July 13, 2016

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-16-01, NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY

Dear Dr. Newton:

During the week of June 22, 2016, the U.S. Nuclear Regulatory Commission (NRC) administered an operator licensing examination at your National Institute of Standards ad Technology reactor. The examination was conducted according to NUREG-1478, "Operator Licensing Examiner Standards for Research and Test Reactors," Revision 2. Examination questions and preliminary findings were discussed with you and those members of your staff identified in the enclosed report at the conclusion of the examination.

In accordance with Title 10 of the Code of Federal Regulations Section 2.390, a copy of this letter and the enclosure will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records (PARS) component of NRC's Agencywide Documents Access and Management System (ADAMS). ADAMS is accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html. The NRC is forwarding the individual grades to you in a separate letter which will not be released publicly. Should you have any questions concerning this examination, please contact Mrs. Paulette Torres at (301) 415-5656 or via e-mail at Paulette.Torres@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. 50-184
Enclosures: 1. Examination Report No. 50-184/OL-16-01
2. Facility Comments with NRC Resolution
3. Written Examination
cc: w/o enclosure: See next page

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DISTRIBUTION w/ encl.
Public RidsNrrDprPrtb RidsNrrDprPrta

ADAMS Accession No. ML 16190A159 **NRR-074**

OFFICE	NRR/DPR/PROB/CE	NRR/DIRS/IOLB/OLA	NRR/DPR/PROB/BC
NAME	PTorres	CRevelle	AMendiola
DATE	6/28/2016	7/08/2016	7/13/2016

OFFICIAL RECORD COPY

cc:

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Director, Department of Natural Resources
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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-16-01

FACILITY DOCKET NO.: 50-184

FACILITY LICENSE NO.: TR-5

FACILITY: National Institute of Standards and Technology Reactor

EXAMINATION DATE: June 22, 2016

SUBMITTED BY: **/RA/** **07/12/16**
Paulette Torres, Chief Examiner Date

SUMMARY:

During the week of June 22, 2016 the NRC administered a licensing examination to one Senior Reactor Operator (SRO) instant candidate. The candidate passed all applicable portions of the examinations.

REPORT DETAILS

1. Examiner: Paulette Torres, Chief Examiner, NRC

2. Results:

	RO PASS/FAIL	SRO PASS/FAIL	TOTAL PASS/FAIL
Written	0/0	1/0	1/0
Operating Tests	0/0	1/0	1/0
Overall	0/0	1/0	1/0

3. Exit Meeting:

Paulette Torres, Chief Examiner, NRC
Daniel E. Hughes, Chief of Reactor Operations
Dr. Tom Newton, Deputy Director

The facility licensee agreed to email their comments on the written examination which were incorporated into the examination report (see Enclosure 2).

ENCLOSURE 1

FACILITY COMMENTS ON THE WRITTEN EXAM WITH NRC RESOLUTION

QUESTION B.13 [1.0 point]
Per Technical Specifications procedures, which ONE of the following is an initial condition for Testing of Primary System Relief Valve?

a. Reactor operating

b. Reactor shutdown

c. Auxiliary D_2O system running

d. Auxiliary D_2O systems shutdown

Answer: d
REF: Technical Specifications Procedures 4.3.1(1), pg. 1 of 1

Facility Comments &
Recommendations: An operator cannot view a single procedure as existing by itself. The initial conditions given for T.S.P 4.4.1(1), Testing of Primary System Relief Valve step 1.1 are: Primary coolant system shutdown per O.I. 2.1; D2O auxiliary system shutdown , per O.I. 2.2; and Helium Sweep shutdown per O.I. 4.1. The initial condition for O.I. 2.1 (step 3.1.1) and for O.I. 2.2 (step 2.1.1) list that the Reactor is shutdown. An initial condition for O.I. 2.1 and O.I. 2.2 must also be an initial condition for T.S.P 4.4.1(1). This would make answers (b) and (d) both correct.

NRC Resolution: The NRC agrees with the facility comment and accepts answers (b) and (d) to be correct for question B.13.

QUESTION B.15 [1.0 point]
A radioactive source generates a dose of 100 mR/hr at a distance of 10 feet. Using a two inch thick sheet of lead for shielding the reading drops to 50 mR/hr at a distance of 10 feet. What is the minimum number of sheets of the same lead shielding needed to drop the reading to less than 5 mR/hr at a distance of 10 feet?

a. 3

b. 4

c. 5

d. 6

Answer: c
REF: Two inches = one-half thickness ($T_{½}$). Using 5 half-thickness will drop the dose by a factor of $(½)^5 = 1/32$. Then 100/32 = 3.125 mR/hr

ENCLOSURE 2

Facility Comments & Recommendations: The question is unclear if the minimum number of lead sheets requested counts the first sheet or how many additional sheets are required. If it is total, then (c) is correct. If it is additional sheets, then (b) is correct. In other words, is the question: “What is the minimum number of sheets of the same lead shielding needed to drop the reading (of 100 mR/hr) to less than 5 mR/hr at a distance of 10 feet?” or “What is the minimum number of sheets of the same lead shielding needed to drop the reading (of 50 mR/hr) to less than 5mR/hr at a distance of 10 feet?” In the first case the answer is c. In the second case the answer is b.

NRC Resolution: The NRC intended to ask “What is the minimum number of sheets of the same lead shielding needed to drop the reading (of 100 mR/hr) to less than 5 mR/hr at a distance of 10 feet?” Based on this question, the NRC noted that there are two correct answers, (c) for 5 sheets as stated in the reference and (d) for 6 sheets ($(½)^6 = 1/64$. Then 100/64 = 1.563 mR/hr). Since there is ambiguity on this question and the opportunity for three correct answers, the NRC has decided to delete question B.15 from the examination.

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

FACILITY: National Institute of Standards and Technology

REACTOR TYPE: TEST

DATE ADMINISTERED: 06/22/2016

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
19.00 ~~20.00~~	33.3	_____	_____	B. NORMAL AND EMERGENCY OPERATING PROCEDURES AND RADIOLOGICAL CONTROLS
20.00	33.3	_____	_____	C. FACILITY AND RADIATION MONITORING SYSTEMS
59.00 ~~60.00~~		_____	_____ %	TOTALS
		FINAL GRADE		

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

_____
Candidate's Signature

ENCLOSURE 3

A. Reactor Theory, Thermohydraulics & Facility Operating Characteristics

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 d ___

A15 a b c d ___

A16 a b c d ___

A17 a b c d ___

A18 a b c d ___

A19 a b c d ___

A20 a b c d ___

(***** END OF SECTION A *****)

B. Normal/Emergency Procedures and Radiological Controls

A N S W E R S H E E T

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

B01 a b c d ___

B02 a b c d ___

B03 a b c d ___

B04 a b c d ___

B05 a b c d ___

B06 a b c d ___

B07 a b c d ___

B08 a b c d ___

B09 a b c d ___

B10 a b c d ___

B11 a b c d ___

B12 a b c d ___

B13 a b c d ___

B14 a b c d ___

~~B15 a b c d ___~~ (deleted per facility/NRC comment)

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 SECTION B *****)

C. Facility and Radiation Monitoring Systems

A N S W E R S H E E T

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

C01 a b c d ___

C02 a b c d ___

C03 a b c d ___

C04 a b c d ___

C05 a b c d ___

C06 a b c d ___

C07 a b c d ___

C08 a b c d ___

C09 a b c d ___

C10 a b c d ___

C11 a ___ b ___ c ___ d ___

C12 a b c d ___

C13 a b c d ___

C14 a b c d ___

C15 a b c d ___

C16 a b c d ___

C17 a b c d ___

C18 a b c d ___

C19 a ___ b ___ c ___ d ___

C20 a b c d ___

(***** END OF SECTION 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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

1 kg = 2.21 lbm

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

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY

Operator Licensing Examination

Week of June 22, 2016

QUESTION A.01 [1.0 point]
Tritium, produced via $^{2}H(n,\gamma)^{3}H$, is a:

a. Low Energy Beta Emitter

b. Low Energy Gamma Emitter

c. High Energy Beta and Gamma Emitter

d. Low Energy Beta and High Energy Gamma Emitter

QUESTION A.02 [1.0 point]
Which ONE of the following is true about “Reflectors”?

a. Produces neutrons.

b. Decrease the critical mass of fissile material.

c. Have a high neutron absorption cross section.

d. Decreases the average power output for a given peak neutron flux.

QUESTION A.03 [1.0 point]
The term “Macroscopic Cross Section” is defined as:

a. An indication of energy loss per collision.

b. The probability of neutron interaction per centimeter of travel in a material.

c. The average distance travelled by a neutron between interactions in a material.

d. The effective cross sectional area of a single nucleus presented to an oncoming neutron.

QUESTION A.04 [1.0 point]
The count rate is 100 cps. An experimenter inserts an experiment into the core using the pneumatic system, and the count rate decreases to 70 cps. Given the initial K_{eff} of the reactor was 0.9, what is the worth of the experiment?

a. $\Delta\rho = - 0.56$

b. $\Delta\rho = + 0.56$

c. $\Delta\rho = - 0.03$

d. $\Delta\rho = + 0.03$

QUESTION A.05 [1.0 point]
Which ONE of the following is the MAJOR source of energy released during fission?

a. Kinetic energy of the fission fragments.

b. Kinetic energy of the fission neutrons.

c. Decay of the fission fragments.

d. Prompt gamma rays.

QUESTION A.06 [1.0 point]
Most text books list β for a U^{235} fueled reactor as 0.0065 ΔK/K and β_{eff} as being 0.0075 ΔK/K. Why is β_{eff} larger than β?

a. Delayed neutrons are born at higher energies than prompt neutrons resulting in a greater worth for these neutrons.

b. Delayed neutrons are born at lower energies than prompt neutrons resulting in a less loss due to leakage for these neutrons.

c. The fuel includes U^{238} which has a relatively large for fast fission.

d. Some U^{238} in the core becomes Pu^{239} (by neutron absorption) which has a larger for fission.

QUESTION A.07 [1.0 point]
As the moderator temperature increases, the resonance escape probability _____.

a. Increases, since the moderator becomes less dense.

b. Decreases, since the time required for a neutron to reach thermal energy increases.

c. Remains constant, since the effect of moderator temperature change is relatively small.

d. Increases, since the moderator-to-fuel ratio increases.

QUESTION A.08 [1.0 point]
Two minutes following shutdown, reactor power is at 10 kW and decreases with a constant reactor period. Which ONE of the following is the correct power for three minutes later?

a. 0.5 kW

b. 1.1 kW

c. 3.3 kW

d. 6.7 kW

QUESTION A.09 [1.0 point]
Which of the following statements is the predominant factor for the change in Xenon concentration for several hours following a reactor scram? Xe-135 concentration will _____.

a. Increase due to reduced nuclear flux.

b. Increase due to the decay of the I-135 inventory.

c. Decrease by natural decay into I-135.

d. Remain constant until it is removed via neutron burnout during the subsequent reactor startup.

QUESTION A.10 [1.0 point]
Which one of the following correctly describes the relationship between differential rod worth (DRW) and integral rod worth (IRW)?

a. DRW is the slope of the IRW curve at a given location.

b. DRW is the area under the IRW curve at a given location.

c. DRW is the square root of the IRW curve at a given location.

d. There is no relationship between DRW and IRW.

QUESTION A.11 [1.0 point]
During a Subcritical Multiplication "1/M" plot, data is required to be taken. What does the 1/M represent?

a. The inverse of fuel elements presented in the core

b. The inverse of the moderator coefficient of reactivity

c. The inverse migration length of neutrons of varying energies

d. The inverse multiplication of the count rate between generations

QUESTION A.12 [1.0 point]
INELASTIC scattering is the process by which a neutron collides with a nucleus and:

a. Recoils with the same kinetic energy it had prior to the collision.

b. Recoils with a lower kinetic energy than it had prior to the collision, with the nucleus emitting a gamma ray.

c. Is absorbed, with the nucleus emitting a gamma ray.

d. Recoils with a higher kinetic energy than it had prior to the collision, with the nucleus emitting a gamma ray.

QUESTION A.13 [1.0 point]
A reactor is at a power level of 50 watts. The operator IMMEDIATELY inserts an experiment with a reactivity worth of $1.00 into the core using the pneumatic system. This insertion will cause:

Given:
T: reactor period, ℓ^*: Prompt neutron lifetime; ρ: reactivity insertion; β: beta fraction

a. A delayed reactor period to be equal to NEGATIVE (-) 80 seconds

b. A number of prompt neutrons equals to a number of delayed neutrons

c. The immediate reactor period to be a function of the prompt neutron lifetime ($T=\ell^*/\rho$)

d. A sudden change of power that equals to the initial power multiplied by $\beta(1-\rho)/(\beta-\rho)$

QUESTION A.14 [1.0 point]
Core Excess Reactivity changes with:

a. Fuel Element Burnup

b. Control Rod Height

c. Neutron Energy Level

d. Reactor Power Level

QUESTION A.15 [1.0 point]
The reactor is critical at 5 watts. Which ONE of the following correctly describes the reactor behavior when rods are withdrawn with a reactivity worth of +0.50 % $\Delta K/K$?

a. Subcritical

b. Critical

c. Supercritical

d. Delayed critical

QUESTION A.16 [1.0 point]
By definition, an exactly critical reactor can be made prompt critical by adding positive reactivity equal to:

a. The shutdown margin

b. The effective multiplication factor

c. The β_{eff} value

d. 1.0 % $\Delta K/K$

QUESTION A.17 [1.0 point]
Which ONE of the following is the correct reason that delayed neutrons enhance control of the reactor?

a. There are more delayed neutrons than prompt neutrons.

b. Delayed neutrons increase the average neutron generation time.

c. Delayed neutrons take longer to reach thermal equilibrium.

d. Delayed neutrons are born at higher energies than prompt neutrons and therefore have a greater effect.

QUESTION A.18 [1.0 point]
Which ONE of the following correctly describes the Six Factor Formula?

a. $K_\infty = K_{eff}$ * the resonance escape probability (p)

b. $K_\infty = K_{eff}$ * the total non-leakage probability ($L_f * L_{th}$)

c. $K_{eff} = K_\infty$ * the total non-leakage probability ($L_f * L_{th}$)

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

QUESTION A.19 [1.0 point]
Which ONE of the following has the highest thermal neutron cross section?

a. Cd-113

b. Xe-135

c. Sm-149

d. U-235

QUESTION A.20 [1.0 point]
The _____ is the ratio of delayed to total core neutrons once they have slowed down to thermal energies.

a. Mean Neutron Lifetime

b. Prompt Neutron Lifetime

c. Delayed Neutron Generation Time

d. Effective Delayed Neutron Fraction

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

QUESTION B.01 [1.0 point]
Per Technical Specifications, which ONE of the following Reactor Safety System Channels has a RUNDOWN minimum nuclear and process channel requirement?

a. Gaseous Effluent Monitors

b. Reactor Outlet Temperature

c. Low flow reactor inner or outer plenum

d. High Flux level

QUESTION B.02 [1.0 point]
Per Technical Specifications applicable to the Primary Fluid Systems, all of the following are true EXEPT:

a. A source of makeup water to the D_2O emergency cooling tank is available.

b. The D_2 concentration in the Helium Sweep System shall not exceed 4% by volume.

c. The reactor vessel coolant level is no more than 25 inches below the overflow standpipe.

d. All materials, including those of the reactor vessel, in contact with the primary coolant shall be compatible with the D_2O environment.

QUESTION B.03 [1.0 point]
Per Technical Specifications, which ONE of the following Limiting Condition for Operation has an applicability for fuel burnup?

a. The maximum available excess reactivity for reference core conditions shall not exceed 15% $\Delta\rho$ (approximately \$20).

b. The average fission density shall not exceed 2×10^{27} fissions/m^3.

c. The nominal reactor power shall not exceed 20 MW thermal.

d. The reactor shall not operate unless all grid positions are filled with full length fuel elements or thimbles.

QUESTION B.04 [1.0 point]
Per Technical Specifications, which ONE of the following Reactor Shutdown Mechanisms provides sufficient negative reactivity to make the normal startup (SU) core subcritical even with all four shim arms fully withdrawn?

a. Rundown

b. Scram

c. Rod Stop Signal

d. Moderator Dump

QUESTION B.05 [1.0 point]
A small radioactive source is to be stored in the reactor building. The source reads 2 Rem/hr at 1 foot. Assuming no shielding is to be used, a Radiation Area barrier would have to be established from the source at least a distance of approximately:

a. 400 feet

b. 40 feet

c. 20 feet

d. 10 feet

QUESTION B.06 [1.0 point]
Per Technical Specifications, an operability test of the emergency exhaust system, including the building static pressure controller and the vacuum relief valve, shall be performed _____.

a. Monthly

b. Quarterly

c. Annually

d. Biennially

QUESTION B.07 [1.0 point]
Per Emergency Plan, under what conditions a radiation worker can have exposure in excess of 10 CFR 20 limits?

a. During a declared Site Area Emergency.

b. In an emergency, for lifesaving activities and other serious events.

c. As long as the radiation worker don't exceed 50 Rem whole body for lifesaving.

d. In an emergency declared by the Emergency Coordinator with concurrence of the Senior Reactor Operator.

QUESTION B.08 [1.0 point]
Per Annunciator Procedure, a possible cause for a HE Sweep Activity High alarm is:

a. D_2O Leak or Spill

b. Argon-41 Release

c. Fuel Element Cladding Failure

d. Thermal Colum Or Beam Port Operations

QUESTION B.09 [1.0 point]
Per Emergency Plan, which ONE of the following is considered an Alert?

a. Prolonged fire threatening the reactor.

b. 375 mrem TEDE accumulated in 24 hours.

c. Security breach affecting the reactor confinement.

d. Report or observation of severe natural phenomenon threatening the reactor.

QUESTION B.10 [1.0 point]
_____ are specific thresholds that initiate appropriate emergency measures.

a. Protection Action

b. Emergency Classes

c. Emergency Procedures

d. Emergency Action Levels

QUESTION B.11 [1.0 point]
Per Emergency Plan, following an evacuation during an emergency, who by title, shall authorize re-occupation of the facility?

a. NBSR Management

b. Emergency Director

c. Emergency Coordinator

d. Senior Health Physicist

QUESTION B.12 [1.0 point]
Which ONE of the following defines the term “Radiation Area”?

a. Any area to which access is limited for any reason.

b. Any area to which access is limited for the purpose of protecting individuals against undue risks from exposure to radiation and radioactive materials.

c. Area where radiation exposure rates would result in a dose equivalent in excess of 5 mrem (0.05 mSv) in one hour at 30 centimeters from the radiation source.

d. Area where radiation exposure rates would result in a dose equivalent in excess of 0.1 rem (1 mSv) in one hour at 30 centimeters from the radiation source.

QUESTION B.13 [1.0 point]
Per Technical Specifications procedures, which ONE of the following is an initial condition for Testing of Primary System Relief Valve?

a. Reactor operating

b. Reactor shutdown

c. Auxiliary D_2O system running

d. Auxiliary D_2O systems shutdown

QUESTION B.14 [1.0 point]
Per Fueling and Defueling Procedures, in the _____ position, the pickup tool is resting in the maze.

a. Receiving

b. Safety

c. Stowed

d. Transfer

~~**QUESTION B.15 [1.0 point]** (deleted per facility/NRC comment)~~
~~A radioactive source generates a dose of 100 mR/hr at a distance of 10 feet. Using a two inch thick sheet of lead for shielding the reading drops to 50 mR/hr at a distance of 10 feet. What is the minimum number of sheets of the same lead shielding needed to drop the reading to less than 5 mR/hr at a distance of 10 feet?~~

~~a. 3~~

~~b. 4~~

~~c. 5~~

~~d. 6~~

QUESTION B.16 [1.0 point]
Reactor Operator works in a high radiation area for eight (8) hours a day. The dose rate in the area is 125 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.17 [1.0 point]
10 CFR 20 defines the "Committed Dose Equivalent" as:

a. The dose equivalent to organs or tissues of reference (T) that will be received from an intake of radioactive material by an individual during the 50-year period following the intake. The units are rem and sievert (Sv).

b. The sum of the products of the weighting factors applicable to each of the body organs or tissues that are irradiated and the committed dose equivalent to these organs or tissues. The units are rem and sievert (Sv).

c. Applies to external whole-body exposure; the dose equivalent at a tissue depth of 1 cm (1000 mg/cm^2). The units are rem and sievert (Sv).

d. The product of the absorbed dose in tissue, quality factor, and all other necessary modifying factors at the location of interest. The units are rem and sievert (Sv).

QUESTION B.18 [1.0 point]
With regard to Radiation Work Permits (RWPs), which ONE of the following statements is NOT true?

a. The work to be performed should be discussed with the Reactor Supervisor and/or Reactor Health Physics in order to evaluate the radiological problems and conditions and to determine the need for an RWP.

b. All radiation safety precautions, monitoring, controls, and personal protective equipment (PPE) that may be required for the job shall be listed on the RWP.

c. The RWP is approved in writing by Reactor Health Physics and the Reactor Supervisor.

d. The RWP will be made out in duplicate. Copy 1, the working copy, is given to the person performing the work or posted in the work area and copy 2 goes to the Reactor Health Physics File.

QUESTION B.19 [1.0 point]
The 14” inlet flow set point for 20 MW operation trips at:

a. 1400 gpm

b. 2000 gpm

c. 5000 gpm

d. 6500 gpm

QUESTION B.20 [1.0 point]
You are currently the licensed operator at the control of the reactor. Which ONE of the following violates 10 CFR Part 55.53 “Conditions of licenses”?

a. Last license medical examination was 26 months ago.

b. Last requalification operating test was 11 months ago.

c. Last quarter you were the licensed operator for 6 hours.

d. Last requalification written examination was 13 months ago.

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

QUESTION C.01 [1.0 point]
Per Technical Specifications, the absolute reactivity of ANY experiment shall not exceed _____.

a. 0.2% Δρ

b. 0.5% Δρ

c. 1.3% Δρ

d. 2.6% Δρ

QUESTION C.02 [1.0 point]
Which ONE of the following nuclear instrumentation channels provides for the automatic control of the reactor?

a. NC-3

b. NC-4

c. NC-5

d. NC-6

QUESTION C.03 [1.0 point]
The start-up source used in the NBSR is a _____ neutron source.

a. Am-Li

b. Am-Be

c. Sb-Be

d. Pu-Be

QUESTION C.04 [1.0 point]
After shutdown from 20 MW power, the minimum number of hours of forced cooling required is:

a. 5 hours

b. 10 hours

c. 20 hours

d. No forced cooling time required

QUESTION C.05 [1.0 point]
The CO_2 Gas System provides a means of purging air from spaces exposed to the neutron flux of the reactor. Purging the air from areas of high neutron flux minimizes the production of:

a. Moisture

b. Hydrogen

c. Argon-41

d. Nitrogen-16

QUESTION C.06 [1.0 point]
Per Technical Specifications applicable to Shim Arms, the reactor shall not be operated unless all of the following are true EXCEPT:

a. The scram time shall not exceed 240 msec for a shim arm insertion of 5 degrees.

b. The reactivity insertion rate for the four shim arms shall not exceed 5×10^{-4} $\Delta\rho$/sec.

c. The reactor shall not be operated unless the shutdown margin provided by the shim arms is less than $1.00.

d. All four shim arms are operable.

QUESTION C.07 [1.0 point]
The NBSR fuel element shall be a MTR plate type elements consisting of:

a. U_3O_8 (93% U-235) mixed with aluminum powder contained in aluminum clad plates.

b. U_3O_8 (96% U-235) mixed with aluminum powder contained in aluminum clad plates.

c. U_3O_8 (93% U-235) mixed with aluminum powder contained in stainless steel clad plates.

d. U_3O_8 (96% U-235) mixed with aluminum powder contained in stainless steel clad plates.

QUESTION C.08 [1.0 point]
Which ONE of the following materials is used as poison in the shim safety arms?

a. Aluminum

b. Boron

c. Cadmium

d. Erbium

QUESTION C.09 [1.0 point]
Operations up to _____ without forced flow are permitted for any length of time since the heat generated by the core is insufficient to cause significant heating of the reactor coolant.

a. 10 kW

b. 500 kW

c. 10 MW

d. 20 MW

QUESTION C.10 [1.0 point]
The NBSR design includes a number of reactivity coefficients EXCEPT:

a. The reactor core is designed so that the moderator temperature coefficient of reactivity is negative.

b. The reactor core is designed so that the void coefficient of reactivity is negative.

c. The reactor core is designed so that the fuel temperature coefficient of reactivity is negative.

d. Light water contamination of the NBSR coolant will result in a negative insertion of reactivity.

QUESTION C.11 [0.25 points each]
Match each operating (volumes) parameters for the Primary Coolant System listed in Column A with a value in Column B. Items in Column B is to be used only once.

Column A	Column B
a. Primary Coolant Loop	1. 240 gallons
b. Inner Reserve Tank	2. 800 gallons
c. D_2O Storage Tank	3. 3,050 gallons
d. D_2O Emergency	4. 6,655 gallons

QUESTION C.12 [1.0 point]
The lifetime of the NBSR fuel element is typically one year because of:

a. Burn Up Limitations

b. Corrosion Damage

c. Fission Gas Release

d. Swelling of the Fuel Plates

QUESTION C.13 [1.0 point]
Which ONE of the following Withdraw Prohibit Inputs has a trip setting of 15 seconds?

a. Rundown

b. Rod Drop Test

c. Rods Not Seated

d. Source Range Period Rod Stop

QUESTION C.14 [1.0 point]
Which ONE of the following core locations contains the regulating control rod? Position _____.

a. D-1

b. E-4

c. F-5

d. G-6

QUESTION C.15 [1.0 point]
Which ONE of the following heat exchangers is located in the Secondary Cooling Pump building?

a. Thermal Shield Heat Exchanger

b. D_2O Purification Heat Exchanger

c. Helium Compressor Heat Exchanger

d. Experimental Demineralized Cooling Water Heat Exchanger

QUESTION C.16 [1.0 point]
Which ONE of the following Exhaust Systems, air passes through a filtering system consisting of both HEPA and charcoal filters before releasing through the stack?

a. Normal Air Exhaust System

b. Emergency Exhaust System

c. Irradiated Air Exhaust System

d. Process Room Exhaust System

QUESTION C.17 [1.0 point]
Which ONE of the following is the detector for the Source Range Channel?

a. Compensated Ion Chamber

b. Uncompensated Ion Chamber

c. B^{10}- Lined Proportional Counter

d. Plastic Scintillation Gamma Detector

QUESTION C.18 [1.0 point]
If trip levels exceed their trip set points, all of the following channels will initiate a reactor scram and seal the confinement building EXCEPT:

a. Normal Air Channel

b. Irradiated Air Channel

c. Stack Monitor Channel

d. Secondary N-16 Channel

QUESTION C.19 [0.25 points each]
Match the experimental facilities in Column A with the number of units in Column B.
Items in Column B are to be used only once.

Column A	Column B
a. Beam Tubes	1. 5
b. Vertical Thimbles	2. 11
c. Cold Neutron Guides	3. 12
d. Pneumatic Tube Penetrations	4. 18

QUESTION C.20 [1.0 point]
Which ONE of the following is a function of the linear circuits NC-3, NC-4, NC-6 within the Reactor Safety System?

a. Produce a withdraw prohibit signal when the period decreases below 15 seconds on any of the channels and with power ≤ 10%

b. Rundown the reactor when the period decreases below 10 seconds on any of the three channels with power ≤ 10%

c. Scram the reactor when the period decreases below 5 seconds on any of the three channels with power ≤ 10%

d. Disable the Period Stop (15 seconds), Period Rundown (10 seconds), and Period Scram (5 seconds) when the reactor power level on all three channels exceeds 10%

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

A.01
Answer: a
REF: SAR 11.1.1.3.1, pg. 11-5

A.02
Answer: b
REF: Glasstone & Sesonske, Nuclear Reactor Engineering, Section 4.46-4.48, pg. 170-171

A.03
Answer: b
REF: Burns, Section 2.5, pg. 2-36 to 2-47
Neutron Interactions Outline, pg. 1

A.04
Answer: a
REF: $CR_1 / CR_2 = (1 – K_{eff2}) / (1 – K_{eff1})$
$100 / 70 = (1 – K_{eff2}) / (1 – 0.90)$
Therefore $K_{eff2} = 0.86$
$\Delta\rho = K_{eff2} – K_{eff1} / K_{eff2} * K_{eff1}$
$\Delta\rho = (0.86 – 0.90) / (0.86 * 0.90)$
$\Delta\rho = - 0.558$

A.05
Answer: a
REF: Burns, Section 3.2.1, and Table 3.2, pg. 3-4 and 3-5
Neutron Interactions Outline, pg. 2

A.06
Answer: b
REF: Burns, Section 3.2.4, pg. 3-12

A.07
Answer: b
REF: Lamarsh, Introduction to Nuclear Engineering, 2nd edition, pg. 372
Burns, Section 3.3.2, pg. 3-18

A.08
Answer: b
REF: $P=P_o e^{t/\tau}$ x =10 kW* $e^{180/-80}$ x = 10 kW *0.105 = 1.05 kW

A.09
Answer: a
REF: DOE Handbook, Volume2, Module 3, “Xenon-135 Response to Reactor Power Changes”, pg. 41

A.10
Answer: a
REF: DOE Handbook, Volume 2, Module 3, “Integral and Differential Control Rod Worth”, pg. 52

A.11
Answer: d
REF: DOE Handbook, Volume 2, Module 4, “Subcritical Multiplication”, pg. 1-9

A.12
Answer: b
REF: DOE Handbook, Volume1, Module 1, “Inelastic Scattering”, pg. 45

A.13
Answer: c
REF: Burns, Section 4.6, pg. 4-17

A.14
Answer: a
REF: Harrer, Nuclear Reactor Control Engineering, pg. 398-399
Burns, Section 6.1, pg. 6-1 and Example 6.2.1(a), pg. 6-2

A.15
Answer: c
REF: Burn, Section 4.2
0.5 % delta-K/K =0.005 delta-K/K <0.007, therefore reactor is supercritical

A.16
Answer: c
REF: Burns, Section 4.2, pg. 4-1 and Figure 4.1, pg. 4-2

A.17
Answer: b
REF: Burns, Section 3.3.7, pg. 3-31 and Problem 3.4.4, pg. 3-33

A.18
Answer: c
REF: DOE Handbook, Volume 2, Module 3, “Six Factor Formula”, pg. 8-10
Neutron Interactions Outline, pg. 3

A.19
Answer: b
REF: Burns, Table 2.5, pg. 2-59
SAR Table 4.5.3, pg. 4-54

A.20

Answer: b
REF: SAR 4.5.2.1.2, pg. 4-29
Lamarsh 3rd ed., Section 7.2, pg. 330

B.01
Answer: b
REF: TS Table 3.2.2, pg. 16 and Table 4.2.2, pg. 34

B.02
Answer: a
REF: TS 3.3.1, pg. 17

B.03
Answer: b
REF: TS 3.1.4, pg. 14

B.04
Answer: d
REF: TS 3.3.3, pg. 19

B.05
Answer: c
REF:

$$DR_1 d_1^2 = DR_2 d_2^2$$
$$d_2^2 = \frac{DR_1}{DR_2} d_1^2$$
$$d_2^2 = \frac{2000}{5} \times 1^2 = 400\,ft^2$$
$$d_2 = 20\,ft$$

B.06
Answer: b
REF: TS 4.5, pg. 37

B.07
Answer: b
REF: EP 7.6, pg. 14
Emergency Instruction 3.6, Section 4, pg. 1-2 of 2

B.08
Answer: c
REF: Annunciator Procedure 2.16, pg. 1 of 1

B.09
Answer: c
REF: EP 5.0, pg. 9
Emergency Instruction 0.3, Section 2.2.4, pg. 2 of 4

B.10
Answer: d
REF: EP 2.0, pg. 4

B.11
Answer: b
REF: EP 3.1, pg. 5
EP 9.0, pg.15-16

B.12
Answer: c
REF: 10 CFR 20.1003
Health Physics Procedure 1.3, pg. 3 of 4

B.13
Answer: b and d per facility comment
REF: Technical Specifications Procedures 4.3.1(1), pg. 1 of 1

B.14
Answer: a
REF: Operation Instruction 6.1, Section 1.2., pg. 1 of 10

~~**B.15**~~ deleted per facility/NRC comment
~~Answer: c~~
~~REF: Two inches = one-half thickness (T½). Using 5 half-thickness will drop the dose by a factor of (½)^5 = 1/32. Then 100/32 = 3.125 mR/hr~~

B.16
Answer: a
REF: 10 CFR 20.1201(a)(1)

$$5000mR * \frac{1hr}{125mR} * \frac{1day}{8hr} = 5days$$

B.17
Answer: a
REF: 10 CFR 20.1003
Health Physics Procedure 1.3, pg. 2 of 4

B.18
Answer: d
REF: Health Physics Procedure 2.3, pg. 1-2 of 2

B.19
Answer: c
REF: Annunciator Procedure 4.10, pg. 1 of 1
Operation Instruction 1.1 CL-A, Section 2.2.1, pg. 2 of 12

B.20

Answer: a

REF: 10 CFR Part 55.53

- 55.53(i) – the licensee shall have a biennial medical examination.
- 55.53(h), 55.59(c) – annual operating tests
- 55.53(e) – the licensee shall actively perform the functions of a licensed operator for a minimum of 4 hours per calendar quarter.
- 55.53(h), 55.59(c)(1) – ”The requalification program must be conducted for a continuous period not to exceed 2 years”

C.01
Answer: b
REF: TS 3.8.1 (1), pg. 26

C.02
Answer: c
REF: SAR 7.3.1.1, pg. 7-6, SAR 7.3.3, pg. 7-12 to 7-13, SAR Figure 7.1, pg. 7-33
Operation Instruction 1.1 CL-A, Section 3.13, pg. 10 of 12
Annunciator Procedure 0.3, Section 3.3, pg. 1 of 2

C.03
Answer: b
REF: SAR 4.2.4, pg. 4-11

C.04
Answer: c
REF: Operating Instruction 1.3, Section 2.1.1, pg. 1 of 3

C.05
Answer: c
REF: SAR 9.9.1, pg. 9-17

C.06
Answer: c
REF: TS 3.2.1, pg. 15

C.07
Answer: a
REF: SAR 4.2.1.1, pg. 4-4

C.08
Answer: c
REF: SAR 1.2.4 a, pg. 1-6
SAR 4.2.2.1, pg. 4-7

C.09
Answer: a
REF: SAR 4.1, pg. 4-2

C.10
Answer: c
REF: SAR 4.5.2.2, pg. 4-30 to 4-31

C.11
Answer: a,4 b,2 c,1 d,3
REF: SAR Table 5.1, pg. 5-15

C.12
Answer: a
REF: SAR 4.2.1.4, pg. 4-6

C.13
Answer: d
REF: SAR Table 7.3, pg. 7-21

C.14
Answer: d
REF: SAR 4.5.1.1.1, pg. 4-17
SAR Figure 4.5.1, pg. 4-71

C.15
Answer: c
REF: SAR 5.3.2.1.6, pg. 5-9
SAR Figure 5.2, pg. 5-17

C.16
Answer: b
REF: SAR 6.1.3, pg. 6-7
SAR 6.2.3.2.1, pg. 6-13

C.17
Answer: c
REF: SAR 7.3.1.1, pg. 7-5

C.18
Answer: d
REF: SAR 7.2.1, pg. 7-2
SAR 7.3.2.1, pg. 7-11

C.19
Answer: a,2 b,4 c,3 d,1
REF: SAR Table 10.1, pg. 10-10

C.20
Answer: d
REF: SAR 7.3.4, pg. 7-16