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

January 9, 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-19-01, NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY

Dear Dr. Newton:

During the week of November 28, 2018, the U.S. Nuclear Regulatory Commission (NRC) administered an operator licensing examination at the National Institute of Standards and 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 Licensing Projects
Office of Nuclear Reactor Regulation

Docket No. 50-184

Enclosures:
1. Examination Report No. 50-184/OL-19-01
2. Facility Comments with NRC Resolution
3. Written Examination

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

SUBJECT: EXAMINATION REPORT NO. 50-184/OL-19-01, NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY DATED JANUARY 9, 2018

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ADAMS Accession No. ML19007A257 **NRR-074**

OFFICE	NRR/DLP/PROB	NRR/DIRS/IOLB/OLA	NRR/DLP/PROB/BC
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DATE	12/19/2018	1/7/2019	1/9/2018

OFFICIAL RECORD COPY

cc:

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

REPORT NO.: 50-184OL-19-01

FACILITY DOCKET NO.: 50-184

FACILITY LICENSE NO.: TR-5

FACILITY: National Institute of Science and Technology Reactor

EXAMINATION DATE: November 28-29, 2018

SUBMITTED BY: ***/RA/*** 12/19/2018
Paulette Torres, Chief Examiner Date

SUMMARY:

During the week of November 28, 2018 the NRC administered a licensing examination to two Senior Reactor Operator (SROI) instant applicants. The two applicants 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	2/0	2/0
Operating Tests	0/0	2/0	2/0
Overall	0/0	2/0	2/0

3. Exit Meeting:
Paulette Torres, Chief Examiner, NRC
Daniel Flynn, Acting Chief Reactor Operations
Warren Eresian, NIST Contractor

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.06 [1.0 point]
Because the temperature of the fuel reacts immediately to changes in reactor power, the Fuel Temperature Coefficient is also called the:

a. Prompt Temperature Coefficient

b. Moderator Temperature Coefficient

c. Nuclear Doppler Effect

d. Void Coefficient

Answer: a
REF: Lamarsh 3rd ed., Section 7.4, pg. 367

Facility Comments &
Recommendations: We do not have a measurable Fuel Temperature Coefficient, since we use very little U-238. For other types of reactors, the Fuel Temperature Coefficient is usually referred to as the "Doppler" coefficient. We believe that both "a" and "c" are correct. Reference Lamarsh 3rd Edition page 367

NRC Resolution: The NRC agrees with the facility comment and accepts answers (a) and (c) to be correct for question A.06.

QUESTION A.12 [1.0 point]
What order process is the radioactive decay differential equation?

a. Zero

b. First

c. Second

d. Third

Answer: b
REF: Burns, 2.4.6, pg. 2-30
Mathematically, radioactive decay can be represented by the first order, linear differential equation $dA/dt = -\lambda A$ where A is the number density of radioactive atoms of a substance and λ is called the decay constant.

Facility Comments &
Recommendations: Our objection to this question is simply based on the observation that our training program is not a course in mathematics theory. We believe that this question has no relevance and should be removed.

NRC Resolution: Thank you for the comment. We will consider writing the question differently in the future.

QUESTION A.16 [1.0 point]
What is the effect of delayed neutrons on the neutron flux decay following a scram from full power?

a. Adds negative reactivity creating a greater shutdown margin.

b. Adds positive reactivity due to the fuel temperature decrease following the scram.

c. Limits the final rate at which power decreases to a -80 second period.

d. Decreases the mean neutron lifetime.

Answer: c
REF: Burns, Section 4.10.12, pg. 4-32 to 4-33

Facility Comments &
Recommendations: We only wish to comment that this applies to a light-water reactor, not the NBSR heavy-water reactor.

NRC Resolution: Thank you for the comment. We will consider writing the question differently in the future.

QUESTION A.17 [1.0 point]
About two minutes following a reactor scram, period has stabilized, and is decreasing at a CONSTANT rate. If reactor power is 10^{-5} % full power what will the power be in three minutes?

a. 5×10^{-6} % full power

b. 2×10^{-6} % full power

c. 1×10^{-6} % full power

d. 5×10^{-7} % full power

Answer: c
REF: $P = P_0\, e^{-(t/T)} = 10^{-5} \times e^{-(180sec/80sec)} = 10^{-5} \times e^{-2.25} = 0.1054 \times 10^{-5} = 1.054 \times 10^{-6}$

Facility Comments &
Recommendations: See Question A.16 comment. In order to correctly answer this question, the candidate needs to know that -80 seconds applies to a light-water reactor, not the NBSR.

NRC Resolution: Thank you for the comment. We will consider writing the question differently in the future.

QUESTION B.02 [1.0 point]
In an emergency in order to protect the public health and safety, 10 CFR 50 allows the operator to depart from a license condition or a technical specification. What is the minimum level of authorization needed to deviate from this action?

a. Reactor Director

b. Reactor Supervisor

c. Licensed Reactor Operator

d. Licensed Senior Reactor Operator

Answer: d
REF: 10 CFR 50.54(y)

Facility Comments &
Recommendations: In an emergency, our Emergency Plan names the Reactor Supervisor as the Emergency Director. We believe that credit should also be given to "b" as a correct answer. Reference: Emergency Plan Section 3.1, page 5, first paragraph.

NRC Resolution: The NRC agrees with the facility comment and accepts answers (b) and (d) to be correct for question B.02.

QUESTION B.11 [1.0 point]
It shall be verified biennially that the charcoal filter banks in the emergency exhaust and recirculation systems have a removal efficiency of 99% for _____.

a. Iodine

b. Argon

c. Xenon

d. Cobalt

Answer: c
REF: TS 4.5 (4), pg. 37

Facility Comments &
Recommendations: Answer 'a' is the correct answer, not answer 'c'. Reference: Technical Specification 4.5(4). Page 37

NRC Resolution: The NRC agrees with the facility comments and will accept (a) as the correct answer for question B.11.

QUESTION B.15 [1.0 point]
Which ONE of the following Reactor Safety System Channels may be bypassed during periods of reactor operation when a reduction in Limiting Safety System Settings are permitted by Technical Specifications?

a. Gaseous Effluent Monitor

b. Reactor Outlet Temperature

c. Low reactor vessel D_2O level

d. Low flow reactor inner or outer plenum

Answer: b
REF: TS Table 3.2.2, Note #3, pg. 16

Facility Comments &
Recommendations: We believe that there are three correct answers, 'b', 'c', and 'd'. Reference: Technical Specification Table 3.2.2, note 3, also applies to level, outlet flow, and inner or outer plenum flow.

NRC Resolution: The NRC understands the facility comments. Question B.15 will be deleted from the examination.

QUESTION B.17 [1.0 point]
Which ONE of the following plant systems does not have a no direct effect on reactor operations?

a. Steam

b. Electrical

c. Chilled Water System

d. Fire Protection System

Answer: d
REF: Operation Instruction 3.7, Section 2.2.5, pg 1 of 1

Facility Comments &
Recommendations: The wording of the question is very confusing.

NRC Resolution: The NRC understands the facility comments. Question B.17 will be deleted from the examination.

QUESTION C.03 [1.0 point]
The total rod worth of the regulating rod is approximately _____ reactivity.

a. 0.05%

b. 0.6%

c. 5.6%

d. 6.5%

Answer: d
REF: SAR 7.3.1.4.2, pg. 7-8

Facility Comments & Recommendations: The answer should be 'b' and not 'd'. Reference: SAR 7.3.1.4.2, page 7-8.

NRC Resolution: The NRC agrees with the facility comments and will accept (b) as the correct answer for question C.03.

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

FACILITY: National Institutte of Standards and Technology

REACTOR TYPE: TEST

DATE ADMINISTERED: 11/29/2018

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
18.00 ~~20.00~~	33.3	_____	_____	B. NORMAL AND EMERGENCY OPERATING PROCEDURES AND RADIOLOGICAL CONTROLS
20.00	33.3	_____	_____	C. FACILITY AND RADIATION MONITORING SYSTEMS
58.00 ~~60.00~~		_____	_____ %	TOTALS
		FINAL GRADE		

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

_____
Candidate's Signature

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 comments

B16 a b c d ___

~~B17 a b c d ___~~ Deleted per facility comments

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 ___ e ___

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

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

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

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

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

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

$$\lambda^* = 1\times10^{-4}\ \text{sec}$$

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

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

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

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

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

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

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

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

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

$$\mathrm{T} = \frac{\lambda^*}{\rho} + \left[\frac{\bar{\beta}-\rho}{\lambda_{eff}\rho + \rho'}\right]$$

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

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

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

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

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

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

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

1ft = 30.48 cm

National Institutte of Standards and Technology

Operator Licensing Examination

Week of November 28, 2018

QUESTION A.01 [1.0 point]
Energy Yield (ΔQ) from a nuclear fission reaction is in the range of (or is approximately):

a. < 1 eV

b. 1.86 keV

c. 200 MeV

d. 1000 MeV

QUESTION A.02 [1.0 point]
A reactor is subcritical if:

a. $\rho = 1.0$

b. $K_{eff} < 1.0$ or $\rho < 0.0$

c. $K_{\infty} = 1.0$, $\rho = \beta$

d. $K_{eff} > 1.0$ or $\rho > 0.0$

QUESTION A.03 [1.0 point]
What is the meaning of any point on a differential rod worth curve? Represents

a. The amount of reactivity that one inch of rod motion would insert at that position in the core.

b. The zero reactivity when the rod is on the bottom and the positive reactivity being added as the rod is withdrawn.

c. The negative reactivity added as the rod is inserted.

d. The cumulative area under the differential curve starting from the bottom of the core.

QUESTION A.04 [1.0 point]
Which ONE of the following changes does not require a movement of control rods in order to maintain constant reactor power?

a. Pool water temperature decrease

b. U-235 burnup

c. Xe-135 buildup

d. N-16 formation

QUESTION A.05 [1.0 point]
The effective multiplication factor (K_{eff}) can be determined by dividing the number of neutrons produced from fission in the fourth generation by the number of neutrons produced from fission in the _____ generation.

a. First

b. Second

c. Third

d. Fifth

QUESTION A.06 [1.0 point]
Because the temperature of the fuel reacts immediately to changes in reactor power, the Fuel Temperature Coefficient is also called the:

a. Prompt Temperature Coefficient

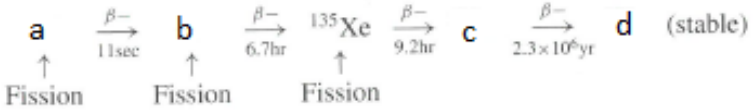
b. Moderator Temperature Coefficient

c. Nuclear Doppler Effect

d. Void Coefficient

QUESTION A.07 [1.0 point, 0.25 each]
Match the items in Column A with the isotopes in Column B.
The most important fission product poison is ^{135}Xe. The process that show how this isotope is formed and its decay is:

Column A



Column B

1. ^{135}Ba
2. ^{135}Cs
3. ^{135}I
4. ^{135}Te

QUESTION A.08 [1.0 point]
Delayed neutrons contribute more to reactor stability than prompt neutrons because they _____ the average neutron generation time and are born at a _____ kinetic energy.

a. Decrease, lower

b. Increase, lower

c. Decrease, higher

d. Increase, higher

QUESTION A.09 [1.0 point]
The neutron interaction in the reactor core that is MOST efficient in thermalizing fast neutrons occurs with the:

a. Hydrogen atoms in the water molecules.

b. Nitrogen-16 from Oxygen.

c. Boron atoms in the control rods.

d. Aluminum atoms in the fuel cladding.

QUESTION A.10 [1.0 point]
Reactivity is defined as the:

a. Fractional change in neutron population per generation.

b. Number of neutrons by which neutron population changes per generation.

c. Rate of change of reactor power in neutron per second.

d. Change in the number of neutrons per second that causes a fission event.

QUESTION A.11 [1.0 point]
Fuel is being loaded into the core. The operator is using a 1/M plot to monitor core loading. 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. The detector is too close to the source and the fuel.

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

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

QUESTION A.12 [1.0 point]
What order process is the radioactive decay differential equation?

e. Zero

f. First

g. Second

h. Third

QUESTION A.13 [1.0 point]
Which ONE of the following is the major source of heat generation after an operating reactor has been shut down and cooled down for several days?

a. Resonance capture

b. Fission fragment decay

c. Delayed neutron reactions

d. Corrosion product activation

QUESTION A.14 [1.0 point]
Which ONE of the following is the primary mechanism for transferring heat through the cladding of a fuel rod?

a. Conduction

b. Convection

c. Radiation

d. Mass Transfer

QUESTION A.15 [1.0 point]
The reaction $_{93}Np^{239} \rightarrow$ _____ + $_{94}Pu^{239}$ is an example of:

a. Alpha Decay

b. Beta Decay

c. Gamma Emission

d. Electron Capture

QUESTION A.16 [1.0 point]
What is the effect of delayed neutrons on the neutron flux decay following a scram from full power?

e. Adds negative reactivity creating a greater shutdown margin.

f. Adds positive reactivity due to the fuel temperature decrease following the scram.

g. Limits the final rate at which power decreases to a -80 second period.

h. Decreases the mean neutron lifetime.

QUESTION A.17 [1.0 point]
About two minutes following a reactor scram, period has stabilized, and is decreasing at a CONSTANT rate. If reactor power is 10^{-5} % full power what will the power be in three minutes?

e. 5×10^{-6} % full power

f. 2×10^{-6} % full power

g. 1×10^{-6} % full power

h. 5×10^{-7} % full power

QUESTION A.18 [1.0 point]
A reactor is subcritical with a K_{eff} of 0.925. Which ONE of the following is the MINIMUM reactivity ($\Delta K/K$) that must be added to produce prompt criticality? Given β_{eff}=0.007

a. 0.012

b. 0.047

c. 0.054

d. 0.088

QUESTION A.19 [1.0 point]
If Beta for U-235 is 0.0065 and Beta effective is approximately 0.007, how does this difference affect reactor period in the reactor period equation, $T=(\beta-p)/\lambda p$? This difference produces a _____ for a given addition of reactivity with Beta effective.

a. Longer period

b. Shorter period

c. Stable period

d. Decay constant (λ) increase

QUESTION A.20 [1.0 point]
Which ONE of the following describes the term Prompt Drop?

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.

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

QUESTION B.01 [1.0 point]
What is the HALF LIFE of the isotope contained in a sample which produces the following count rates?

Time (Minutes)	Counts per Minute (cpm)
Initial count	840
30	740
60	615
90	512
180	270

a. 310 minutes

b. 210 minutes

c. 110 minutes

d. 60 minutes

QUESTION B.02 [1.0 point]
In an emergency in order to protect the public health and safety, 10 CFR 50 allows the operator to depart from a license condition or a technical specification. What is the minimum level of authorization needed to deviate from this action?

e. Reactor Director

f. Reactor Supervisor

g. Licensed Reactor Operator

h. Licensed Senior Reactor Operator

QUESTION B.03 [1.0 point]
The exposure rate for a point source is 100 mR/hr at a distance of 4 m. What is the exposure rate at a distance of 2 m?

a. 200 mR/hr

b. 400 mR/hr

c. 600 mR/hr

d. 800 mR/hr

QUESTION B.04 [1.0 point]
Given the following instruments, which ONE is the best to check your hands and clothing for beta-gamma contamination upon leaving a contamination zone?

a. GM Pancake

b. Ionization chamber survey instrument

c. Portable sodium Iodide (NaI) detector

d. Zinc Sulfide (ZnS) detector

QUESTION B.05 [1.0 point]
As a research reactor licensed operator, you were unable to perform the functions of an operator for the minimum number of hours during the previous calendar quarter. What are the minimum number of hours you must complete before resumption of functions authorized by your license?

a. 4

b. 6

c. 8

d. 12

QUESTION B.06 [1.0 point]
Per Reactor Core Parameter, Limiting Condition for Operations, the reactor scram set point for a reactor power level safety channel shall not exceed _____ of full power.

a. 95%

b. 100%

c. 125%

d. 135%

QUESTION B.07 [1.0 point, 0.20 each]
Match the Action Levels listed in Column A with its Emergency Class listed in Column B. Items in Column B can be used once, more than once or not at all.

Column A	Column B
a. Bomb threats.	1. Notification of Unusual Events
b. Prolonged fire threatening the reactor.	2. Alert
c. Security breach affecting the reactor confinement.	3. Site Area Emergency
d. Radiological effluents at the boundary exceeding 375 mrem TEDE accumulated in 24 hours.	
e. Actual or projected radiation levels at the boundary of 100 mrem CDE to the thyroid.	

QUESTION B.08 [1.0 point]
Which ONE of the following buildings is not part of the Emergency Planning Zone (EPZ)?

a. Building 235

b. Exclusion Area

c. Emergency Control Station

d. National Naval Medical Center

QUESTION B.09 [1.0 point, 0.25 each]
Match the following Reactor Shutdown Mechanisms in Column A with its corresponding definition in Column B.

Column A	Column B
a. Reactor Rundown	1. A scram accompanied by the immediate activation of the confinement isolation system.
b. Scram	2. The electrically driven insertion of all shim arms and the regulating rod at their normal operating speed.
c. Major Scram	3. An action which drops the water level to approximately one inch (2.5 cm) above the reactor core, thereby ensuring a subcritical state for an emergency shutdown under all reactor operating conditions.
d. Moderator Dump	4. The spring assisted gravity insertion of all shim arms.

QUESTION B.10 [1.0 point]
If the setpoint Reactor Level indicator (LIA-40) trips at 145", the corresponding panel annunciator(s) is/are "Vessel Level _____".

a. Low

b. Rundown

c. Low and Rundown

d. Low, Clutch Power Abnormal, and Scram

QUESTION B.11 [1.0 point]
It shall be verified biennially that the charcoal filter banks in the emergency exhaust and recirculation systems have a removal efficiency of 99% for _____.

a. Iodine

b. Argon

c. Xenon

d. Cobalt

QUESTION B.12 [1.0 point]
Which ONE of the following Beam Tubes operations affects the neutron level seen by the NC-5 detector?

a. BT-1

b. BT-3

c. BT-5

d. BT-7

QUESTION B.13 [1.0 point]
Which ONE of the following systems shall remain in operation when reactor power exceeds 100 kW?

a. Secondary Cooling System

b. Storage Pool Cooling System

c. Thermal Shield Cooling System

d. Demineralized Water Experimental Cooling System

QUESTION B.14 [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.15 [1.0 point]** Deleted per facility comments~~
~~Which ONE of the following Reactor Safety System Chhannels may be bypassed during periods of reactor operation when a reduction in Limiting Safety System Settings are permitted by Technical Specifications?~~

~~a. Gaseous Effluent Monitor~~

~~b. Reactor Outlet Temperature~~

~~c. Low reactor vessel D_2O level~~

~~d. Low flow reactor inner or outer plenum~~

QUESTION B.16 [1.0 point]
Per Emergency Plan, the Emergency Response for ALERT: Reactor Shutdown falls under:

a. Assestment Action

b. Corrective Action

c. Immediate Action

d. Protective Action

~~**QUESTION B.17 [1.0 point]** Deleted per facility comments~~
~~Which ONE of the following plant systems does not have a no direct effect on reactor operations?~~

~~a. Steam~~

~~b. Electrical~~

~~c. Chilled Water System~~

~~d. Fire Protection System~~

QUESTION B.18 [1.0 point]
Reactor site is the area around the reactor within a radius of _____ meters centered at the reactor stack.

a. 60 meter

b. 150 meter

c. 400 meter

d. 760 meter

QUESTION B.19 [1.0 point]
_____ to the rabbit system should be placed in service prior to use of the rabbit system and secured after use is complete.

a. CO_2

b. He

c. N_2

d. Air

QUESTION B.20 [1.0 point]
For primary tritium concentrations of greater than 4 Ci/l, the primary water shall be sampled _____.

a. Daily

b. Monthly

c. Quarterly

d. Annually

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

QUESTION C.01 [1.0 point]
Which ONE of the following Nuclear Instrument Channels has no related protective actions?

a. NC-1

b. NC-3

c. NC-5

d. NC-7

QUESTION C.02 [1.0 point]
The NBSR MTR-type fuel element shall be such that the central 7 inches of the fuel element contains:

a. No fuel

b. U_3O_8

c. Air

d. Aluminum

QUESTION C.03 [1.0 point]
The total rod worth of the regulating rod is approximately _____ reactivity.

e. 0.05%

f. 0.6%

g. 5.6%

h. 6.5%

QUESTION C.04 [1.0 point, 0.20 each]
Match the Radiation Monitoring System Channels in Colum A with its corresponding Radiation Monitoring System in Column B. Answers may be used once, more than once or not at all.

Column A	Column B
a. RM1-1 thru RM1-10	1. Tritium Monitor Channel
b. RM1-11 thru RM1-13	2. Duct Filter Monitor Channel
c. RM1-15	3. Area Radiation Monitor Channel
d. RM3-1 and RM3-3	4. Helium Sweep Gas Radiation Channel
e. RM3-2	5. Secondary Cooling N-16 Radiation Channel

QUESTION C.05 [1.0 point]
Logic selector switch in “2 of 3” verifies for proper operation of the _____ trip.

a. Nuclear Instrument Test Fault

b. Linear Rundown at 115%

c. Clutch Power Abnormal

d. Scram

QUESTION C.06 [1.0 point]
Which ONE of the following pumps delivers 800 gpm at 24 feet of total head?

a. D_2O Experimental Cooling Pumps

b. D_2O Main Circulating Pumps

c. D_2O Storage Tank Pump

d. D_2O Shutdown Pumps

QUESTION C.07 [1.0 point]
Gas-flow ion chamber and “Cold trap” sampling are used to sample for _____.

a. Argon

b. Tritium

c. Nitrogen

d. Helium

QUESTION C.08 [1.0 point]
The Thermal Power Recorder Channel (BTUR) combines a _____ input with _____ input to derive the reactor power level for display and recording.

a. Power / Coolant Level

b. Count Rate / K-Effective

c. Period Rise / Shutdown Margin

d. Differential Temperature / Flow

QUESTION C.09 [1.0 point]
What are the two motor control centers (MCC) associated with the Facility Distribution System?

a. MCC-A1 and MCC-A2

b. MCC-A3 and MCC-B4

c. MCC-A5 and MCC-B6

d. MCC-A7 and MCC-B8

QUESTION C.10 [1.0 point]
The reactor safety system channels shall be _____ annually.

a. Channel-Checked

b. Channel-Calibrated

c. Channel-Replaced

d. Channel-Tested

QUESTION C.11 [1.0 point]
The CO_2 purge gas system is supplied from a bulk storage tank located:

a. In the process room

b. Near the stack

c. Outside of the confinement building

d. In cold lab basement

QUESTION C.12 [1.0 point]
Which ONE of the following coolant/cooling systems is also an Engineered Safety Feature?

a. Primary Coolant System

b. Emergency Cooling System

c. D_2O Experimental Cooling System

d. Primary Coolant Purification System

QUESTION C.13 [1.0 point]
_____ Exhaust Fan # EF-2 discharges air directly into the base of the “A” section of the Exhaust Stack.

a. Dilution

b. Irradiated

c. Normal

d. Process Room

QUESTION C.14 [1.0 point]
Which ONE of the following is the original use of the Neutron Source in the reactor core?

a. Ensure the reactor change from subcritical to critical by using neutron source only.

b. Provides a reference point where all instruments undergo a check before the reactor is brought to a critical position.

c. Provides enough neutron to assure proper nuclear instrumentation response during initial reactor startup.

d. Prevent the reactor changing from a manual to automatic if a period exceeds 10 seconds.

QUESTION C.15 [1.0 point]
Which ONE of the following utilizes an experimental thimble port that allows placement of a large volume of low temperature moderating material close to the core?

a. Cold Neutron Source

b. Radial Beam

c. Reflector Thimble

d. Tube Thermal Column

QUESTION C.16 [1.0 point]
Air-operated diaphragm valves are provided in all of the following EXCEPT:

a. Moderator Dump (DWV-9)

b. Vessel Normal Overflow (DWV-10)

c. Reactor Outlet Isolation (DWV-19)

d. Fuel Transfer Overflow (DWV-37)

QUESTION C.17 [1.0 point]
Which ONE of the following is a Withdraw Prohibit Input?

a. Startup Prohibit

b. Period Bypass

c. Rod Drop Test

d. Moderator Dump

QUESTION C.18 [1.0 point]
The shim safety arms contain 0.040 inch (0.102 cm) thick _____ poison sheet clad with _____ on both sides.

a. Boral / Erbium

b. Cadmium / Aluminum

c. Graphite / Stainless Steel

d. Aluminum / Boron Stainless Steel

QUESTION C.19 [1.0 point]

Non-vital equipment on the critical power panels includes all of the following EXCEPT:

a. Effluent Monitors

b. Nuclear Instrumentation

c. Process Instrumentation

d. AC and DC Valve Control Power

QUESTION C.20 [1.0 point]
NBSR Technical Specifications requires all fuel elements to be stored and handled in a geometry where the calculated k_{eff} shall not exceed _____.

a. 0.6

b. 0.7

c. 0.8

d. 0.9

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

A.01
Answer: c
REF: Lamarsh 3rd, Table 3.6, pg. 88

A.02
Answer: b
REF: Burns, Table 3.5, pg. 3-22

A.03
Answer: a
REF: Burns, Example 7.2 (b), pg. 7-4

A.04
Answer: d
REF: Burns, Problem 7.7.4, pg. 7-17

A.05
Answer: c
REF: Burns, Section 3.3.1, pg. 3-16

A.06
Answer: a and c per facility comments
REF: Lamarsh 3rd ed., Section 7.4, pg. 367

A.07
Answer: a, 4 b, 3 c,2 d,1
REF: Lamarsh 3rd ed., Section 7.5, pg. 377
Burns, Figure 8.1, pg. 8-6

A.08
Answer: b
REF: Burns, Section 3.2.4, pg. 3-12 and Section 3.4.4, pg. 3-33

A.09
Answer: a
REF: Burns, Section 6.4.1, pg. 6-5

A.10
Answer: a
REF: Burns, Section 1.3.1, pg. 1-5

A.11
Answer: a
REF: Burn, Section 5.5, pg. 5-18
A detector that is too far from the source and fuel will underestimate the effects of adding fuel, since the measured counts will not appreciably increase with each fuel element addition.

A.12
Answer: b
REF: Burns, 2.4.6, pg. 2-30
Mathematically, radioactive decay can be represented by the first order, linear differential equation $dA/dt = -\lambda A$ where A is the number density of radioactive atoms of a substance and λ is called the decay constant.

A.13
Answer: b
REF: DOE Handbook, NP-03, pg. 34

A.14
Answer: a
REF: Lamarsh 3rd, Section 8.3, pg. 417

A.15
Answer: b
REF: DOE Fundamentals Handbook, NP-01, pg. 24

A.16
Answer: c
REF: Burns, Section 4.10.12, pg. 4-32 to 4-33

A.17
Answer: c
REF: $P = P_0\, e^{-(t/T)} = 10^{-5} \times e^{-(180sec/80sec)} = 10^{-5} \times e^{-2.25} = 0.1054 \times 10^{-5} = 1.054 \times 10^{-6}$

A.18
Answer: d
REF: From k = 0.925 to criticality (k=1), $\rho = (k-1)/k = -0.081\ \Delta k/k$ or $0.081\ \Delta k/k$ needs to be added to reach criticality. From criticality to JUST prompt, $\rho = \beta_{eff}$ is required, so minimum reactivity = 0.081+0.007= 0.088.

A.19
Answer: a
REF: Burns, Example 3.4.3, pg. 3-32, 3-33
In the reactor period equation, $T=(\beta-p)/\lambda p$, if Beta effective is used instead of Beta for U-235, the term $(\beta_{eff}-p)$ is larger giving a longer period.

A.20
Answer: c
REF: Burns, Section 4.7, pg. 4-21

B.01
Answer: c
REF: $A = A_0e^{-\lambda t}$
$270 = 840e^{-180\lambda}$, $180\lambda = -\ln(0.321)$, $\lambda = 0.00631\ min^{-1}$
$t_{1/2} = 0.693 / \lambda, = 0.693 / 0.00631\ min^{-1} = 109.8$ minutes

B.02
Answer: b and d per facility comments
REF: 10 CFR 50.54(y)

B.03
Answer: b
REF: $I_2=I_1D_1^2/d_2^2 = (100\ mR/hr)(4m)^2 / (2m)^2 = 400\ mR/hr$

B.04
Answer: a
REF: Glasstone, Sesonske, Nuclear Reactor Engineering, Section 9.88, pg. 537

B.05
Answer: b
REF: 10 CFR 55.53 (f)

B.06
Answer: c
REF: TS 3.1.1, pg. 13

B.07
Answer: a. 1, b. 1, c. 2, d. 3, e. 2
REF: EP 5.0, pg. 9
Emergency Instruction 0.3, pg. 1, 2 and 3 of 4

B.08
Answer: d
REF: EP 6.0, pg. 10

B.09
Answer: a. 2, b. 4, c. 1, d. 3
REF: TS 1.3.10, 1.3.22, 1.3.26, 1.3.26.1, pg. 7-9

B.10
Answer: c
REF: Operation Instruction 1.1 CL-A, Section 2.2.17, pg. 3 of 14

B.11
Answer: ~~c~~ a per facility comments
REF: TS 4.5 (4), pg. 37

B.12
Answer: d
REF: Operation Instruction 1.2, Section 3.1.6.3, pg. 2 of 2

B.13
Answer: c
REF: Operating Instruction 3.4, Section 2.1, pg. 1 of 11

B.14
Answer: d
REF: 10CFR20.1301(a)(2)

~~**B.15**~~
~~Answer: b~~ Deleted per facility comments
~~REF: TS Table 3.2.2, Note #3, pag. 16~~

B.16
Answer: b
REF: EP 7.4 (c), pg. 12

~~**B.17**~~
~~Answer: d~~ Deleted per facility comments
~~REF: Operation Instruction 3.7, Section 2.2.5, pg 1 of 1~~

B.18
Answer: c
REF: EP 2.0, pg. 4

B.19
Answer: a
REF: Operation Instruction 4.4, Section 2.3, pg. 1 of 3

B.20
Answer: c
REF: TS 4.7.1 (5), pg. 40

C.01
Answer: c
REF: SAR 7.3.1.1, pg. 7-6

C.02
Answer: a
REF: TS 5.3 (1), pg. 44
SAR 4.2.1.2, pg. 4-4

C.03
Answer: ~~d~~ b per facility comments
REF: SAR 7.3.1.4.2, pg. 7-8

C.04
Answer: a. 3, b.2, c.3, d.5, e.4
REF: SAR 7.3.2, pg. 7-10 to 7-12

C.05
Answer: b
REF: OI 1.1 CL-A, Section 3.10 & 3.11, pg. 9 of 14

C.06
Answer: d
REF: SAR Table 3.4, pg. 3-17

C.07
Answer: b
REF: SAR 11.1.4.2, pg. 11-17

C.08
Answer: d
REF: SAR 5.2.2.5.5, pg. 5-7

C.09
Answer: a
REF: SAR 8.1.2.2, pg. 8-2
SAR Table 8.2A, pg. 8-10
SAR 8.2B, pg. 8-11

C.10
Answer: b
REF: TS 4.1.1(2), pg. 32

C.11
Answer: c
REF: SAR 9.9.1, pg. 9-17

C.12
Answer: b
REF: SAR 3.1.2, pg. 3-8
SAR 6.1.1, pg. 6-4

C.13
Answer: a
REF: SAR 6.2.3.3.4, pg. 6-15
SAR Figure 6.8, pg. 6-25

C.14
Answer: c
REF: SAR 4.2, pg. 4-3
SAR 4.2.4, pg. 4-11

C.15
Answer: a
REF: SAR 10.2.3, pg. 10-2

C.16
Answer: c
REF: SAR 5.2.2.4.1, pg. 5-4

C.17
Answer: c
REF: SAR Table 7.3, pg. 7-21

C.18
Answer: b
REF: SAR 4.2.2.1, pg. 4-7

C.19
Answer: b
REF: SAR 8.2.2, pg. 8-6

C.20
Answer: d
REF: TS 3.9.1(1), pg. 29
SAR 9.1.3, pg. 9-1