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

April 23, 2018

Dr. Thomas H. Newton, Deputy Director
NIST Center for Neutron Research
National Institute of Standards and Technology
U.S. Department of Commerce
100 Bureau Drive, Mail Stop 8561
Gaithersburg, MD 20899-8561

SUBJECT: EXAMINATION REPORT NO. 50-184/OL-18-01, NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY

Dear Dr. Newton:

During the week of February 26, 2018, the U.S. Nuclear Regulatory Commission (NRC) administered operator licensing examinations at your National Institute of Standards and Technology 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 those members of your staff identified in the enclosed report.

In accordance with Title 10, Section 2.390 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 (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 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 internet e-mail John.Nguyen@nrc.gov.

Sincerely,

/RA/

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

Docket No. 50-184

Enclosures:
1. Examination Report No. 50-184/OL-18-01
2. Written Examination

cc: Daniel E. Hughes

cc w/o enclosures: See next page

SUBJECT: EXAMINATION CONFIRMATION LETTER NO. 50-184/OL-18-01, NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY DATED APRIL 23, 2018

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ADAMS ACCESSION NO. ML18087A802 **NRR-079**

OFFICE	NRR/DLP/PROB/CE	NRR/DLP/PROB	NRR/DLP/PROB/BC
NAME	JNguyen	AFerguson	AMendiola
DATE	03/29/2018	04/05/2018	04/23/2018

OFFICIAL RECORD COPY

cc:

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Director, Department of Natural Resources
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President
Montgomery County Council
100 Maryland Avenue
Rockville, MD 20850

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

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

REPORT NO.: 50-184/OL-18-01

FACILITY DOCKET NO.: 50-184

FACILITY LICENSE NO.: TR-5

FACILITY: National Institute of Standards and Technology Reactor

EXAMINATION DATES: February 27 – March 1, 2018

SUBMITTED BY: ***/RA/*** **03/27/2018**
John T. Nguyen, Chief Examiner Date

SUMMARY:
During the week of February 26, 2018 the NRC administered operator licensing examinations to four Senior Reactor Operator candidates. The 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	0/0	4/0	4/0
Operating Tests	0/0	4/0	4/0
Overall	0/0	4/0	4/0

3. Exit Meeting:

Tom Newton, Deputy Director, NIST
Warren Eresian, Training Supervisor, NIST
Ricky Sprow, Mechanical Engineer, NIST
John Nguyen, Chief Examiner, NRC

The NRC examiner thanked the facility for their support in the administration of the examinations. The examiner noted that all candidates were well prepared for the examination.

ENCLOSURE 1

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

FACILITY: NIST

REACTOR TYPE: TEST

DATE ADMINISTERED: 02/28/2018

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. 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 ___ (0.33 each)

A03 a b c d ___

A04 a b c d ___

A05 a b c d ___

A06 a b c d ___

A07 a b c d ___

A08 a b c d ___

A09 a b c d ___

A10 a b c d ___

A11 a b c d ___

A12 a b c d ___

A13 a b c d ___

A14 a b c d ___

A15 a b c d ___

A16 a ___ b ___ c ___ d ___ (0.25 each)

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 ___ (0.25 each)

B02 a b c d ___

B03 a b c d ___

B04 a b c d ___

B05 a b c d ___

B06 a ___ b ___ c ___ d ___ (0.25 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 ___ (0.25 each)

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 ___

C04 a b c d ___

C05 a b c d ___

C06 a b c d ___

C07 a b c d ___

C08 a b c d ___

C09 a ___ b ___ c ___ d ___ (0.5 each)

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 ___ (0.25 each)

C18 a ___ b ___ c ___ d ___ (0.25 each)

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

$Q = m\, c_p\, \Delta T$

$Q = m\, \Delta h$

$Q = UA\, \Delta T$

$$SUR = \frac{26.06\,(\lambda_{eff}\rho)}{(\beta - \rho)}$$

$SUR = 26.06/\tau$

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

$P = P_0\, e^{(t/\tau)}$

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

$\tau = (P^*/\rho) + [(\bar{\beta}-\rho)/\lambda_{eff}\rho]$

$\rho = (Keff-1)/Keff$

$\rho = \Delta Keff/Keff$

$\bar{\beta} = 0.007$

$DR_1D_1^2 = DR_2D_2^2$

$Cp\ (H20) = 0.146\ \frac{kw}{gpm} \cong EF$

$\lambda_{eff} = 0.1/\sec$

$SCR = S/(1-Keff)$

$CR_1\,(1-Keff)_1 = CR_2\,(1-Keff)_2$

$$M = \frac{(1-Keff)_0}{(1-Keff)_1}$$

$M = 1/(1-Keff) = CR_1/CR_0$

$SDM = (1-Keff)/Keff$

$I = I_o\, e^{-ux}$

$P^* = 1 \times 10^{-4}$ seconds

$\tau = P^*/(\rho-\bar{\beta})$

$R = 6\, C\, E\, n/r^2$

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

$DR = DR_o e^{-\lambda t}$

$P = S / (1 - Keff)$

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

---

1 Curie = 3.7×10^{10} dps

1 hp = 2.54×10^3 BTU/hr

1 BTU = 778 ft-lbf

931 Mev = 1 amu

1 kg = 2.21 lbm

1 Mw = 3.41×10^6 BTU/hr

EF = 9/5EC + 32

EC = 5/9 (EF - 32)

QUESTION A.01 [1.0 point]
Which ONE of the following is a correct statement of why delayed neutrons enhance the ability to control reactor power than prompt neutrons?

a. Delayed neutrons are born at higher energy levels than prompt neutrons, so delayed neutron can easily cause fission with U-235.

b. Delayed neutrons increase the average neutron lifetime that allows the reactor control rods control the population of delayed neutrons.

c. Prompt neutrons can cause fissions in both U-235 and U-238; whereas delayed neutrons can only cause fissions in U-235.

d. The absorption cross section of delayed neutrons is lower than the absorption cross section of prompt neutrons with U-235.

QUESTION A.02 [1.0 point, 0.33 each]
Match the term listed in Column A with its corresponding unit listed in column B.

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

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

a. 803 W

b. 223 W

c. 94 W

d. 54 W

QUESTION A.04 [1.0 point]
Which ONE of the following is the stable reactor period which will result in a power rise from 1% to 100% power in 2 minutes?

a. 0.5 second

b. 13 seconds

c. 26 seconds

d. 43 seconds

QUESTION A.05 [1.0 point]
Given a source strength of 1000 neutrons per second (N/sec) and $K_{eff} = 0.8$, which ONE of the following is the expected stable neutron count rate?

a. 700 N/sec

b. 5000 N/sec

c. 10000 N/sec

d. 20000 N/sec

QUESTION A.06 [1.0 point]
The reactor is SHUTDOWN by 5 $\%\Delta\rho$ 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.07 [1.0 point]
Inelastic scattering can be described as a process whereby a neutron collides with a nucleus and leaves the nucleus in an excited state. The nucleus later:

a. emits a gamma ray and a neutron with lower energy.

b. emits a gamma ray and a neutron with higher energy.

c. emits a beta particle and a neutron with lower energy.

d. emits an alpha particle ONLY.

QUESTION A.08 [1.0 point]
While a reactor is at 5 watts, the reactor operator is withdrawing a control rod to insert a positive reactivity of 0.156 $\%\Delta\rho$. 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.09 [1.0 point]
For the alpha decay of a nuclide, the number of protons will _____ and its atomic mass number will _____.

a. increase by 2 / increase by 2

b. decrease by 2 /decrease by 4

c. decrease by 4 / decrease by 2

d. increase by 4 / increase by 2

QUESTION A.10 [1.0 point]
A reactor is subcritical with a K_{eff} of 0.927. If you add 7.875%$\Delta\rho$ into the core, the reactor will be:

a. subcritical

b. critical

c. supercritical

d. prompt critical

QUESTION A.11 [1.0 point]
The reactor is critical. A reactor operator makes a mistake by inserting an experiment that causes the reactor to prompt critical. Which ONE of the following best describes the reactor kinetic?

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

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

c. $K_{eff} > 1$ and $\rho > 1$

d. $K_{eff} > 1$ and β-eff $\leq \rho < 1$

QUESTION A.12 [1.0 point]
Which of ONE the following does NOT affect the Effective Multiplication Factor (K_{eff})?

a. The moderator-to-fuel ratio.

b. The physical dimensions of the core.

c. The core materials such as moderator.

d. The strength of the installed neutron source.

QUESTION A.13 [1.0 point]
Which term is described by the following?
"The increase in neutron population by providing a positive additional reactivity while the reactor is subcritical"

a. Inverse Multiplication

b. Subcritical Multiplication

c. Neutron Production

d. Source Strength

QUESTION A.14 [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.15 [1.0 point]
Which ONE of the following factors of the Six Factor formula is most affected by changing the core materials (poison or moderator) in the reactor?

a. Thermal Utilization Factor (f)

b. Resonance Escape Probability (p)

c. Fast Fission Factor (ε)

d. Fast Non-Leakage Factor (L_f)

QUESTION A.16 [1.0 point, 0.25 each]
Replace "X" with the type of decay necessary (Alpha, Beta, Gamma or Neutron emission) to produce the following reactions. Choices may be used once, more than once, or not at all.

a. $_{92}U^{238} \rightarrow {}_{90}Th^{234} + X$

b. $_{83}Bi^{203} \rightarrow {}_{82}Pb^{203} + X$

c. $_{2}He^{4} + {}_{4}Be^{9} \rightarrow {}_{6}C^{12} + X$

d. $_{84}Po^{210} \rightarrow {}_{82}Pb^{206} + X$

QUESTION A.17 [1.0 point]
Given the thermal neutron flux (Ø) is 1.0×10^{13} neutrons/cm^2/second, and the macroscopic cross-section (Σ_f) for fission is 0.1 cm-1. The fission rate is:

a. 1.0×10^{12} fissions/cm/second

b. 1.0×10^{14} fissions /cm/second

c. 1.0×10^{12} fissions/cm^3/second

d. 1.0×10^{14} fissions /cm^3 / second

QUESTION A.18 [1.0 point]
Which ONE of the following describes the term **PROMPT JUMP**?

a. A reactor is subcritical at negative 80-second period.

b. A reactor has attained criticality on prompt neutrons alone.

c. The instantaneous change in power level due to inserting a control rod.

d. The instantaneous change in power level due to withdrawing a control rod.

QUESTION A.19 [1.0 point]
Given the following Core Reactivity Data (not at MITR):

Control Rod	Total Worth ($)	Core excess ($) at 100 watts)	
Shim 1	1.60	Full out (0.0)	
Shim 2	3.50	2.50	
Shim 3	2.70	0.70	
Shim 4	2.30	1.50	
Reg rod	1.20	0.80	

Which one of the following is the calculated shutdown margin that would satisfy the Technical Specification Minimum Shutdown Margin? Assume that all blades are scrammable.

a. $0.6

b. $1.1

c. $2.3

d. $3.5

QUESTION A.20 [1.0 point]
The reactor is operating at 100 W with a fuel temperature of 50 °F. When a control rod with an average rod worth of 0.2%Δρ/inch is withdrawn 5 inches, reactor power increases and becomes stable at a higher level. What is the final fuel temperature? Given the fuel temperature coefficient of reactivity of -1.25 E-4 Δρ / °F and ignoring any other temperature effects.

a. -80 °F

b. 30 °F.

c. 80 °F

d. 130 °F

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

Section B: Normal/Emergency Procedures and Radiological Controls

QUESTION B.01 [1.0 point, 0.25 each]
Fill out a blank with appropriate data provided in the bracket. The Limiting Safety System Settings:

a. for maximum thermal power shall be _____ (125% / 130% /135%) of full power.

b. for the minimum forced coolant flow shall be _____ (60 gpm/MW / 65 gpm/MW / 70 gpm/MW) for the inner plenum.

c. for the maximum outlet temperature shall be _____. (140 °F / 147 °F / 157 °F)

d. for the minimum forced coolant flow shall be _____ (220 gpm/MW / 230 gpm/MW / 235 gpm/MW) for the outer plenum.

QUESTION B.02 [1.0 point]
Reactor Operator works in a high radiation area for eight (8) hours a day. The dose rate in the area is 100 mR/hour. Which ONE of the following is the MAXIMUM number of days in which Reactor Operator may perform his duties WITHOUT exceeding 10 CFR 20 limits?

a. 5 days

b. 6 days

c. 7 days

d. 12 days

QUESTION B.03 [1.0 point]
You receive a quarterly dosimetry report stating that you have received whole body occupational exposures of:
1 mrem of beta
1 mrem of alphas
1 mrem of neutrons of unknown energy
What would be the total effective dose equivalent?

a. 3 mrem

b. 12 mrem

c. 22 mrem

d. 31 mrem

Section B: Normal/Emergency Procedures and Radiological Controls

QUESTION B.04 [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. The absolute reactivity of any experiment exceeding 0.5 %$\Delta\rho$

b. The sum of the absolute value of reactivity of all experiments in the reactor and facilities exceeding 1.3 %$\Delta\rho$

c. explosive materials

d. corrosive materials

QUESTION B.05 [1.0 point]
An annual test of the nuclear instrument was performed. Which ONE of the following is the latest the test that must be performed again without violation of the Technical Specifications?

a. Not to exceed 13 months

b. Not to exceed 14 months

c. Not to exceed 15 months

d. Not to exceed 16 months

QUESTION B.06 [1.0 point, 0.25 each]
Match the events listed in column A with its emergency classification listed in column B. Values in Column B can be used once, more than once or not at all.

	Column A	Column B
a.	Security threat affecting the reactor	1. Unusual Event
b.	Fire in the reactor control room	2. Alert
c.	Hurricane causing a major damage to the fuel and primary water system.	3. Site Area Emergency
d.	Projected radiation levels at the boundary of 20 mremTEDE accumulated in 1hour.	4. General Emergency

QUESTION B.07 [1.0 point]
Per Technical Specifications, the D_2 concentration in the Helium Sweep System shall be _____ by volume.

a. less than 4%

b. higher than 8%

c. less than 8%

d. no limit

QUESTION B.08 [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. 6.5 hours

b. 7.5 hours

c. 8.5 hours

d. 9.5 hours

QUESTION B.09 [1.0 point]
A radioactive material is decayed 30% after one hour. Determine its half-life?

a. 2 hours

b. 3 hours

c. 4 hours

d. 5 hours

Section B: Normal/Emergency Procedures and Radiological Controls

QUESTION B.10 [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. operating whenever it is not unsecured or shutdown.

d. it is capable of performing its intended function.

QUESTION B.11 [1.0 point]
All applicants for an RO or SRO license must submit Form 396 and 398 to the U.S. NRC before taking the examinations. This requirement is specified in 10 CFR:

a. Part 19

b. Part 20

c. Part 50

d. Part 55

QUESTION B.12 [1.0 point]
A two-curie source emits 80% of a 500 K-ev gamma, what is its dose rate at 2 feet?

a. 1.2 R/hr

b. 4.8 R/hr

c. 16 R/hr

d. 21 R/hr

Section B: Normal/Emergency Procedures and Radiological Controls

QUESTION B.13 [1.0 point]
What is a minimum level of authority to approve minor changes of the written procedure? The changes do not effect reactor safety or the intent of the procedure?

a. The Safety Evaluation Committee

b. The Chief, Reactor Operations and Engineering

c. The Reactor Supervisor

d. The Senior Reactor Operator

QUESTION B.14 [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 may be used once, more than once or not at all.)

	Column A	Column B	
a.	Worth of single secured experiment	1.	0.1 %$\Delta\rho$
b.	Worth of sum of the experiment	2.	0.5 %$\Delta\rho$
c.	Excess reactivity	3.	0.757 %$\Delta\rho$
d.	Shutdown margin	4.	1.0 %$\Delta\rho$
		5.	2.6 %$\Delta\rho$
		6.	15 %$\Delta\rho$

QUESTION B.15 [1.0 point]
Which ONE of the following medical facilities is available for handling of contaminated injured personnel?

a. Montgomery County Emergency Service.

b. National Institute of Health (NIH).

c. Shady Grove Medical Center.

d. Holy Cross Germantown Hospital.

Section B: Normal/Emergency Procedures and Radiological Controls

QUESTION B.16 [1.0 point]
The charcoal emergency filter bank shall be verified its efficiency of 99%. The verification shall be performed at least:

a. quarterly

b. semi-annually

c. annually

d. biennially

QUESTION B.17 [1.0 point]
The below items are listed as the special reports, EXCEPT:

a. Fuel cladding failure.

b. Shutdown margin provided by the shim arms is greater than 5 %$\Delta\rho$.

c. Reactor operation when one of shim arms is inoperable.

d. Performance of Reactor operation without a completion of the startup checklist.

QUESTION B.18 [1.0 point]
The principal barrier to be used for specification of the safety limit is the:

a. Reactor fuel cladding temperature.

b. Reactor thermal power.

c. Bulk pool temperature.

d. Coolant height.

QUESTION B.19 [1.0 point]
Which ONE of the following changes must be submitted to NRC for approval prior to implementation?

a. Replace a secondary cooling pump with an 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 Section 6.8, Records, listed in the NBSR Technical Specifications.

QUESTION B.20 [1.0 point]
Per NBSR Technical Specifications, the insertion rates of four shim arms simultaneously shall not exceed _____.

a. 5×10^{-3} $\Delta\rho$/sec

b. 5×10^{-4} $\Delta\rho$/sec

c. 5×10^{-3} $\%\Delta\rho$/sec

d. 5×10^{-4} $\%\Delta\rho$/sec

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

Section C: Facility and Radiation Monitoring Systems

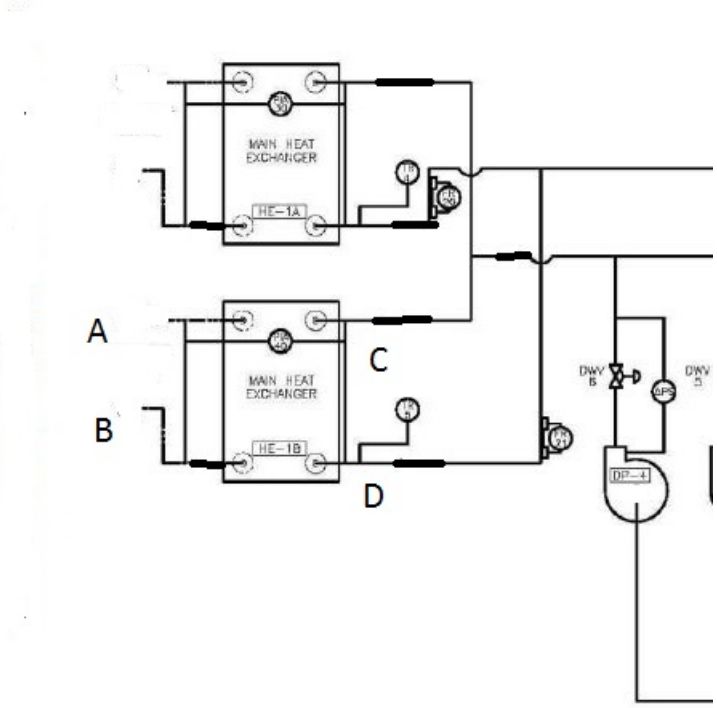
QUESTION C.01 [1.0 point]
The figure below depicts a part of the NBSR primary coolant system. Which one of the following labels is the primary water INPUT to the heat exchanger?

a. A

b. B

c. C

d. D



Section C: Facility and Radiation Monitoring Systems

QUESTION C.02 [1.0 point]
If AC power is lost to the input of both battery chargers, the trickle charge to the sixty cell lead acid battery bank would cease and that battery bank would assume the loads on the 125 VDC panel for about _____.
.

a. 2 hours

b. 3 hours

c. 4 hours

d. Unlimited

QUESTION C.03 [1.0 point]
During emergency conditions, the MAIN purpose of the activated charcoal section in the filter bank is to remove 99% of any airborne radioactive _____ present in the reactor room air.

a. Argon-41

b. Nitrogen -16

c. Iodine

d. Xenon-135

QUESTION C.04 [1.0 point]
Which ONE of the following will cause the reactor RUNDOWN if exceeding the Limiting Safety System Setting?

a. High flux level.

b. Low reactor vessel D_2O.

c. Low flow reactor outlet.

d. Reactor outlet temperature.

Section C: Facility and Radiation Monitoring Systems

QUESTION C.05 [1.0 point]
Which ONE of the following signals will generate a MAJOR SCRAM?

a. High flux level

b. Short period below 5% rated power

c. High gaseous effluent monitor activity level

d. Manual (outside of the control room)

QUESTION C.06 [1.0 point]
Which ONE of the following will automatically cause the confinment isolation if exceeding its limit setting?

a. Area Radiation Monitor in the control room.

b. Loss of primary coolant flow.

c. Stack Gas Monitor.

d. Tritium Monitor.

QUESTION C.07 [1.0 point]
Which ONE of the following best describes the ventilation system under accident condition? If high radiation levels are detected:

a. all ventilation systems will be completely shutdown. No air interior is circulated in the confinement building.

b. the normal ventilation system will be shutdown. The emergency ventilation system will be activated. The emergency exhaust fans AUTOMATICALLY turn ON to draw down the building air until a pressure of -0.25" H_2O is reached.

c. the normal ventilation system will be shutdown. The emergency ventilation system will be activated. The emergency exhaust fans MANUALLY turn ON to draw down the building air until a pressure of -0.25' H_2O is reached.

d. the normal ventilation system will be shutdown. The emergency ventilation system will be activated. The emergency exhaust fans AUTOMATICALLY turn ON to draw down the building air until a pressure of +0.25" H_2O is reached.

Section C: Facility and Radiation Monitoring Systems

QUESTION C.08 [1.0 point]
Which ONE of the following best describes how the Uncompensated Ion Chamber (UIC) and Compensated Ion Chamber (CIC) operate?

a. 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.

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 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.

QUESTION C.09 [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 High Flux Channel NC-3 and NC-4 during reactor operations	1. Channel Check
b.	During startup, you verify the reactor period scram	2. Channel Test
c.	During startup, you verify the MAJOR manual scram.	3. Channel Calibration
d.	You adjust a limit setting of gaseous effluent monitor after conducting a source calibration.	

Section C: Facility and Radiation Monitoring Systems

QUESTION C.10 [1.0 point]
The MAIN purpose of a safety relief valve installed on the 3" line branched from the suction line of DP-4 is to:

a. Prevent over-pressurization of the primary system by relieving pressure when exceeded.

b. Prevent over-pressurization of the secondary system by relieving pressure when exceeded.

c. Prevent over-pressurization of the primary system by isolating the core water to the D_2O storage tank.

d. Add D_2O from storage tank to the core when water core level exceeded.

QUESTION C.11 [1.0 point]
During a reactor operation, you discover the Fission Product Monitor (FPM) 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 FPM is still operable.

c. Continue with reactor operation. Up to 1 week hours is allowed to run reactor before replacing the new monitor.

d. Continue with reactor operation. The Technical Specifications require two of three gaseous effluent monitors during reactor operation.

QUESTION C.12 [1.0 point]
The main purpose for providing a moderator dump system is to:

a. Maintain the departure of nucleate boiling ratio (DNBR) greater than the unity.

b. Provide a shutdown capability for any core configuration.

c. Maximize gamma dose to the experiments if needed.

d. Minimize Ar-41 released to the public.

Section C: Facility and Radiation Monitoring Systems

QUESTION C.13 [1.0 point]
You discover several scratches on the outer plate of a fuel element. You inform the Reactor Supervisor who decides to use the element. The decision to use this element was:

a. appropriate because the outer plates contain no fuel.

b. appropriate because the outer two plates are thicker than the inner plates, due to thicker cladding.

c. inappropriate because of the higher fuel loading of the outer plates.

d. inappropriate because it could lead to fission product release from the plate due to reduced cladding.

QUESTION C.14 [1.0 point]
The final step in testing the safety system in the startup checklist is:

a. Initiate a MAJOR scram with all shim arms at 12˚.

b. Initiate a scram with all shim arms at 12˚.

c. Initiate a scram with all shim arms at 6˚

d. Initiate a Rundown Test.

QUESTION C.15 [1.0 point]
The neutron startup source for NBSR is an encapsulated:

a. Americium-Beryllium (Am-Be)

b. Plutonium-Beryllium (Pu-Be)

c. Radon-Beryllium (Ra-Be)

d. Beryllium Reflector

Section C: Facility and Radiation Monitoring Systems

QUESTION C.16 [1.0 point]
Which ONE of the following is NOT required to be determined for core shutdown margin?

a. Annually surveillance is required

b. Core reflection is changed

c. Shim arm is changed

d. The reactivity worth of experiments is changed

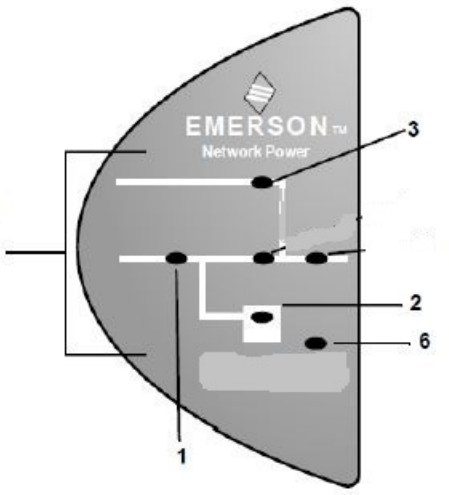
QUESTION C.17 [1.0 point, 0.25 each]
Figure below depicts the front panel mimic indicator for the Liebert UPS in C200. Match each of the Mimic indicators in column A with its corresponding value numbers.

a. Status indicator

b. Rectifier indicator

c. Bypass indicator

d. Battery indicator



Section C: Facility and Radiation Monitoring Systems

QUESTION C.18 [1.0 point, 0.25 each]
Match the input signals listed in column A with their responses listed in column B. (Items in column B can be used once, more than once or not at all.)

	Column A		Column B
a.	Source Range Period = 16 sec	1.	Indicate ONLY
b.	Count rate signal (NC-1) = 1 cps	2.	Interlock
c.	Building Exhaust Activity (RM3-4) = 55k cpm	3.	Rod Run down
d.	48V Relay Power OFF	4.	Scram

QUESTION C.19 [1.0 point]
The following rules apply during the refueling work affecting core reactivity, EXCEPT:

a. All shim arms at their bottom limit and Control Power and Rod Drive Power keys off and removed from the console.

b. At least two on-scale nuclear channels shall be operational.

c. A licensed operator shall be stationed in the Control Room to monitor instrumentation.

d. The emergency ventilation shall be activated.

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

Section A - Theory, Thermo & Fac. Operating Characteristics

A.01
Answer: b
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1982, Section 3.3.7, page 3-37

A.02
Answer: a(2) b(1) c(3) (0.33 each)
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, Sec 2.6

A.03
Answer: b
Reference: $P = P0\ e^{-t/T}$ = 1 kW * e(120sec/-80sec) = 1 kW * exp(-1.5) = 0.22 * 1 kW = 0.223 kW = 223 W

A.04
Answer: c
Reference: $P = P_0\ e^{t/T}$ —> T= t/Ln(P/ P_0)
T= 120/Ln(100); T = 26 sec.

A.05
Answer: b
Reference: CR = S/(1-K) → CR = 1000/(1 - 0.8) = 5000 N/sec

A.06
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.07
Answer: a
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Sec 2.4.5, page 2-29.

A.08
Answer: c
Reference: Reactivity added = 0.156 %∆k/k = 0.00156 ∆k/k
$\tau = (\beta-\rho)/\lambda_{eff}\rho$ = (0.0073 - 0.00156)/ ((0.1)*(0.00156))
= 37 seconds

A.09
Answer: b
Reference: Chart of the Nuclides

A.10
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 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 critical

A.11
Answer: d
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Sec 4.2

A.12
Answer: d
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Sec 3.3.2

A.13
Answer: b
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, Section 5.1, Subcritical Multiplication

A.14
Answer: c
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Section 3.2, Table 3.1

A.15
Answer: a
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Sec 3.3.1

A.16
Answer: a, alpha b, $_{+1}\beta^{0}$ c, neutron d, alpha (0.25 each)
Reference: NRC Standard Question

A.17
Answer: c
Reference: Fission rate = thermal flux (Ø) x macroscopic cross-section. (Σ_f) = 1.0 x 10^{13} neutrons/cm^2/second x 0.1 cm^{-1} = 1.0 × 10^{12} neutrons/cm^3/second
Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Sec 2.6.2

A.18
Answer: d
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1982, Page 4-21.

A.19
Answer: b
Reference: Shutdown = Total rod worth – core excess
$11.3 – $5.5 = $5.8
Minimum SDM = Shut down – (highest worth of control rod + Reg rod worth)
$5.8 - $3.5 + $1.2 = $1.1

A.20
Answer: d
Reference: Reactivity added by control rod = +(0.002 Δk/k/inch)((5 inches) = 0.01 Δ k/k
Fuel temperature change = - reactivity of rod/fuel temp. coeff.
(- 0.01 Δ k/k)/(- 1.25E-4 Δ k/k/°F) = 80 °F
Final Fuel temperature = 50 °F +80 °F = 130 °F

Section B - Normal/Emergency Procedures and Radiological Controls

B.01
Answer: a (130%) b (60 gpm/MW) c (147 degree F) d. (235 gpm/MW) (0.25 each)
Reference: TS 2.2

B.02
Answer: b
Reference: 10CFR20.1201(a)(1) [5000 mr x $\frac{1\ hr}{100\ mr}$ x $\frac{day}{8\ hr}$ = 6.25 days

B.03
Answer: a
Reference: The report already provides a conversion in mrem, so you just add them up.

B.04
Answer: a
Reference: TS 3.8.1 & 3.8.2

B.05
Answer: c
Reference: TS Definition 1.3.32

B.06
Answer: a(1) b(1) c(3) d(2) (0.25 each)
Reference: EP 4.0 and 5.0

B.07
Answer: a
Reference: TS 3.3.1

B.08
Answer: b
Reference: $DR = DR_{\circ} * e^{-\lambda t}$
$1.25\ rem/hr = 5\ rem/hr * e^{-\lambda(5hr)}$
$Ln(1.25/5) = -\lambda * 5 \rightarrow \lambda = 0.277$; solve for t: $Ln(.625/5) = -0.277 * t$
t=7.5 hours

B.09
Answer: a
Reference: $DR = DR_{\circ} * e^{-\lambda t}$
30% is decayed, so 70% is still there $70\% = 100\% * e^{-\lambda(3hrs)}$
$Ln(70/100) = -\lambda * 1 \rightarrow \lambda = 0.357$ $t_{1/2} = Ln(2)/\lambda \rightarrow .693/.357$ t=1.94 hours

B.10
Answer: d
Reference: TS 1.3.12

B.11
Answer: d
Reference: 10CFR55

Section B - Normal/Emergency Procedures and Radiological Controls

B.12
Answer: a
Reference: 6CEN = R/hr @ 1 ft. -> 6 x 2 x 0.8 x 0.5 = 4.8 R/hr at 1ft.
At 2 feet: $I_1 * D_1^{\ 2} = I_2 * D_2^{\ 2}$
4.8 R/hr * 1 = X * 4
X = 4.8 R/hr / 4 = 1.2 R/hr

B.13
Answer: c
Reference: TS 6.4

B.14
Answer: a, 2 b,5 c,6 d,3 (0.25 each)
Reference: TS 1.3.19 & 3.8

B.15
Answer: a
Reference: Emergency Plan 8.3

B.16
Answer: d
Reference: TS 4.5.4

B.17
Answer: b
Reference: TS 6.7.2

B.18
Answer: a
Reference: TS 2.1

B.19
Answer: d
Reference: 10 CFR 50.59
Any TS changes required an amendment.

B.20
Answer: b
Reference: TS 3.2.1

Section C - Facility and Radiation Monitoring Systems

C.01
Answer: c
Reference: SAR, Figure 5.1

C.02
Answer: c
Reference: SAR 8.1.2.4

C.03
Answer: c
Reference: TS 4.5.4

C.04
Answer: d
Reference: TS 3.2.2

C.05
Answer: c
Reference: TS 3.2.2

C.06
Answer: c
Reference: SOP O.I. 1.1

C.07
Answer: b
Reference: SAR 6.2.3.2.2

C.08
Answer: d
Reference: SAR 7.3.1.1

C.09
Answer: a (1) b(2 c(2) d(3) (0.5 each)
Reference: TS 1.3.2

C.10
Answer: a
Reference: SAR 5.2.2.4.2

C.11
Answer: a
Reference: TS 3.7.1

C.12
Answer: b
Reference: TS 3.3.3

Section C - Facility and Radiation Monitoring Systems

C.13
Answer: a
Reference: TS 5.3

C.14
Answer: b
Reference: SOP OI 1.1 CL-A

C.15
Answer: a
Reference: SAR 4.2.4

C.16
Answer: d
Reference: NRC Standard Question

C.17
Answer: a (6) b(1) c(3) d(2) (0.25 each)
Reference: SOP OI 5.8

C.18
Answer: a (1) b(2) c(4) d(4) (0.25 each)
Reference: SAR, Table 7.1, 7.2 , and 7.3

C.19
Answer: d
Reference: SOP OI 6.1