October 18, 2011

Mr. Ralph A. Butler, Chief Operating Officer
Research Reactor Facility
University of Missouri
Columbia, MO 65211

SUBJECT: EXAMINATION REPORT NO. 50-186/OL-11-02, UNIVERSITY OF MISSOURI RESEARCH REACTOR

Dear Dr. Butler:

During the week of September 19, 2011, the U.S. Nuclear Regulatory Commission (NRC) administered an operator licensing examination at your University of Missouri – Columbia 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 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/

Johnny H. Eads, Jr., Chief
Research and Test Reactors Oversight Branch
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Docket No. 50-186

Enclosures: 1. Examination Report No. 50-186/OL-11-02
2. Corrected written examination

cc: John Fruits, Assistant Reactor Manager of Operations
cc: w/o enclosures: See next page

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DISTRIBUTION w/ encls.:

PUBLIC	PRTB r/f	RidsNRRDPRPRTA
RidsNRRDPRPRTB	Facility File (CRevelle) O-07 F-08	

ADAMS ACCESSION #: ML112840432 **TEMPLATE #:NRR-074**

OFFICE	PRTB:CE		IOLB:LA	E	PRTB:BC	
NAME	JNguyen		CRevelle		JEads	
DATE	10/3/2011		10/11 /2011		10/18 /2011	

C = COVER E = COVER & ENCLOSURE N = NO COPY

OFFICIAL RECORD COPY

cc:

John Ernst, Associate Director
Regulatory Assurance Group
Research Reactor Facility
Columbia, MO 65201

Homeland Security Coordinator
Missouri Office of Homeland Security
P.O. Box 749
Jefferson City, MO 65102

Planner, Dept of Health and Senior Services
Section for Environmental Public Health
930 Wildwood Drive, P.O. Box 570
Jefferson City, MO 65102-0570

Deputy Director for Policy
Department of Natural Resources
1101 Riverside Drive
Fourth Floor East
Jefferson City, MO 65101

A-95 Coordinator
Division of Planning
Office of Administration
P.O. Box 809, State Capitol Building
Jefferson City, MO 65101

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.: 50-186/OL-11-02

FACILITY DOCKET NO.: 50-186

FACILITY LICENSE NO.: R-103

FACILITY: University of Missouri-Columbia

EXAMINATION DATES: September 19 - September 20, 2011

SUBMITTED BY: **/RA/** 10/3/2011
John T. Nguyen, Chief Examiner Date

SUMMARY:

During the week of September 19, 2011, the NRC administered operator licensing examinations to one Reactor Operator candidate. The applicant passed the examinations.

ENCLOSURE 1

REPORT DETAILS

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

2. Results:

	RO PASS/FAIL	SRO PASS/FAIL	TOTAL PASS/FAIL
Written	1/0	0/0	1/0
Operating Tests	1/0	0/0	1/0
Overall	1/0	0/0	1/0

3. Exit Meeting:

John T. Nguyen, Chief Examiner, NRC
John Fruits, Assistant Reactor Manager of Operations, MURR
Robert Hudson, Training Coordinator, MURR

At the conclusion of the site visit, the examiner met with representatives of the facility staff to discuss the results of the examinations. The examiner thanked the facility for their support of the examination.

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

FACILITY:	University of Missouri - Columbia
REACTOR TYPE:	Tank
DATE ADMINISTERED:	9/20/2011
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 ___

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 *****)

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 ___

B03 a b c d ___

B04 a b c d ___

B05 a b c d ___

B06 a b c d ___

B07 a b c d ___

B08 a b c d ___

B09 a b c d ___

B10 a b c d ___

B11 a b c d ___

B12 a b c d ___

B13 a b c d ___

B14 a b c d ___

B15 a b c d ___

B16 a b c d ___

B17 a b c d ___

B18 a ___ b ___ c ___ d ___

B19 a b c d ___

(***** 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 ___

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

$\dot{Q} = \dot{m}\, c_p\, \Delta T$

$\dot{Q} = \dot{m}\, \Delta h$

$\dot{Q} = UA\, \Delta T$

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

$SUR = 26.06/\tau$

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

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

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

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

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

$\rho = \Delta Keff/Keff$

$\bar{\beta} = 0.007$

$DR_1D_1^2 = DR_2D_2^2$

$Cp\ (H20) = 0.146\ \frac{kw}{gpm \cdot {}^\circ F}$

$\lambda_{eff} = 0.1/sec$

$SCR = S/(1-Keff)$

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

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

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

$SDM = (1-Keff)/Keff$

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

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

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

$R = 6\ C\ E\ n$

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

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

$P = S / (1 - Keff)$

---

1 Curie = 3.7×10^{10} dps

1 hp = 2.54×10^3 BTU/hr

1 BTU = 778 ft-lbf

931 Mev = 1 amu

1 kg = 2.21 lbm

1 Mw = 3.41×10^6 BTU/hr

$^\circ F = 9/5\,^\circ C + 32$

$^\circ C = 5/9\ (^\circ F - 32)$

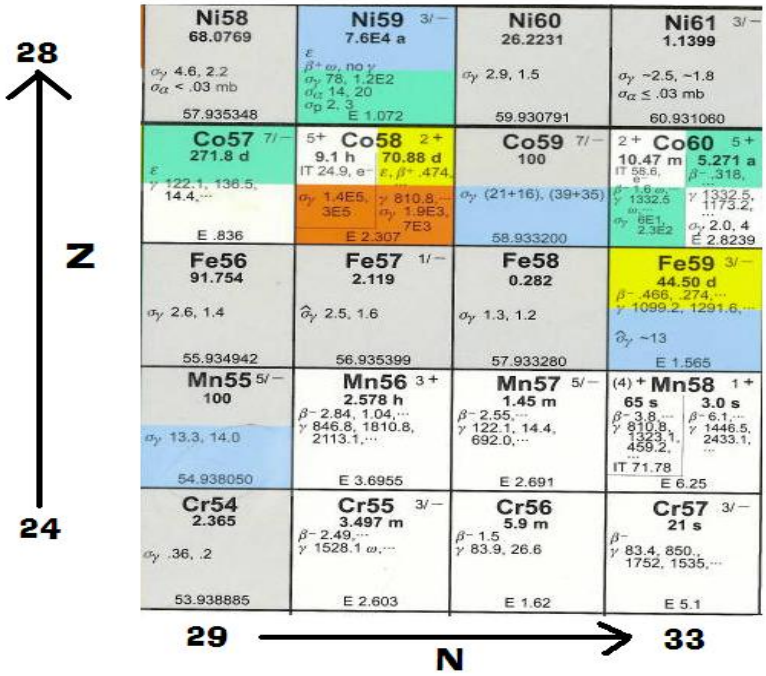
QUESTION **A.01** [1.0 point]
Using the applicable portion from the chart of the nuclides, what will Mn-57 decay into?

a. Mn-56

b. Co-60

c. Fe-57

d. Cr-55



QUESTION **A.02** [1.0 point]
K_{eff} is K_∞ times ...

a. the reproduction factor (η)

b. the resonance escape probability (p)

c. the fast fission factor (ε)

d. the total non-leakage probability ($\mathfrak{L}_f \times \mathfrak{L}_{th}$)

QUESTION **A.03** [1.0 point]
Which ONE of the following statements describes on how moderator temperature affects the core operating characteristics?

a. Increase in moderator temperature will increase the neutron multiplication factor due to the resonance escape probability increase.

b. Increase in moderator temperature will decrease the neutron multiplication factor due to the resonance escape probability decrease.

c. Increase in moderator temperature will decrease the neutron multiplication factor due to the fast non leakage probability increase.

d. Increase in moderator temperature will increase the neutron multiplication factor due to the fast non leakage probability decrease.

QUESTION **A.04** [1.0 point]
Delayed neutrons are produced by:

a. decay of O-16

b. Photoelectric Effect

c. decay of fission fragments

d. directly from the fission process

QUESTION **A.05** [1.0 point]
Given a source strength of 100 neutrons per second (N/sec) and a multiplication factor of 0.8, which ONE of the following is the expected stable neutron count rate?

a. 125 N/sec

b. 250 N/sec

c. 400 N/sec

d. 500 N/sec

QUESTION **A.06** [1.0 point]
Given a reactor period of 32 seconds, approximately how long will it take for power to double?

a. 22 seconds

b. 32 seconds

c. 46 seconds

d. 64 seconds

QUESTION **A.07** [1.0 point]
Which ONE of the following types of neutrons has a mean neutron generation lifetime of 12.5 seconds?

a. Prompt

b. Fast

c. Delayed

d. Thermal

QUESTION **A.08** [1.0 point]
Xenon-135 (Xe^{135}) is produced in the reactor by two methods. One is directly from fission; the other is indirectly from the decay of :

a. Xe^{136}

b. Sm^{136}

c. Cs^{135}

d. I^{135}

QUESTION **A.09** [1.0 point]
Which ONE of the following conditions will **DECREASE** the shutdown margin of a reactor?

a. Increase moderator temperature (Assume negative temperature coefficient)

b. Insertion of a negative reactivity worth experiment

c. Burnout of a burnable poison

d. Fuel depletion

QUESTION **A.10** [1.0 point]
A reactor is subcritical with a K_{eff} of 0.955. Which ONE of the following is the MINIMUM reactivity ($\Delta K/K$) that must be added to produce PROMPT criticality? Given β_{eff}=0.007

a. 0.007

b. 0.047

c. 0.054

d. 0.064

QUESTION **A.11** [1.0 point]
A reactor with K_{eff} = 0.5 contributes 1000 neutrons in the first generation. Changing from the first generation to the SECOND generation, how many neutrons are there in the second generation?

a. 1250

b. 1500

c. 1750

d. 2000

QUESTION **A.12** [1.0 point]
Reactor A increases power from 5% to 10% with a period of 30 seconds. Reactor B increases power from 30% to 50% with a period of also 30 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.13** [1.0 point]
During the time following a reactor scram, reactor power decreases on an 80 second period, which corresponds to the half-life of the longest-lived delayed neutron precursors, which is approximately :

a. 80 seconds

b. 55 seconds

c. 40 seconds

d. 20 seconds

QUESTION **A.14** [1.0 point]
Given the following core reactivity data (not at MURR) when the reactor is at critical:

Control Rod	Total Worth (%ΔK/K)	Worth Removed (%ΔK/K)
Safety Rod 1	2.70	1.68
Safety Rod 2	3.20	2.60
Safety Rod 3	2.60	1.52
Regulating Rod	0.40	0.40

Which ONE of the following is the calculated core excess reactivity of the reactor?

a. 2.70 %ΔK/K

b. 3.00 %ΔK/K

c. 5.70 %ΔK/K

d. 6.20 %ΔK/K

QUESTION **A.15** [1.0 point]
Which ONE of the following is accurate concerning control rod worth?

a. Doubling the poison content of a rod doubles its worth.

b. Rod worth increases as reactor coolant temperature decreases.

c. Rod worth increases as reactor coolant temperature increases.

d. A rod located in the edge of the core is worth more than one located near the center of the core.

QUESTION **A.16** [1.0 point]
Which ONE of the following describes the term **PROMPT JUMP**?

a. A reactor is critical at 80-second period.

b. A reactor has attained criticality on prompt neutrons alone.

c. The instantaneous change in power level due to inserting a control rod.

d. The instantaneous change in power level due to withdrawing a control rod.

QUESTION **A.17** [1.0 point]
Which ONE of the following statements correctly describes thermal neutrons?

a. A neutron that experiences a linear decrease in energy as the temperature of the moderator increases.

b. A neutron at resonant epithermal energy levels that causes fissions to occur in U-238.

c. A neutron that experiences an increase in energy levels after collisions with larger atoms of the moderator.

d. A neutron that experiences no net change in energy after several collisions with atoms of the moderator.

QUESTION **A.18** [1.0 point]
The number of neutrons passing through a one square centimeter of target material per second is the definition of :

a. Neutron Population (np)

b. Neutron Impact Potential (nip)

c. Neutron Flux (nv)

d. Neutron Density (nd)

QUESTION **A.19** [1.0 point]
Which ONE of the following statements is the definition of REACTIVITY?

a. A measure of the core's fuel depletion.

b. A measure of the core's deviation from criticality.

c. Equal to 1.00 ΔK/K when the reactor is critical.

d. Equal to 1.00 ΔK/K when the reactor is prompt critical.

QUESTION **A.20** [1.0 point]
List from high to low by thermal neutron cross section of the following isotopes:
1. B-10 2. Sm-149 3. Xe-135 4. U-235

a. 3,2,1,4

b. 2,3,4,1

c. 3,1,4,2

d. 3,1,2,4

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

Section B Normal/Emergency Procedures and Radiological Controls

QUESTION **B.01** [1.0 point]
Reactor Operator works a standard forty (40) hour work week. His duties require him to work in a radiation area for (6) hours a day. The dose rate in the area is 20 mR/hour. Which ONE of the following is the MAXIMUM number of days Reactor Operator may perform his duties WITHOUT exceeding 10 CFR 20 limits?

a. 35 days

b. 41 days

c. 42 days

d. 46 days

QUESTION **B.02** [1.0 point]
A sheet of 1/2-inch-thick lead reduces a radiation beam from 200 mR/hr to 100 mR/hr at one foot. Which ONE of the following will be the radiation measurement at ten feet if you add another ½- inch- thick lead sheet?

a. 0.20 mR/hr

b. 0.35 mR/hr

c. 0.50 mR/hr

d. 1.00 mR/hr

QUESTION **B.03** [1.0 point]
A room contains a source which, when exposed, results in a general area dose rate of 175 millirem per hour. This source is scheduled to be exposed continuously for 35 days. Select an acceptable method for controlling radiation exposure from the source within this room.

a. Lock the room to prevent inadvertent entry into the room.

b. Equip the room with a device to visually display the current dose rate within the room.

c. Equip the room with a motion detector that will alarm in the control room.

d. Post the area with the words "Danger-Radiation Area".

Section B Normal/Emergency Procedures and Radiological Controls

QUESTION **B.04** [1.0 point]
The special unit for absorbed dose "Rem" is defined in 10 CFR Part 20 in terms of a dose equivalent. What does the term dose equivalent relate to?

a. It is derived by accounting for the amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in one year.

b. It is equal to the absorbed dose (rad) multiplied by the quality factor (Q) of the radiation.

c. It is equal to the absorbed dose (rad) divided by the quality factor (Q) of the radiation.

d. It is the equivalent dose one would receive during the 50-year period following intake.

QUESTION **B.05** [1.0 point]
During a normal reactor startup you must stop pulling the shim-safety blades in gang when you reach the position equivalent to _____ inches below the ECP position.

a. 5

b. 2-½

c. 2

d. 1-¼

QUESTION **B.06** [1.0 point]
The reactor has been shutdown for the last four hours due to severe storm, (substantial loss of power). No shutdown checksheet has been performed. Which of the following meets the MINIMUM requirements to restart the reactor? The reactor may startup after:

a. performing a hot startup with the SRO directing.

b. performing a short form Startup Checksheet.

c. checking the electrical power to the reactor console whether it is available, then performing a short form Startup Checksheet.

d. performing a Long Form Startup Checksheet.

Section B Normal/Emergency Procedures and Radiological Controls

Question **B.07** [1.0 point]
What is the exposure rate at 1 foot from the 5 curie-Co-60 source? Co-60 emits two gamma photons per decay with energies of 1.17 Mev and 1.33 Mev.

a. 0.75 R/hr

b. 37.5 R/hr

c. 75.0 R/hr

d. 120.5 R/hr

QUESTION **B.08** [1.0 point]
Which ONE of the following meets the definition of "Safety Limit"?

a. Setting for an automatic protective device related to a variable having a significant safety function.

b. Limit imposed to the reactor safety system instrument channels for safe reactor operation.

c. Limit imposed to the reactor core and the reactivity worths for a reference core condition.

d. Limits on important process variables to protect the integrity of the physical barriers which guard against the uncontrolled release of radioactivity.

QUESTION **B.09** [1.0 point]
Which ONE of the following materials shall NOT be irradiated at MURR?

a. A short half-life material

b. 100 curies of iodine -131

c. 10 curies of strontium-90

d. 20 mg of explosive material

Section C Facility and Radiation Monitoring Systems

QUESTION **B.10** [1.0 point]
Which ONE of the following is the definition for “Annual Limit on Intake” (ALI)?

a. 10 CFR 20 derived limit, based on a Committed Effective Dose Equivalent of 5 rems whole body or 50 rems to any individual organ, for the amount of radioactive material inhaled or ingested in a year by an adult worker.

b. The concentration of a radionuclide in air which, if inhaled by an adult worker for a year, results in a total effective dose equivalent of 100 millirem.

c. The effluent concentration of a radionuclide in air which, if inhaled continuously over a year, would result in a total effective dose equivalent of 50 millirem for noble gases.

d. Projected dose commitment values to individuals that warrant protective action following a release of radioactive material.

QUESTION **B.11** [1.0 point]
During a startup, the reactor is not critical at ECP. Per AP-RO-110, the minimum level of staff authorized to permit a continuation of the startup is :

a. Any licensed Senior Reactor Operator

b. Lead Senior Reactor Operator

c. Assistant Reactor Manager

d. Reactor Manager

QUESTION **B.12** [1.0 point]
“The shim blades shall be capable of insertion to the 20% withdrawn position in less than 0.7 seconds.” This is an example of a:

a. safety limit

b. limiting safety system setting

c. limiting condition for operation

d. surveillance requirement

Section C Facility and Radiation Monitoring Systems

QUESTION **B.13** [1.0 point]
During reactor operations, a senior reactor operator (SRO) becomes ill and is taken to the hospital. Only a reactor operator (RO) and a knowledgeable student remain in the facility. Per Operation Procedure AP-RO-110, reactor operations:

a. must be discontinued because reactor operations needs 2 licensed operators, one of whom will be licensed as an SRO.

b. may continue if an RO informs the Reactor Manager the emergency situation.

c. may continue until a replacement SRO can arrive at the facility within 60 minutes.

d. may continue since the RO can monitor the console while the student can carry out prescribed written instructions.

QUESTION **B.14** [1.0 point]
If the reactor core contains NEW fuel, an estimated critical position (ECP) adjustment needs to be :

a. subtracted 0.2 inch from an ECP that is based on ONE new fuel element

b. subtracted 0.6 inch from an ECP that is based on TWO new fuel element

c. added 0.2 inch from an ECP that is based on ONE new fuel element

d. added 0.6 inch from an ECP that is based on TWO new fuel element

QUESTION **B.15** [1.0 point]
Reactor is at 200 kW power. The MAXIMUM distance between the HIGHEST and LOWEST shim blade shall not exceed:

a. 0.5 inch

b. 1.0 inch

c. 2 inches

d. 4 inches

Section C Facility and Radiation Monitoring Systems

QUESTION **B.16** [1.0 point]
A release of airborne radioactive material where a person at the reactor site boundary is expected to receive 400 mRem whole body over a 24 hour period is classified as:

a. Unusual Event

b. Alert

c. Site Area Emergency

d. General Emergency

QUESTION **B.17** [1.0 point]
Which ONE of the following is the large contributor to Ar-41 production?

a. Neutron interaction with the hydrogen in the reactor pool water

b. Gamma interaction with the oxygen in the reactor pool water

c. Beta interaction with the Nitrogen in the reactor pool water

d. Neutron interaction with dissolved air in the reactor pool water

QUESTION **B.18** [2.0 points, 0.5 each]
Column A below lists four activities in which a senior operator might participate. Column B lists four categories of procedures in which the activities are described. Match the procedure in Column B to the activity in Column A. Each procedure can be used once, more than once, or not at all.

Column A		Column B	
a.	Measurement of differential worth of a shim blade	1.	Administrative Policy
b.	a routine patrol of the facility	2.	Standard Operating Procedure
c.	Issue a Radiation Work Permit	3.	Reactor Physicist Procedure
d.	Verify nuclear instrumentation during startup	4.	Health Physics Procedure

Section C Facility and Radiation Monitoring Systems

QUESTION **B.19** [1.0 point]
The calculated K_{eff} in the fuel storage shall be less than _____ under all conditions of moderation.

a. 0.80

b. 0.85

c. 0.90

d. 0.95

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

Section C Facility and Radiation Monitoring Systems

QUESTION **C.01** [1.0 point]
To reduce the dose rate at the pool surface, the DI water returns to the primary pool about :

a. 2 feet below the pool surface.

b. 2 feet above the reactor core.

c. 4 feet below the pool surface.

d. 4 feet above the reactor core.

QUESTION **C.02** [1.0 point]
To prevent the start motor damage due to many attempts, the emergency diesel generator (EDG) is equipped with :

a. an over crank trip after three (3) failed attempts to start automatically.

b. a voltage regulator trip after three (3) failed attempts to start automatically.

c. an over crank trip after five (5) failed attempts to start automatically.

d. a voltage regulator trip after three (3) failed attempts to start automatically.

QUESTION **C.03** [1.0 point]
During normal operation, a period on the Intermediate Range Monitor 2 (IRM2) reaches 10 seconds, the reactor will :

a. cause a rod run-in.

b. cause a reactor scram.

c. have no effect on the operation.

d. prevent withdrawal of control rods.

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QUESTION **C.04** [1.0 point]
The ventilation system has two backup doors located in the ventilation supply and return plenums which shut on containment isolation. Which ONE of the following is the method used to shut these doors? The doors are:

a. air motor operated, with their own emergency air supply tanks.

b. motor operated, with air supplied from the emergency air supply system.

c. held open by air pressure, if the solenoid fails, the doors is closed by gravity.

d. held open by hydraulic system, which when deenergized, the door is closed by gravity.

QUESTION **C.05** [1.0 point]
Which ONE of the following will de-energize the automatic control during reactor operation?

a. One of the SHIM rods is not in contact with magnet.

b. The Regulating Rod reaches less than 20% withdrawn.

c. The Shim Rods insert when the Regulating Rod position is at 20% withdrawn position.

d. The Shim Rods withdraw when the Regulating Rod position is at 80% withdrawn position.

QUESTION **C.06** [1.0 point]
Which one of the following design features minimizes the effects of H^3 (Tritium)?

a. ~~Vent~~ Exhaust system at the top of the pool

b. Hold up tanks in the primary coolant system

c. Primary demineralizer system

d. Controlled release of the gases held in the beam ports

Section C Facility and Radiation Monitoring Systems

QUESTION **C.07** [1.0 point]
What is the minimum level of management who may authorize continuing the reactor startup after unresolve of the unscheduled shutdown?

a. RO on duty

b. SRO

c. Assistant Reactor Manager

d. Reactor Manager

QUESTION **C.08** [1.0 point]
Which ONE of the following describes on how the automatic control operates?

a. The output of the Wide Range Monitor is delivered to the Servo Amplifier, which senses the error between the reactor power and the power demand set point, and actuates relays which cause the movement of the regulating rod.

b. The output of the Source Range Monitor is delivered to the Pre-Amplifier, which senses the error between the reactor power and the power demand set point, and actuates relays which cause the movement of the regulating rod.

c. The output of the Wide Range Monitor is delivered to the Pre-Amplifier, which senses the error between the reactor power and the power demand set point, and actuates relays which cause the movement of the regulating rod.

d. The output of the Source Range Monitor is delivered to the Servo Amplifier, which senses the error between the reactor power and the power demand set point, and actuates relays which cause the movement of the regulating rod.

QUESTION **C.09** [1.0 point]
Which ONE of the following is the method used to prevent an accidental siphoning of the MURR reactor primary pool?

a. Siphon break is automatically controlled by computer.

b. Low pool water level signal automatically initiates pump power OFF.

c. Pressurized air is entered to the reactor loop at the highest point in the inverted loop.

d. Pressurized water is entered to the reactor loop at the lowest point in the inverted loop.

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QUESTION **C.10** [1.0 point]
Which ONE of the following is the main purpose of a diffuser spool installed in the pool coolant system?

a. To reduce Nitrogen-16 by generating a swirling motion to the water in the reactor pool.

b. To provide for purification of pool coolant water, thereby, reducing the radioactive nuclide inventory.

c. To provide a good mixing a room air temperature and the reactor pool water temperature for natural convection.

d. To provide a good mixing between a return water and the reactor pool water, and prevent flow directly to the pool surface.

QUESTION **C.11** [1.0 point]

The Compensated Ion Chamber (CIC) detector provides a signal input for the:

a. Source Range Monitor (SMR1).

b. Intermediate Range Monitor (IRM 2).

c. Power Range Monitor (PRM 4)

d. Wide Range Monitor (WRM).

QUESTION **C.12** [1.0 point]
Which ONE of the following describes the status of reactor coolant systems when reactor pressure decreases to a critical level?

a. The isolation valves (~~V509~~ V507A/B) closes, primary coolant pumps turn off.

b. The isolation valves (~~V509~~ V507A/B) opens, primary coolant pumps turn off

c. The isolation valves (~~V509~~ V507A/B) closes, primary coolant pumps turn on

d. The isolation valves (~~V509~~ V507A/B) opens, primary coolant pumps turn on

Section C Facility and Radiation Monitoring Systems

QUESTION C.13 [1.0 point]
Where does waste water from the primary and pool sampling station discharge to?

a. Labyrinth Sump

b. Liquid Waste Tank

c. Drain Collection Tank

d. Containment Hot Sump

QUESTION **C.14** [1.0 point]
Off-Gas Stack monitors may be taken out of service up to _____ hour(s) for maintenance and calibration.

a. 1

b. 2

c. 3

d. 4

QUESTION **C.15** [1.0 point]
In the event of a loss of normal primary coolant flow, which ONE of the following valves will automatically change status from CLOSE to OPEN?

a. the Primary Coolant Isolation Valves 507A/B

b. In Pool Heat Exchanger Valve 546A/B

c. Primary Heat Exchanger Valves 503A/B

d. Primary Pump Valves 501A/B

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QUESTION **C.16** [1.0 point]
In order to minimize check valve slam:

a. start both ~~secondary~~ primary coolant pumps simultaneously.

b. secure both ~~secondary~~ primary coolant pumps simultaneously.

c. start the first ~~secondary~~ primary coolant pump, then wait at least 5 minutes before starting the second pump.

d. secure the first ~~secondary~~ primary coolant pump, then wait at least 5 minutes before securing the second pump.

QUESTION **C.17** [1.0 point]
Before removal of experiments in the 3-Barrel center test hole position with radiation level of 70 mR/hr on contact, the Senior Reactor Operator must :

a. shutdown the reactor.

b. inform the Reactor Manager.

c. fill out a Radiation Work Permit.

d. change the power level to Mode III Operation.

QUESTION **C.18** [1.0 point]
Which ONE of the following prevents structural damage to the containment building if the design limit of 2 PSI over-pressure is exceeded?

a. 16" valves

b. Door 101

c. Utility Entry Water Trap

d. Electrical Entry penetration plates

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QUESTION **C.19** [1.0 point]
Which ONE of the following conditions will result in a reactor scram?

a. Loss of entry door seal pressure

b. Pressurizer High Pressure = 80 psia

c. Pool Low Water Level = 27 feet

d. Coolant Isolation Valve 509 Off Open Position in Mode II

QUESTION **C.20** [1.0 point]
When the “Vent Tank Low Level Rod Run In” annunciator alarms, it means that:

a. Valve 537 has opened, reducing pressure to 75 psi.

b. Valve 526 has opened, reducing pressure to 65 psi.

c. Vent Tank 552 B has opened, water level reaches 7” to 11” below centerline of tank

d. Vent Tank 552 A has opened, water level reaches 7” to 11” above centerline of tank

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

Section A Rx Theory, Thermo & Fac. Operating Characteristics

A.01
Answer: c
Reference: Mn-57 is beta decay, which is the conversion of a neutron into a proton and electron. Baum, E., Knox, H., and Miller, T. 2002. Nuclides and Isotopes 16th Ed. p. 28

A.02
Answer: d
Reference: DOE Handbook Vol 2, Rx Theory (Nuclear Parameters), E.O. 1.1 a&b, pg. 9

A.03
Answer: b
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1982, Sec 3.3.1

A.04
Answer: c
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1982, Sec 3.2.1

A.05
Answer: d
Reference: $CR = S/(1-K) \rightarrow CR = 100/(1 - .8) = 500$

A.06
Answer: a
Reference: $P=P_o e^{t/\tau}$ $2=1* e^{t/32}$ $t = 32 \text{ sec}*\ln(2) = 22.2 \text{ sec}$

A.07
Answer: c
Reference: DOE Handbook Vol. 1 Section 3

A.8
Answer: d
Reference: DOE Handbook, Vol. 2, Section 3

A.09
Answer: c
Reference: Standard NRC question

A.10
Answer: c
Reference: from k=0.995 to criticality (k=1), $\rho = (k-1)/k = -0.047\ \Delta k/k$ or $0.047\ \Delta k/k$ needs to be added to reach criticality. From criticality to JUST prompt, $\rho = \beta_{eff}$ required, so minimum reactivity = 0.047+0.007= 0.054

A.11
Answer: b
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1982, § 5.3, p. 5.6
2-nd generation=n + K*n=1000+500=1500 neutrons

A.12
Answer: d
Reference: The power of reactor A increases by a factor of 2, while the power of reactor B increases by a factor of 1.67. Since the periods are the same (rate of change is the same), power increase B takes a shorter time.

A.13
Answer: b
Reference: Group 1 is the longest-lived delayed neutron precursor for thermal fission in U-235, with a half-life of 55.72 sec. Lamarsh, J. "Introduction to Nuclear Engineering" p. 88

A.14
Answer: a
Reference:
SDM = ∑Total rod worth - ∑total rod worth removed = 8.9%dk/k – 6.2%dk/k = 2.7 %dk/k

A.15
Answer: c
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, § 3.3.2, p. 3-18.

A.16
Answer: d
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1982, Page 4-21.

A.17
Answer: d
Reference: NRC Standard Question

A.18
Answer: c
Reference: DOE Handbook Vol. 2

A.19
Answer: b
Reference DOE Handbook Vol 1 Module 3

A.20
Answer: a
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, Table2.5, page 2-59.

Section B Normal/Emergency Procedures and Radiological Controls

B.01
Answer: b
Reference: 10CFR20.1201(a)(1) [5000 mr x $\frac{1\ hr}{20\ mr}$ x $\frac{day}{6\ hr}$ = 41 days

B.02
Answer: c
Reference: Add another sheet, a radiation level will reduce its intensity by ½, or 50 mR/hr. At 10 feet, the radiation level will be: 50 (mR/hr)/$(10)^2$ =0.5 mR/hr

B.03
Answer: a
Reference: 10CFR20.1601(a)(3)

B.04
Answer: b
Reference: 10CFR20.1003 and NRC Training Material

B.05
Answer: c
Reference: OP-RO-210, Precaution 3.4.

B.06
Answer: d
Reference: AP-RO-110, Sec 6.6.2

B.07
Answer: c
Reference: R/hr = 6CE = 6 x 5 x 1*(1.17+1.33) = 75 R/hr

B.08
Answer: d
Reference: TS 1.27

B.09
Answer: c
Reference: TS 3.6

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

B.11
Answer: c
Reference: AP-RO-110, § 6.6.5.d

B.12
Answer: c
Reference: TS 3.2.c

Section B Normal/Emergency Procedures and Radiological Controls

B.13
Answer: a
Reference: AP-RO-110, Section 6.5.1

B.14
Answer: a
Reference: RP-RO-100, Section 6.3.3

B.15
Answer: b
Reference: TS 3.2.b

B.16
Answer: c
Reference: EP-RO-410, sec 6.1.4

B.17
Answer: d
Reference: NRC Standard Question

B.18
Answer: a, 3 b, 1 c, 4 d, 2
Reference: RP-RO-200, AP-RO-110, AP-HP-105

B.19
Answer: c
Reference: TS 3.8

Section C Facility and Radiation Monitoring Systems

C.01
Answer: a
Reference: MURR HSR, § 7.1.10 p. 7-15.

C.02
Answer: a
Reference: MURR Training Manual, Emergency Electrical Distribution, p.ELD2-3

C.03
Answer: a
Reference: MURR Training Manual, Nuclear Instrumentation, p. RCI4-5

C.04
Answer: c
Reference: MURR HSR § 3.2.5, p. 3-5.

C.05
Answer: a
Reference: MURR TS 3.4

C.06
Answer: a
Reference: Facility Walk-through

C.07
Answer: d
Reference: AP-RO-110, Section 6.6.8

C.08
Answer: a
Reference: MURR Training Manual, Nuclear Instrumentation, p. RCI4-10

C.09
Answer: c
Reference: MURR HSR, § 5.2.5 , p.5-7 ¶,

C.10
Answer: d
Reference: MURR Training Manual, Pool Coolant System, p.POOL1-2

C.11
Answer: d
Reference: MURR Training Manual, Nuclear Instrumentation, p. RCI4-5

C.12
Answer: a
Reference: MURR HSR, § 5.2.6 , p.5-17

C.13
Answer: c
Reference: MURR Training Manual, Drain Collection System

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C.14
Answer: b
Reference: OP-RO-720

C.15
Answer: b
Reference: MURR Training Manual, Primary Coolant Loop, p. PRI1-4

C.16
Answer: b
Reference: OP-RO-480, *Secondary Coolant System*

C.17
Answer: a
Reference: OP-RO-110, sec 6.9.2

C.18
Answer: c
Reference: MURR HSR § 6.2.3.1

C.19
Answer: d
Reference: TS 3.3

C.20
Answer: c
Reference: Training Manual for Reactor Operations, Vent Tank System