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

July 31, 2019

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

SUBJECT: EXAMINATION REPORT NO. 50-184/OL-19-02, NATIONAL INSTITUTE OF SCIENCE AND TECHNOLOGY

Dear Dr. Dimeo:

During the week of July 18, 2019, the U.S. Nuclear Regulatory Commission (NRC) administered an operator licensing examination at your National Institute of Standards and Technology Reactor (NBSR). 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 Paulette.Torres@nrc.gov.

Sincerely,

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-19-02
2. Facility Comments with NRC Resolution
3. Written Examination

cc: Mr. Daniel Flynn, Acting Chief Reactor Operations
cc: w/o enclosure: See next page

cc:

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Montgomery County Council
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Test, Research and Training
Reactor Newsletter
Attention: Amber Johnson
Dept of Materials Science and Engineering
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Dr. Thomas H. Newton, Deputy Director
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U. S. NUCLEAR REGULATORY COMMISSION
OPERATOR LICENSING INITIAL EXAMINATION REPORT

REPORT NO.: 50-184OL-19-02

FACILITY DOCKET NO.: 50-184

FACILITY LICENSE NO.: TR-5

FACILITY: National Institute of Science and Technology Reactor

EXAMINATION DATE: July 18, 2019

SUBMITTED BY: Paulette A. Torres July 22, 2019
Paulette Torres, Chief Examiner Date

SUMMARY:

During the week of July 18, 2019 the NRC administered a licensing examination to one Senior Reactor Operator (SROI) instant applicant. The applicant passed all portions of the examination.

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 Flynn, Acting Chief Reactor Operations
Tom Newton, Deputy Director
Meagan Nydegger, Chief of Reactor Operation
Justin Hudson, NBSR Operations Training Specialist

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

FACILITY COMMENTS ON THE WRITTEN EXAM WITH NRC RESOLUTION

QUESTION A.02 [1.0 point]
A few minutes following a reactor scram from 500 kW, the reactor period has stabilized and the power level is decreasing at a CONSTANT rate. What is the approximate power level one minute later from 1 kW?

a. 0.2 kW

b. 0.5 kW

c. 0.8 kW

d. 2.1 kW

Answer: c
REF: K_{eff} = 1.05*0.80*0.90*0.92*1.86*x X= 1/1.294 = 0.773

Facility Comments & Recommendations: The answer key has the answer "C" 0.8 kW. The supporting calculation uses the six-factor formula which does not have any bearing on this question. Using the period equation: $P=P_0\ e^{(t/T)}$ Using -80 as the period, T, one minute or 60 seconds for the time, t, and the initial power level, P_0, of 1 kW (1000 W), the calculation yields: 1000e^((-60)/80)=472.3666 W=0.5 kW. The correct answer should be B.

NRC Resolution: The NRC agrees with the facility comments and will accept (B) as the correct answer for question A.02.

QUESTION C.02 [1.0 point]
Which one of the following is NOT a mechanism for titrated water entering the reactor confinement building?

a. Failure of in-core experiment.

b. Helium leaks from the sweep gas system.

c. Component leakage in the primary system.

d. Loading and unloading of fuel elements from the reactor area.

Answer: d
REF: NBSR HP 2.5, Section 2, pg. 1

Facility Comments &
Recommendations: The correct answer should be A, since a failure of an experiment would not release tritium into the building do to how the experiments are designed. HP 2.5 does not state that a failed experiment would release tritium to the building.

HP 2.5 states:

1. Tritiated Water Vapor
   1.1. Tritiated water vapor can enter the reactor confinement building atmosphere via a number of mechanisms, including the following:
      1.1.1. Fuel elements or experiments cooled directly by the heavy water are loaded and unloaded from the reactor;
      1.1.2. The D_2O or helium system is opened for maintenance or modification;
      1.1.3. Samples are taken of the D2O or helium;
      1.1.4. Accidental spillage of D2O occurs;
      1.1.5. Helium leaks from the sweep gas system; and
      1.1.6. Component of the primary system leaks.

Technical Specification 3.8 Experiments states:
3.8.1(3) No experiment malfunction shall affect any other experiment so as to cause its failure. Similarly, no reactor transient shall cause an experiment to fail in such a way as to contribute to an accident.

Basis for 3.8.1(3)
In addition to all reactor experiments being designed not to fail from internal gas buildup or overheating, they shall be designed so that their failure does not affect either the reactor or other experiments. They shall also be designed to withstand, without failure, the same transients that the reactor itself can withstand without failure.

NRC Resolution: The NRC agrees with the facility comments and will accept (A) as the correct answer for question C.02.

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

FACILITY: National Institute of Standards and Technology

REACTOR TYPE: TEST

DATE ADMINISTERED: 07/18/2019

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 3

A. Reactor Theory, Thermohydraulics & Facility Operating Characteristics

ANSWER SHEET

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

ANSWER SHEET

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 ___

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

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

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

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

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

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

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

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

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

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

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

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

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

$$M = \frac{1 - K_{eff_1}}{1 - K_{eff_2}}$$

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

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

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

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

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

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

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

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

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

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

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

1 Curie = 3.7 x 10^{10} dis/sec
1 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
1ft = 30.48 cm

1 kg = 2.21 lbm
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
1 pcm = 10^{-5} ΔK/K

U.S.NRC

UNITED STATES NUCLEAR REGULATORY COMMISSION

Protecting People and the Environment

National Institute of Standards and Technology

Operator Licensing Examination

Week of July 18, 2019

QUESTION A.01 [1.0 point]
A reactor with Keff = 0.7 contributes 1000 neutrons in the first generation. Changing from the first generation to the SECOND generation, how many total neutrons are there after the second generation?

a. 700

b. 1300

c. 1700

d. 2100

QUESTION A.02 [1.0 point]
A few minutes following a reactor scram from 500 kW, the reactor period has stabilized and the power level is decreasing at a CONSTANT rate. What is the approximate power level one minute later from1 kW?

a. 0.2 kW

b. 0.5 kW

c. 0.8 kW

d. 2.1 kW

QUESTION A.03 [1.0 point]
A reactor is increasing power from 100 W to 10 kW in steady state mode. Which ONE of the following best describes the values of K_{eff} and ρ during the power increment?

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

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

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

d. $K_{eff} > 1$ and $0 < \rho < \beta_{\text{-eff}}$

QUESTION A.04 [1.0 point]
Given a reactor period of 32 seconds, approximately how long will it take for power to triple?

a. 22 seconds

b. 35 seconds

c. 46 seconds

d. 64 seconds

QUESTION A.05 [1.0 point]
Reactor is at 10 W. The reactor operator immediately inserts an experiment of 500 pcm reactivity worth into the core. This insertion will cause:
Given:
T: reactor period, ℓ^*: Prompt neutron lifetime; ρ: reactivity insertion; β: beta fraction; λ-eff: delayed neutron precursor constant

a. A sudden drop in delayed neutrons.

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

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

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

QUESTION A.06 [1.0 point]
Which ONE of the following describes the term PROMPT JUMP?

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

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

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

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

QUESTION A.07 [1.0 point]
Which ONE of the following is the longest-lived source of delayed neutrons in a nuclear reactor?

a. Br-87

b. I-137

c. Xe-143

d. Cs-145

QUESTION A.08 [1.0 point]
The process in which a neutron strikes a nucleus leaving the nucleus in an excited state is referred to as:

a. Elastic scattering

b. Inelastic scattering

c. Radiative capture

d. Neutron annihilation

QUESTION A.09 [1.0 point]
Which ONE of the following best describes the source of Nitrogen-16 produced in the reactor primary coolant?

a. Neutron decay of deuterium.

b. Neutron activation of a nitrogen atom.

c. Neutron scattering of the nucleus of a boron atom.

d. Neutron capture by the nucleus of an oxygen atom.

QUESTION A.10 [1.0 point]
The probability that a thermal neutron will be absorbed in the fuel is referred to as:

a. Reproduction probability

b. Thermal utilization probability

c. Resonance escape probability

d. Thermal non-leakage probability

QUESTION A.11 [1.0 point]
During Reg Rod calibration, doubling time was recorded to be 78 seconds. What was reactor period?

a. 39 seconds

b. 54 seconds

c. 113 seconds

d. 156 seconds

QUESTION A.12 [1.0 point]
Which ONE of the following atoms will cause a neutron to lose the most energy in an elastic collision?

a. H-1

b. O-16

c. Ar-40

d. U-238

QUESTION A.13 [1.0 point]
Which ONE of the following describes the factors that have the greatest effect on the fast fission factor?

a. Arrangement of the fuel and temperature of the moderator.

b. Arrangement of the fuel and concentration of the moderator.

c. Enrichment of the fuel and temperature of the moderator.

d. Enrichment of the fuel and concentration of the moderator.

QUESTION A.14 [1.0 point]
A critical reactor is operating at a low power level when the primary pump is turned off decreasing the rate of flow of the coolant through the reactor. What affect will the change in coolant flow rate have on reactivity? Given: NIST low power level is ~10 kW.

a. Varying the coolant flow at low power levels does not result in measurable reactivity changes.

b. Varying the coolant flow at low power levels will cause the addition of negative reactivity due to the reduction in pressure, resulting in a prompt drop.

c. Varying the coolant flow at low power levels will cause the addition of positive reactivity due to the increase of reactor coolant density, resulting in a power level increase.

d. Varying the coolant flow at low power levels will cause the addition of negative reactivity due the increase in coolant temperature, resulting in the reactor becoming subcritical.

QUESTION A.15 [1.0 point]
Which ONE of the following best describes the relationship between reactor power and neutron flux?

a. Reactor power is two times greater than the fission rate of the fuel.

b. Reactor power increases exponentially as the fission rate increases.

c. The rate of energy produced by the reactor is linearly proportional to the fission rate in the core.

d. Thermal power can be calculated by multiplying the neutron flux by the total volume of the core.

QUESTION A.16 [1.0 point, 0.25 each]
Identify whether each of the following conditions will INCREASE or DECREASE the shutdown margin of a reactor.

a. Burnout of a burnable poison.

b. Insertion of boron graphite to the reactor core.

c. Moving one fuel element from reactor core to fuel storage.

d. Decreasing moderator temperature. (Assume negative temperature coefficient.)

QUESTION A.17 [1.0 point]
Reactor A has a K_{eff} of 0.1 while Reactor B has a K_{eff} of 0.8. K_{eff} for each reactor is increased by 0.1. The amount of reactivity added in reactor A is ______ the amount of reactivity added to Reactor B.

a. Less than

b. Eight times

c. The same as

d. Thirty-six times

QUESTION A.18 [1.0 point]
Which ONE of the following is a direct result of heavy water moderation?

a. Less xenon accumulation.

b. Longer prompt neutron lifecycle.

c. Radially distributed thermal neutron flux.

d. Greater maximum reactivity insertion for shim arms.

QUESTION A.19 [1.0 point]
During reactor startup, which ONE of the following conditions would result in a non-conservative prediction of core critical mass, i.e., the reactor would reach criticality prior to the predicted critical mass?

a. The detector is too far away from the source and the fuel.

b. A fuel element is placed between the source and the detector.

c. Excessive time is allowed between fuel elements being loaded.

d. Withdrawing the shim arms from the core in decreasing increments.

QUESTION A.20 [1.0 point]
What effect does moderator temperature have on neutron population?

a. As the density of the moderator decreases, less moderation occurs and more neutrons leaks from the core.

b. As the density of the moderator increases, less moderation occurs and more neutrons leak from the core.

c. As the density of the moderator decreases, more moderation occurs and less neutrons leak from the core.

d. As the density of the moderator increases, less moderation occurs and less neutrons leak from the core.

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

QUESTION B.01 [1.0 point]
Which ONE of the following would NOT be permitted during reactor startup?

a. Reactor period greater than 20 seconds.

b. Two out of three effluent monitors are operable.

c. Bypass of the reactor outlet temperature rundown.

d. Only one source of makeup water available to the D_2O cooling tank.

QUESTION B.02 [1.0 point, 0.25 points each]
Identify the emergency classification for each of the following emergency action levels:

a. Fuel Cladding Failure with confinement breach.

b. Security breach affecting the reactor confinement.

c. Report of severe natural phenomenon (e.g. tornado or hurricane) threatening the reactor.

d. Actual or projected measurements at the Site Boundary which equal or exceed 75 mrem/24 hours.

QUESTION B.03 [1.0 point]
Which ONE of the following is TRUE regarding forced cooling operating conditions?

a. Technical specifications require for forced coolant flow during all modes of operation.

b. All core grid positions are not required to be filled when operating with forced cooling.

c. Operation with natural circulation can only be done when coolant level is no more than 25 inches below the overflow standpipe.

d. Below 10 kW, forced coolant is not necessary because heat generation due to fission and decay heat is insufficient to cause core damage.

QUESTION B.04 [1.0 point]
Which ONE of the following emergency response positions has the authority to terminate an emergency condition?

a. Emergency Director

b. Senior Reactor Operator

c. NIST Emergency Coordinator

d. Chief, Reactor Operations (Emergency Coordinator)

QUESTION B.05 [1.0 point]
Which ONE of following should be verified as an indication that the Cold Box Vacuum system is operating?

a. AOV701 is CLOSED.

b. Cold box enclosure 208 VAC breaker is ON.

c. Turbo Pump and Vacuum Roughing Pump are ON.

d. VG701A and VG701B are reading greater than $1x10^{-6}$ Torr.

QUESTION B.06 [1.0 point, 0.25 points each]
Indicate the normal alignment (OPEN/CLOSED) of the following valves in the primary coolant system:

a. 10" Inlet Isolation (DWV-2)

b. Inner Plenum Drain (DWV-117)

c. Fuel Transfer Overflow (DWV-37)

d. DP-4 Outlet Nozzle Check (DVW-6)

QUESTION B.07 [1.0 point]
Which ONE of the following is the radiation dose limit for the public in an unrestricted area?

a. No limit

b. 2 rem in a year

c. 2 rem in any one hour

d. 2 mrem in any one hour

QUESTION B.08 [1.0 point, 0.25 points each]
Match the 10 CFR parts in Column A with the requirements in Column B.

Column A	Column B
a. 10 CFR 19	1. Technical information including the proposed maximum power level
b. 10 CFR 20	2. Medical examination by a physician every two years
c. 10 CFR 50	3. Individual radiation exposure data
d. 10 CFR 55	4. Postings of notices to workers

QUESTION B.09 [1.0 point]
In accordance with TSP 4.3.1, which ONE of the following must be performed to restore the primary system to normal after testing the primary system relief valve?

a. STOP the D_2O storage tank pump and fully OPEN the throttled storage tank pump discharge valve.

b. STOP the D_2O storage tank pump and fully CLOSE the throttled storage tank pump discharge valve.

c. START the D_2O storage tank pump and fully OPEN the throttled storage tank pump discharge valve.

d. START the D_2O storage tank pump and fully CLOSE the throttled storage tank pump discharge valve.

QUESTION B.10 [1.0 point]
How long will it take an 80 Curie Cobalt-60 source, with a half-life of 5.27 years, to decay to 2 Curie?

a. 24 years

b. 26 years

c. 28 years

d. 30 years

QUESTION B.11 [1.0 point]
Which ONE of the following surveillance is required to be performed annually?

a. Cycling of the moderator dump valve.

b. Automatic start of the diesel generator.

c. Operation of the confinement closure system.

d. Operability of the emergency exhaust system.

QUESTION B.12 [1.0 point]
A radioactive material is DECAYING at a rate of 25% per hour. Determine its half-life?

a. 1.2 hours

b. 2.0 hours

c. 2.4 hours

d. 3.0 hours

QUESTION B.13 [1.0 point]
Which ONE of the following is an immediate action to be taken upon receiving a Thermal Column Temperature High alarm?

a. Check DTCV-15 operation.

b. Check the instrument channel.

c. Check thermal column tank level.

d. Check position of DTCV-19 if system is shutdown.

QUESTION B.14 [1.0 point]
Which ONE of the following is the definition of Total Effective Dose Equivalent (TEDE)?

a. The sum of thyroid dose and external dose.

b. The sum of the external deep dose and the organ dose.

c. The sum of the deep dose equivalent and the committed effective dose equivalent.

d. The dose that your whole body is received from the source but excluded from the deep dose.

QUESTION B.15 [1.0 point]
Which ONE of the following changes requires NRC approval prior to implementation?

a. Add a new requirement to the Reactor Startup Checklist.

b. Replace the primary heat exchange with an identical heat exchanger.

c. Delete a definition of Channel Test listed in the Technical Specifications.

d. Add more responsibilities to the role of Senior Reactor Operator position described in AP 1.0.

QUESTION B.16 [1.0 point]
The reactor has been shutdown following a suspected D_2O leak. In accordance with AP 2.17, after stopping the cooling tower fans, the next sequential action is to:

a. Stop primary pumps.

b. Stop secondary pumps.

c. Secure secondary blowdown.

d. Isolate and vent the secondary side of the heat exchanger.

QUESTION B.17 [1.0 point]
How often are licensed reactor operators required to pass a comprehensive requalification operating test, in accordance with the 10 CFR 55.59?

a. Only for initial qualification

b. Every six years

c. Biennially

d. Annually

QUESTION B.18 [1.0 point]
A radiation field is 200 mR/hr at 5 feet. What is the dose rate at 2 feet away from the source?

a. 250 mR/hr

b. 625 mR/hr

c. 1250 mR/hr

d. 2500 mR/hr

QUESTION B.19 [1.0 point]
Which ONE of the following is the 10 CFR 20 definition for "Annual Limit on Intake"?

a. The concentration of a radionuclide in air which, if inhaled by an adult worker for a year, results in a Total Effective Dose Equivalent of 100 mrem

b. The effluent concentration of a radionuclide in air which, if inhaled continuously over a year would result in a Total Effective Dose Equivalent of 50 mrem for noble gases

c. The Committed Effective Dose Equivalent of 5 rem whole body or 50 rems to any individual organ, for the amount of radioactive material inhaled or ingested in a year by an adult worker.

d. The projected Committed Effective Dose Equivalent commitment to individuals that warrants protective action following a release of radioactive material

QUESTION B.20 [1.0 point]
As a commitment to safety, shift crew are expected to promptly identify, evaluate, and correct issues commensurate with their significance. In accordance with AR 1.0, this trait is referred to as:

a. Work Process

b. Personnel Accountability

c. Environment for Raising Concerns

d. Problem Identification and Resolution

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

QUESTION C.01 [1.0 point]
Which ONE of the following can be used as an alternative to the secondary coolant activity monitor for monitoring primary water leakage into the secondary?

a. Level indicator in the D_2O storage tank.

b. Filters in the secondary purification line.

c. Fission product monitor in the helium sweep gas.

d. Charcoal sampler in the secondary sampling line.

QUESTION C.02 [1.0 point]
Which one of the following is NOT a mechanism for titrated water entering the reactor confinement building?

a. Failure of in-core experiment.

b. Helium leaks from the sweep gas system.

c. Component leakage in the primary system.

d. Loading and unloading of fuel elements from the reactor area.

QUESTION C.03 [1.0 point]
Which ONE of the following radiation monitoring equipment can detect a pin hole failure in the fuel cladding?

a. Fission monitor in helium gas sweep.

b. Criticality detector in the spent fuel storage pool area.

c. Continuous air monitor in the spent fuel storage pool area.

d. Fixed gamma area radiation monitor in confinement building.

QUESTION C.04 [1.0 point]
Which ONE of the following is required to establish confinement?

a. The reactor building truck door is capable of being close.

b. All automatic isolation valves in the ventilation system are de-energized.

c. All manual isolation valves in the process piping and guide tubes can be closed within 10 minutes.

d. At least one set of reactor building vestibule doors for each automatic personnel door is closed or attended.

QUESTION C.05 [1.0 point]
Which ONE of the following is an input to the measurement of thermal power by the Thermal Power Recorder Channel?

a. Log/Linear Channel

b. Wide Range Linear Channel

c. Reactor Vessel Outlet Flow Channel

d. Reactor Outer Plenum Flow Channel

QUESTION C.06 [1.0 point]
The maximum rate of reactivity control with the regulating rod is approximately:

a. 0.05% per second

b. 0.6% per second

c. 6.5 % per second

d. 10 % per second

QUESTION C.07 [1.0 point]
Which ONE of the following represents the reactor being in a secured condition?

a. The reactor is in drop test mode, and a senior reactor operator is in direct charge if the operation.

b. The control power key switch is in the off position with the key removed and under the control of a senior reactor operator.

c. The Rod Drive power key switch is on the off position with the key removed and there no experiments in any reactor experiment facility.

d. No work is in progress involving core fuel, core structure, installed shim arms, or shim arm drives, unless the shim arm drive shafts are mechanically fixed and there are no experiments in any reactor experiment facility.

QUESTION C.08 [1.0 point]
Which ONE of the following is NOT utilized as a fixed personal contamination monitor at NBSR?

a. Portal monitors

b. Dose rate meters

c. G-M hand and foot monitors

d. Half body contamination monitors

QUESTION C.09 [1.0 point]
Which ONE of the following conditions associated with the cold neutron source would result in a reactor rundown?

a. Loss of heavy water supply.

b. Hydrogen boiling within the system.

c. Oxygen intrusion into to the system.

d. Failure of the uninterruptible power supply.

QUESTION C.10 [1.0 point]
Which ONE of the following describes the flow path of the primary coolant system?

a. UP the inner plenum through the six center fuel element and UP the outer plenum through the remaining twenty-four fuel elements.

b. DOWN the inner plenum through the six center fuel element and DOWN the outer plenum through the remaining twenty-four fuel elements.

c. UP the inner plenum through the six center fuel element and DOWN the outer plenum through the remaining twenty-four fuel elements.

d. DOWN the inner plenum through the six center fuel element and UP the outer plenum through the remaining twenty-four fuel elements.

QUESTION C.11 [1.0 point]
Which ONE of the following channels produces a startup prohibit signal when the count rate drops below 2 cps?

a. NC-1

b. NC-3

c. NC-5

d. NC-7

QUESTION C.12 [1.0 point]
In the event of a total loss of offsite power and emergency generator AC power, vital equipment would remain energized for four hours, while non-vital equipment on the critical power panels will remain powered for __________?

a. 1 hour

b. 2 hours

c. 4 hours

d. Non-vital equipment will not receive power in the event of a total loss of offsite power.

QUESTION C.13 [1.0 point]
The capacity of the two identical centrifugal pumps that provide circulation of the storage pool water is:

a. 10 gpm

b. 30 gpm

c. 60 gpm

d. 75 gpm

QUESTION C.14 [1.0 point]
Which ONE of the following best describes the ventilation system under accident conditions? If high radiation levels are detected:

a. All ventilation systems will be completely shutdown. No air is circulated within the confinement building.

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

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

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

QUESTION C.15 [1.0 point]
What instrumentation is used to measure the flow of primary coolant through the main heat exchangers?

a. Orifice

b. Venturi

c. Ultrasonic flow element

d. Positive displacement meter

QUESTION C.16 [1.0 point]
The reactor has been operating at full power for a week, when all commercial power is lost. How is decay heat removed from the core?

a. Natural Circulation flow due to large ΔT across core and inlet higher than outlet.

b. Natural Circulation flow due to large ΔT across core and outlet higher than inlet.

c. DC Shutdown pumps powered from the emergency battery.

d. D_2O injection from the emergency tank.

QUESTION C.17 [1.0 point, 0.25 each]
Match the type of valve in Column A with its function in the primary coolant system listed in Column B.

Column A	Column B
a. Air operated diaphragm valve	1. Inlet Isolation Valve, DWV-1
b. Motor operated butterfly valve	2. Reactor Isolation Valve, DWV-19
c. Pneumatic operated butterfly valve	3. Normal Overflow Valve, DWV-10
d. 12-inch motor operated diaphragm valve	4. Heat Exchanger Isolation Valve, DWV-95B

QUESTION C.18 [1.0 point]
When the radiation monitors required by TS 3.7 are inoperable, portable instruments maybe substituted for:

a. 24 hours

b. 2 weeks

c. A duration of a reactor run

d. Indefinitely until repairs can be made

QUESTION C.19 [1.0 point]
Which ONE of the following detectors is used 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.20 [1.0 point]
Which experimental facility allows for a flux of approximately 2.0×10^{14} n/cm^2?

a. Through Tubes

b. Thermal Column

c. Radial Beam Tubes

d. Cold Neutron Sources

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

A.01
Answer: c
REF: Burn, Section 5.3, pg. 5.6, 2nd generation=n + K*n=1000+700=1700 neutrons

A.02
Answer: b Per facility comments
REF: $P=P_oe^{t/T}$

$$1000e^{\frac{-60}{80}} = 472.3666\,W = 0.5\,kW$$

A.03
Answer: d
REF: Burn, Section 4.2

A.04
Answer: b
REF: $P=P_oe^{t/T}$ 3=1* et/32 t = 32 sec*ln(3) = 35.2 sec

A.05
Answer: d
REF: Burn, Section 4.6, pg. 4-17

A.06
Answer: d
REF: Burn, Section 4.7, pg. 4-21

A.07
Answer: a
REF: Burn Section, 1.3, pg. 1-6

A.08
Answer: b
REF: Burn, Section 2.4, pg. 2-28

A.09
Answer: d
REF: NBSR SAR Chapter 11.2.1.3, pg. 11-5

A.10
Answer: b
REF: Burn, Section 3.3, pg. 3-16

A.11
Answer: c
REF: $T = DT/\ln(2) = 78$ seconds$/0.693 = 112.55 \approx 113$ seconds

A.12
Answer: a
REF: Burn, Section 2.5, pg. 2-45

A.13
Answer: b
REF: DOE Fundamentals of Reactor Theory, Volume 2, NP-03, pg. 3

A.14
Answer: a
REF: DOE Fundamentals of Reactor Theory, Volume 2, NP-04, pg. 30

A.15
Answer: c
REF: Burn, Section 2.8, pg. 2-64

A.16
Answer: (a) DECREASE; (b) INCREASE; (c) INCREASE; (d) DECREASE
REF: DOE Fundamentals of Reactor Theory, Volume 2, NP-04, pg.28

A.17
Answer: d
REF: Burn, Section 3.3, pg. 3-21.
$\Delta\rho$ reactor A = $(K_{eff1}-K_{eff2})/(K_{eff1}*K_{eff2})$. $(0.2-0.1)/(0.2*0.1) = 5\ \Delta k/k$
$\Delta\rho$ reactor B = $(K_{eff1}-K_{eff2})/(K_{eff1}*K_{eff2})$. $(0.9-0.8)/(0.9*0.8) = 0.139\ \Delta k/k$
$5/0.139 = 36$

A.18
Answer: b
REF: NBSR SAR, Chapter 1.2, pg. 1-5

A.19
Answer: a
REF: Burn, Section 5.5, pg. 5-18

A.20
Answer: a
REF: Burn, Section 6.5, pg. 6-14

B.01
Answer: c
REF: NBSR OI 1.1, Section 4, pg. 3

B.02
Answer: (a) Site Area Emergency; (b) Alert; (c) NOUE; (d) Alert
REF: NBSR EI 0.3, Section 1-3, pgs. 1-3

B.03
Answer: d
REF: NBSR TS 2.2, pg. 11

B.04
Answer: a
REF: NBSR Emergency Plan, Section 9, pg. 15

B.05
Answer: c
REF NBSR OI 7.1, Section 3, pg. 4

B.06
Answer: (a) OPEN; (b) CLOSED; (c) CLOSED; (d) OPEN
REF: NBSR OI 2.1, pgs. 1-2

B.07
Answer: d
REF: 10CFR20.1301(a)(2)

B.08
Answer: (a) 4; (b) 3; (c) 1; (d) 2
REF: 10 CFR 19.11, 10 CFR 20.1501(2)(i), 10 CFR 50.34(1)(ii)(A), 10 CFR 55.21

B.09
Answer: a
REF: NBSR TSP 4.3.1

B.10
Answer: c
REF: $\lambda = \ln(2)/T_{1/2}$ = 0.693/5.27 = 0.1315
$A = A_0e^{-\lambda t} \rightarrow 2 = 80e^{-0.1315(t)} \rightarrow \ln(2/80) = -0.315t \rightarrow t = 28$ years

B.11
Answer: a
REF: NBSR TS 4.3, pg. 36

B.12
Answer: c
REF: 25% is decayed, so 75% is still there
$75\% = 100\% * e^{-\lambda(1hr)}$
$Ln(75/100) = -\lambda*1 \rightarrow \lambda = 0.287$
$t_{1/2} = Ln(2)/\lambda \rightarrow 0.693/0.287$ t=2.4 hours

B.13
Answer: a
REF: AP 3.12, pg. 4

B.14
Answer: c
REF: 10 CFR 20.1003

B.15
Answer: c
REF: 10 CFR 50.59

B.16
Answer: b
REF: AP 2.17, Section 3, pg. 3

B.17
Answer: d
REF: 10 CFR 55.59(a)(2)

B.18
Answer: c
REF: $DR_1d_1^2 = DR_2d_2^2 \rightarrow 200*(5)^2 = DR*(2)^2 \rightarrow 5000 = DR*4 \rightarrow DR=1250$
mR/hr

B.19
Answer: c
REF: 10 CFR 20.1003

B.20
Answer: d
REF: NBSR AR 1.0, Section 5, pg. 5

C.01
Answer: a
REF: NBSR TS 3.7, pg. 24

C.02
Answer: a Per facility comments
REF: HP 2.5, TS 3.8.1(3)

C.03
Answer: a
REF: NBSR TS 3.7, pg. 24

C.04
Answer: d
REF: NBSR TS 3.4, pg. 21

C.05
Answer: c
REF: NBSR SAR, Chapter 7.3, pg. 7-6

C.06
Answer: a
REF: NBSR SAR, Chapter 7.3, pg. 7-8

C.07
Answer: a
REF: NBSR TS, Section 1.3, pg. 8

C.08
Answer: b
REF: NBSR SAR, Chapter 11.1, pg. 11-17

C.09
Answer: a
REF: NBSR SAR, Chapter 10.2, pg.10-4

C.10
Answer: a
REF: NBSR SAR, Chapter 5.2, pg. 5-2

C.11
Answer: a
REF: NBSR SAR, Chapter 7.3, pg. 7-5

C.12
Answer: c
REF: NBSR SAR, Chapter 8.2, pg. 8-6

C.13
Answer: d
REF: NBSR SAR, Chapter 9.2, pg. 9-6

C.14
Answer: b
REF: NBSR SAR, Chapter 6.2.3.2.2 pg. 6-13

C.15
Answer: c
REF: NBSR SAR, Chapter 5.2, pg. 5-6

C.16
Answer: c
REF: NBSR SAR, Section 5.2, pg. 5-3

C.17
Answer: (a) 3; (b) 2; (c) 4; (d) 1
REF: NBSR SAR, Section 5.2, pg. 5-4

C.18
Answer: c
REF: NBSR TS 3.7, pg. 23

C.19
Answer: c
REF: NBSR 7.3.1, pg. 7-5

C.20
Answer: c
REF: NBSR SAR, Chapter 10.2.1, pg. 10-1

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