August 30, 2012

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

SUBJECT: EXAMINATION REPORT NO. 50-186/OL-12-01, UNIVERSITY OF MISSOURI – COLUMBIA

Dear Mr. Butler:

During the week of August 6, 2012, 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/

Gregory T. Bowman, 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-12-01
2. Written examination

cc: John Fruits, 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 #: ML12243A112 **TEMPLATE #:NRR-074**

OFFICE	PRTB:CE		IOLB:LA	E	PRTB:BC	
NAME	JNguyen		CRevelle		GBowman	
DATE	8/14/2012		8/30 /2012		8/30 /2012	

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-12-01
FACILITY DOCKET NO.:	50-186
FACILITY LICENSE NO.:	R-103
FACILITY:	University of Missouri-Columbia
EXAMINATION DATES:	August 6 – August 7, 2012
SUBMITTED BY:	____________**/RA/**___________ John T. Nguyen, Chief Examiner

__08/14/2012____
Date

SUMMARY:

During the week of August 6, 2012, the NRC administered operator licensing examinations to two Reactor Operator (RO) and two Senior Reactor Operator Upgrade (SROU) candidates. The candidates 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	2/0	0/0	2/0
Operating Tests	2/0	2/0	4/0
Overall	2/0	2/0	4/0

3. Exit Meeting:

John T. Nguyen, Chief Examiner, NRC
Les Foyto, Associate Director – Reactor & Facility Operations
John Fruits, Reactor Manager
Brain Jacobi, Assistant Reactor Manager – Operations
Rob Hudson, Reactor Operations Training Coordinator

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:	08/7/2012
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 ___ (0.5 each)

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 ___ (0.25 each)

B12 a b c d ___

B13 a ___ b ___ c ___ d ___ (0.25 each)

B14 a ___ b ___ c ___ d ___ (0.25 each)

B15 a b c d ___

B16 a b c d ___

B17 a b c d ___

B18 a ___ b ___ c ___ d ___ (0.25 each)

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 <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.

EQUATION SHEET

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

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

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

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

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

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

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

$$M = \frac{1 - K_{eff_0}}{1 - K_{eff_1}}$$

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

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

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

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

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

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

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

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

$$T_{‰} = \frac{0.693}{\lambda}$$

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

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

$$\lambda_{eff} = 0.1/\text{sec}$$

$$DR = \frac{6CiE(n)}{R^2}$$

$$DR_1 d_1^2 = DR_2 d_2^2$$

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

1 Curie = 3.7×10^{10} dps	1 kg = 2.21 lbm
1 hp = 2.54×10^{3} BTU/hr	1 Mw = 3.41×10^{6} BTU/hr
1 BTU = 778 ft-lbf	$^\circ$F = 9/5°C + 32
931 Mev = 1 amu	$^\circ$C = 5/9 ($^\circ$F - 32)

Question A.1 [1.0 point]
Attached is the applicable portion from the chart of the nuclides, what will U-234 decay into?

a. U-235

b. Pa-232

c. Th-230

d. Np-234

Question A.2 [1.0 point]
In a subcritical reactor with K_{eff} of 0.931, a reactivity worth of 0.017 Δk is inserted into the reactor core. Which ONE of the following is the NEW K_{eff} ?

a. 0.925

b. 0.933

c. 0.946

d. 1.001

Question A.3 [1.0 point]
The reactor is critical. The reactor operator accidentally inserts a fuel element in the core and K_{eff} changes to 1.010. What is the period of the reactor? Given a prompt neutron lifetime (ℓ^*) of 1×10^{-4} seconds.

a. 0.001 sec

b. 0.01 sec

c. 0.10 sec

d. 1.0 sec

Question A.4 [1.0 point]

The following data was obtained during a reactor fuel load.

No. of Elements	Detector A (count/min)
0	300
10	400
20	600
30	1000
50	3000

Which **ONE** of the following is the closest number of fuel elements required to make the reactor critical?

a. 55

b. 60

c. 65

d. 70

Question A.5 [1.0 point]

Which ONE of the following is the **most correct reason** for having an installed neutron source within the core?

An installed neutron source is very important during startup because without of a neutron source...

a. the reactor could result in a sudden increase in power if the control rods were pulled out far enough

b. the compensating voltage on the source range detector doesn't work

c. the startup channel would NEVER indicate neutron population

d. the chain reaction in the reactor core would NOT start

Question A.6 [1.0 point]

Two critical reactors at low power are identical, except that Reactor 1 has a beta fraction of 0.0065 and Reactor 2 has a beta fraction of 0.0072. Which ONE of the following best describes the response if an equal amount of positive reactivity is inserted into both reactors?

a. Period of the Reactor 1 will be longer than the period of the Reactor 2

b. The final power in the Reactor 1 will be lower than the final power in the Reactor 2

c. The trace (power vs. time) of the Reactor 1 will be higher than the trace of the Reactor 2

d. The trace (power vs. time) of the Reactor 1 will be identical to the trace of the Reactor 2

Question A.7 [1.0 point]

Which ONE of the following best describes the effects of moderator temperature increase on neutron multiplication?

a. Resonance escape probability ↑; Thermal non-leakage↓; Rod worth ↑

b. Resonance escape probability ↓; Thermal non-leakage↓; Rod worth ↑

c. Resonance escape probability ↑; Thermal non-leakage↑; Rod worth ↓

d. Resonance escape probability ↓; Thermal non-leakage↓; Rod worth ↓

Question A.8 [1.0 point]

In a just critical reactor, the reactor operator immediately inserts a rabbit of 0.005 Δk reactivity worth into the core. This insertion will cause:

Given:

T: reactor period, ℓ^*: Prompt neutron lifetime; ρ: reactivity insertion; β: beta fraction

a. A sudden drop in delayed neutrons

b. A number of prompt neutrons equals to a number of delayed neutrons

c. The resultant period to be a function of the prompt neutron lifetime ($T=\ell^*/\rho$)

d. A sudden change of power that equals to the initial power multiplied by $\beta(1-\rho)/(\beta-\rho)$

Question A.9 [1.0 point]
Which ONE of the following is the MAIN reason for operating with thermal neutrons instead of fast neutrons?

a. Decrease β-eff, so it is easy to control the reactor.

b. Moderator temperature coefficient becomes positive as neutron energy increases.

c. Neutron absorption in non fuel material increases exponentially as neutron energy increases.

d. The fission cross section of the fuel is much higher for thermal energy neutrons than fast neutrons.

Question A.10 [1.0 point]
Which ONE of the following is a correct statement of why delayed neutrons enhance the ability to control reactor power?

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

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

c. Prompt neutrons can cause fissions in both U-235 and U-238; whereas delayed neutrons can only cause fissions in U-235

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

Question A.11 [1.0 point]
During a reactor startup, the reactor operator observes the position of the current control rods is LOWER than the last startup. Which ONE of the following reasons could be the cause?

a. Higher moderator temperature (assume negative temperature coefficient)

b. Insertion of a negative reactivity worth experiment

c. Burnout of xenon

d. Fuel depletion

Question A.12 [1.0 point]
A reactor with K_{eff} = 0.8 contributes 1000 neutrons in the first generation. Changing from the first generation to the THIRD generation, how many TOTAL neutrons are there after the third generation?

a. 1800

b. 2440

c. 3240

d. 6400

Question A.13 [1.0 point]
Which ONE of the following will be the resulting stable reactor period when a 0.00245 Δk reactivity insertion is made into an **exactly critical** reactor core? Neglect any effects from prompt. Given β_{eff} =0.0070 and λ=0.1

a. 13 seconds

b. 16 seconds

c. 19 seconds

d. 22 seconds

Question A.14 [1.0 point]
An example of a **FISSIONABLE NUCLEI** is:

a. Pu-239

b. U-238

c. U-235

d. U-233

Question A.15 [1.0 point]

About few minutes following a reactor scram, the reactor period has stabilized and the power level is decreasing at a CONSTANT rate. Given that reactor power at time t_0 is 100 kW power, what will it be five minutes later?

a. 0.50 kW

b. 1.25 kW

c. 2.35 kW

d. 11.70 kW

Question A.16 [1.0 point]

The reactor is STARTED UP following a SHUTDOWN. Which ONE of the following statements is true about xenon?

a. The concentration of ^{135}Xe will increase due to decay of ^{135}Cs

b. The concentration of ^{135}Xe will increase due to increase nuclear flux

c. The concentration of ^{135}Xe will decrease due to the burnout of the ^{135}Xe inventory

d. The concentration of ^{135}Xe will remain constant due to equilibrium of xenon burnout and xenon production

Question A.17 [1.0 point]

Which ONE statement below describes a NEGATIVE moderator temperature coefficient?

a. When moderator temperature increases, negative reactivity is added

b. When moderator temperature decreases, negative reactivity is added

c. When moderator temperature increases, positive reactivity is added

d. When moderator temperature increases, no change in reactivity

Question A.18 [1.0 point]
Which ONE of the following factors in the “six factor” formula is the MOST affected by the CONTROL BLADES?

a. Fast fission factor

b. Reproduction factor

c. Thermal utilization factor

d. Resonance escape probability

Question A.19 [1.0 point]
Given a source strength of 300 neutrons per second (N/sec) and a multiplication factor of 0.7, which ONE of the following is the expected stable neutron count rate?

a. 210 N/sec

b. 1000 N/sec

c. 2100 N/sec

d. 2500 N/sec

Question A.20 [1.0 point]
The injection of a sample results in a 50 millisecond period. If the scram setpoint is **5 MEGAWATTS** and the scram delay time is 0.1 seconds, which ONE of the following is the peak power of the reactor at shutdown?

a. 12 megawatts

b. 25 megawatts

c. 37 megawatts

d. 370 megawatts

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

Question B.1 [1.0 point]
Which ONE of the following conditions requires the NRC APPROVAL for changes?

a. Revise the Safety Analysis Report

b Revise the requalification operator licensing examination

c Major changes in the Conduct of Operations procedure, AP-RO-110

d Permanent changes of the facility organization described in the Technical Specifications

Question B.2 [1.0 point]
A radioactive source reads 70 Rem/hr on contact. Ten hours later, the same source reads 3.0 Rem/hr. How long is the time for the source to decay from a reading of 70 Rem/hr to 100 mRem/hr?

a. 16 hours

b. 21 hours

c. 24 hours

d. 30 hours

Question B.3 [2.0 points, 0.5 each]
Identify each of the following surveillances as a channel check (**CHECK)**, a channel test (**TEST)**, or a channel calibration (**CAL)**.

a. During the HOT startup at 5 MW, you verify proper response of “Reactor Power Calculator”

b. During 10 MW power, you compare the readings of nuclear instrumentation

c. Exposing a 2 mCi check source to the continuous air monitor (CAM) detector to verify that its output is operable.

d. Adjust the Power Range Monitor gain potentiometer in accordance with recent data collected on the reactor power calibration.

Question B.4 [1.0 point]

The radiation from an unshielded source is 1 rem/hr. You insert 60 mm thickness of lead sheet; the radiation level reduces to 125 mrem/hr. What is the half-value-layer of lead? (HVL: thickness of lead required so that the original intensity will be reduced by half)

a. 10 mm

b. 20 mm

c. 30 mm

d. 40 mm

Question B.5 [1.0 point]

Assume that there is no leak from outside of the demineralizer tank. You use a survey instrument with a window probe to measure the dose rate from the demineralizer tank. Compare to the reading with a window **CLOSED,** the reading with a window **OPEN** will :

a. increase, because it can receive an additional alpha radiation from (Al-27) (n,α), (Na-24) reaction.

b. remain the same, because the Quality Factors for gamma and beta radiation are the same.

c. increase, because the Quality Factor for beta and alpha is greater than for gamma.

d. remain the same, because the survey instrument would not be detecting beta and alpha radiation from the tank.

Question B.6 [1.0 point]

According to MURR Tech Spec, which ONE of the following would most likely be considered a Reportable Event (the Facility shall report to the NRC within 24 hours)?

a. You receive a bomb threat directed toward the facility

b. You did not pay attention while raising the control blades to power, which causes reactor scram

c. You observe an abnormal loss of core coolant at a rate that exceeds the normal makeup capacity.

d. You load an unknown sample of 0.008 Δk worth of reactivity. Reactor scrams due to your loading.

Question B.7 [1.0 point]

Before entering to the experimental facility, you see a sign posted at the door “CAUTION, HIGH RADIATION AREA”. You would expect that radiation level in the facility could result in an individual receiving a dose equivalent of:

a. 10 mRem/hr at 30 cm from the source

b. 100 mRem/hr at 30 cm from the source

c. 100 mRem/hr at 1 m from the source

d. 500 Rads/hr at 1 m from the source

Question B.8 [1.0 point]

The area bounded by a 150 meter radius from the MURR exhaust stack is defined as:

a. Emergency Planning Zone (EPZ)

b. Nearest Site Boundary

c. Onsite

d. Operations Boundary

Question B.9 [1.0 point]

The MURR reactor has been shutdown due to a fuel element leak. Which ONE of the following radioactive GASES poses the most significant hazard during the research for the leaking fuel element? (Assume the fuel element is leaking during the search)?

a. Argon

b. Iodine

c. Cesium

d. Nitrogen

Question B.10 [1.0 point]
A Radiation Work Permit (RWP) is required if non-routine work is being performed with anticipated MINIMUM exposure rates of ______ per hour.

a. 20 mR

b. 50 mR

c. 100 mR

d. 150 mR

Question B.11 [1.0 point, 0.25 each]
Fill out the blank with MAXIMUM or MINIMUM specification of the following Limiting Safety System Settings (LSSS) for the MODE II operation.

a. Primary Coolant Flow 1625 gpm (_____)

b. Inlet Water Temperature 155 °F (______)

c. Pressurizer Pressure 75 Psia (______)

d. Reactor Power 125 % Full Power at 5MW (______)

Question B.12 [1.0 point]
You follow the Standing Order Guidance 12-03 for changes in verifying the Flux Trap Loading Sheet with Installation of the First Device. This Standing Order will remain in effect until:

a. you complete verifying the reactivity worth for each loading

b. cancelled by the Senior Reactor Operator

c. cancelled by the Lead Senior Reactor Operator

d. cancelled by the Reactor Manager

Section C Facility and Radiation Monitoring Systems

Question B.13 [1.0 point, 0.25 each]

Match each of the Technical Specification Limits in column A with its corresponding value in column B. (Each limit has only one answer, values in Column B may be used once, more than once or not at all.)

Column A	Column B
a. Absolute Value of all experiments in Center test hole	1. 0.0025 ΔK
b. Core Excess Reactivity	2. 0.0060 ΔK
c. Reactivity worth of each secured Removable Experiment	3. 0.0200 ΔK
d. Minimum Shutdown Margin	4. 0.0980 ΔK

Question B.14 [1.0 point, 0.25 each]

Match the terms in column A with their respective definitions in column B.

	Column A		Column B
a.	Radioactivity	1.	To remove a facility or site safely from service and reduce residual radioactivity to a level that permits in 10 CFR 52.
b.	Contamination	2.	An impurity pollutes or adulterates another substance. The transferable radioactive materials are the sources of ionizing radiations.
c.	Dose	3.	The quantity of radiation absorbed per unit mass by the body or by any portion of the body.
d.	Decommission	4.	That property of a substance which causes it to emit ionizing radiation. This property is the spontaneous transmutation of the atoms of the substance.

Section C Facility and Radiation Monitoring Systems

Question B.15 [1.0 point]

Per 10 CFR 55, 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. 2

b. 4

c. 6

d. 8

Question B.16 [1.0 point]

What is the **HALF LIFE** of the isotope contained in a sample which produces the following count rates?

Time (Minutes)	Counts per Minute (cpm)
Initial count	900
30	740
60	615
90	512
180	294

a. 551 minutes

b. 312 minutes

c. 111 minutes

d. 88 minutes

Question B.17 [1.0 point]

Radiation level at the distance corresponding to the nearest site boundary exceed 20 mRem/hr for 1 hour whole-body is classified as:

a. Unusual Event

b. Alert

c. Site Area Emergency

d. General Emergency

QUESTION B.18 [1.0 point, 0.25 each]

Per MURR Technical Specifications, match each component of Reactor Safety Systems listed in column A with its associated Trip Set Point in column B. Items in column B is to be used once, more than once or not at all.

	Column A		Column B
a.	Pool Low Water Level (Mode III)	1.	8.00 psi
b.	Pressuizer Low Water Level	2.	4.00 psi
c.	Differential Pressure across the Core (Mode II)	3.	1600 gpm
d.	Differential Pressure across the Reflector (Mode I)	4.	23 feet
		5.	16 inches
		6.	25 feet

Question B.19 [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

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

Section C Facility and Radiation Monitoring Systems

QUESTION C.1 [1.0 point]
Which ONE of the following correctly describes the function of a rectifier in the Uninterruptible Power Supply (UPS) system?

a. Covert alternating current (AC) from the Emergency Distribution to direct current (DC). This DC signal is then sent in parallel to the inverter and a float charge of the battery bank.

b. Covert DC from the battery bank to a step-like AC. This AC signal is then sent to the Static Switch for distribution of the UPS loads during a loss of electrical power.

c. Step down 480-V three-phase AC to 120-V single phase AC. This 120-V AC signal is sent to the Static Switch for distribution of the UPS loads during a loss of electrical power.

d. Switch the electrical power from the normal source to the Emergency Power source during a loss of electrical power.

QUESTION C.2 [1.0 point]
During the startup checklist, you push on the normal (green) lamp on the remote module of the BRIDGE Area Radiation Monitor. This action will cause:

a. an upscale reading on the meter ONLY

b. an upscale reading on the meter and an initiation of alert alarm

c. a “zero” reading on the meter due to removal of the check source

d. an upscale reading on the meter and initiation of alert alarm and Containment Building Isolation

QUESTION C.3 [1.0 point]
The Fission Product Monitor samples the PRIMARY COOLANT at a point:

a. between the outlet of the primary pumps and the inlet to the heat exchangers (HX503A/B)

b. between the outlet of the heat exchangers (HX 503A/B) and the inlet to the core

c. between the outlet of the pool heat exchanger (HX 521) and the inlet to the pool

d. at the Holdup Tank

QUESTION C.4 [1.0 point]
Which ONE of the following is the method used to operate Reactor Inlet & Outlet Isolation Valves (V507A/B) of the primary coolant system?

a. Air to open/spring to close/butterfly valves

b. Spring to open/Air to close/butterfly valves

c. Air to open/Gravity to close/ gate valves

d. hydraulic to open/spring to close/ ball valves

QUESTION C.5 [1.0 point]
Auto control system will prevent reactor switching to auto control mode when its power is below 5 KW. This signal comes from:

a. Source Range Monitor 1 (SRM1)

b. Intermediate Range monitor 2 (IRM2)

c. Power Range Monitor 5 (PRM5)

d. Wide Range Monitor (WRM)

QUESTION C.6 [1.0 point]
Which ONE of the following is the method used to CONTINUOUSLY sample air for the MURR stack gas monitor?

a. Isokinetic Method

b. Anisokinetic Method

c. Evacuated Bottle Method

d. Instrumental Reference Method

QUESTION C.7 [1.0 point]
The YELLOW leg signal of the Safety System is disconnected to the non-coincidence logic unit (NCLU) A. This action will :

a. de-energize only 2K20 relay; and scram rod A/ rod B

b. de-energize 2K20 and 2K21 relays; and scram rod A / rod B / rod C/ rod D

c. de-energize only 1K8 relay; and cause rod run-in A/ B

d. de-energize 1K8 and1K9 relays; and cause rod run-in A /B /C/ D

QUESTION C.8 [1.0 point]
Which ONE of the following is the correct statement regarding Valve S1 of the Secondary Coolant System? When the PRIMARY coolant outlet temperature rises above 120 °C,

a. valve S-1 will automatically move toward the fully CLOSED position that allows more water from secondary coolant passing through the PRIMARY COOLANT HEATEXCHANGERS (HX503A/B)

b. valve S-1 will automatically move toward the fully OPENED position to limit the secondary coolant passing through the PRIMARY COOLANT HEATEXCHANGERS (HX503A/B)

c. valve S-1 will automatically move toward the fully CLOSED position that allows more water from the secondary coolant passing through the POOL COOLANT HEATEXCHANGER (HX521)

d. valve S-1 will automatically move toward the fully OPENED position that restricts secondary coolant passing through the POOL COOLANT HEATEXCHANGER (HX521)

QUESTION C.9 [1.0 point]
Which ONE statement below describes the operation of the three-way solenoid valve of the Anti-Siphon Isolations (543 A&B)? During normal operation, the solenoid valve is:

a. energized; the exhaust port is closed, and air is continuously supplied to the actuator

b. de-energized; the supply port is closed, and air from the actual port is vented through the exhaust port

c. energized; the supply port is closed, and no air flows in exhaust port nor the actuator

d. de-energized; the exhaust port is opened and air is continuously supplied to the exhaust port

QUESTION C.10 [1.0 point]
When the “High level” alarm in the drain collection tank (DCT) actuates, the DCT water is discharged back to:

a. the suction side of the pool Demineralizer Pump

b. the DI Columns of Primary coolant system

c. the pool water hold-up tank

d. the Pressurizer

QUESTION C.11 [1.0 point]
Which ONE of the following is the reason for the 100 gallon holdup tank in the purification system? This tank

a. allows N^{16} gamma activity to decay off

b. provides the emergency water to the reactor core

c. contains spent resin from the demineralizer units

d. provides water hammer protection for the purification system

QUESTION C.12 [1.0 point]
During 5 MW power, the pressure in the Pressurizer System suddenly changes to 65 psig. This pressure change will open the nitrogen gas valve to:

a. vent nitrogen gas to the exhaust line, and initiate “Press Lo Pressure Alarm”

b. add nitrogen gas to the system, and initiate “Press Lo Pressure Alarm”

c. vent nitrogen gas to the exhaust line, and initiate “Press Hi Pressure Alarm”

d. add nitrogen gas to the system, and initiate “Press Hi Pressure alarm”

QUESTION C.13 [1.0 point]
Which ONE of the following provides a positive reactivity to the reference core?

a. Void Coefficient of the Core

b. Void Coefficient of the Flux Trap

c. Temperature Coefficient of the Core

d. Xenon worth after 16 hour shutdown

QUESTION C.14 [1.0 point]
Reactor is at 10 MW power. Which ONE of the following indications considers an abnormal operation?

a. Primary Coolant Flow 3800 gpm
Inlet Water Temperature 120 °F
Pressurizer Pressure 70 Psig

b. Primary Coolant Flow 3815 gpm
Inlet Water Temperature 119 °F
Pressurizer Pressure 67 Psig

c. Primary Coolant Flow 3755 gpm
Inlet Water Temperature 120 °F
Pressurizer Pressure 76 Psig

d. Primary Coolant Flow 3752 gpm
Inlet Water Temperature 119 °F
Pressurizer Pressure 66 Psig

QUESTION C.15 [1.0 point]
The Un-compensated Ion Chamber (UCIC) detector provides a signal input for the:

a. Source Range Monitor (SMR1) that provides a Rod Run-In at 114% power

b. Intermediate Range Monitor (IRM 2) that provides a Rod Run-In at 119% power

c. Power Range Monitor 6 (PRM 6) that provides a Rod Run-In at 114% power

d. Power Range Monitor 4 (PRM 4) that provides a Rod Run-In at 95% power

QUESTION C.16 [1.0 point]
Which ONE of the following correctly describes the Primary coolant flow through the reactor Core during normal operation? Primary coolant water enters:

a. the spool piece and flows downward through the vessel tube and fuel region then exits through the lower tee.

b. the Isolation Valve 507A and flows upward through the vessel tube and fuel region then exits through the lower tee.

c. the spool piece and flows downward through the vessel tube and fuel region then exits through the pool outlet.

d. the Isolation Valve 507A and flows upward through the vessel tube and fuel region then exits through the Isolation Valve 507B.

QUESTION C.17 [1.0 point]
Which ONE of the following describes on how the automatic control operates?

a. The output of the Power 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 Power 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 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.

QUESTION C.18 [1.0 point]
Which ONE of the following conditions will result in a reactor scram?

a. IRM 2 period = 11 seconds

b. RC Sys Low Flow (FT-912 A/E) = 1800 gpm

c. High Reflector ΔP (PT-917) = 8 psi

d. RC High Conductivity =2 μS

QUESTION C.19 [1.0 point]
The reactor has been operating for six days straight at full power when the facility has a complete loss of power. How is damage to the fuel prevented?

a. Two thermally (temperature) actuated valves open, allowing steam to escape from the primary system, which is quenched in the pool water.

b. Two air operated valves fail open due to loss of electrical power, lining up the primary to an in-pool heat exchanger. Water flow is via natural convection.

c. Two thermally (temperature) actuated valves open, lining up the primary to an in-pool heat exchanger. Water flow is via natural convection.

d. Two motor operated valves (powered off the diesel) open, lining up the primary to an in-pool heat exchanger.

QUESTION C.20 [1.0 point]
Reactor is at 5 MW power in Auto Mode. You accidently move the Regulating Blade Switch 1S5, your action will cause:

a. Scram

b. Rod Run-In

c. Terminate the Auto Mode

d. No effect to the Auto Mode

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

A.1
Answer: c
Reference: Chart of the Nuclides (α decay: U-234 → Th-230)

A.2
Answer: c
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1982, Sec 3.3.3, page 3-21.
$\Delta\rho = (Keff_1-Keff_2)/(Keff_1*Keff_2)$. 0.017 = (x-0.931)/(x*0.931); 0.017*0.931*x =x-0.931
0.01583x=x-0.931; 0.98417x =0.931; x=0.931/0.98417; x=0.946

A.3
Answer: b
Reference: Using equations provided in the equation sheet:

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

ρ = (1.01-1)/1.01
ρ = 0.01
For prompt,

$$T = \frac{\ell^*}{\rho} = 0.0001/0.01 = 0.01 \text{ sec}$$

A.4
Answer: b
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1982, Sec 5.5, page 5-18-5-25.

No. fuel	A(cpm)	1/M (Source/Count (Co/C)
0	300	1
10	400	0.75
20	600	0.5
30	1000	0.3
50	3000	0.1

A.5
Answer: a
Reference: NRC Standard Question

A.6
Answer: c
Reference: Equation Sheet. $\tau = (\ell^*/\rho) + [(\beta-\rho)/\lambda_{eff}\rho]$. Since the period of the reactor 1 is shorter than the reactor 2, the trace (power vs. time) of the Reactor 1 will be higher than the trace of the Reactor 2

A.7
Answer: b
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Sec 3.3.2

A.8
Answer d
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, Sec 4.6, page 4-17

A.9
Answer: d
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1982, Figure 2.6, page 2-39

A.10
Answer: b
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1982, Section 3.3.7, page 3-37

A.11
Answer c
Reference: Standard NRC question.

A.12
Answer: b
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1982, § 5.3, p. 5.6
3-nd generation=n + K*n + K^2 *n=1000+800+640= 2440neutrons

A.13
Answer: c
$T = (\beta-\rho)/\lambda\rho$
$T = (0.0070 - 0.00245)/0.1 \times 0.00245 = 18.57$ seconds

A.14
Answer: b
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* 1988 Section 3.2 page 3-2

A.15
Answer: c
Reference: $P = P_0\ e^{-T/\tau} = 100\ kW \times e^{(300sec/-80sec)} = 100\ kW \times e^{-3.75} = 0.0235 \times 100\ kW = 2.35$ KW

A.16
Answer: c
Reference: Introduction to Nuclear Operation, Reed Burn, 1982, Sec 8.4.2

A.17
Answer a
Reference: Introduction to Nuclear Operation, Reed Burn, 1982, Sec 6.4

A.18
Answer: c
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1982, Sec 3.2.2, page 3-18.

A.19
Answer: b
Reference: CR = S/(1-K) → CR = 300/(1 - .7) = 1000

A.20
Answer: c
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1982,
$P = P_0 e^{t/\tau}$, $P = 5$ megawatts $\times e^{0.1/0.05} = 5 \times e^2 = 37$ megawatts

Section B Normal/Emergency Procedures and Radiological Controls

B.1
Answer: d
Reference: TS 6.5.d and 10 CFR 50.59

B.2
Answer: b
Reference: $DR = DR_o * e^{-\lambda t}$
3.0 rem/hr =70 rem/hr* $e^{-\lambda(10hr)}$
Ln(3.0/70) = -λ*10 --> λ=0.315; solve for t: Ln(.1/70)=-0.623 (t) → t=20.8 hours

B.3
Answer: a = CHECK; b = CHECK; c = TEST; d = CAL
Reference: MURR Technical specification, Definitions

B.4
Answer: b
Reference: $DR = DR_o * e^{-\mu X}$
Find μ : 125 = 1000* $e^{-\mu*60}$; μ = 0.03466
If insertion of an HVL (thickness of lead), the original intensity will be reduced by half.
Find X: 1 = 2* $e^{-0.03466*X}$; X= 20 mm
Find HVL by shortcut:
1000mR- 500 mR is the 1st HVL
500 mR – 250 mR is the 2nd HVL
500mR-125 mR is the 3rd HVL
So HVL=60mm/3 = 20 mm

B.5
Answer: d
Reference: BASIC Radiological Concept (Betas and alpha don't make through the demineralizer tank)

B.6
Answer: d
Reference: TS 6.5 and TS 1.1

B.7
Answer: b
Reference: 10 CFR 20.1003

B.8
Answer: a
Reference: Emergency Plan, Section 9.8

B.9
Answer: b
Reference: Standard NRC question

B.10
Answer: c
Reference: AP-HP-105

Section B Normal/Emergency Procedures and Radiological Controls

B.11
Answer: a (MINIMUM) b(MAXIMUM) c(MINIMUM) d(MAXIMUM)
Reference: MURR TS 2.2

B.12
Answer: d
Reference: Standing Order 12-03

B.13
Answer: a, 3 b,1 c,4 d,2
Reference: Technical Specifications § 3.1

B.14
Answer: a(4) b(2) c(3) d(1)
Reference: 10 CFR 20

B.15
Answer: b
Reference: 10CFR55.53(e)

B.16
Answer: c
Reference: $A = A_o e^{-\lambda t}$
$294 = 900e^{-180\lambda}$, $180\lambda = -\ln 0.327$, $\lambda = 0.00623\ \text{min}^{-1}$
$t_{1/2} = 0.693 / \lambda$, $= 0.693 / 0.00623\ \text{min}^{-1}$, $= 111$ minutes

B.17
Answer: b
Reference: EP Table I

B.18
a(4) b(5) c(3) d(1)
REF MURR TS 3.3

B.19
Answer: c
Reference: AP-RO-110

Section C Facility and Radiation Monitoring Systems

C.1
Answer: a
Reference: MURR Reactor Operations Training Manual, UPS System

C.2
Answer: a
Reference: MURR Reactor Operations Training Manual, Area Radiation Monitor System

C.3
Answer: b
Reference: MURR Reactor Operations Training Manual, Primary Coolant Loop

C.4
Answer: a
Reference: MURR Reactor Operations Training Manual, Primary Coolant Loop

C.5
Answer: d
Reference: MURR Reactor Operations Training Manual, Nuclear Instrumentation (WRM)

C.6
Answer: a
Reference: MURR Reactor Operations Training Manual, Stack Monitor

C.7
Answer: b
Reference: MURR Reactor Operations Training Manual, Safety System and Rod Run-In System

C.8
Answer: a
Reference: MURR Reactor Operations Training Manual, Secondary Coolant System

C.9
Answer: a
Reference: MURR Reactor Operations Training Manual, Valve Operating System

C.10
Answer: a
Reference: MURR Reactor Operations Training Manual, drain Collection System

C.11
Answer: a
Reference: MURR Reactor Operations Training Manual, Pool Coolant System

C.12
Answer: b
Reference: MURR Reactor Operations Training Manual, Pressurizer System

C.13
Answer: b
Reference: Hazards Summary Report, Table 4.1

C.14
Answer: c
Reference: AP-RO-110, Normal Reactor Operating Parameters

C.15
Answer: c
Reference: MURR Reactor Operations Training Manual, Nuclear Instrumentation

C.16
Answer: a
Reference: MURR Reactor Operations Training Manual, Reactor Core Assembly Support Structure

C.17
Answer: d
Reference: MURR Training Manual, Nuclear Instrumentation, p. RCI4-10

C.18
Answer: c
Reference: AP-RO-110, Scram Trip Setpoints

C.19
Answer: b
Reference: MURR Reactor Operations Training Manual, Valve Operating System, PRI8-3

C.20
Answer: c
Reference: OP-RO-211, Section 5.2.16