July 21, 2017

Mr. Robert J. Agasie, Director
Nuclear Reactor Laboratory
University of Wisconsin - Madison
1513 University Avenue, Room 1209
Madison, WI 53706

SUBJECT: EXAMINATION REPORT NO. 50-156/OL-16-01, UNIVERSITY OF WISCONSIN - MADISON

Dear Mr. Agasie:

During the week of May 31, 2016, the U.S. Nuclear Regulatory Commission (NRC) administered an operator licensing examination at your University of Wisconsin – Madison Nuclear Reactor. The examinations were conducted according to NUREG-1478, "Operator Licensing Examiner Standards for Research and Test Reactors," Revision 2. Examination questions and preliminary findings were discussed with you and Corey Andrews, Reactor Supervisor/Training Coordinator, 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 Ms. Michele DeSouza at (301) 415-1169 or via e-mail at Michele.DeSouza@nrc.gov.

Sincerely,

/RA/

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

Docket No. 50-156

Enclosures:
1. Examination Report No. 50-156/OL-16-01
2. Written Examination

cc: w/o enclosures: See next page

July 21, 2016

Mr. Robert J. Agasie, Director
Nuclear Reactor Laboratory
University of Wisconsin - Madison
1513 University Avenue, Room 1209
Madison, WI 53706

SUBJECT: EXAMINATION REPORT NO. 50-156/OL-16-01, UNIVERSITY OF WISCONSIN - MADISON

Dear Mr. Agasie:

During the week of May 31, 2016, the U.S. Nuclear Regulatory Commission (NRC) administered an operator licensing examination at your University of Wisconsin – Madison Nuclear Reactor. The examinations were conducted according to NUREG-1478, "Operator Licensing Examiner Standards for Research and Test Reactors," Revision 2. Examination questions and preliminary findings were discussed with you and Corey Andrews, Reactor Supervisor/Training Coordinator, 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 Ms. Michele DeSouza at (301) 415-1169 or via e-mail at Michele.DeSouza@nrc.gov.

Sincerely,

/RA/

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

Docket No. 50-156

Enclosures:
1. Examination Report No. 50-156/OL-16-01
2. Written Examination

cc: w/o enclosures: See next page

DISTRIBUTION w/ encls.:
PUBLIC AMendiola CBassett AAdams STraiforos

ADAMS Accession No.: ML16179A121 **NRR-079**

OFFICE	NRR/DPR/PROB/CE	NRR/DPR/PROB/OLA	NRR/DPR/PROB/BC
NAME	MDeSouza	CRevelle	AMendiola
DATE	06/27/2016	06/27/2016	07/21/2016

OFFICIAL RECORD COPY

cc:

Mayor of Madison
City Hall
210 Martin Luther King Jr. Boulevard
Room 403
Madison, Wisconsin 53703

Chairman, Public Service
Commission of Wisconsin
610 North Whitney Way
Madison, WI 53707-7854

Paul Schmidt, Manager
Radiation Protection Section
Division of Public Health
Wisconsin Dept of Health Services
P.O. Box 2659
Madison, WI 53701-2659

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

Jason Timm, Assistant Director
& Radiation Safety Officer
University of Madison - Wisconsin
Department Environmental Health & Safety
Environmental Protection and Safety Bldg.
30 E. Campus Mall
Madison, WI 53715

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

REPORT NO.: 50-156/OL-16-01

FACILITY DOCKET NO.: 50-156

FACILITY LICENSE NO.: R-74

FACILITY: University of Wisconsin Nuclear Reactor

EXAMINATION DATES: May 31 – June 2, 2016

SUBMITTED BY: **/RA/** **07/21/16**
Michele DeSouza, Chief Examiner Date

SUMMARY:
During the week of May 31, 2016, the NRC administered an operator licensing examination to four Reactor Operator candidates. The Reactor Operator candidates passed all applicable portions of the examinations.

REPORT DETAILS

1. Examiner: Michele DeSouza, Chief Examiner, NRC

2. Results:

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

3. Exit Meeting:
Michele C. DeSouza, Chief Examiner, NRC
Mr. Robert Agasie, Director, University of Wisconsin Nuclear Reactor
Cory Andrews, Reactor Supervisor/Training Coordinator

Per discussion with the facility, prior to administration of the examination, adjustments were accepted. Upon completion of the examination, the NRC Examiner met with facility staff representatives to discuss the results. At the conclusion of the meeting, the NRC examiner thanked the facility for their support in the administration of the examination.

After peer and management review of the Operating Test, the staff has reached the following conclusion “a lack of procedural completeness significantly contributed to the difficulties that two applicants encountered when placing the servo control in automatic mode.” Their actions resulted in unexpected short period alarms on the facility console requiring immediate operator action to stabilize the situation. As a result of the conversation between the NRC Examiner and Mr. Agasie on, June 29, 2016, we look forward to hearing from you about your corrective actions on this issue.

ENCLOSURE 1

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

FACILITY: University of Wisconsin Nuclear Reactor

REACTOR TYPE: TRIGA

DATE ADMINISTERED: 06/02/2016

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

Category A – Reactor Theory, Thermodynamics, & 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 ___ (0.25 each)

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 CATEGORY A *****)

Category B – Normal/Emergency Operating 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 ___ (0.25 each)

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 ____ (0.25 each)

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 ___ (0.25 each)

B17 a b c d ___

B18 a ___ b ___ c ___ (0.33 each)

B19 a b c d ___

B20 a b c d ___

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

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

NRC RULES AND GUIDELINES FOR LICENSE EXAMINATIONS

During the administration of this examination the following rules apply:

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

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

3. Restroom trips are to be limited and only one candidate at a time may leave. You must avoid all contacts with anyone outside the examination room to avoid even the appearance or possibility of cheating.

4. Use black ink or dark pencil only to facilitate legible reproductions.

5. Print your name in the blank provided in the upper right-hand corner of the examination cover sheet and each Answer sheet.

6. Mark your Answers on the Answer sheet provided. USE ONLY THE PAPER PROVIDED AND DO NOT WRITE ON THE BACK SIDE OF THE PAGE.

7. The point value for each question is indicated in [brackets] after the question.

8. If the intent of a question is unclear, ask questions of the examiner only.

9. When turning in your examination, assemble the completed examination with examination questions, examination aids and Answer sheets. In addition turn in all scrap paper.

10. Ensure all information you wish to have evaluated as part of your Answer is on your Answer sheet. Scrap paper will be disposed of immediately following the examination.

11. To pass the examination you must achieve a grade of 70 percent or greater in each category.

12. There is a time limit of three (3) hours for completion of the examination.

EQUATION SHEET

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

1 kg = 2.21 lb

1 Horsepower = 2.54 x 10^3 BTU/hr

1 Mw = 3.41 x 10^6 BTU/hr

1 BTU = 778 ft-lb

°F = 9/5 °C + 32

1 gal (H_2O) ≈ 8 lb

°C = 5/9 (°F - 32)

c_P = 1.0 BTU/hr/lb/°F

c_p = 1 cal/sec/gm/°C

Category A: Reactor Theory, Thermodynamics, and Facility Operating Characteristics

QUESTION A.01 [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.02 [1.0 point]

How high will the reactor power get given the following: the lowest of the reactor high power scram set points is 120%, the scram delay time is 0.5 seconds, the reactor is operating at 100% power prior to the scram, and the reactor period is positive 20 second?

a. 113%

b. 119%

c. 123%

d. 125%

QUESTION A.03 [1.0 point]

The following shows part of a decay chain for the radioactive element Pb-190:

$_{82}Pb^{190} \rightarrow {}_{83}Bi^{190}$

This decay chain is an example of _____ decay.

a. Alpha

b. Beta

c. Gamma

d. Neutron

QUESTION A.04 [1.0 point]

Which ONE of the following best describes the difference between reflectors and moderators?

a. Reflectors decrease thermal leakage while moderators decrease fast leakage

b. Reflectors thermalize neutrons while moderators decrease core leakage

c. Reflectors decrease core leakage while moderators thermalize neutrons

d. Reflectors shield against neutrons while moderators decrease core leakage

Category A: Reactor Theory, Thermodynamics, and Facility Operating Characteristics

QUESTION A.05 [1.0 point]
Which ONE of the following power changes will take the LONGEST time to complete? Assume the reactor is on a CONSTANT positive period.

a. From 1 W to 5 W

b. From 10 W to 30 W

c. From 10 kW to 20 kW

d. From 100 kW to 150 kW

QUESTION A.06 [1.0 point]
Which ONE of the following conditions would INCREASE the shutdown margin of a reactor?

a. Inserting an experiment adding positive reactivity

b. Depletion of Uranium fuel

c. Depletion of a burnable poison

d. Lowering moderator temperature if the moderator temperature coefficient is negative

QUESTION A.07 [1.0 point]
A subcritical reactor, k_{eff} is increased from 0.924 to 0.987. Which ONE of the following is the amount of reactivity that was added to the core?

a. 0.034 $\Delta k/k$

b. 0.069 $\Delta k/k$

c. 5.53%$\Delta k/k$

d. 6.53%$\Delta k/k$

QUESTION A.08 [1.0 point]
Reactor is critical. What would be the corresponding k_{eff} when removing 5% $\Delta k/k$ from its criticality?

a. 0.922

b. 0.943

c. 0.952

d. 0.973

Category A: Reactor Theory, Thermodynamics, and Facility Operating Characteristics

QUESTION A.09 [1.0 point]
Which ONE of the following directly produces 95% of all Xenon in a nuclear reactor?

a. Fission of Th-233

b. Fission of Th-238

c. Beta decay of Cs-135

d. Decay of I-135

QUESTION A.10 [1.0 point, 0.25 each]
Match the following Neutron term in Column A with the appropriate definition in Column B (each used only once)

Column A	Column B
a. Delayed Neutron	1. Neutron born directly from fission
b. Fast Neutron	2. Neutron in equilibrium with its surroundings
c. Thermal Neutron	3. Neutron born due to decay of a fission product
d. Prompt Neutron	4. Neutron at an energy level greater than its surroundings

QUESTION A.11 [1.0 point]
Which ONE of the following is the MAJOR source of heat released after shutdown?

a. Production of prompt gamma rays

b. Spontaneous fission of U^{238}

c. Decay of fission products

d. Production of delayed neutrons

QUESTION A.12 [1.0 point]
Which factors of the six factor formula are affected by an INCREASE in core temperature and how are they affected? L_f - Fast non-leakage probability L_t – Thermal non-leakage probability ε - Fast fission factor p – Resonance escape probability η – Thermal fission factor f – Thermal utilization factor

a. $\downarrow L_f$, $\downarrow$p, $\uparrow f$

b. $\uparrow \varepsilon$, $\uparrow L_f$, $\downarrow L_t$, $\uparrow$p

c. $\uparrow \varepsilon$, $\downarrow L_f$, $\downarrow L_t$, $\downarrow$p, $\uparrow \eta$, $\uparrow f$

d. $\uparrow \varepsilon$, $\uparrow L_f$, $\downarrow L_t$, $\downarrow$p, $\uparrow \eta$, $\uparrow f$

QUESTION A.13 [1.0 point]
Which ONE of the following describes the general shape of the integral rod worth of a control rod?

a. Parabolic shaped, with the maximum at the top and bottom of the core height

b. S-shaped, with the net change in reactivity from bottom to top

c. Cosine shaped, with the largest change in the middle of the core height

d. Exponentially shaped, with the maximum at the bottom of the core height

QUESTION A.14 [1.0 point]
Which ONE of the following statements correctly differentiates between operating a reactor with thermal neutrons instead of fast neutrons?

a. The fission cross section of the fuel is much higher for fast neutrons than thermal energy neutrons. Since fast neutrons are easier to cause fission, a reactor cannot control with fast neutrons

b. The neutron lifetime of thermal neutrons is longer than fast neutrons, so the fuel has enough time to capture thermal neutrons

c. The fission cross section of the fuel is much higher for thermal energy neutrons than fast neutrons, so thermal neutrons are easier to cause fission

d. The atomic weight of thermal neutrons is larger than fast neutrons, so thermal neutrons are easily to slow down and be captured by the fuel

QUESTION A.15 [1.0 point]
Which ONE of the following is a correct statement of how delayed neutrons enhance the ability to control reactor power?

a. Prompt neutrons can cause fissions in both U-235 and U-238 and delayed neutrons can only cause fissions in U-235

b. Delayed neutrons increase the average neutron lifetime that allows a reactor to be controlled

c. The average number of delayed neutrons produced per fission is higher than the average number of prompt neutrons

d. Delayed neutrons are born at higher energy levels than prompt neutrons

Category A: Reactor Theory, Thermodynamics, and Facility Operating Characteristics

QUESTION A.16 [1.0 point]
What are the two common FISSION PRODUCTS that have especially large neutron cross sections and play a significant role in reactor physics?

a. Nitrogen-16 and Argon-41

b. Argon-41 and Cobalt-60

c. Iodine-131 and Cesium-137

d. Xenon-135 and Samarium-149

QUESTION A.17 [1.0 point]
Which ONE of the following conditions will DECREASE the reactor core excess?

a. Fuel depletion

b. Burnable poison burnout

c. Insertion of a positive reactivity worth experiment

d. Lowering moderator temperature (assume negative temperature coefficient)

QUESTION A.18 [1.0 point]
Assume that the worths of the Shim rod is $3.70, Safety rod is $4.45, and Reg rod is $2.10. The reactor is critical at 15 W after WITHDRAWING the following control rod worths: Shim $2.10, Safety $3.50, and Reg $1.50. What is the CORE EXCESS?

a. $2.85

b. $3.15

c. $5.50

d. $7.10

QUESTION A.19 [1.0 point]
What is β?

a. The fractional change in neutron population per generation

b. The fraction of all fission neutrons that are born as delayed neutrons

c. The time required for the reactor to change by power by a factor of e

d. The fraction of all delayed neutrons that reach thermal energy

QUESTION A.20 [1.0 point]

Which ONE of the following is the expected stable neutron count rate given a source strength of 300 neutrons per second (N/sec) and a multiplication factor of 0.5?

a. 150 N/sec

b. 300 N/sec

c. 450 N/sec

d. 600 N/sec

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

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.01 [1.0 point]
Which ONE of the following reactor primary coolant conditions is a violation of UWNR Technical Specifications?

a. Primary coolant conductivity is 4 μS/cm averaged over a week

b. Primary pool pH is 6.5

c. Primary coolant outlet temperature is 140^{o}F

d. Primary coolant pool level decreases six inches below normal level

QUESTION B.02 [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.03 [1.0 point]
Which ONE of the following is the 10CFR20 definition for “Derived Air Concentration-hour”?

a. Product of concentration of radioactive material in air and time of exposure in hours, Committed Effective Dose Equivalent of 5 Rems

b. 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. Projected Committed Effective Dose Equivalent commitment to individuals that warrants protective action following a release of radioactive material

d. 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

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.04 [1.0 point, 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. Tornado affecting confinement	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.05 [1.0 point]
Per UWNR Technical Specifications, what is the MINIMUM shutdown margin required with the reactor in reference core condition, the most reactive rod fully withdrawn, and experiments in their most reactive state?

a. 0.01%Δk/k

b. 0.02%Δk/k

c. 0.1%Δk/k

d. 0.2%Δk/k

QUESTION B.06 [1.0 point]
According to the UNWR Emergency Plan, “transportation of a contaminated and injured person requiring transport to the hospital will be by_____”?

a. Senior Reactor Operator

b. Reactor Safety Committee

c. UW Police Department

d. Madison Fire Department

QUESTION B.07 [1.0 point]
A radioactive source has a current activity of 3 Curies. The activity 30 years ago was 300 Curies. What is the half-life of the radioactive source?

a. 4.5 years

b. 10.5 years

c. 15 years

d. 20 years

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.08 [1.0 point]
How many hours (MINIMUM) are Test and Research Reactors licensed operators required to perform the functions of a licensed operator to resume activities if a licensee has not been actively performing the functions of a reactor operator or senior reactor operator?

a. 4 hours

b. 6 hours

c. 8 hours

d. 10 hours

QUESTION B.09 [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). Write the correct answer on your answer sheet next to the space given for each example listed below.

a. During performance of the daily checklist, you compare the readings of radiation area monitor one and radiation monitor two

b. During performance of the daily checklist, you press the scram button to verify a scram on the safety system channel

c. Adjustment of the wide range monitor channel in accordance with recent data collected during a reactor power calibration

d. You expose a 2 mCi check source to the continuous air monitor detector to verify that its output is operable

QUESTION B.10 [1.0 point]
UWNR Technical Specification requires the worth of all single unsecured experiments shall be < _____ and the worth of all experiments shall be < _____.

a. 0.7%Δk/k and no limit

b. 1.4%Δk/k and 5.6%Δk/k

c. 0.7%Δk/k and 1.4%Δk/k

d. No limit and 5.6%Δk/k

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.11 [1.0 point]
Which ONE of the following meets the MINIMUM staffing requirement when the reactor is NOT secured?

a. 1 RO in the control room, 1 SRO on call, and a second person within 1000 feet

b. 1 SRO in the control room and Reactor Operations Manager on call

c. 1 RO in the control room, Reactor Operations Manager on call

d. 1 SRO in the control room and a second person within 1500 feet

QUESTION B.12 [1.0 point]
Calculate an individual's total whole body dose given the individual received the following doses: 20 mrad of alpha, 10 mrad of gamma, and 5 mrad of neutron (unknown energy)

a. 35 mrem

b. 415 mrem

c. 435 mrem

d. 460 mrem

QUESTION B.13 [1.0 point]
A radiation field is 330 mR/hr at 4 feet. What is your dose rate at 2 feet away from the source?

a. 499 mR/hr

b. 580 mR/hr

c. 660 mR/hr

d. 1320 mR/hr

QUESTION B.14 [1.0 point]
Which ONE of the following experiments is NOT allowed in accordance with UWNR Technical Specifications?

a. Liquid fissionable materials

b. Compounds highly reactive with water

c. 30 milligrams of explosive materials

d. Materials corrosive to reactor components

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.15 [1.0 point]
Which ONE of the following locations is the normal (no evacuation required) Emergency Support Center per the Emergency Plan?

a. Reactor Control Room

b. Reactor Shop

c. Reactor Director's Office

d. Lobby of Mechanical Engineering Building

QUESTION B.16 [1.0 point, 0.25 each]
Match the appropriate 10CFR part in Column A with the requirements in Column B.

Column A	Column B
a. 10CFR19	1. Technical information including the proposed maximum power level
b. 10CFR20	2. Individual radiation exposure data
c. 10CFR50	3. Postings of notices to workers
d. 10CFR55	4. Medical examination by a physician every two years

QUESTION B.17 [1.0 point]
Which ONE of the following meets the required MINIMUM radiation monitoring channels for reactor operation? Area Radiation Monitor (ARM)

a. 4 Environmental Dosimeters, 1 ARM, and 1 Gas Stack

b. 4 Environmental Dosimeters, 3 ARM, 1 Particulate, and 1 Gas Stack

c. 2 Environmental Dosimeters, 3 ARM, 1 Particulate and 1 Gas Stack

d. Environmental Dosimeters are not required, 1 ARM, and 1 Gas Stack

QUESTION B.18 [1.0 point, 0.33 each]
Match the following limitations in Column A with its specification in Column B (Assume natural convection; Answers may be used more than once or not at all)

Column A	Column B
a. Safety Limit	1. Maximum pulse 1 kW
b. Limiting Safety System Setting	2. Maximum fuel temperature 1150^{o}C
c. Limiting Condition for Operation	3. Maximum 1.25MW

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.19 [1.0 point]
A 25 curie source emits a 1.332MeV gamma and a 1.117 gamma 100% of the time. The source will be placed in the reactor storage room. How far from the source should a high radiation area sign be posted?

a. Not required

b. 30 feet

c. 45 feet

d. 60 feet

QUESTION B. 20 [1.0 point]
Which ONE of the following surveillance checks shall be tested at least quarterly?

a. Pool water radioactivity

b. Scram times

c. HV channel test

d. Fuel temperature calibration

(***** End of Category B *****)

Category C: Facility and Radiation Monitoring Systems

QUESTION C.01 [1.0 point]
What instrumentation region is associated with “the voltage is such that every primary ion produces an avalanche of secondary ions”? This region also cannot differentiate between types of radiation.

a. Region I, Recombination

b. Region II, Ionization

c. Region III, Proportional

d. Region IV, Geiger-Mueller

QUESTION C.02 [1.0 point]
Which ONE of the following conditions correctly describes the result from a primary leak with the heat exchanger compromised?

a. Intermediate high pressure annunciator due to increase in water flow

b. Influx of degraded water will result in an increase in conductivity

c. If operating, reactor will SCRAM due to intermediate pressure increase

d. Decrease in primary water will actuate low pool level alarm

QUESTION C.03 [1.0 point]
Which ONE of the following is the primary function of the demineralizer?

a. Remove large particles to increase convective flow

b. Stabilize temperature to allow even secondary flow

c. Dissipate heat from the primary system to prevent degradation of systems

d. Maintain resistivity high to prevent corrosion of reactor components

QUESTION C.04 [1.0 point]
Which ONE of the following Area Radiation Monitor (ARM) readings will NOT result in an ‘Alarm’?

a. Thermal column 8 mR/hr

b. Pool top 50 mR/hr

c. Thermal column 10 mR/hr

d. Demineralizer 90 mR/hr

Category C: Facility and Radiation Monitoring Systems

QUESTION C.05 [1.0 point]
The Log-N Channel is the neutron flux monitoring channel that provides a signal indicating which ONE of the following?

a. Percent power – ability to readout in a way specified by a certain amount resulting from the reactor power

b. Linear – a result from the reactor power in a generally straight or nearly straight line

c. Count rate – the total number of emissions per amount of time as a result of the reactor power

d. Period – the time required for reactor power to change by a factor of about 2.718

QUESTION C.06 [1.0 point]
When fuel is stored in a safe array outside of the reactor core what is the MAXIMUM k_{eff} allowed per UWNR Technical Specifications?

a. 0.5

b. 0.6

c. 0.7

d. 0.8

QUESTION C.07 [1.0 point]
What is the purpose for the holes drilled in the primary inlet and outlet pipes?

a. Prevent scum buildup on the pool surface

b. Delay N^{16} from rising to the surface of the pool

c. Prevent a loss of pool water from a primary pipe break

d. Provide a homogenous mixture for circulation through the heat exchanger

QUESTION C.08 [1.0 point]
Which ONE of the following is used with Aluminum as the poison in UWNR safety blades?

a. Boron Carbide

b. Zirconium Hydride

c. Aluminum Oxide

d. Graphite

Category C: Facility and Radiation Monitoring Systems

QUESTION C.09 [1.0 point]
Which ONE of the following is correct regarding the Stack Air Monitor (SAM) and Continuous Air Monitor (CAM)?

a. SAM measures gaseous activity and the CAM measures gaseous and particulate activity

b. SAM measures gaseous and particulate activity and the CAM measures gaseous activity

c. SAM and CAM each measure both gaseous and particulate activity

d. SAM measures gaseous activity and the CAM measures particulate activity

QUESTION C.10 [1.0 point]
What is the purpose of the small holes in the control blade shroud and guide tubes?

a. Prevent excessive withdrawal speeds

b. Ensures water displacement

c. Holes allow for proper distribution of the flux

d. Streams radiation in the proper direction

QUESTION C.11 [1.0 point]
When the diffuser pump is set to 'automatic', it will start when the reactor power reaches what level?

a. 25 kW

b. 50 kW

c. 75 kW

d. 100 kW

QUESTION C.12 [1.0 point]
Which ONE of the following regions of the pulse size versus applied voltage characteristic curve does UNWR's Log-N channel operate?

a. Proportional

b. Ion Chamber

c. Geiger-Mueller

d. Limited Proportional

Category C: Facility and Radiation Monitoring Systems

QUESTION C.13 [1.0 point]
The fuel element reflector is _____ and the poison is _____?

a. Aluminum and Zirconium Hydride

b. Boron and Erbium

c. Cadmium and Graphite

d. Graphite and Erbium

QUESTION C.14 [1.0 point]
Which ONE of the following is the method used to determine the safety blade position?

a. A mechanical counter, consisting of a series of disks mounted on an axle, with a metal wiper

b. As the rod moves, it move into or out of a coil, generating a signal proportional to rod position

c. A logic circuit receives input from two sensors which count 100 pulses per revolution along with detecting direction, converting these signals to rod position

d. As the rod moves up and down, the magnet opens and closes a series of over 1000 limits switches which generate a signal which is converted to rod position

QUESTION C.15 [1.0 point]
Which power channel provides the period indication?

a. Startup

b. Log-N

c. Pulse

d. Linear

QUESTION C.16 [1.0 point]
Oxygen-16 in the reactor pool water produces significant quantities of which ONE of the following isotopes?

a. N-16

b. Ar-41

c. Co-60

d. I-131

Category C: Facility and Radiation Monitoring Systems

QUESTION C.17 [1.0 point]
Which ONE of the following conditions is the MAIN purpose a nuclear reactor core requires a neutron source for startup?

a. Prevent the period becoming too short and resulting in an inadvertent power excursion

b. Provide enough delayed neutrons for all nuclear instrumentations before the reactor can go to a critical position

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

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

QUESTION C.18 [1.0 point]
Which ONE of the following is the primary function of the graphite sections on both sides of the fuel element?

a. Absorb thermal neutrons

b. Absorb fission product gases

c. Reduces neutron leakage

d. Increases fast neutron flux

QUESTION C.19 [1.0 point]
What gas is used in the pneumatic system to move rabbit samples into and out of the reactor?

a. Air

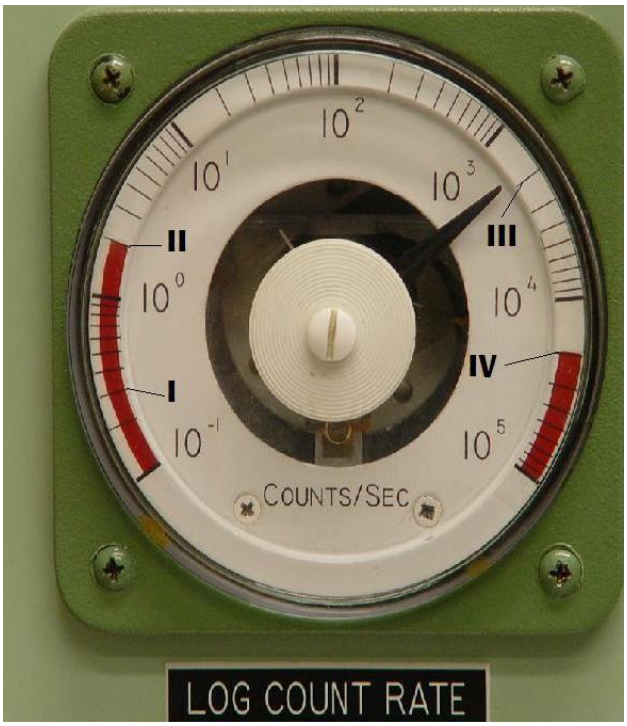
b. Nitrogen

c. Hydrogen

d. Carbon Dioxide

Category C: Facility and Radiation Monitoring Systems

QUESTION C.20 [1.0 point]
Which ONE of the following roman numerals indicates the value for an alarm associated with LOG COUNT RATE meter below? (Note: disregard the readout indication of the channel).



a. I

b. II

c. III

d. IV

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

Category A: Reactor Theory, Thermodynamics, and Facility Operating Characteristics

A.01
Answer: d
Reference: LaMarsh, *Introduction to Nuclear Engineering*, Page 340-341
$(1- \beta)k=1$ manipulated reads $k=1/(1- \beta)$

A.02
Answer: c
Reference: $P/P_o = 120\%$, T = 20 seconds, t = 0.5, $P/P_o = 120\ e^{\wedge 0.5/20} = 123\%$

A.03
Answer: b
Reference: Chart of the Nuclides

A.04
Answer: c
Reference: Burn, *Introduction to Nuclear Reactor Operations,* Section 5.4

A.05
Answer: a
Reference: $P=P_o e^{t/T} \rightarrow t=T*\ln(P/P_o)$ assume constant period=1
The smallest ratio of P/P_o is the shortest time to complete

A.06
Answer: b
Reference: Burn, *Introduction to Nuclear Reactor Operations*, Section 6.2.3

A.07
Answer: b
Reference: Burn, *Introduction to Nuclear Reactor Operations*, Section 3.3.4, Page 3-20&21
$\Delta\rho=(k_{eff2}-k_{eff1})/(k_{eff1}*k_{eff2})$ = (0.987-0.924)/(0.987*0.924) = 0.0690Δk/k or 6.9%Δk/k

A.08
Answer: c
Reference: $\rho=(k-1)/k-0.05 \rightarrow 1=k-(-0.05k)=k(1+0.05) \rightarrow k=1/1.05 =0.952$

A.09
Answer: d
Reference: DOE Fundamentals Handbook *Nuclear Physics and Reactor Theory*, Volume 2, Module 3, Page 35

A.10
Answer: a(3), b(4), c(2), d(1)
Reference: DOE Fundamentals Handbook *Nuclear Physics and Reactor Theory*, Volume 1, Module 2, Pages 29-37

A.11
Answer: c
Reference: Burn*, Introduction to Nuclear Reactor Operations*, Section 4.10.14, Page 4-33

A.12
Answer: a
Reference: DOE Fundamentals Handbook *Nuclear Physics and Reactor Theory*, Volume 2, Module 1

Category A: Reactor Theory, Thermodynamics, and Facility Operating Characteristics

A.13
Answer: b
Reference: UWNR Training Manual, Chapter 10.3, Figure 10.6

A.14
Answer: c
Reference: Burn, *Introduction to Nuclear Reactor Operations,* Figure 2.6, Page 2-39

A.15
Answer: b
Reference: Burn, *Introduction to Nuclear Reactor Operations,* Section 3.3.2, Page 3-7

A.16
Answer: d
Reference: Burn, *Introduction to Nuclear Reactor Operations*, Section 8.1, Page 8-1

A.17
Answer: a
Reference: NRC standard question

A.18
Answer: b
Reference: Total Worth = $3.70+$4.45+$2.10=$10.25
Reactivity at 15 W=$2.10+$3.50+$1.50 = $7.10
Core Excess = Total Worth – Reactivity@15 W = $10.25-$7.10= $3.15

A.19
Answer: b
Reference: DOE Fundamentals Handbook *Nuclear Physics and Reactor Theory*, Volume 2, Module 4

A.20
Answer: d
Reference: CR=S/(1-k)→300/(1-0.5) = 600 N/sec

Category B: Normal/Emergency Operating Procedures and Radiological Controls

B.1
Answer: c
Reference: UWNR Technical Specification 3.3

B.2
Answer: a
Reference: UNWR, Emergency Plan 7.4

B.3
Answer: a
Reference: 10CFR20.1003

B.4
Answer: a(2),b(2),c(3),d(1)
Reference: UWNR Emergency Plan Table 2

B.5
Answer: d
Reference: UNWR TS 3.1.2

B.6
Answer: d
Reference: UNWR Emergency Plan 8.3

B.7
Answer: a
Reference: $T\ A = A_{\circ} * e^{-\lambda t}$
$3Ci = 300Ci * e^{-\lambda(t)}$ Note: $\lambda = -\ln 2/t^{1/2}$
$\ln(3/300) = -\ln 2/X\ yr * (30\ years) \rightarrow -4.605/-1.021 \rightarrow$
solve for t: 4.51 years

B.8
Answer: b
Reference: 10CFR55.53(f)(2)

B.9
Answer: a (check), b (test), c (cal) , d (test)
Reference: UWNR Technical Specifications 1, definitions

B.10
Answer: c
Reference: UWNR Technical Specifications 3.8

B.11
Answer: a
Reference: UWNR Technical Specifications 6.1.3

B.12
Answer: d
Reference: 20mrad Alpha x 20 = 400mrem, 10mrad Gamma x 1 = 10mrem, 5mrad neutron x 10 = 50mrem → 400mrem + 10mrem + 50mrem = 460mrem

Category B: Normal/Emergency Operating Procedures and Radiological Controls

B.13
Answer: d
Reference: $I_1D_1^2=I_2D_2^2 \rightarrow$ 330mR/hr@$(4ft)^2=I_2$@$(2ft)^2 \rightarrow$1320mR/hr

B.14
Answer: c
Reference: UWNR Technical Specifications 3.8.2

B.15
Answer: c
Reference: UWNR Emergency Plan 8.1

B.16
Answer: a (3), b(2), c(1), d(4)
Reference: 10CFR19.11, 10CFR20.1501(2)(i), 10CFR50.34(1)(ii)(A), 10CFR55.21

B.17
Answer: b
Reference: UWNR Technical Specifications 3.7.1, Table 3.7.1

B.18
Answer: a(2),b(3),c(1)
Reference: UWNR Technical Specifications 2.1, 2.2, and 3.1.3

B.19
Answer: d
Reference: I=6CEn=R/hr@ft.$\rightarrow$ 6 x 25Ci x [(1.332Mev x 100%)+(1.117x100%)] = 367.35 R/hr@$(1ft)^2$ = 626.25 R/hr = 0.1 R/hr@ $D^2 = \sqrt{3673.5}$ R/hr = 60.6 ft.

B.20
Answer: a
Reference: UWNR Technical Specifications 4.2 & 4.3

Category C: Facility and Radiation Monitoring Systems

C.01
Answer: d
Reference: NRC standard question

C.02
Answer: b
Reference: UWNR SAR 5.3

C.03
Answer: d
Reference: UWNR SAR 5.5 and UWNR Training Manual NE 234, Reactor Water Systems III, I - Purpose

C.04
Answer: a
Reference: UWNR Training Manual NE 234, Control and Instrumentation V.3, Page 6

C.05
Answer: d
Reference: UWNR Training Manual, NE 234, Control and Instrumentation II.3, Page 7

C.06
Answer: d
Reference: UWNR Technical Specification 5.6 and UWNR SAR 9.2.2

C.07
Answer: c
Reference: UWNR SAR 5.5 and UWNR Training Manual NE 234, Reactor Water Systems

C.08
Answer: a
Reference: UWNR SAR 4.2.2.2

C.09
Answer: c
Reference: UWNR SAR 7.7.2

C.10
Answer: b
Reference: UWNR SAR 4.2.2.1

C.11
Answer: d
Reference: UWNR Training Manual NE 234, Reactor Water Systems IV.I Purpose, Page 2

C.12
Answer: b
Reference: UWNR SAR

C.13
Answer: d
Reference: UWNR SAR 4.1.2 and 4.2.3

Category C: Facility and Radiation Monitoring Systems

C.14
Answer: a
Reference: UWNR SAR 4.2.2.5

C.15
Answer: b
Reference: UWNR SAR 7.2.3

C.16
Answer: a
Reference: NRC Standard Question

C.17
Answer: a
Reference: UWNR SAR 4.2.4

C.18
Answer: c
Reference: NRC Standard question and UWNR SAR 4.2.4

C.19
Answer: d
Reference: UWNR SAR 4.1.3.4

C.20
Answer: d
Reference: UWNR NEEP 234, Page 9