non-secured worth exceeding 300 pcm

c. Experiment with pressure buildup 210 psi

d. Any flammable material

QUESTION B.13 [1.0 point]
A system or component is defined as "OPERABLE" 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]
The MAIN purpose to encapsulate a corrosive material irradiated in the reactor core is to prevent:

a. contamination in the pool water.

b. pressure build up in the sample holder.

c. release of corrosive gas to the reactor bay.

d. contamination to handling tools.

QUESTION B.15 [1.0 point]
The MINIMUM level of management who shall approve all experiment loading and unloading is the:

a. Reactor Director

b. Health Physics in duty

c. RO on duty

d. DSRO

QUESTION B.16 [1.0 point]
The NCSU Technical Specifications define that a Reportable Event is the circumstances of the event that the licensee shall make a report by telephone to the NRC Headquarters Operations Center no later than the following working day, followed by a written report, submitted to the NRC Document Control Desk, within 14 days. The below items are listed as a Report Event, EXCEPT:

a. The Over-the Pool RAM indicates 120 mR/hr without alarm during fuel movement.

b. A reactor operator accidently inserts a fuel element into the core while reactor is at 5 W.

c. Fission products are detected in the stack particulate monitor during reactor operation.

d. An uncontrolled reactivity change in reactivity exceeds 0.1 %ΔK/K.

QUESTION B.17 [1.0 point]
The N-16 calibration shall be performed at least:

a. monthly.

b. quarterly.

c. semi-annually.

d. annually.

QUESTION B.18 [1.0 point]
Which ONE of the following changes must be submitted to NRC for approval prior to implementation?

a. Replace a primary cooling pump with identical pump.

b. Add new limitation to the Pre-Startup Checklist Procedure.

c. Add more responsibilities to the Radiation Protection Officer listed in the health physics procedure.

d. Delete a definition of “Reactor Shutdown” listed in the NCSU Technical Specifications.

QUESTION B.19 [1.0 point]
Assume that there is no leak from outside of the demineralizer tank. You use a survey instrument with a window probe to measure the dose rate from the demineralizer tank. Compare to the reading with a window **CLOSED,** the reading with a window **OPEN** will: (Assume that there is NO contamination from the outside of the demineralizer tank)

a. increase, because it can receive an additional alpha radiation from [(Al-27) (n,α) → (Na-24)] reaction.

b. remain the same, because the Quality Factors for gamma and beta radiation are the same.

c. increase, because the Quality Factor for beta and alpha is greater than for gamma.

d. remain the same, because the survey instrument would not be detecting beta and alpha radiation from the demineralizer tank.

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 the Stack Particulate Monitor?

a. Ar-41

b. I-133

c. N-16

d. Co-60

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

QUESTION C.01 [1.0 point]
During reactor operation, which ONE of the following best describes on how the amplifier of the Safety Channel (Uncompensated Ion Chamber) works? The amplifier converts ionization signal from:

a. (n,β) reaction into a d.c. current then amplifies the d.c. current in a logarithmic manner

b. (n,α) reaction into a d.c. current then amplifies the d.c. signal in a logarithmic manner

c. fission fragment into a d.c. current then amplifies the d.c. signal in a logarithmic manner

d. (n,p) reaction into an a.c. current then amplifies the a.c. signal in a logarithmic manner

QUESTION C.02 [1.0 point]
Which ONE of the following channels may provide the first indications of a fuel pin failure?

a. N-16 Channel

b. Safety Channel

c. Linear Channel

d. Log and Linear Channel

QUESTION C.03 [1.0 point]
Identify the exceeding limit (MAXIMUM or MINIMUM) of the following Limiting Safety System Settings (LSSS) for the forced convection flow.

a. Primary Coolant Flow 450 gpm

b. Pool Water Temperature 117 °F

c. Water Height 14 ft 2

d. Reactor Power 1.3 MWt

QUESTION C.04 [1.0 point]
During the Startup in Forced Convection Mode, you find the actual Shutdown Margin (SDM) is 350 pcm. For this calculation, you will:

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

b. continue the startup and get approval from the Designated Senior Reactor Operator.

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

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

QUESTION C.05 [1.0 point]
During a startup checklist for the Stack Gas Monitor, you notice that the flow fault light is NOT "on" and its annunciator is NOT "lit", when the sampling pump is running. These conditions show that the Stack Gas Monitor is in:

a. normal condition.

b. fail mode.

c. test mode.

d. calibration mode.

QUESTION C.06 [1.0 point]
The NCSU reactor fuel shall be UO_2 with a nominal enrichment of between:

a. 4% – 6% in U-235, aluminum clad.

b. 4% – 6% in U-235, zircaloy clad.

c. 6% – 8% in U-235, zircaloy clad.

d. 6% – 8% in U-235, stainless steel clad.

QUESTION C.07 [1.0 point]
When a reactor is at 10 kW, you accidently remove the check source out of the reactor core. This action will cause:

a. Nothing (normal operation)

b. Rod run down

c. Rod withdraw prohibit

d. Scram

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

Column A	Column B
a. Pool Resistivity = 1MΩ	1. Normal Operation
b. Loss of Natural Gas Pressure	2. Alarm ONLY
c. West Wall Radiation = 2 mR/hr	3. Interlock
d. Linear Power = 1.3 MW	4. Automatic Scram (with or without Alarm)

QUESTION C.09 [1 point]
During a reactor operation, you discover the Stack Particulate Monitor (SPM) pump has been turned OFF since yesterday. Which ONE of the following actions should you take?

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

b. Immediately secure reactor, but this event is NOT a TS violation because the SPM is still operable.

c. Continue with reactor operation. Up to 24 hours is allowed to run reactor before replacing the Stack Particulate Monitor.

d. Continue with reactor operations. The NCSU Technical Specifications require only RAMs and Stack Gas monitors during reactor operation.

QUESTION C.10 [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.

QUESTION C.11 [2.0 point, 0.5 each]
Match the following actions used in Column A with their respective definitions in Column B:

COLUMN A	COLUMN B
a. You compare readings of Safety Channel with Linear Channel during reactor operations	1. Channel Check
b. During startup, you verify the reactor scram at 1.3 MW	2. Channel Test
c. During startup, you remove a neutron source to verify rod withdrawal prohibit	3. Channel Calibration
d. You adjust a safety channel reading after conducting a thermal power calibration	

QUESTION C.12 [1.0 point]
A reactor is at full power. Which ONE of the following methods will reduce the MOST buildup of N-16 in the reactor pool surface?

a. Turn primary pumps OFF, so it increases the amount of time for N-16 staying in the reactor coolant system.

b. Turn primary pumps ON, so it increases the amount of time for N-16 staying in the reactor coolant system.

c. Turn the exhaust fan ON, so N-16 will be exhausted through the stack

d. Turn the intake louvers ON, so N-16 will be diluted with air coming from the building outside.

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. reactivity vs. rod height

b. reactivity vs. period

c. pool level vs. coolant flow

d. count rate 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 capacitor which changes capacitive 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 precision wound resistor which changes resistance proportional to the change in temperature.

QUESTION C.15 [1.0 point]
Which ONE of the following is the NORMAL range for magnet currents of the Safety control rod?

a. 36 – 38 mA

b. 40 – 42 mA

c. 44 - 46 mA

d. 48 -50 mA

QUESTION C.16 [1.0 point]
After losing commercial power, you attempt to start the Auxiliary Generator but the cranking limiter contact opens up. To restart the generator you must:

a. place the Start switch to stop than to start.

b. place the Run-Stop-Remote switch in the Run position.

c. place the Auxiliary Distribution Panel switch in the open position.

d. reset the cranking limiter at the Auxiliary Generator control panel.

QUESTION C.17 [1.0 point]
Which ONE of the following will indicate the cleanest pool water?

a. Highest pH

b. Highest resistivity

c. Highest conductivity

d. Lowest pH

QUESTION C.18 [1.0 point]
Which ONE of the following is the method use to get rid of radioactive low-level solid waste at NCSU reactor? Radioactive low-level solid waste is:

a. burned, then dumped to the public trash system.

b. packed, then transferred to the Department of Energy.

c. packed, then transferred to the NCSU University Radiation Safety Division.

d. diluted with water to less than 10CFR20 limits, then pumped to the sanitary sewer system.

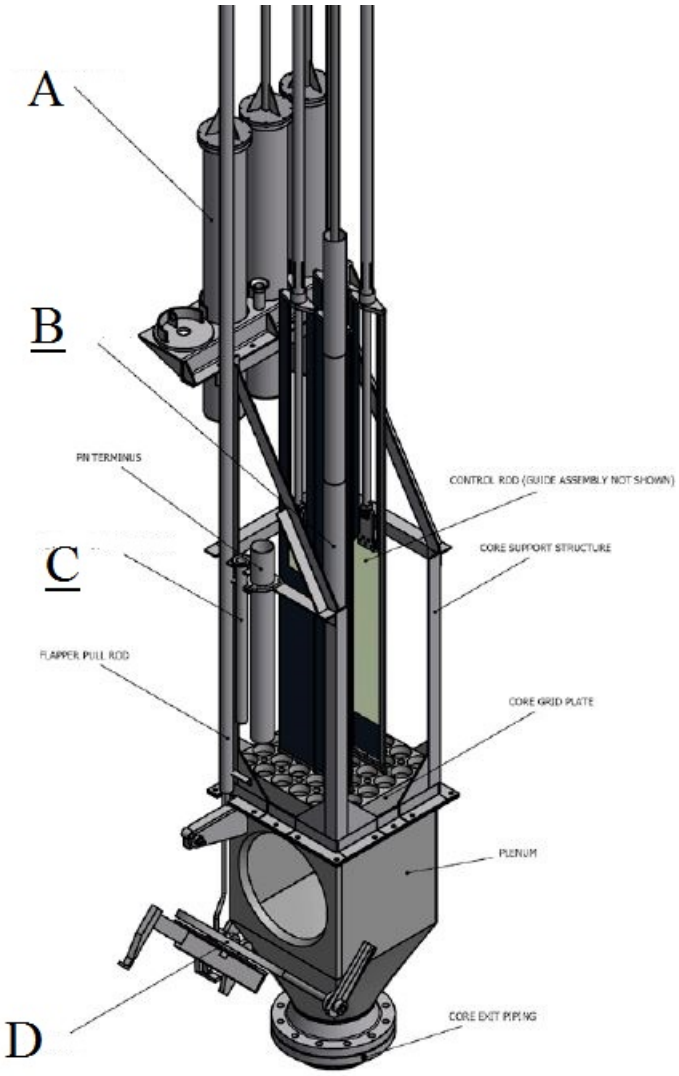
QUESTION C.19
The Figure 4.6 depicts the reactor core support structure. Which letter indicates the correct location of Fission Chamber?

a. A

b. B

c. C

d. D



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

A.01
Answer: d
Reference: Burn, R., Introduction of Nuclear Reactor Operations, © 1988, Sec 3.2

A.02
Answer: c
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1982, Section 5.3.
3-nd generation=n + K*n = K^2* n=1000+700+490=2190 neutrons

A.03
Answer: c
Reference: K eff = 1.05*0.80*0.90*0.92*1.86*x
X= 1/1.294 = 0.773

A.04
Answer: c
Reference:
Keff1=1/1- ρ1
Keff1 =1/(1-(-.05)) —>Keff1= 0.952,
Count1*(1-Keff1) = Count2*(1-Keff2)
Count1*(1-0.952) = Count2*(1-Keff2)
1000*(1-0.952) = 4000(1- Keff2); Keff2 = 0.988

A.05
Answer: a
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, Sec 2.5.2, page 2-43.

A.06
Answer: c
Reference:
Reactivity added = 156 pcm = 0.00156 ∆k/k
$\tau = (\beta-\rho)/\lambda_{eff}\rho$ = (0.0073 - 0.00156)/ ((0.1)*(0.00156)) = 37 seconds

A.07
Answer: d
Reference: Burn, R., Introduction of Nuclear Reactor Operations, © 1988, Sec 3.3.4

A.08
Answer: a
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Sec 3.3.1

A.09
Answer: b
Reference: SDM = (1- keff)/keff = (1-0.927)/0.927 = 0.07875 Δk/k. So if you add the same amount of SDM, the reactor is just critical.
Another method: you can find the new value of Keff when adding 0.07875 Δk/k to reactor.
Δp = (k2 –k1)/ k1*k2
0.07875 = (k2- 0.927)/(0.927* k2), solve for k2
K2 = 1, hence the reactor is just critical

A.10
Answer: d
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Sec 4.2

A.11
Answer: b
Reference: NRC Standard Question

A.12
Answer: c
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1982, Figure 2.6, page 2-39

A.13
Answer: a
Reference: Burn, R., Introduction of Nuclear Reactor Operations, © 1988, Sec 8.4

A.14
Answer: a(2) b(1) c(3)
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, Sec 2.6

A.15
Answer: c
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, subcritical Multiplication process.

A.16
Answer: c
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Section 3.2, Table 3.1

A.17
Answer: a
Reference: Core excess = Total Rod Worth - Rod Worth removed at 5 watts
9000 pcm – 7000 pcm = 2000 pcm

A.18
Answer: d
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, Section 4.5, Table 4.3

A.19
Answer: c
Reference:
$\rho = k-1/k = 0.001$
Period $T = l^*/\rho$
$T = 0.1 /0.001 = 100$

A.20
Answer: c
Reference: Time is related to ratio of final power to initial power. 2:1 is the largest ratio.

B.01
Answer: a
Reference: HP8, Section 4.1.1

B.02
Answer: b
Reference: EP 7.5.7

B.03
Answer: a(1) b(1) c(4) d(1)
Reference: 10 CFR 20

B.04
Answer: b
Reference: $DR = DR_{\circ} * e^{-\lambda t}$
$1.25 \text{ rem/hr} = 5 \text{ rem/hr} * e^{-\lambda(5hr)}$
$\ln(1.25/5) = -\lambda * 5 \rightarrow \lambda = 0.277$; solve for t: $\ln(.625/5) = -0.277 * t$
t=7.5 hours

B.05
Answer: d
Reference: TS 3.2
All experiment limit = 2890 pcm = 2.890 % Δk/k > 2000 pcm or 2.0 % Δk/k

B.06
Answer: c
Reference: TS 3.2

B.07
Answer: a
Reference: Emergency Plan 2.13

B.08
Answer: b
Reference: $R/hr = 6CE/r^2 = 6 \times 5 \times 1*(1.17+1.33)/ 6^2 = 2.08$ R/hr

B.09
Answer: c
Reference: TS 6.1.3

B.10
Answer: c
Reference: TS Table 3.3

B.11
Answer: a
Reference: 10 CFR Part 20.1003

B.12
Answer: c
Reference: TS 3.7

B.13
Answer: c
Reference: TS 1.2.15

B.14
Answer: a
Reference: TS 3.7.a

B.15
Answer: d
Reference: NRP-OP-104, section 4.1.1

B.16
Answer: d
Reference: TS 1.2.24 (less than $1)

B.17
Answer: c
Reference: TS 4.2

B.18
Answer: d
Reference: 10 CFR 50.59

B.19
Answer: d
Reference: Basic radiological concept (beta and alpha radiation don't make through the demineralizer tank)

B.20
Answer: b
Reference: NCSU Training Manual 13.2

C.01
Answer: b
Reference: SAR 7.2.2
B-10 + n → Li-7 + alpha

C.02
Answer: a
Reference: NCSU Training Manual 7.2.5

C.03
Answer: a (MINIMUM) b(MAXIMUM) c(MINIMUM) d(MAXIMUM)
Reference: TS 2.2

C.04
Answer: c
Reference: NCSU Training Manual, Section NRP-OP-101 “Reactor Startup and Shutdown”

C.05
Answer: a
Reference: NRP-OP-101, Appendix B

C.06
Answer: b
Reference: NCSU Training Manual 4.5.3.2.5 and TS 5.1

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

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

C.09
Answer: a
Reference: TS 3.5

C.10
Answer: a
Reference: NCSU Training Manual 8.3.4

C.11
Answer: a(1) b(2) c(2) d(3)
Reference: TS 1.2

C.12
Answer: b
Reference: NRC Standard Question

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

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

C.15
Answer: c
Reference: NCSU Training Manual, Section 7.3.8

C.16
Answer: d
Reference: NCSU Training Manual, Section 8.3.3

C.17
Answer: b
Reference: NRC Standard Question

C.18
Answer: c
Reference: NCSU Training Manual, Section 10.1.3

C.19
Answer: b
Reference: NCSU Training Manual Figure 4-6