June 11, 2015

Dr. Timothy Koeth, Director
The University of Maryland
Radiation Facilities and Nuclear Reactor
Department of Materials Science and Engineering
2309D Chemical and Nuclear Engineering Building
Building 090, Stadium Drive
College Park, MD 20742-2115

SUBJECT: EXAMINATION REPORT NO. 50-166/OL-15-01, UNIVERSITY OF MARYLAND

Dear Dr. Koeth:

During the week of April 7, 2015, the U.S. Nuclear Regulatory Commission (NRC) administered an operator licensing examination at your University of Maryland 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 Mr. Vincent Adams of your staff 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 that will not be publicly released. Should you have any questions concerning this examination, please contact Mr. Patrick Isaac at (301) 415-1019 or via e-mail Patrick.Isaac@nrc.gov.

Sincerely,

/RA/

Kevin Hsueh, Chief
Research and Test Reactors Oversight Branch
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Docket No. 50-166

Enclosures:
1. Examination Report No. 50-166/OL-15-01
2. Facility Comments with NRC Resolution
3. Written examination

cc: w/o enclosures: See next page

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<u>DISTRIBUTION</u> w/ encls.:
PUBLIC RidsNRRDPRPROB

ADAMS ACCESSION #: ML15160A590 **TEMPLATE #:NRR-079**

OFFICE	NRR/DPR/PROB:CE		NRR/DPR/ IOLB:OLA		NRR/DPR/PROB:BC	
NAME	PIsaac		CRevelle		KHsueh	
DATE	6/11/2015		6/09/2015		6/11/2015	

OFFICIAL RECORD COPY

cc:

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Power Plant Siting Program
Energy & Coastal Zone Administration
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Maryland Department Environment
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Test, Research, and Training
Reactor Newsletter
University of Florida
202 Nuclear Sciences Center
Gainesville, FL 32611

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

REPORT NO.: 50-166/OL-15-01

FACILITY DOCKET NO.: 50-166

FACILITY: UMD

EXAMINATION DATES: April 7-10, 2015

SUBMITTED BY: /RA/ 05/19/15
Patrick Isaac, Chief Examiner Date

SUMMARY:
During the week of April 7, 2015, the NRC administered operator licensing examinations to two Reactor Operator and three Senior Reactor Operator candidates. The candidates passed all applicable portions of the examinations.

REPORT DETAILS

1. Examiners: Patrick Isaac, Chief Examiner, NRC
Michele DeSouza, Examiner Trainee

2. Results:

	RO PASS/FAIL	SRO PASS/FAIL	TOTAL PASS/FAIL
Written	2/0	3/0	5/0
Operating Tests	2/0	3/0	5/0
Overall	2/2	3/0	5/0

3. Exit Meeting:

Patrick Isaac, Chief Examiner, NRC
Michele DeSouza, Examiner Trainee, NRC
Vincent Adams, Operations Manager

At the conclusion of the examinations, the NRC examiners thanked the facility for their support in the administration of the examinations. The examiners reminded Mr. Adams that the written examination will not be graded until the facility licensee's comments have been received by the NRC. Mr. Adams committed to provide any comments on the written examination in a timely manner.

ENCLOSURE 1

Facility Comments with NRC Resolution

Question A.01

Facility Comment:
Either a or b can correct depending on whether you are talking about our reactor or reactors in general due to the sign of the moderator coefficient.

Please consider accepting both a and b as correct.

NRC Resolution:
Comment partially accepted. The answer key is corrected to accept a as the correct answer as this is the answer applicable to the facility.

Question A.04

Facility Comment:
The question does not specify over what time interval the factor is affected. Choice a is correct for short term effects and choice c is correct for long term effects.

Please consider accepting both a and c as correct.

NRC Resolution:
Comment accepted. The answer key is corrected to accept both a and c as correct.

Question: A.09

Facility Comment:
Both a and d should be correct since they describe the same characteristics on different scales
Justification: Pages 17-18 of DOE Fundamentals Handbook Vol 2 Module 4 show a direct relation between reactor period and doubling time with a simple scalar proportional relationship of ln(2)

Please consider accepting both a and d as correct

NRC Resolution:
Comment accepted. The answer key is corrected to accept both a and d as correct.

Question A.19

Facility Comment:
There is no specification of what “the neutron is”. If “the neutron” is the neutron that causes fission answers c and d would be correct since the number of neutrons produced is not effected by the energy of the fission causing neutron.

NRC Resolution:
Question deleted. The facility provided comments but did not provide a suggestion or recommendation. NRC agrees this question was not clear and agrees to delete the question.

Question A.20

Facility Comment:

When B_{eff} is less than reactivity the reactor is both Prompt Critical and Supercritical. If B_{eff} is less than reactivity then K_{eff} must be greater than 1 and by definition the reactor is Supercritical.

Please consider answers c and d as correct

NRC Resolution:
Comment accepted. The answer key is corrected to accept both c and d as correct.

Question B.11

Facility Comment:

There is a typo in choice d, the exponent should be "-6" making it the correct answer.

There is no correct answer with typo, correct answer should read 5x10E-6mhos/cm.

NRC Resolution:
Comment accepted, however, no correction to the answer key is necessary.
The documentation submitted by the facility was used in the preparation of the written examination and did in fact have the answer as listed in the question. The candidates discussed with the proctor their belief that a correct answer was not present. After consultation, the proctor clarified to all the candidates that choice "d" should state 5×10^{-6} mhos/cm.

Question C.09

Facility Comment:

For our reactor both b and d are correct. We do not have an individual "Purification System" as it is a part of the Primary water system.

Please consider accepting both b and d as correct.

NRC Resolution:
Comment accepted. The answer key is corrected to accept both b and d as correct.

Question C.10

Facility Comment:

This question is worded in a confusing or incomplete manner. During the exam, candidates were unsure if this intended to mean a loss integrity of fuel cladding as opposed to the homogenous UZrH fuel contained within the cladding. Depending on interpretation both answers a and d are acceptable.

Please consider accepting both a and d as correct.

NRC Resolution:
Comment rejected. This question has only one correct answer and remains as written.

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

FACILITY: University of Maryland

REACTOR TYPE: UMD TRIGA

DATE ADMINISTERED: 4/07/2015
CANDIDATE: ________________________

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

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

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

____
Candidate's Signature

ENCLOSURE 3

Section 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 ___ (0.25 each)

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 *****)

Section 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 ___ (0.33 each)

B07 a b c d ___

B08 a b c d ___

B09 a ___ b ___ c ___ (0.33 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 ___

B17 a b c d ___

B18 a b c d ___

B19 a b c d ___

B20 a b c d ___

(***** END OF SECTION B *****)

Section 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 ___ (0.25 each)

C04 a b c d ___

C05 a b c d ___

C06 a b c d ___

C07 a b c d ___

C08 a b c d ___

C09 a b c d ___

C10 a b c d ___

C11 a b c d ___

C12 a b c d ___

C13 a b c d ___

C14 a b c d ___

C15 a b c d ___

C16 a b c d ___

C17 a b c d ___

C18 a b c d ___

C19 a b c d ___

C20 a b c d ___

(***** END OF SECTION C *****)
(********** END OF EXAMINATION **********)

NRC RULES AND GUIDELINES FOR LICENSE EXAMINATIONS

During the administration of this examination the following rules apply:

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

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

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

4. Use black ink or dark pencil <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.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

1 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

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

QUESTION A.01 [1.0 point]
How will an increase in moderator temperature affect neutron multiplication?

a. Resonance escape probabilities, thermal and fast non leakage increase

b. Resonance escape probabilities, thermal and fast non leakage decrease

c. Slowing down and diffusion length decrease

d. Slowing down and diffusion length decrease with a decrease in rod worth as secondary

QUESTION A.02 [1.0 point]
Which ONE of the following is the **MAJOR** source of energy released during fission?

a. Fission fragments

b. Fission product decay

c. Prompt gamma rays

d. Fission neutrons (kinetic energy)

QUESTION A.03 [1.0 point, 0.25 each]
Match the following Neutron Interactions (each used only once)

a. Fission	1. Neutron enters nucleus, forms a compound nucleus, then decays by gamma emission
b. Radiative capture	2. Particle enters nucleus, forms a compound nucleus and is excited enough to eject a new particle with incident neutron remaining in nucleus
c. Scattering	3. Nucleus absorbs neutron and splits into two similarly sized parts
d. Particle ejection	4. Nucleus is struck by a neutron and emits a single neutron

QUESTION A.04 [1.0 point]
What has the greatest effect on the THERMAL UTILIZATION FACTOR in the six-factor formula?

a. Xenon build-up

b. Moderator temperature

c. Fuel burn-up

d. Fuel density

QUESTION A.05 [1.0 point]
The following shows part of a decay chain for the radioactive element Pa-234:
$_{91}Pa^{234} \rightarrow {}_{92}U^{234}$
This decay chain is an example of _______ decay.

a. Alpha

b. Beta

c. Gamma

d. Neutron

QUESTION A.06 [1.0 point]
Which ONE defines a differential rod worth curve?

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

b. Exponentially shaped with maximum at the bottom of the core height

c. S shaped with minimum at the middle of the core height

d. Cosine shaped with maximum at the middle of the core height

QUESTION A.07 [1.0 point]
In a subcritical reactor, k_{eff} is increased from 0.914 to 0.965. Which one of the following is the amount of reactivity that was added to the core?

a. 3.64%Δk/k

b. 4.38%Δk/k

c. 5.78%Δk/k

d. 6.57%Δk/k

QUESTION A.08 [1.0 point]
A reactor is operating at criticality. Instantaneously, all of the delayed neutrons are suddenly removed from the reactor. The K_{eff} of the reactor in this state would be approximately:

a. 1.007

b. 1.000

c. 0.993

d. 0.000

QUESTION A.09 [1.0 point]
A rapid change in reactor power will result from a smaller value of _________.

a. Reactor period

b. Reactivity

c. Effective delayed neutron fraction

d. Doubling time

QUESTION A.10 [1.0 point]
The fuel temperature coefficient of reactivity is -2.5×10^{-4} k/k/°C. When a control rod with an average rod worth of 0.2 % k/k/inch is withdrawn 12 inches, reactor power increases and becomes stable at a higher level. At this point, the fuel temperature has:

a. decreased by 96°C

b. increased by 96°C

c. decreased by 0.67°C

d. increased by 0.67°C

QUESTION A.11 [1.0 point]
β_{eff} is defined as:

a. Ratio of delayed neutrons to total core neutrons once they have slowed down to thermal energies
b. Ratio of prompt neutrons to thermal neutrons
c. Probability of prompt neutrons becoming thermal neutrons
d. Probability of delayed neutrons becoming thermal neutrons

QUESTION A.12 [1.0 point]
A reactor is operating at 5kW and is placed on a positive 3 second period. How long will it take for the power to increase 1.0MW?

a. 3.45 seconds

b. 10.88 seconds

c. 12.21 seconds

d. 15.89 seconds

QUESTION A.13 [1.0 point]
Two common FISSION PRODUCTS that have especially large neutron cross sections and play a significant role in reactor physics are Sm-149 and _______.

a. Xe-135

b. Ar-41

c. N-16

d. I-131

QUESTION A.14 [1.0 point]
The reactor is on a **CONSTANT** positive period. Which ONE of the following power changes will take the **longest time** to complete?

a. 5%, from 95% to 100%

b. 10%, from 80% to 90%

c. 15%, from 15% to 30%

d. 20%, from 60% to 80%

QUESTION A.15 [1.0 point]
What is the material called that is used for the purpose of thermalizing neutrons?

a. Absorber

b. Poison

c. Moderator

d. Void coefficient

QUESTION A.16 [1.0 point]
During the time following a reactor scram, reactor power decreases on a negative 80 second period, which of the following corresponds to the half-life of the longest-lived delayed neutron precursors?

a. 80 seconds

b. 55 seconds

c. 40 seconds

d. 20 seconds

QUESTION A.17 [1.0 point]
Which one of the following best represents a characteristic of subcritical multiplication?

a. The number of neutrons gained per generation increases by a factor of x2 for each succeeding generation.

b. For equal reactivity additions, it takes less time for the equilibrium subcritical neutron population level to be reached as Keff approaches one.

c. A constant neutron population is achieved when the total number of neutrons produced in one generation is equal to the number of source neutrons in the next generation

d. Doubling the indicated power will reduce the margin to criticality by approximately one half

QUESTION A.18 [1.0 point]
A reactor that has a reactivity of -$2.39 has a count rate of 50 cps on nuclear instrumentation. Calculate what the neutron level (i.e., count rate) should be after a reactivity insertion of $1.21 from the withdrawal of the control rods. Assume β=0.0070

a. 25 cps

b. 50 cps

c. 100 cps

d. 200 cps

~~**QUESTION A.19 [1.0 point]**~~ DELETED
~~As the energy of the neutron is raised, the average number of neutrons released (both prompt and delayed) ___________.~~

~~a. Increases~~

~~b. Decreases~~

~~c. Stays the same~~

~~d. Has no effect~~

QUESTION A.20 [1.0 point]
When B_{eff} is less than reactivity the reactor is __________.

a. Subcritical

b. Critical

c. Supercritical

d. Prompt critical

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

Section B: Normal and Emergency Operating Procedures and Radiological Controls

QUESTION B.1 [1.0 point]
The following emergency class action levels pertain to which emergency class, "sustained fire or minor explosion within the reactor building or failure of an experiment involving a significant release of radioactivity within the reactor building":

a. Class 0

b. Class 1

c. Class 2

d. Class 3

QUESTION B.2 [1.0 point]
Per UMD Radiation Safety Procedures, personnel monitoring TLD badges, or equivalent, will be exchanged:

a. Daily

b. Weekly

c. Monthly

d. Quarterly

QUESTION B.3 [1.0 point]
The reactor shall **NOT** be operated unless the following measuring channels are operable:

a. 1 linear power channel and 1 fuel element temperature channel

b. 2 reactor power level channels and 1 fuel element temperature channel

c. 2 linear power channels and 2 fuel element temperature channels

d. 2 fuel element temperature channels and 2 log power channels

Section B: Normal and Emergency Operating Procedures and Radiological Controls

QUESTION B.4 [1.0 point, 0.25 each]
Match the limitations on experiments from Column B (may be used more than once) with Column A:

Column A	Column B
a. Non secured experiment	1. $0.50
b. Any single experiment	2. $1.00
c. Total in-core experiment	3. $2.00
d. Shutdown margin	4. $3.00

QUESTION B.5 [1.0 point]
How many hours per calendar quarter must you perform the functions of an RO or SRO to maintain an active RO or SRO license?

a. 4

b. 6

c. 8

d. 12

QUESTION B.6 [1.0 point, 0.33 each]
Match the appropriate item in column A with its definition in column B:

Column A	Column B
a. Channel Calibration	1. Qualitative verification of acceptable performance by observation of channel behavior
b. Channel Check	2. An adjustment of the channel such that its output corresponds with acceptable accuracy to known values of the parameter that the channel measures
c. Channel Test	3. The introduction of a signal into the channel for verification that it is operable

QUESTION B.7 [1.0 point]
How long will it take a 50 Curie source, with a half-life of 5.26 years, to decay to 2 Curie?

a. 10.5 Years

b. 15.5 Years

c. 24.5 Years

d. 35.5 Years

QUESTION B.8 [1.0 point]
Why is pool water evaluated for gross gamma activity?

a. Detect particulates

b. Detect fission product release

c. Prevent heat exchanger issues

d. Prevent demineralizer clogging

QUESTION B.9 [1.0 point, 0.33 each]
Per UMD Emergency Classification match the emergency class with the emergency action level (Use each only once):

Column A	Column B
a. Severe or extensive fuel damage involving multiple clad failures	1. Personnel Emergency
b. An explosion or a fire in the reactor building	2. Class 1 - Notification of Unusual Events
c. Incidents involving one or more persons requiring medical treatment	3. Class 2 - Alert

QUESTION B.10 [1.0 point]
10 CFR 20 limits the annual occupational exposure to the **WHOLE BODY** of an individual to:

a. 50 rem

b. 15 rem

c. 100 rem

d. 5 rem

QUESTION B.11 [1.0 point]
Conductivity of pool water shall be no higher than ____________.

a. 2×10^{-3}mhos/cm

b. 3×10^{-2}mhos/cm

c. 4×10^{-1}mhos/cm

d. 5×10^{-0}mhos/cm

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

a. 190 mrem

b. 200 mrem

c. 210 mrem

d. 220 mrem

QUESTION B.13 [1.0 point]
You are standing three feet from a radiation field of 250 mR/hr. What is your dose rate at 9 feet away from the source?

a. 24 mR/hr

b. 28 mR/hr

c. 32 mR/hr

d. 36 mR/hr

QUESTION B.14 [1.0 point]
The emergency procedure uses the acronym **SAVE** to provide instructions for the evacuation of personnel from the Reactor Building. The acronym **SAVE** stands for:

a. Scram, alarms, vent, and evacuate

b. Secure, alert, vent, and execute

c. Safeguard, awareness, visualize, and education

d. Scram, alert, visualize, and execute

QUESTION B. 15 [1.0 point]
Select the list that gives the order of types of radiation from the LEAST penetrating to the MOST penetrating (i.e. travels further in air)

a. Neutron, gamma, beta, alpha

b. Alpha, neutron, beta, gamma

c. Beta, alpha, gamma, neutron

d. Alpha, beta, neutron, gamma

QUESTION B.16 [1.0 point]
After a building evacuation, who has the authority to allow reentry to the reactor building or allow access to the reactor building roof?

a. Senior Reactor Operator

b. Reactor Director

c. Emergency Director

d. NRC

QUESTION B.17 [1.0 point]
Which one of the following **DOES NOT** require supervision by a senior reactor operator?

a. Initial startup following new fuel loading

b. Resuming operation after an unscheduled electrical shutdown

c. Removal of control rods in the core

d. In-core experiment manipulation of greater than $0.80

QUESTION B.18 [1.0 point]
The statement, "the excess reactivity relative to the cold critical conditions, with or without experiments in place shall not be >$3.50" is an example of __________.

a. Limiting condition for operation (LCO)

b. Limiting safety system settings (LSSS)

c. Safety limit

d. Administrative control

QUESTION B.19 [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.20 [1.0 point]
A two curie source emits a 2MeV gamma 100% of the time. The source will be placed in the reactor storage building. How far from the source should a high radiation area sign be posted?

a. Not required

b. 10.5 feet

c. 12.5 feet

d. 15.5 feet

(*****End of Section B *****)

Section C: Facility and Radiation Monitoring Systems

QUESTION C.01 [1.0 point]
The beam ports are stepped to prevent ________.

a. Coolant leakage

b. Streaming radiation

c. Loss of experiment

d. Corroding piping systems

QUESTION C.02 [1.0 point]
Primary coolant temperature is measured by the following EXCEPT_________.

a. Four thermocouples in the primary system

b. Two thermocouples before and two thermocouples after the heat exchanger

c. Two thermocouples in the reactor pool

d. Four thermocouples in the secondary system

QUESTION C.03 [0.25 each point]
Match the following UMD control rod drive components with their corresponding definitions. Answers are used only once.

Column A	Column B
a. Potentiometer	1. Switch will reverse position according to whether the magnet is at or above its completely depressed position
b. Rod down limit switch	2. Provides rod position indications
c. Magnet up limit switch	3. Switch reverses position according to whether the magnet is at or below its full up position
d. Magnet down limit switch	4. Foot is depressed by armature when rod is fully lowered

Section C: Facility and Radiation Monitoring Systems

QUESTION C.04 [1.0 point]
Which ONE of the followings interlocks prevents the withdrawal of two or more control rods in steady state mode?

a. Rod drive control interlock

b. Startup count rate interlock

c. Log power level interlock

d. Pulse power interlock

QUESTION C.05 [1.0 point]
The difference between the total worth of all control rods in the core and the reactivity which needs to be inserted into the core in order for the reactor to become critical is the _________.

a. Shutdown margin

b. Thermal output

c. Excess reactivity

d. Coefficient of reactivity

QUESTION C.06 [1.0 point]
Typical annual exposures at the pool surface are ________.

a. 100 mrem

b. 20 mrem

c. 1000 mrem

d. 50 mrem

Section C: Facility and Radiation Monitoring Systems

QUESTION C.07 [1.0 point]
Which ONE of the following systems is used at UMD in the event of a rupture in the primary piping?

a. A diffuser system

b. A deionizer

c. A siphon break

d. A skimmer

QUESTION C.08 [1.0 point]
What is the purpose of limiting conditions for operation?

a. Provide excess reactivity >$3.50

b. Provide a reactor scram to prevent reaching the safety limit

c. Ensure the reactor can be controlled and shut down at all times and not exceed safety limits

d. Ensure the fuel element temperature not exceed $1000^{o}C$

QUESTION C.09 [1.0 point]
Which system is responsible for removing radioactive ions and particles, reducing conductivity, and maintaining optical clarity?

a. Makeup system

b. Purification system

c. Secondary system

d. Primary system

QUESTION C.10 [1.0 point]
A loss in fuel integrity could result in a buildup of pressure between the _________ and the _______.

a. Fuel moderator and reflector

b. Reflector and cladding

c. Primary and secondary coolant

d. Fuel moderator and cladding

QUESTION C.11 [1.0 point]
The ion chamber power indications are correlated to the heat balance calculated thermal power by:

a. Physically adjusting the height of the detectors in the support assembly

b. Moving the graphite reflectors to change the neutron flux near the detectors

c. Adjusting the circuit comparator voltage

d. Adjusting the detector high voltage

QUESTION C.12 [1.0 point]
Which ONE of the following radiation monitoring systems SCRAM the reactor if the set point is exceeded?

a. Reactor bridge and glove box monitors

b. Reactor bridge and exhaust vent monitors

c. Exhaust vent and glove box monitors

d. Glove box monitor only

QUESTION C.13 [1.0 point]
An experiment with corrosive or liquid fissionable materials shall be:

a. Limited to $0.50

b. Double encapsulated

c. No greater than 5 mCi

d. Supervised by Reactor Director

QUESTION C.14 [1.0 point]
When going to automatic from manual rod control the regulating rod will automatically be limited to a ________ reactor period until the power has reached the demand setpoint on the % DEMAND controller for the current range selected on the REACTOR POWER RANGE SWITCH.

a. 15 second

b. 25 second

c. 10 second

d. 5 second

QUESTION C.15 [1.0 point]
Where do the thermocouples in the instrumented fuel bundle measure temperature?

a. Interior of the fuel

b. Center of the zirconium rod

c. Interior surface of the cladding

d. Outer surface of the fuel

QUESTION C.16 [1.0 point]
The purpose of the Nitrogen-16 diffuser is _______.

a. Assist with natural circulation through the reactor core

b. Reduce radiation levels at the pool surface

c. Sweep away fission products in order to prevent them from reaching the pool surface

d. Take a suction on the primary pool and discharge it to the purification system to remove activated impurities

Section C: Facility and Radiation Monitoring Systems

QUESTION C.17 [1.0 point]
The fuel storage racks can hold up to 13 fuel clusters and criticality calculations show $k_{eff} < 0.4$. k_{eff} must be < than what level?

a. 0.9

b. 0.8

c. 0.7

d. 0.6

QUESTION C.18 [1.0 point]
What radiation does the compensated ion chamber discriminate between?

a. Neutrons and gamma

b. Gamma and beta

c. Beta and alpha

d. Neutrons and fission fragments

QUESTION C.19 [1.0 point]
Which ONE of the following types of detectors is used to detect surface contamination and determine radiation fields around the reactor?

a. Ionization chamber

b. Scintillation detector

c. Proportional counter

d. Geiger-Mueller meter

QUESTION C.20 [1.0 point]
Pool water conductivity and ________ shall be determined monthly.

a. Neutron levels

b. Particulate activity

c. Gross gamma activity

d. Beta/gamma activity

(***** END OF SECTION C *****)
((***** END OF EXAM *****))

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

A.01
Answer: a
Reference: Burn*, Introduction to Nuclear Reactor Operations,* Section 3.3.2(b), Page 3-18

A.02
Answer: a
Reference: Burn*, Introduction to Nuclear Reactor Operations*, Table 3.2, Page 3-5

A.03
Answer: a 3; b 1; c 4; d 2
Reference: DOE Fundamentals Handbook *Nuclear Physics and Reactor Theory*, Volume 1, Module 1, Page 43-46

A.04
Answer: a or c
Reference: Burn, *Introduction to Nuclear Reactor Operations*, Section 3.3.2, Page 3-18

A.05
Answer: b
Reference: Chart of the Nuclides

A.06
Answer: d
Reference: Burn, *Introduction to Nuclear Reactor Operations*, Section 7.2, Page 7-4

A.07
Answer: c
Reference: Burn, *Introduction to Nuclear Reactor Operations*, Section 3.3.4, Page 3-20&3-21
$\Delta\rho=(k_{eff2-}k_{eff1})/(k_{eff1}*k_{eff2)}$ = (0.965-0.914)/(0.965*0.914) = 0.0578Δk/k=5.78%Δ/k

A.08
Answer: c
Reference: DOE Fundamentals Handbook *Nuclear Physics and Reactor Theory*, Volume 1, Module 2, Page 30

A.09
Answer: a or d
Reference: DOE Fundamentals Handbook *Nuclear Physics and Reactor Theory*, Volume 2, Module 4, Page 11

A.10
Answer: b
Reference: Lamarsh, *Introduction to Nuclear Engineering*, Page 365

A.11
Answer: a
Reference: Burn, Introduction to Nuclear Reactor Operations, Section 3.2.4, Page 3-12

A.12
Answer: d
Reference: $P = P_0\ e^{(t/T)}$; P=1MW, P_o=5kW, T= 3seconds,
t=(3sec)*ln(1000000W/5000W), t =15.89 seconds

A.13
Answer: a
Reference: Burn, *Introduction to Nuclear Reactor Operations*, Section 8.1, Page 8-1

A.14
Answer: c
Reference: Time is related to ratio of final power to initial power. 2:1 is the largest ratio

A.15
Answer: c
Reference: DOE Fundamentals Handbook *Nuclear Physics and Reactor Theory,* Volume 2, Module 2, Page 23

A.16
Answer: b
Reference: LaMarsh, *Introduction to Nuclear Engineering,* Page 88

A.17
Answer: d
Reference: DOE Fundamentals Handbook *Nuclear Physics and Reactor Theory*, Volume 2, Module 4, Pages 1-6

A.18
Answer: c
Reference: DOE Fundamentals Handbook *Nuclear Physics and Reactor Theory,* Volume 2, Module 1
This question can be answered in two ways. One way is through the equations as shown below, or two, use a rule of thumb that if the reactor moves halfway from its subcritical state towards criticality, the count rate will double.
$CR_1/CR_2=1-k_2/1-k_1 \rightarrow CR_2=CR_1(1-k_1/1-k_2)$=50cps(1-0.984/1-0.992)=100
Where, ρ($)=ρ/β, p_1=(0.0070)x(-$2.39)= -0.01673, p_2= (0.0070)x(1.21)= 0.00850= 821 pcm--> -0.00823
$K_1=1/1-p_1$=1/10.01673=0.984, $k_2=1/1-p_2$=1/1+0.00823=0.9918

~~**A.19**~~ Question deleted
~~Answer: a~~
~~Reference: LaMarsh, *Introduction to Nuclear Engineering*, Page 85~~

A.20
Answer: c or d
Reference: Burn, *Introduction to Nuclear Reactor Operations*, Section 4.6, Page 4-16 & Table 4.3

Section B: Normal and Emergency Operating Procedures and Radiological Controls

B.1
Answer: b
Reference: MUTR Emergency Plan

B.2
Answer: c
Reference: MUTR Radiation Safety Procedure

B.3
Answer: b
Reference: TS, Table 3-1a

B.4
Answer: a (2), b (2), c (4), d (1)
Reference: TS, 3.1 & 3.6

B.5
Answer: a
Reference: 10CFR55.53(e)

B.6
Answer: a (2), b (1), c (3)
Reference: TS 1.2.1-1.2.3 Definitions

B.7
Answer: c
Reference: T $A = A_{\circ} * e^{-\lambda t}$
$2Ci = 50Ci * e^{-\lambda(t)}$
Ln(2/50) = -ln2/5.27 yr*(t) --> -3.2189/-0.1315 →
solve for t: 24.47 years

B.8
Answer: b
Reference: TS, 4.3

B.9
Answer: a (3), b (2), c (1)
Reference: MUTR Emergency Plan

B.10
Answer: d
Reference: 10 CFR 20.1201

B.11
Answer: d
Reference: TS 3.4.1

B.12
Answer: c
Reference: 5mrad Alpha x 20=100mrem, 10mrad Gamma x 1=10mrem, 10mrad neutron x 10 = 100mrem →100mrem+10mrem+100mrem= 210mrem

Section B: Normal and Emergency Operating Procedures and Radiological Controls

B.13
Answer: b
Reference: $I_1D_1^2=I_2D_2^2 \rightarrow$ 250mR/hr@(3ft)^2=I_2@(9ft)^2 $\rightarrow$28mR/hr

B.14
Answer: a
Reference: MUTR, EP-401

B.15
Answer: d
Reference: DOE Fundamentals Handbook, *Nuclear Physics and Reactor Theory*, Volume 1, Module 1, Pages 64-66

B.16
Answer: c
Reference: E-Plan

B.17
Answer: b
Reference: MUTR, training admin

B.18
Answer: a
Reference: TS 3.1(1&2)

B.19
Answer: d
Reference: 10CFR20.1301(a)(2)

B.20
Answer: d
Reference: I=6CEn=R/hr@ft.$\rightarrow$2Ci x 2Mev x 100% = 24 R/hr@ (1ft)^2 = 24 R/hr = 0.1 R/hr@ D^2 = $\sqrt{240}$ R/hr = 15.5 ft

Section C: Facility and Radiation Monitoring Systems

C.01
Answer: b
Reference: SAR 10.2.2

C.02
Answer: d
Reference: SAR 5.2

C.03
Answer: a, 2 b, 4 c, 3 d, 1
Reference: SAR 4.2.2.3

C.04
Answer: a
Reference: TS 3.3, Table 3-1a

C.05
Answer: c
Reference: ENNU 320, Volume 2, Section 7.5, Page 7-2

C.06
Answer: a
Reference: SAR 4.2.2.b, Table 4.3, Page 4-12

C.07
Answer: c
Reference: SAR 4.1, Page 4-2

C.08
Answer: c
Reference: SAR 2.2

C.09
Answer: b or d
Reference: TS 5.1

C.10
Answer: d
Reference: TS 2.1

C.11
Answer: a
Reference: ENNU 320, Volume 2, Section 7.3, Page 7-1

C.12
Answer: b
Reference: SAR 7.7

C.13
Answer: b
Reference: TS 3.6(4)

Section C: Facility and Radiation Monitoring Systems

C.14
Answer: a
Reference: ENNU 320, Volume 2, Section 6.2.2, Page 6-8

C.15
Answer: a
Reference: ENNU 320, Volume 2, Section 3.1.2, Page 3-1

C.16
Answer: b
Reference: ENNU 320, Volume 2, Section 7.5, Page 7-2

C.17
Answer: b
Reference: TS 5.3 and ENNU 320, Volume 2, Section 7.1, Page 7-1

C.18
Answer: a
Reference: ENNU 320, Volume 2, Section 3.3.5.3, Page 3-7

C.19
Answer: d
Reference: ENNU 320, Volume 1, Section 10.5, Page 10-4

C.20
Answer: c
Reference: TS 3.8.3, Page TS-21