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

June 22, 2018

Mr. Robert J. Agasie, Reactor Director
Nuclear Reactor Laboratory
1513 University Avenue, Room 141ME
University of Wisconsin
Madison, WI 53706-1687

SUBJECT: EXAMINATION REPORT NO. 50-156/OL-18-01, UNIVERSITY OF WISCONSIN-MADISON

Dear Mr. Agasie:

During the week of May 21, 2018, the U.S. Nuclear Regulatory Commission (NRC) administered an operator licensing examination at your University of Wisconsin - Madison research reactor. The examinations were conducted in accordance with NUREG-1478, "Operator Licensing Examiner Standards for Research and Test Reactors," Revision 2. Examination questions and preliminary findings were discussed with 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 enclosures will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records (PARS) component of NRC's Agencywide Documents Access and Management System (ADAMS). ADAMS is accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html. The 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 Mr. John T. Nguyen at (301) 415-4007, or via internet e-mail John.Nguyen@nrc.gov.

Sincerely,

/RA/

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

Docket No. 50-156

Enclosures: 1. Examination Report No. 50-156/OL-18-01
2. Written examination

cc: w/o enclosures: See next page

SUBJECT: EXAMINATION REPORT NO. 50-156/OL-18-01, UNIVERSITY OF WISCONSIN-MADISON DATED JUNE 22, 2018

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OFFICE	NRR/DLP/PROB:CE	NRR/DLP/PROB/OLA	NRR/DLP/DLP/PROB:BC
NAME	JNguyen	JRandiki	AMendiola
DATE	06/06/2018	06/20/2018	06/22/2018

OFFICIAL RECORD COPY

cc:

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Test, Research, and Training
Reactor Newsletter
University of Florida
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U. S. NUCLEAR REGULATORY COMMISSION
OPERATOR LICENSING INITIAL EXAMINATION REPORT

REPORT NO.: 50-156/OL-18-01

FACILITY DOCKET NO.: 50-156

FACILITY LICENSE NO.: R-74

FACILITY: TRIGA

EXAMINATION DATES: May 21, 2018

SUBUCITED BY: ***/RA/*** ***06/06/2018***
John T. Nguyen, Chief Examiner Date

SUMMARY:
During the weeks of May 21, 2018, the NRC administered operator licensing examinations to 4 Reactor Operator (RO) candidates. All candidates passed all applicable portions of the examinations.

REPORT DETAILS

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

2. Results:

	RO PASS/FAIL	SRO PASS/FAIL	TOTAL PASS/FAIL
Written	4/0	N/A	4/0
Operating Tests	4/0	N/A	4/0
Overall	4/0	N/A	4/0

3. Exit Meeting:
Robert Agasie, Director, UWNR
John T. Nguyen, Chief Examiner, NRC

At the conclusion of the meeting, the NRC Examiner thanked the facility for their support in the administration of the examinations. The examiner noticed that all candidates were well prepared for the examination.

ENCLOSURE 1

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

FACILITY: Pool

REACTOR TYPE: TRIGA

DATE ADMINISTERED: 5/24/2016

CANDIDATE: ______________________

INSTRUCTIONS TO CANDIDATE:
Answers are to be written on the Answer sheet provided. Attach all Answer sheets to the examination. Point values are indicated in parentheses for each question. A 70% in each category is required to pass the examination. Examinations will be picked up three (3) hours after the examination starts.

CATEGORY VALUE	**% OF TOTAL**	**CANDIDATE'S SCORE**	**% OF CATEGORY VALUE**		**CATEGORY**
20.00	**33.3**	________	_____	**A.**	**REACTOR THEORY, THERMODYNAMICS AND FACILITY OPERATING CHARACTERISTICS**
20.00	**33.3**	________	_____	**B.**	**NORMAL AND EMERGENCY OPERATING PROCEDURES AND RADIOLOGICAL CONTROLS**
20.00	**33.3**	________	_____	**C.**	**FACILITY AND RADIATION MONITORING SYSTEMS**
60.00		________ **FINAL GRADE**	_____%		**TOTALS**

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

____
Candidate's Signature

ENCLOSURE 2

A. RX THEORY, THERMO & FAC OP CHARS

A N S W E R   S H E E T

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

A01 a b c d ___

A02 a b c 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 ___ (0.25 each)

A13 a b c d ___

A14 a ___ b ___ c ___ d ___ (0.25 each)

A15 a b c d ___

A16 a b c d ___

A17 a b c d ___

A18 a b c d ___

A19 a b c d ___

A20 a b c d ___

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

B. NORMAL/EMERG PROCEDURES & RAD CON

A N S W E R   S H E E T

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

B01 a b c d ___

B02 a ___ b ___ c ___ d ___ (0.25 each)

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

B04 a b c d ___

B05 a b c d ___

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

B07 a b c d ___

B08 a b c d ___

B09 a b c d ___

B10 a b c d ___

B11 a b c d ___

B12 a ___ b ___ c ___ d ___ (0.25 each)

B13 a b c d ___

B14 a b c d ___

B15 a ___ b ___ c ___ d ___ (0.25 each)

B16 a b c d ___

B17 a b c d ___

B18 a b c d ___

B19 a ___ b ___ c ___ d ___ (0.25 each)

B20 a b c d ___

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

C. PLANT AND RAD MONITORING SYSTEMS

A N S W E R   S H E E T

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

C01 a b c d ___

C02 a ___ b ___ c ___ d ___ (0.25 each)

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 ___ (0.25 each)

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 ___ (0.5 each)

C16 a b c d ___

C17 a b c d ___

C18 a b c d ___

C19 a b c d ___

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

NRC RULES AND GUIDELINES FOR LICENSE EXAMINATIONS

During the administration of this examination the following rules apply:

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

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

3. Restroom trips are to be UCI 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 <u>only</u> 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.

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

$Q = m\, \Delta h$

$Q = UA\, \Delta T$

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

$SUR = 26.06/\tau$

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

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

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

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

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

$\rho = \Delta Keff/Keff$

$\bar{\beta} = 0.007$

$DR_1D_1^2 = DR_2D_2^2$

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

$\lambda_{eff} = 0.1/sec$

$SCR = S/(1-Keff)$

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

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

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

$SDM = (1-Keff)/Keff$

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

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

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

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

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

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

$P = S\, /\, (1 - Keff)$

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

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1 Curie = 3.7×10^{10} dps

1 kg = 2.21 lbm

1 hp = 2.54×10^3 BTU/hr

1 Mw = 3.41×10^6 BTU/hr

1 BTU = 778 ft-lbf

EF = 9/5EC + 32

931 Mev = 1 amu

EC = 5/9 (EF - 32)

QUESTION A.01 [1.0 point]
Select a contributor of the prompt negative temperature coefficients in the TRIGA fuel in one of the following statements.

a. As the fuel heats up the resonance absorption peaks broaden and increases the likelihood of neutron absorption in U-238.

b. As the fuel heats up a rapid increase in moderator temperature occurs through conduction and convection heat transfer mechanisms which adds negative reactivity.

c. As the fuel heats up fission product poisons (e.g., Xe) increase in concentration within the fuel matrix and add negative reactivity via neutron absorption.

d. As the fuel heats up the oscillating hydrogen in the ZrH lattice imparts energy to a thermal neutron, thereby increasing its mean free path and probability of escape.

QUESTION A.02 [1.0 point]
You're increasing reactor power on a steady +15 second period. How long will it take to increase power by a factor of five?

a. 10 seconds

b. 24 seconds

c. 33 seconds

d. 43 seconds

QUESTION A.03 [1.0 point]
Which ONE of the following conditions will require the control rod withdrawal to maintain constant power level after the following change?

a. Adding of a fuel experiment such as U-235 into the core.

b. Insertion of an experiment containing borated graphite.

c. Decrease of pool water temperature.

d. Burnout of Xenon in the core.

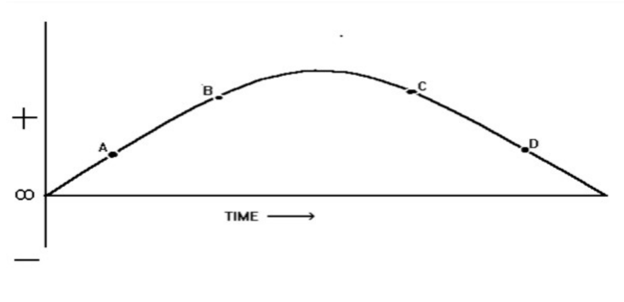
QUESTION A.04 [1.0 point]
Shown below is a trace of reactor period as a function of time. Between points B and D, the reactor power is:

a. constant.

b. continually increasing.

c. increasing, then decreasing.

d. increasing, then constant.



QUESTION A.05 [1.0 point]
If the multiplication factor, k, is increased from 0.800 to 0.950, the amount of reactivity added is:

a. 0.150

b. 0.163

c. 0.184

d. 0.197

QUESTION A.06 [1.0 point]
Which ONE of the following correctly describes the SIX- FACTOR FORMULA at the University of Wisconsin Nuclear Reactor (UWNR)? The multiplication factor, K-effective, is the product of k-infinitive and the:

a. Reproduction factor.

b. Thermal utilization factor.

c. Resonance escape probability.

d. Total non-leakage probability.

QUESTION A.07 [1.0 point]
A reactor is critical at 18.1 inches on a controlling blade. The controlling blade is withdrawn to 18.4 inches. The reactivity inserted is 14.4 cents. What is the differential rod worth?

a. 14.4 cents/inch at 18.25 inches.

b. 48 cents/inch at 18.4 inches.

c. 48 cents/inch at 18.25 inches.

d. 14.4 cents/inch at 18.1 inches

QUESTION A.08 [1.0 point]
The reactor is critical at 10 watts. A rod is pulled to insert a positive reactivity of $0.18. Which ONE of the following will be the stable reactor period as a result of this reactivity insertion? Given beta effective = 0.007.

a. 10 seconds

b. 46 seconds

c. 55 seconds

d. 66 seconds

QUESTION A.09 [1.0 point]
Which ONE of the following statement best defines the reactor excess reactivity? The reactor excess reactivity is:

a. a measure of the additional fuel loaded to overcome fission product poisoning.

b. a measure of remaining control rod worth when the reactor is exactly critical.

c. the combined control rod negative reactivity worth required to keep the reactor shutdown.

d. a measure of remaining control rod worth when the reactor is sub-critical.

QUESTION A.10 [1.0 point]
Which ONE of the following best describes the likelihood of fission occurring in U-235 and U-238?

a. Neutron cross sections of U-235 and U-238 are independent from the neutron velocity.

b. Neutron cross section of U-235 increases with increasing neutron energy, whereas neutron cross section of U-238 decreases with increasing neutron energy.

c. Neutrons at low energy levels (eV) are more likely to cause fission with U-238 than neutrons at higher energy levels (MeV).

d. Neutrons at low energy levels (eV) are more likely to cause fission with U-235 than neutrons at higher energy levels (MeV).

QUESTION A.11 [1.0 point]
Reactor A increases power from 10% to 30% with a period of 25 seconds. Reactor B increases power from 70% to 100% with a period of also 25 seconds. Compared to Reactor A, the time required for the power increase of Reactor B is:

a. longer than A

b. exactly the same as A

c. twice that of A

d. shorter than A

QUESTION A.12 [1.0 point, 0.25 each]
Identify whether each of the following conditions will INCREASE or DECREASE the <u>shutdown margin</u> of a reactor.

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

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

c. Insertion of boron graphite to the reactor core.

d. Burnout of a burnable poison.

QUESTION A.13 [1.0 point]
Which ONE of the following isotopes has the largest microscopic absorption cross-section for thermal neutrons?

a. Sm^{149}

b. U^{235}

c. Xe^{135}

d. B^{10}

QUESTION A.14 [1.0 point, 0.25 each]
Replace "X" with the type of decay necessary (Alpha, Positron, Gamma or Neutron emission) to produce the following reactions. Choices may be used once, more than once, or not at all.

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

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

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

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

QUESTION A.15 [1.0 point]
Which term is described by the following?
"The increase in neutron population by providing a positive additional reactivity while the reactor is subcritical"

a. Inverse Multiplication

b. Subcritical Multiplication

c. Neutron Production

d. Source Strength

QUESTION A.16 [1.0 point]
A reactor is slightly <u>supercritical</u> with the following values for each of the factors in the six-factor formula:

Fast fission factor	1.03
Fast non-leakage probability	0.84
Resonance escape probability	0.96
Thermal non-leakage probability	0.88
Thermal utilization factor	0.70
Reproduction factor	1.96

A control rod is inserted to bring the reactor back to critical. Assuming all other factors remain unchanged, the new value for the thermal utilization factor is:

a. 0.698

b. 0.701

c. 0.073

d. 0.075

QUESTION A.17 [1.0 point]
Which ONE of the following is a correct statement describing prompt and delayed neutrons? Prompt neutrons:

a. are released during U-238 interacts with fast neutrons, while delayed neutrons are released during U-235 interacts with thermal neutrons.

b. account for less than 1% of the neutron population, while delayed neutrons account for the rest.

c. are released during the fission process, while delayed neutrons are released from precursors.

d. are the dominating factor in determining reactor period, while delayed neutrons have no effect on reactor period.

QUESTION A.18 [1.0 point]
What is the condition of the reactor when $k = \frac{1}{1-\beta}$?

a. Subcritical

b. Critical

c. Super critical

d. Prompt critical

QUESTION A.19 [1.0 point]
Which ONE of the following atoms will cause a neutron to lose the most energy in an elastic collision?

a. U-238

b. Ar-40

c. O-16

d. H-1

QUESTION A.20 [1.0 point]
Reactor is at 100 % power. The following graph shows the reactor time behavior following a reactor scram. Which ONE of the following best describes the transition of power between point C and D after the initial rod insertion? .

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

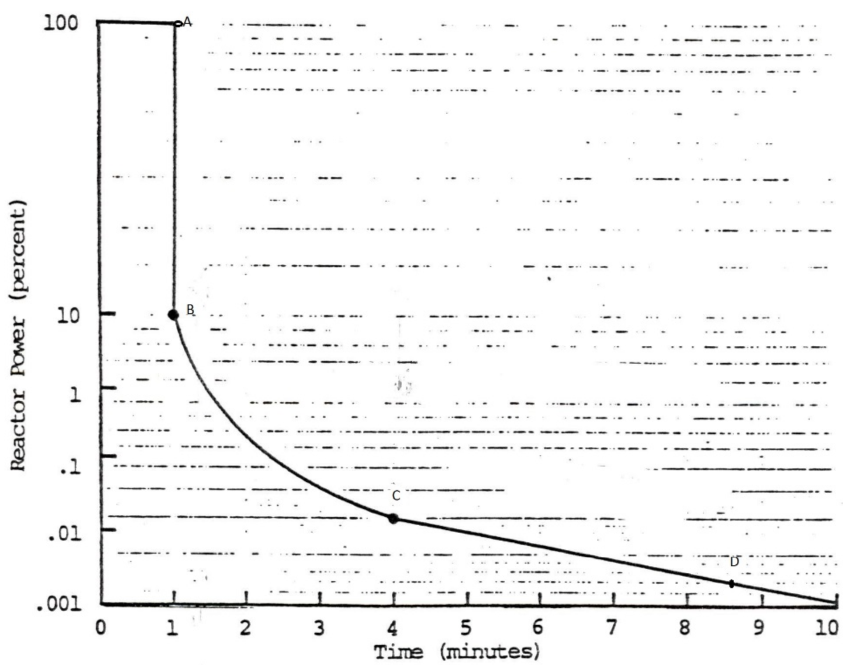
b. Fission product gases such as xenon begin to buildup causing the expansion of fuel density.

c. The **longest** lived delayed neutron precursor begins to effect.

d. The **short** lived delayed neutron precursors begin to effect.

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

Figure 4.3 Reactor Time Behavior Following a Reactor Scram



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

Section A: Theory, Thermo & Fac. Operating Characteristics

Section B: Normal/Emergency Procedures and Radiological Controls

QUESTION B.01 [1.0 point]
Which of the following statements best states the MINIMUM staffing requirements for an initial startup of the reactor?

a. 1 RO in the control room, 1 SRO present at facility, and a second designated person within 1000 feet of the facility.

b. 1 RO in the control room, 1 SRO immediately available on call, and a second designated person within 1000 feet of the facility.

c. 1 RO license in the control room and another RO license at the facility.

d. 1 RO license in the control room and an extra person capable of performing a reactor shutdown at the facility.

QUESTION B.02 [1.0 point, 0.25 each]
Match the radiation reading from Column A with its corresponding radiation area classification (per 10 CFR 20) listed in Column B. Answer in Column B can be used more than once, or not at all.

	Column A	Column B
a.	2 mrem/hr at 1m	1. Public Area
b.	20 mrem/hr at 1m	2. Radiation Area
c.	120 mrem/hr at 1 m	3. High Radiation Area
d.	4.5 grays/hr at 1 m	4. Very High Radiation Area

QUESTION B.03 [1.0 point, 0.25 each]
Fill out the blanks with the Limiting Conditions of Operation (LCO) listed in the UWNR Technical Specifications.

	Safety System	LCO
a.	Core excess reactivity	______ %Δk/k
b.	Steady State reactor power	______ % full power
c.	Pulse limit	______ %Δk/k
d.	Pool Water Temperature	______°F

QUESTION B.04 [1.0 point]
In accordance with UWNR emergency plan exposure guidelines, which ONE of the following is the exposure and intake limit for life threatening situations, or to deal with situations which are likely to lead to life-threatening situations?

a. 25 Rem

b. 30 Rem

c. 45 Rem

d. 50 Rem

QUESTION B.05 [1.0 point]
Per UWNR Technical Specifications, the following measuring channels are required to be operable in the Steady State mode of operations:

a. 1 fuel temperature + 2 power level + 1 pulse + 1 Startup

b. 1 fuel temperature + 3 power level + 1 Startup

c. 2 fuel temperature + 3 power level + 1 pulse

d. 2 fuel temperature + 2 power level + 1 Startup

QUESTION B.06 [1.0 point, 0.25 each]
Identify each of the following surveillances as a channel check (**CHECK)**, a channel test (**TEST)**, or a channel calibration (**CAL)**.

a. During the startup, you verify a reactor period interlock.

b. During the startup, you verify the reactor interlock system by performing simultaneous manual withdrawal of two control blades.

c. During reactor operation, you compare reading of radiation monitors.

d. Adjust the scram set point of the CAM with recent data collected on the calibration.

QUESTION B.07 [1.0 point]
Per Technical Specifications, which ONE of the following will violate the Limiting Safety System Settings?

a. An unanticipated change in reactivity of one dollar.

b. Instrumented fuel temperature exceeds 380 °C.

c. Steady State reactor power exceeds 1.25 MW.

d. Pulse reactivity insertion exceeds 1.4% $\Delta k/k$.

QUESTION B.08 [1.0 point]
Which ONE of the following changes must be submitted to NRC for approval prior to implementation?

a. Replace a primary cooling pump with an identical pump.

b. Add new limit to the pre-startup checklist procedure.

c. Delete Section 6.3, Radiation Safety, listed in the Technical Specifications.

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

QUESTION B.09 [1.0 point]
A two-curie source, emitted 80% of 100 Kev gamma, is to be stored in the reactor building. How far from the source will it read 100 mrem/hr?

a. 3 feet

b. 10 feet

c. 13 feet

d. 100 feet

QUESTION B.10 [1.0 point]
In order to ensure the health and safety of the public, 10CFR50 allows the operator to deviate from SOPs. What is the minimum level of authorization needed to deviate from SOPs?

a. Reactor Director

b. Reactor Supervisor

c. Licensed Senior Reactor Operator

d. Licensed Reactor Operator

QUESTION B.11 [1.0 point]
Which ONE of the following best states the reactor secured?

a. The reactor is shut down which means subcritical by at least 0.7% Δk/k.

b. The core has been unloaded such that there is not enough fuel in the reactor to attain criticality in the most optimum conditions of moderation and reflection with all control elements in the full out position.

c. The console key switch in the "OFF" position and the key is removed from the console and under the control of a licensed operator or stored in a locked storage area.

d. No work is in progress involving core fuel, core structures, control elements, or control element drives unless the work on the drive cannot move the control element.

QUESTION B.12 [1.0 point, 0.25 each]
Match the annual dose limit values to the type of exposure. Answer in Column B can be used more than once, or not at all.

	Type of Exposure		Annual Dose Limit Value
a.	Extremities	1.	0.1 rem.
b.	Lens of the Eye	2.	0.5 rem.
c.	Occupational Total Effective Dose Equivalent (TEDE)	3.	5.0 rem.
d.	TEDE to a member of the public	4.	15.0 rem.
		5.	50.0 rem.

QUESTION B.13 [1.0 point]
Which ONE of the following statements correctly describes the relationship between the Safety Limit (SL) and the Limiting Safety System Setting (LSSS)?

a. The SL is a maximum operationally limiting value that prevents exceeding the LSSS during normal operations.

b. The SL is a parameter that assures the integrity of the fuel cladding. The LSSS initiates protective actions to preclude reaching the SL.

c. The SL is a maximum setpoint for instrumentation response. The LSSS is the minimum number of channels required to be operable.

d. The LSSS is a parameter that assures the integrity of the fuel cladding. The SL initiates protective action to preclude reaching the LSSS.

QUESTION B.14 [1.0 point]
The Emergency Support Center is defined as:

a. The area that consists of the suite of the reactor offices rooms, 1205-1226, of the Mechanical Engineering Building.

b. The area, including the Mechanical Engineering Building and extending 100 feet in every direction from center of the reactor.

c. The area that consists of the control room and the reactor bay.

d. The area for which offsite emergency planning is performed to assure that prompt and effective actions can be taken to protect public in the event of an accident.

QUESTION B.15 [1.0 point, 0.25 each]
Match type of radiation listed in column A with their quality factor listed in column B. Items in column B can be used once, more than once or not at all.

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

QUESTION B.16 [1.0 point]
Per UWNR Technical Specifications, a corrective action shall be taken or the reactor shut down if the water pool conductivity exceeds ______ over a period of one week:

a. average 2 μS/cm

b. average 5 μS/cm

c. dropping from 5 μS/cm to 2 μS/cm

d. exceeding 0.5 Mega-ohm/cm

QUESTION B.17 [1.0 point]
A tour group is to visit the facility. Which ONE of the following statements is correct?

a. Each member of the tour group must wear dosimetry.

b. A maximum number of each tour is fifteen members including the reactor staff.

c. At least one member of each tour group must carry the portable radiation survey meter and wear dosimetry.

d. Group members will not be exposed to radiation levels above 0.5 mrem/hour.

QUESTION B.18 [1.0 point]
Per Technical Specifications, when the Radiation Area Monitor (RAM) is inoperable, the reactor Operations may continue only if:

a. Particulate Radiation Monitor is still operable.

b. Exhaust Gas Radiation Monitor is still operable.

c. Only if portable gamma sensitive instruments with their own alarms are substituted for periods not to exceed <u>one week</u>.

d. Only if portable gamma sensitive instruments with their own alarms are substituted for periods not to exceed <u>one month</u>.

QUESTION B.19 [1.0 points, 0.25 each]
Match the emergency situation listed in Column A with the classification level listed in Column B. (Answers may be used more than once or not at all)

	Column A	Column B
a.	Receive a bomb threat	1. Alert
b.	Security breach of the reactor facility	2. Unusual Event
c.	Laboratory fire extinguished in 5 minutes	3. No Classification
d.	Severe fuel clad leak, pool empty, and ventilation inoperable	

QUESTION B.20 [1.0 point]
Per Technical Specifications, temporary changes to the procedures that do not change their intent may be made by the responsible ______ or designate alternate. Such temporary changes shall be documented and reviewed by ______.

a. RO / SRO on duty

b. SRO / Dean of School

c. SRO / Reactor Safety Committee

d. Director / NRC

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

Section C: Facility and Radiation Monitoring Systems

QUESTION C.01 [1.0 point]
A control blade is partially withdrawn from the core. At this point, the source level, for some unknown reason, drops to 1 count per second. As a result:

a. the control blade cannot be withdrawn any further.

b. the control blade cannot be inserted any further.

c. the control blade stuck and cannot be moved in any direction.

d. the control blade can only be inserted by placing the key switch in the “OFF” position.

QUESTION C.02 [1.0 point. 0.25 each]
Match the item provided in column A, with the correct Nuclear Instrumentation Channel from column B. (Items in column B may be used once, more than once, or not at all.)

	Column A		Column B
a.	< 1 cps rod withdrawal inhibit	1.	Start-up Channel
b.	Prevent firing the Transient rod when power level above 1 kW	2.	Log N –Period Channel
c.	Scram at 120% of full power	3.	Pulse Power Channel
d.	Using a gamma ion chamber	4.	Safety Channel
		5.	Fuel Temperature Channel

QUESTION C.03 [1.0 point]
The fuel element reflector is ___________ and the poison is ____________?

a. Aluminum / Zirconium Hydride

b. Boron / Erbium

c. Cadmium / Graphite

d. Graphite / Erbium

QUESTION C.04 [1.0 point]
Which ONE of the following statements is true regarding the Stack Air Monitor and the Continuous Air Monitor?

a. The Stack Gas Monitor measures only Ar-41 activity, while the Continuous Air Monitor measures only N-16 activity.

b. The Stack Gas Monitor measures both gaseous and particulate activity, while the Continuous Air Monitor only measures gaseous activity.

c. The Stack Gas Monitor measures only fission product gaseous activity, while the CAM measures Ar-41 and N-16 activity.

d. The Stack Gas Monitor and the Continuous Air Monitor each measure both gaseous and particulate activity.

QUESTION C.05 [1.0 point]
Reactor Operator completely sets up a $1.50 pulse. Which ONE of the following statements is true while the reactor is in a Pulse mode?

a. Reactor Operator can withdraw the Shim blades.

b. Reactor Operator can “fire” a pulse when a reactor power level is at 1.5 KW.

c. Reactor Operator can move the Transient rod drive in any direction after setting up its position.

d. Reactor Operator cannot change back to a Manual mode from a Pulse mode without firing a pulse.

Section C: Facility and Radiation Monitoring Systems

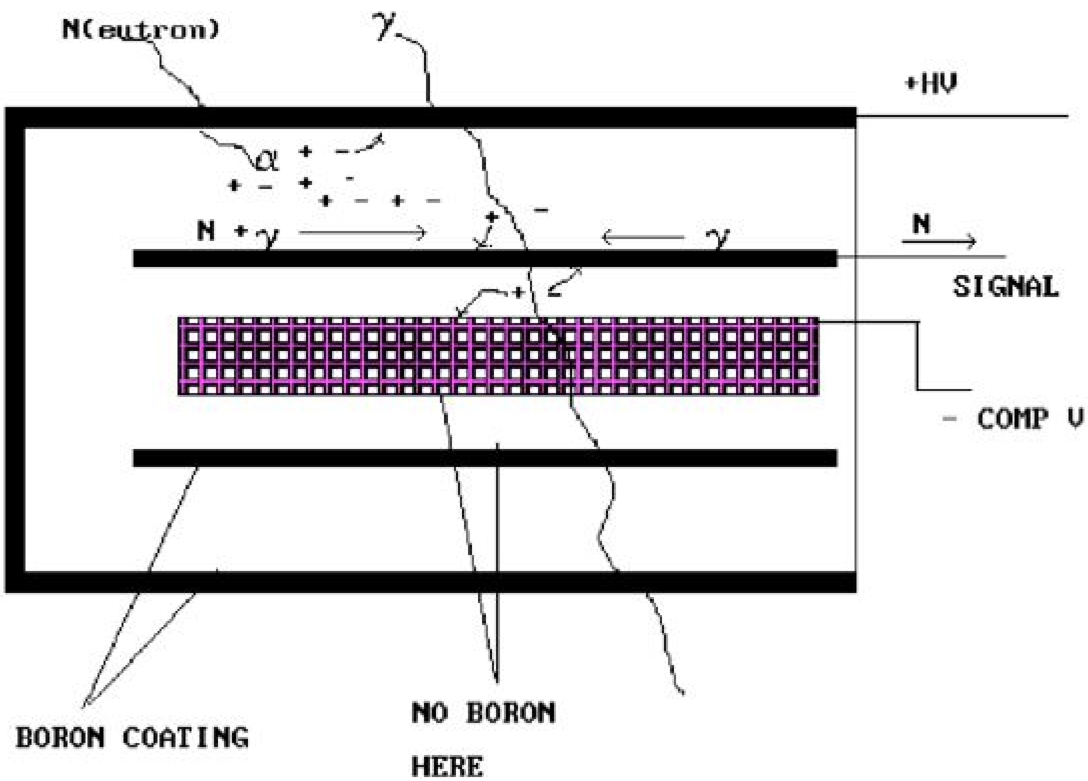
QUESTION C.06 [1.0 point]
The Figure below depicts:

a. The Compensated Ion Chamber.

b. The Uncompensated Ion Chamber.

c. The Gamma Ion Chamber.

d. The Fission Chamber.



QUESTION C.07 [1 point]
Water returning to the pool from the diffuser system is ejected through an angled nozzle, which causes a swirling motion in the pool. Which ONE of the following is a purpose for this design?

a. To increase the heat transfer rate due to increased convective flow.

b. To increase the transport time for N^{16} to reach the surface of the pool.

c. To break up O^{16} bubbles in the pool thereby decreasing the production of N^{16}.

d. To decrease the activation rate of O^{16} to N^{16} due to a decrease in time within the core.

QUESTION C.08 [1.0 point, 0.25 each]

When reactor is at full power, identify the transfer mechanism (Forced Convection, Force Flow with no heat transfer, Natural Convection, or Conduction) for each of the following:

a. Cooling the Core.

b. Cooling the Pool.

c. Remove ions by demineralizer.

c. Transfer of heat across the tubes or plates of the heat exchanger.

QUESTION C.09 [1.0 point]
In the event of a loss of electrical building power, the Uninterruptible Power Supply (UPS) is capable of providing power to:

a. Building security system, emergency lights, and exit signs.

b. Building security system and Radiation Area monitors.

c. Reactor console and instrumentation, Stack Gas monitor, and Continuous Air Monitor.

d. Primary coolant pump, Stack Gas monitor, and Continuous Air Monitor.

QUESTION C.10 [1.0 point]
The Main reason to set the Log Count Rate High Alarm at $2*10^{4}$ cps is to:

a. Warn the reactor operator not to exceeding a count rate limit during the fuel movement.

b. Provide automatic withdrawal of the drive when count rate is off range.

c. Warn the reactor operator not to exceeding a reactor period.

d. Prevent detector damage from high neutron flux.

QUESTION C.11 [1.0 point]
Which ONE of the following is the MAIN purpose to have a neutrons source in the reactor core?

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

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

c. Provide enough neutrons to assure proper nuclear instrumentation response during reactor startup.

d. Prevent the reactor changing from a Steady State mode to a Pulse mode if a period exceeds 10 seconds.

QUESTION C.12 [1.0 point]
Thermocouples in an instrumented TRIGA fuel element measure temperature at the:

a. surface of the cladding.

b. interior of the fuel section.

c. surface of graphite reflector.

d. center of the zirconium rod.

QUESTION C.13 [1.0 point]
When the OUTLET resistivity of the demineralizer reads 10 MΩ-cm and the INLET resistivity reads 1.0 MΩ-cm, it indicates that:

a. the resin bed has been depleted and it needs to be changed.

b. the outlet leg of the demineralizer has been logged.

c. the inlet leg of the demineralizer has been logged.

d. The demineralizer is operable and no need to change the resin bed.

QUESTION C.14 [1.0 point]
Reactor Operator performs a fuel element inspection. In measuring the transverse bend, he finds the bend of one fuel element exceeds the original bend by 0.10 inches. For this measurement, he will:

a. continue the fuel inspection because this bend is within TS limit.

b. continue the fuel inspection because the Technical Specifications require the elongation measurement only.

c. stop the fuel inspection; you immediately report the result to the supervisor because it is considered a damaged fuel element.

d stop the fuel inspection, you immediately report the result to the U.S. NRC since it is a reportable occurrence.

QUESTION C.15 [2.0 points, 0.5 each]
The Transient rod is continuously rising from 5 in to 10 in during the Steady State operation. Select (Open/Closed) for the Limit Switches and (ON/OFF) for the lights.
"Open" means: not been activating.

a. Rod DOWN limit switch (Open/Close)

b. Drive UP limit switch (Open/Close)

c. Air Switch (Open/Close)

d. ENG'D AIR light (ON/OFF)

QUESTION C.16 [1.0 point]
Half-way through a 6-hour reactor operation at full power, you discover that all of the stack exhaust fans are OFF, and could not turn ON. Which ONE of the following actions should you take?

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

b. Immediately secure reactor. This event is NOT a TS violation because the supply fans are still operating.

c. Continue with reactor operations. Up to the next working day is allowed to repair the exhaust fans.

d. Continue with reactor operations. Technical Specifications specify the exhaust fans shall turn OFF during full power.

QUESTION C.17 [1.0 point]
Which ONE of the following materials is used as the neutron absorber in the Transient Control rod?

a. Hafnium

b. Cadmium

c. Samarium

d. Boron Carbide

QUESTION C.18 [1.0 point]
Reactor Operator is performing a PULSE operation. Which ONE of the following preliminaries is NOT required before switching to a PULSE Wave mode?

a. Position the transient rod drive.

b. Set a preset timer for 10 seconds.

c. Ensure a power level between 1 and 1000 watts.

d. Set the safety channel range switches on their full power ranges (1MW).

QUESTION C.19 [1.0 point]
The fuel element used at UWNR is a mixture of U-Zr-H alloy:

a. containing 20% weight of with nominal enriched of 19.75% U^{235}

b. containing 19.75% weight of uranium enriched to 30% U^{235}

c. containing 8% weight of uranium with nominal enriched of 20% U^{235}

d. containing 30% weight of uranium with nominal enriched of 19.75% U^{235}

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

(***** END OF EXAMINATION *****)

Section A L Theory, Thermo & Fac. Operating Characteristics

A.01
Answer: a
Reference: NE 234 Reactor Physics III

A.02
Answer: b
Reference: ln (P/P_0) × period = time. ln(5) × 15 = 1.61 × 15 = 24 seconds

A.03
Answer: b
Reference: Burn, R., Introduction of Nuclear Reactor Operations, © 1988, Sec 3.3.1

A.04
Answer: b
Reference: Reactor is continually increasing, since a reactor period is still positive.

A.05
Answer: d
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1982, Sec 3.3.3, page 3-21.
In order to solve the question A.05, the applicant can use one of the following methods:
At k=0.8; ρ = ∆Keff/Keff or ρ = Keff-1/Keff = -0.2/0.8 =-0.25. At k=0.95, ρ =-0.05/0.95
ρ = -0.053. The difference between ρ is the answer ,i.e. -0.053-(-0.25)=0.197
∆ ρ = ρ1 – ρ2 where ρ1 = Keff1-1/Keff1 and ρ2 = Keff2-1/Keff2. Substitute ρ1 and ρ2 with Keff1 and Keff2 into the equation above, the result is ∆ρ = (keff1-keff2)/(keff1 x keff2) = (0.95-0.8)/(0.8*0.95)=0.197

A.06
Answer: d
Reference: Burn, R., Introduction of Nuclear Reactor Operations, © 1988, Sec 3.3

A.07
Answer: c
Reference: Burn, R., Introduction of Nuclear Reactor Operations, © 1988, Sec 7.3
Differential position is at the midpoint (18.25)
Δρ = 14.4 cents
Δx = 18.4 - 18.1 = 0.3 inches
Differential rod worth (Δρ/in) = (Δρ)/(∆x)
= 14.4 cents /0.3 = 48 cents at midpoint (18.25 inches)

A.08
Answer: b
Reference:
Reactivity added = $0.18 x .007 = 0.00126

$$\tau = (\beta-\rho)/\lambda_{eff}\rho = \frac{0.007 - 0.00126}{(0.1)\ (.00126)} = 45.6 \text{ seconds}$$

A.09
Answer: b
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Sec 6.2

A.10
Answer: d
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, Section 3.2

A.11
Answer: d
Reference: The power of reactor A increases by a factor of 3, while the power of reactor B increases by a factor of 1.43. Since the periods are the same (rate of change is the same), power increase of reactor B takes a shorter time.

A.12
Answer: a, DECREASE; b, INCREASE; c, INCREASE; d, DECREASE
Reference: DOE Fundamentals Handbook, Volume 2, Module 4, Reactor Theory (Reactor Operations), Enabling Objective 3.6

A.13
Answer c
Reference: Introduction to Nuclear Operation, Reed Burn, 1988, Sec 8.1

A.14
Answer: a, alpha b, $_{+1}\beta^0$ c, neutron d, alpha
Reference: NRC Standard Question

A.15
Answer: b
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, Section 5.1, Subcritical Multiplication

A.16
Answer: a
Reference: K eff = 1.03*0.84*0.96*0.88*1.96*x
X= 1/1.4326 = 0.698

A.17
Answer: c
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1988

A.18
Answer: d
Reference: LaMarsh, Introduction to Nuclear Engineering, Page 340-341
$(1-\beta)k=1$ manipulated reads $k=1/(1-\beta)$

A.19
Answer: d
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Sec 2.5.3

A.20
Answer: c
Reference: Burn, R., Introduction to Nuclear Reactor Operations, ©4.5, 1988

Section B Normal/Emergency Procedures and Radiological Controls

B.01
Answer: a
Reference: UWNR 001

B.02
Answer: a(2); b(3); c(3); d(3)
Reference: 10 CFR 20.1003 Definitions
2 mrem/hr at 1m will be equal to 22.2 mrem/hr at 30 cm :=> radiation area
20 mrem/hr at 1m will be equal to 222 mrem/hr at 30 cm :=> high radiation area
120 mrem/hr at 1m will be equal to 1332 mrem/hr at 30 cm :=> high radiation area
4.5 grays→ 450 rad/hr at 1 m ➔ high radiation area
Definition
Radiation Area: 5 mrem/hr at 30 cm
High Radiation Area: 100 mrem/hr at 30 cm
Very High Radiation Area: 500 rads/hr at 1 m

B.03
Answer: a, 5.6 b,125 c,1.4 d,130
Reference: TS 3.1.1, 3.1.3, and 3.2.4

B.04
Answer: a
Reference: UNWR, Emergency Plan 7.4

B.05
Answer: b
Reference: TS 3.2.8

B.06
Answer: a = TEST; b = TEST; c = CHECK; d = CAL
Reference: Technical specification, Definitions

B.07
Answer: c
Reference: TS 2.2

B.08
Answer: c
Reference: TS change requires an amendment.

B.09
Answer: a
Reference: 6CEN = R/hr @ 1 ft. -> 6 x 2 x 0.8 x 0.1 = 0.96 R/hr at 1ft.
$I_0D_0^2 = I*D^2$
0.96 R/hr*(1 ft)^2 = 0.1 R/hr *D^2
D= sqrt(0.96/0.1) = 3 ft.

B.10
Answer: c
Reference: 10CFR50.54(y)

B.11
Answer: b
Reference: UWNR 001

B.12
Answer: a = 5; b = 4; c = 3; d = 1
Reference: 10 CFR 20 §§ 1201.a(2)(ii), 1201.a(1), 1201.a(2)(i), 1301

B.13
Answer: b
Reference: Standard NRC question on Safety Limits

B.14
Answer: a
Reference: EP 2.0

B.15
Answer: a(1) b(1) c(4) d(3)
Reference: 10 CFR 20

B.16
Answer: b
Reference: TS 3.3

B.17
Answer: d
Reference: UWNR 001

B.18
Answer: c
Reference: TS 3.7.1

B.19
Answer: a,2 b,2 c,3 d,1
Reference: UWNR Emergency Plan Table 2

B.20
Answer: c
Reference: TS 6.4

Section C Facility and Radiation Monitoring Systems

C.01
Answer: a
Reference: TS 3.2.5

C.02
Answer: a,1 b,2 c,4 d,3
Reference: UWNR Training Manual, Control and Instrumentation

C.03
Answer: d
Reference: UWNR SAR 4.1.2 and 4.2.3

C.04
Answer: d
Reference: Controls & Instrumentation VI, “System: Stack Air Monitor (SAM) and Continuous Air Monitor (CAM)”

C.05
Answer: c
Reference: UWNR 119A and NRC Standard Question

C.06
Answer: a
Reference: Controls & Instrumentation II, “Nuclear Instrumentation”

C.07
Answer: b
Reference: SAR 5.7

C.08
Answer: a = NC; b = FC; c = FF d = Con
Reference: Standard NRC question

C.09
Answer: c
Reference: SAR 8.2.1 and 8.2.2

C.10
Answer: d
Reference: Controls & Instrumentation I & II, “Log Count Rate – Fission Counter Drive”

C.11
Answer: c
Reference: TS 3.2.5

C.12
Answer: b
Reference: Controls & Instrumentation I, “Temperature Measurements”

Section C Facility and Radiation Monitoring Systems

C.13
Answer: d
Reference: TS 3.3

C.14
Answer: a
Reference: TS 3.1.6

C.15
Answer: a, OPEN b, Open c, Close d, ON
Reference: NRC Standard Question

C.16
Answer: a
Reference: TS 3.5

C.17
Answer: d
Reference: TS 4.2.2.4

C.18
Answer: b
Reference: Controls & Instrumentation III, “Square Wave Operation”

C.19
Answer: d
Reference: TS 5.3