February 23, 2017

Mr. Ralph A. Butler, Executive Director
University of Missouri-Columbia
Research Reactor Center
1513 Research Park Drive
Columbia, MO 65211

SUBJECT: EXAMINATION REPORT NO. 50-186/OL-17-01, UNIVERSITY OF MISSOURI-COLUMBIA

Dear Mr. Butler:

During the week of January 9, 2017, the U. S. Nuclear Regulatory Commission administered operator licensing examinations 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. Phillip T. Young at (301) 415-4094 or via e-mail at Phillip.Young@nrc.gov.

Sincerely,

/RA/

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

Docket No. 50-186

Enclosures:
1. Examination Report No. 50-186/OL-17-01
2. Written Examination

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

EXAMINATION REPORT NO. 50-186/OL-17-01, UNIVERSITY OF MISSOURI-COLUMBIA, dated February 23, 2017

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GWertz PYoung

ADAMS ACCESSION #: ML17034A239 **TEMPLATE #:NRR-074**

OFFICE	NRR/DPR/PROB: CE	NRR/DIRS/IOLB: OLA	NRR/DPR/PROB: BC:
NAME	PYoung	ABaxter	AMendiola
DATE	1/27/2017	02/03/2017	2/23/2017

OFFICIAL RECORD COPY

cc:

Les Foyto, Associate Director
Reactor and Facilities Operations
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U.S. NUCLEAR REGULATORY COMMISSION

OPERATOR LICENSING INITIAL EXAMINATION REPORT

REPORT NO.: 50-186/OL-17-01

FACILITY DOCKET NO.: 50-186

FACILITY LICENSE NO.: R-103

FACILITY: University Of Missouri – Columbia

EXAMINATION DATES: January 9 and 10, 2017

SUBMITTED BY: /RA/ 1/27/17

Phillip T. Young, Chief Examiner Date

SUMMARY:

During the week of January 9, 2017 the NRC administered licensing examinations to two Reactor Operator (RO) applicants and one RO retake applicant. The applicants passed all portions of the examination.

REPORT DETAILS

1. Examiner: Phillip T. Young, Chief Examiner, NRC

2. Results:

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

3. Exit Meeting:
   Phillip T. Young
   Bruce Meffert, Reactor Manager
   Rob Hudson, Reactor Operations Training Coordinator

   The examiner thanked the facility for their assistance ensuring the exam administration went smoothly and for their feedback on the written examination.

U. S. NUCLEAR REGULATORY COMMISSION

NON-POWER REACTOR INITIAL LICENSE EXAMINATION

FACILITY: University of Missouri – Columbia Reactor

REACTOR TYPE: TANK

DATE ADMINISTERED: 1/10/2017

CANDIDATE: _____

INSTRUCTIONS TO CANDIDATE:

Answers are to be written on the answer sheet provided. Attach the answer sheets to the examination. Points for each question are indicated in parentheses for each question. A 70% in each section 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		_____	____%	TOTALS

FINAL GRADE

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

_____ Candidate's Signature

Enclosure 2

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

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

$CR_1\,(1-K_{eff})_1 = CR_2\,(1-K_{eff})_2$

$SUR = 26.06/\tau$

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

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

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

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

$DR_1D_1^2 = DR_2D_2^2$

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

$DR = 6CiE/D^2$

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

1 eV = 1.6×10^{-19} watt-sec.

1 Curie = 3.7×10^{10} dps

1 gallon water = 8.34 pounds

1 Btu = 778 ft-lbf

$°F = 9/5\,°C + 32$

1 Mw = 3.41×10^6 BTU/hr

$°C = 5/9\,(°F - 32)$

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

1 Curie = 3.7×10^{10} dis/sec

1 kg = 2.21 lbm

1 Horsepower = 2.54×10^3 BTU/hr

1 Mw = 3.41×10^6 BTU/hr

1 BTU = 778 ft-lbf

$°F = 9/5\,°C + 32$

1 gal (H_2O) . 8 lbm

$°C = 5/9\,(°F - 32)$

$c_P = 1.0$ BTU/hr/lbm/°F

$c_p = 1$ cal/sec/gm/°C

Question A.01 [1 point] (1.0)
Reactor is stabilized at 100 watts. ΔK_{eff} and $\Delta\rho$ respectively are:
a. 0 and 0
b. 0 and 1
c. 1 and 0
d. 1 and 1

Answer: A.01 a.
Reference: Burn, R., Introduction of Nuclear Reactor Operations, © 1988, Sec 4.2
b. Cannot be correct because $\beta < \beta$-effective (finite)

Question A.02 [1 point] (2.0)
You're increasing reactor power on a steady + 26 second period. How long will it take to increase power by a factor of 1000?

a. 1 minute
b. 3 minutes
c. 5 minutes
d. 180 minutes

Answer: A.02 b.
Reference: Burn, R., Introduction of Nuclear Reactor Operations, © 1988
$\ln(P/P_0) \times$ period = time, $\ln(1000) \times 26 = 6.908 \times 26 = 179.6 \approx 180$ seconds = 3 min.

Question A.03 [1 point] (3.0)
During a fuel loading of the core, as the reactor approaches criticality, the value of 1/M:
a. Increases toward one
b. Decreases toward one
c. Increases toward infinity
d. Decreases toward zero

Answer: A.03 d.
Reference: Module 4, ℞Theory (℞Operations), E.O. 1.4, pg. 7 and
DOE Fundamentals Handbook Nuclear Physics and
Reactor Theory Volumes 1 and 2, January 1993.

Question A.04 [1 point] (4.0)
Which one of the following accurately details a factor contributing to Xenon balance within the reactor?

a. Most Xe^{135} is formed by fission.
b. Te^{135} is a fission product which quickly decays to I^{135}.
c. Within approximately 8 hours after startup, Xe^{135} has reached its equilibrium value.
d. Several minutes following a reactor shutdown, Xe level is increasing because I^{135} is not being produced.

Answer: A.04 b.
Reference: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, Volume X, Module Y, Enabling Objective Z.Z

Question A.05 [1 point] (5.0)
Which ONE of the following is an example of neutron decay?

a. ${}_{35}Br^{87} \rightarrow {}_{33}As^{83}$
b. ${}_{35}Br^{87} \rightarrow {}_{35}Br^{86}$
c. ${}_{35}Br^{87} \rightarrow {}_{34}Se^{86}$
d. ${}_{35}Br^{87} \rightarrow {}_{36}Kr^{87}$

Answer: A.05 b.
Reference: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory.

Question A.06 [1 point] (6.0)
The reactor is operating at a constant power level with equilibrium xenon. You double Reactor power. The equilibrium xenon level at the higher power level will be …

a. the same as at the lower power level.
b. higher than its value at the lower power level, but not twice as high.
c. twice as high.
d. more than twice as high.

Answer: A.06 b.
Reference: DOE Fundamentals Handbook, Module 3, Xenon, page 37.

Question A.07 [1 point] (7.0)
Which ONE of the following is the <u>most correct reason</u> 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.

Answer: A.07 a.
Reference: NRC Standard Question

Question A.08 [1 point] (8.0)
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

Answer: A.08 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

Question A.09 [1 point] (9.0)
Which ONE of the following best describes the effects of <u>moderator temperature decrease</u> on neutron multiplication?

a. Fast non-leakage probability ↑; Thermal non-leakage probability ↓; Rod worth ↑
b. Fast non-leakage probability ↓; Thermal non-leakage probability ↓; Rod worth ↑
c. Fast non-leakage probability ↑; Thermal non-leakage probability ↑; Rod worth ↓
d. Fast non-leakage probability ↑; Thermal non-leakage probability ↑; Rod worth ↑

Answer: A.09 c
Reference: Burn, R., Introduction of Nuclear Reactor Operations, © 1988, Sec 3.3.2

Question A.10 [1 point] 109.0)
Which ONE of the following best describes the likelihood of fission reactions occurring in U-235 and U-238?

a. Neutron cross sections of U-235 and U-238 are independent in the neutron energy.

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

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

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

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

Question A.11 [1 point] (11.0)
Which ONE of the following factors is the most significant in determining the differential worth of a control rod?

a. The rod speed.
b. Reactor power.
c. The flux shape.
d. The amount of fuel in the core.

Answer: A.11 c.
Reference DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, (Reactor Operations), Enabling Objective 5.4

Question A.12 [1 point] (12.0)
During a reactor startup, the count rate is increasing linearly on a logarithmic scale, with no rod motion. This means that the reactor is:

a. subcritical and the count rate increase is due to the buildup of delayed neutron precursors.
b. subcritical and the count rate increase is due to source neutrons.
c. critical and the count rate increase is due to source neutrons.
d. supercritical.

Answer: A.12 d.
Reference: DOE Fundamentals Handbook, Module 4, Reactor Kinetics, page 14.

Question A.13 [1 point] (13.0)

A subcritical nuclear reactor has a count rate of 300 cps with a shutdown reactivity of 2.0% ΔK/K. Approximately how much positive reactivity must be added to establish a count rate of 600 cps?

a. 0.40% ΔK/K
b. 1.03% ΔK/K
c. 1.40% ΔK/K
d. 1.62% ΔK/K

Answer: A.13 b.

Reference: First, find K_{eff1} with ρ = -2.0% ΔK/K (shutdown: negative reactivity)

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

$-0.02\ K_{eff1} = K_{eff1} - 1$ so $1.02\ K_{eff1} = 1$ $K_{eff1} = 0.980$ $CR_2(1 - K_{eff2}) = CR_1\ (1 - K_{eff1})$

$600/300 = (1 - 0.980)/(1 - K_{eff2})$

Then find: $K_{eff2} = 0.990$

$\Delta\rho = (K_{eff2}-K_{eff1})/(K_{eff1}*K_{eff2}) = (0.990-0.980)/(0.990*0.98) = 1.03\%\ \Delta K/K$

Question A.14 [1 point] (14.0)

A 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 is 200 kW, what will it be five minutes later?

a. 0.5 kW
b. 2.3 kW
c. 4.7 kW
d. 110.0 kW

Answer: A.14 c.

Reference: $P = P_0\ e^{(t/\tau)} = 200\ kW\ .e^{(300sec/-80sec)} = 200\ kW\ .e^{-3.75} =$
$0.0235\ .\ 200\ kW = 4.7\ KW$

Question A.15 [1 point] (15.0)
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

Answer: A.15 c.
Reference: Standard NRC question

Question A.16 [1 point] (16.0)
Reactor power is increasing on a constant positive reactor period. Which ONE of the following power changes would finish in the shortest time?

a. 5% power – from 1% to 6%
b. 10% power – from 10% to 20%
c. 15% power – from 20% to 35%
d. 20% power – from 40% to 60%

Answer: A.16 d.
Reference: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, Volume

Question A.17 [1 point] (17.0)
If the primary flow rate is 3700 gpm and the ΔT across the primary side of the heat exchanger is 15.5°F, what is the power being transferred to the secondary side of the heat exchanger? (Assume no losses to the ambient surroundings, including the pool).

a. 12 megawatts.
b. 10 megawatts.
c. 8 megawatts.
d. 6 megawatts.

Answer: A.17 c.
Reference: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory.
$\dot{Q} = \dot{m} c P \Delta T$

$\dot{Q}$ = 3700 gal/min x 8 lbm/gal x 60 min/hr x 1 BTU/°F-lbm x 15.5 °F x 1 Mw-Hr./3..412 x 10^6 BTU

Question A.18 [1 point] (18.0)
An experimenter makes an error loading a rabbit sample. Injection of the sample results in a 100 millisecond period. If the scram setpoint is 12.5 Mwatt and the scram delay time is 0.1 seconds, WHICH ONE of the following is the peak power of the reactor at shutdown. (Assume Rabbit system is operational for this question.)

a. 12.5 Mw
b. 25.0 Mw
c. 34.0 Mw
d. 125 Mw

Answer: A.18 c.
Reference: DOE Fundamentals Handbook, Volume 2, Module 4, pp. 11.
$P = P0\ e^{t/T}$ $P = 12.5$ Mwatts $\times e^{(0.1/0.1)} = 12.5 \times 2.71828 = 33.98$

Question A.19 [1 point] (19.0)
Identify each isotope as being produced by the irradiation of **air**, irradiation of **wat**er, or is a **fiss**ion product.

a. N^{16}
b. Ar^{41}
c. H^{3}
d. Xe^{135}

Answer: A.18 a. = Water; b. = Air; c. = Water; d. = Fission
Reference: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, Volume 2, Module 4, Reactor Theory (Reactor Operations), Enabling Objective

Question A.20 [1 point] (20.0)
Core excess reactivity changes with …
a. fuel element burnup
b. control rod height
c. neutron energy level
d. reactor power level

Answer: A.20 a.
Reference: Technical Specification Requirement.

(*** End of Section A ***)

Question B.01 [1.0 point, 0.25 each] (1.0)
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. Pressurizer 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

Answer: B.01 a. = 4; b. = 5; c. = 3; d. = 1
Reference: Technical Specification 3.3

Question B.02 [1.0 point] (2.0)
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 Operator

Answer: B.02 c.
Reference: AP-RO-110 6.6.5 d)

Question B.03 [1.0 point] (3.0)
A “Knowledgeable Person” is defined as an operations trainee who has …
a. been designated by his/her shift LSRO.
b. successfully complete a 50% board.
c. successfully complete a 90% board.
d. been designated by the Reactor Manager.

Answer: B.03 b.
Reference: AP-RO-110 Conduct of Operations

Question B.04 [1.0 point] (4.0)
Per OP-RO-250, 2 Fuel Handling, when unlatching an element in the reactor, the fuel handling tool _____.

a. must be lifted up slightly to be removed from the fuel element.
b. must float off of the fuel element with no assistance from the operator.
c. must be pushed down then lifted up to be removed from the fuel element.
d. must be pushed down and twisted to be removed from the fuel element.

Answer: B.04 b.
Reference: OP-RO-250 Fuel Handling {Precaution 3.5}

Question B.05 [1.0 point] (5.0)
Per MURR Emergency Plan, the individual authorized to terminate an emergency and initiating recovery action is the:

a. U.S. NRC Emergency Operation Coordinator
b. Radiation Safety Officer
c. Campus Police Chief
d. Emergency Director

Answer: B.05 d.
Reference: Emergency Plan, 2.1

Question B.06 [1.0 point] (6.0)
While working in an area marked "Caution, Radiation Area," you discover your dosimeter is off scale and leave the area. Assuming you had been working in the area for 45 minutes, what is the maximum dose you would have received?

a. 3.8 mr
b. 35.6 mr
c. 75 mr
d. 100 mr

Answer: B.06 c.
Reference: 10 CFR 20.1003 Maximum dose in a rad area is 100 mr/hr.
100 mr/hr × 0.75 hr = 75 mr.

Question B.07 [1.0 point] (7.0)
The siphon break system pressure will be verified, recorded, and readjusted as required every _____ as part of the facility routine patrol.

a. 1 hour
b. 2 hours
c. 4 hours
d. 6 hours

Answer: B.07 c.
Reference: Technical Specifications, 3.9 d.

Question B.08 [1.0 point] (8.0)
In the event of an accident involving personnel injury and potential radiological contamination, which ONE of the following is the correct treatment facility by the MURR E-Plan used?

a. UMC Police Station
b. UMC Radiation Safety Office
c. Columbia Fire Department Station
d. University of Missouri Hospital and Clinics

Answer: B.08 d.
Reference: EP-RO-005, Medical Emergency

Question B.09 [1.0 point] (9.0)
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

Answer: B.09 b.
Reference: 10 CFR 20.1003

Question B.10 [1.0 point] (10.0)
Fill out the blank with **MAX**IMUM or **MIN**IMUM 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	(___)

Answer: B.10 a. = Min; b. = Max; c. = Min; d. = Max
Reference: Technical Specifications, 2.2

Question B.11 [1.0 point] (11.0)
Before depressing “Rod Run-In” or “Scram” push button for a normal shutdown, you should:

a. SET Intermediate Range Monitor Level Recorder to FAST speed and START Source Range Monitor Level Recorder and Scaler.

b. SET Intermediate Range Monitor Level Recorder to FAST speed and STOP Source Range Monitor Level Recorder and Scaler.

c. SET Intermediate Range Monitor Level Recorder to SLOW speed and START Source Range Monitor Level Recorder and Scaler.

d. SET Intermediate Range Monitor Level Recorder to SLOW speed and STOP Source Range Monitor Level Recorder and Scaler.

Answer: B.11 a.
Reference: OP-RO-220, Section 5.1

Question B.12 [1.0 point] (12.0)
You conduct a facility tour for the U.S. President. The reactor is operating at a certain power level and the area radiation monitor near the President reads 5 mrem/hr. How long can the President stay before he exceeds his 10 CFR 20 limit?

a. 50 hrs
b. 20 hrs
c. 10 hrs
d. 2 hrs

Answer: B.12 b.
References: 100 mrem dose limit to members of the public (10 CFR 20)

Question B.13 [1.0 point] (13.0)
In the event of a high stack monitor readings (in excess of alarm points), the reactor operator should immediately:

a. notify the LSRO.
b. scram the reactor.
c. shut down the reactor.
d. reduce power slowly until the alarm clears.

Answer: B.13 a.
Reference: REP-RO-100 – REP-4

Question B.14 [1.0 point] (14.0)
Per the definition in the Emergency Plan, an EMERGENCY is …

a. The person or persons appointed by the Emergency Coordinator to ensure that all personnel have evacuated the facility or a specific part of the facility.

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

c. a condition or conditions which call(s) for immediate action, beyond the scope of normal operating procedures, to avoid an accident or to mitigate the consequences of one.

d. Specific instrument readings, or observations; radiological dose or dose rates; or specific contamination levels of airborne, waterborne, or surface- deposited radioactive materials that may be used as thresholds for establishing emergency classes and initiating appropriate emergency measures.

Answer: B.14 c.
Reference: Emergency Plan - Definitions

Question B.15 [1.0 point] (15.0)
You follow the Standing Order Guidance 16-07 for Guidance for Operation of the Pneumatic Tube (P-Tube) System. This Standing Order will remain in effect until:

a. Until a new Operating Procedure EX-RO-110 is approved
b. cancelled by the Senior Reactor Operator
c. cancelled by the Lead Senior Reactor Operator
d. cancelled by the Reactor Manager

Answer: B.15 d.
Reference: Standing Order 16-07

Question B.16 [1.0 point] (16.0)
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

Answer: B.16 b.
Reference: Emergency Plan Table I, Emergency Classes

Question B.17 [1.0 point] (17.0)
Which ONE of the following will be **violate** the Limiting Safety System Settings in MODE I operation?

a. Primary Coolant Flow of 1800 gpm
b. Inlet Water Temperature of 150 °F
c. Pressurizer Pressure of 70 Psia
d. Reactor Power of 10 MW

Answer: B.17 c.
Reference: Technical Specifications, 2.2

Question B.18 [1.0 point] (18.0)
An unshielded source reads 300 mr/hr at 100 cm. You store it in a lead pig and perform a survey. It reads 200 mr/hr on contact, and 10 mr/hr at 100 cm. If a shielded source is stored in a lead pig, how do you post this area with your justification?

a. Very High Radiation Area because an unshielded source reads 3333 mr/hr at 30 cm
b. High Radiation Area because a shielded source reads 200 mr/hr on contact
c. High Radiation Area because a shielded source reads 111 mr/hr at 30 cm from the lead pig
d. Radiation Area because a shielded source reads 10 mr/hr at 100 cm from the lead pig

Answer: B.18 c.
Reference: 10 CFR 20.
$10 \text{ mR/hr } (100 \text{ cm})^2 = X * (30 \text{ cm})^2$ X = 111 mR/hr at 30 cm

Question B.19 [1.0 point] (19.0)
A survey instrument with a window probe was used to measure an irradiated experiment. The results were 100 millirem/hr window open and 60 millirem/hr window closed. What was the gamma dose?

a. 40 millirem/hr
b. 60 millirem/hr
c. 100 millirem/hr
d. 160 millirem/hr

Answer: B.19 b.
Reference: NRC Generic Section B Bank
{Instrument reads only gamma with window closed therefore reading with window closed is gamma dose.}

Question B.20 [1.0 point] (20.0)
An experimenter wishes to irradiate three specimens with reactivity worths of 0.0005 Δk/k, 0.0013 Δk/k and 0.0027 Δk/k. Can these specimens be placed in the reactor as UNSECURED experiments and why (why not).

a. Yes, each specimen is less than 0.006 Δk/k.
b. No, one of the specimens is greater than 0.0025 Δk/k.
c. Yes, the sum of the three specimens is less than 0.025 Δk/k.
d. No, the sum of the three specimens is greater than 0.01 Δk/k.

Answer: B.20 b.
Reference: Technical Specifications, §§ 3.1(g)–(k).

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

Question C.01 [1 point] (1.0)
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

Answer: C.01 c.
Reference: SOP-501

Question C.02 [1.0 point] (1.0)
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.

Answer: C.02 a.
Reference: MURR Reactor Operations Training Manual, Reactor Core Assembly Support Structure

Question C.03 [1.0 point, 0.25 each] (3.0)
Identify whether each of the following valves fails OPEN or SHUT.
a. Pressurizer Drain Valve (527A)
b. Vent Tank Vent Valve (552A)
c. Pressurizer Isolation Valve (527C)
d. Demin Inlet Isolation Valve (527E)

Answer: C.03 a. = S; b. = S; c. = S; d. = S
Reference: Reactor Operations Training Manual

Question C.04 [1.0 points, 0.25 points each] (4.0)
Identify the components labeled a through d on the figure of the cross section of the core area provided. (Note: Only one answer per letter.)

a. A 1. Active Fuel Region
   2. Mounting Bracket
b. B 3. Beryllium Skirt
   4. Outer Pressure Vessel
c. C 5. Graphite Reflector
   6. Control Blade
d. D 7. Beryllium Reflector

Answer: C.04 a. = 1; b. = 4; c. = 6; d. = 7
Reference: Reactor Operations Training Manual

Question C.05 [1 point] (5.0)
A Facility Evacuation can be manually initiated from the control console and:
a. the reactor bridge.
b. equipment room 278.
c. the front lobby.
d. equipment room 114.

Answer: C.05 c.
Reference: CP-6 Building Evacuation/Isolation Scram

Question C.06 [1 point] (6.0)
Which ONE statement below describes the operation of the three-way solenoid valves in the Valve Operating System? When the solenoid valve is …

a. energized, the vent side of the valve closes, directing air pressure to the isolation valve operator.

b. deenergized, the vent side of the valve closes, directing air pressure to the isolation valve operator.

c. energized, the vent side of the valve opens, directing air pressure to the isolation valve operator.

d. deenergized, the vent side of the valve opens, directing air pressure to the isolation valve operator.

Answer: C.06 a.
Reference: Training Manual for Reactor Operations, Section - Valve Operating System

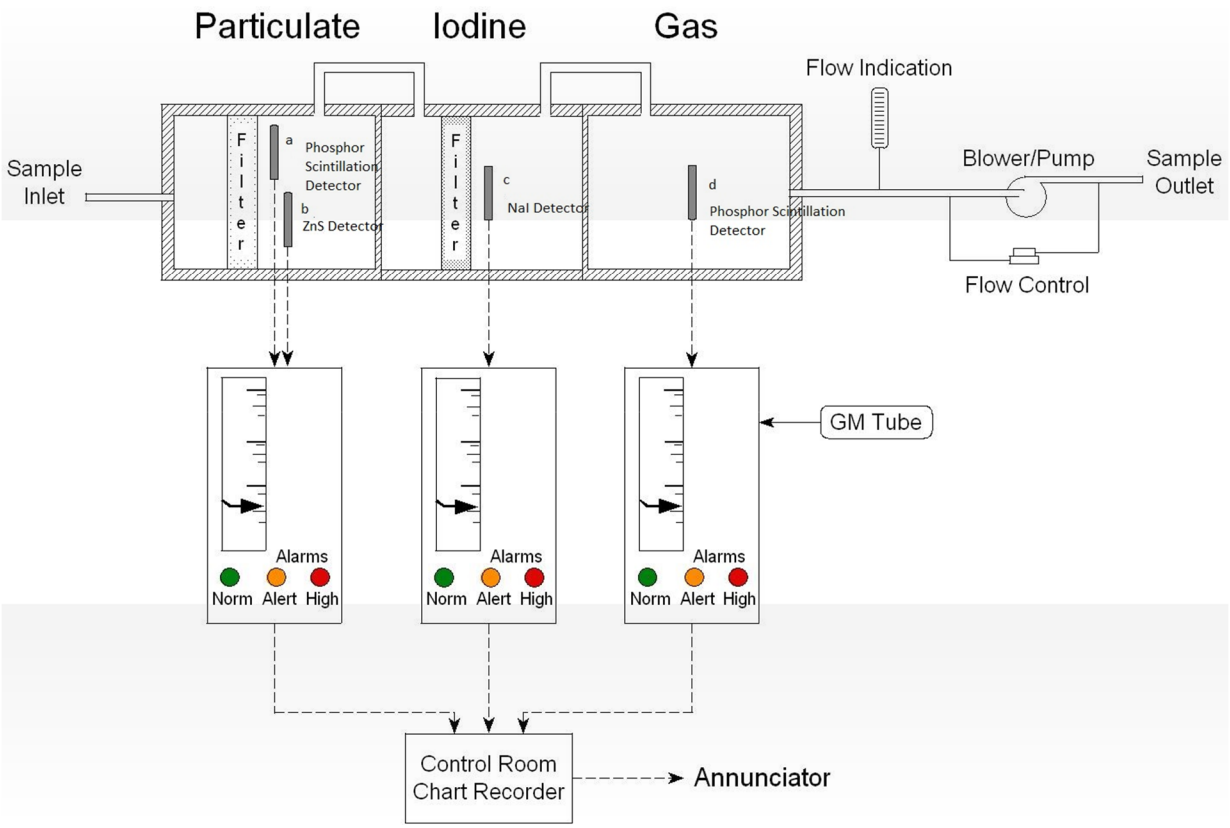
Question C.07 [1 point] (7.0)
Which ONE of the following is the method used to DE-ICE the cooling tower fans.
a. Run the cooling tower fan in reverse.
b. Use the facilities steam line located in the area for that purpose.
c. Use a heat gun (similar to a hair dryer) designated for de-icing use.
d. De-icing is not necessary due to anti-freeze added to cooling tower water.

Answer: C.07 a.
Reference: OP-RO-480, § 7.0 Note #2

Question C.08 [1 point] (8.0)
The following diagram depicts the Off-Gas Radiation Monitoring System. Match the locations of radiation detectors in column A with what it detects in column B. Items in column B can be used once, more than once or not at all.

Column A	Column B
a. Particulate (Phosphor Scintillation Detector)	1. alpha
b. Particulate (ZnS Detector)	2. beta
c. Iodine (NaI Detector)	3. gamma
d. Gas (Phosphor Scintillation Detector)	4. Neutron

Answer: C.08 a. = 2; b. = 1; c. = 3; d. = 2
Reference: MURR Reactor Operations Training Manual, Stack Monitor - Eberline



Question C.09 [1 point] (9.0)

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.

Answer: C.09 a.
Reference: MURR Reactor Operations Training Manual, UPS System

Question C.10 [1 point] (10.0)
The Fission Product Monitor samples the PRIMARY COOLANT at a point:
a. at the Holdup Tank.
b. between the outlet of the pool heat exchanger (HX 521) and the inlet to the pool.
c. between the outlet of the heat exchangers (HX 503A/B) and the inlet to the core.
d. between the outlet of the primary pumps and the inlet to the heat exchangers (HX503A/B).

Answer: C.10 c.
Reference: MURR Reactor Operations Training Manual, Primary Coolant Loop

Question C.11 [1 point] (11.0)
Which ONE of the following Primary Coolant System components is connected to the primary coolant loop, at the highest points of the inverted loop and the In-Pool Heat Exchanger, through half inch lines?

a. Anti-Siphon System
b. Pool Skimmer System
c. Pressurizer System
d. Vent Tank System

Answer: C.11 d.
Reference: MURR Operations Training Manual, II. System Description/Operation, pg. 2-4A and 2-4D

Question C.12 [1 point] (12.0)
Secondary Cooling System pumps should not be started at the same time because:
a. the power surge will trip the pump motor supply breakers.
b. initial high flow rates will result in thermal shock to the heat exchangers.
c. the pressure surge may produce a water hammer in the heat exchangers.
d. the basin level will be reduced, resulting in a low sump level trip.

Answer: C.12 d.
Reference: SOP VI.1.

Question C.13 [1 point] (13.0)
The “island tube”, part of the reactor core assembly support structure, is a single component of the:

a. Inner Pressure Vessel
b. Lower Reflector Plenum
c. Outer Pressure Vessel
d. Upper Reflector Tank

Answer: C.13 a.
Reference: MURR Operations Training Manual, II. System Description/Operation, pg. 2-8B

Question C.14 [1 point] (14.0)
Which ONE of the following is the purpose of the spacers set between the pressure vessel and the beryllium reflector?

a. To allow for natural circulation during operations below 100 kW.
b. To increase control blades travel speed.
c. To reduce the possibility of rod binding.
d. To signal control blade position indication.

Answer: C.14 c.
Reference: MURR Operations Training Manual, II. System Description/Operation, pg. 1-8C

Question C.15 [1 point] (15.0)
Reactor is in operation. The BRIDGE Radiation Monitor System (ARMS) changes from normal to a failure mode. Its failure mode will cause:

a. The reactor is initiated the rod run-in
b. The Evacuation Relays (R3A & R3B) are tripped
c. The containment building exhaust isolation valves 16A and 16B remain in the open mode
d. Warning light at the entrance to the containment building personnel airlock will illuminate

Answer: C.15 d.
Reference: MURR Reactor Operations Training Manual, Reactor Isolation and Facility Evacuation

Question C.16 [1 point] (16.0)
Which ONE of the following is the method used to CONTINUOUSLY sample air for the MURR stack gas monitor?

a. Instrumental Reference Method
b. Evacuated Bottle Method
c. Anisokinetic Method
d. Isokinetic Method

Answer: C.16 d.
Reference: MURR Reactor Operations Training Manual, Stack Monitor

Question C.17 [1 point] (17.0)
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"

Answer: C.17 b.
Reference: MURR Reactor Operations Training Manual, Pressurizer System

Question C.18 [1 point] (18.0)
Which ONE of the following radiation monitors is not required by Technical Specifications?
a. Stack Radiation Monitor
b. Reactor Bridge Radiation Monitor
c. Reactor Building Exhaust Air Plenum Radiation Monitor
d. Beam Hole Floor Radiation Monitor

Answer: C.18 d.
Reference: TS 3.4 a, pg. 1 of 6 and HSR 8.3, pg. 8.8

Question C.19 [1 point] (19.0)
The Emergency Power Panel provides 480V power to which ONE of the following?
a. The Pneumatic Tube System.
b. The Emergency Air Compressor.
c. The Emergency Lighting Panel 1 (ELP-1).
d. The Emergency Lighting Panel 2A (ELP-2A.

Answer: C.18 b.
Reference: MURR Reactor Operations Training Manual - 2B Emergency Electrical Distribution

Question C.20 [1 point] (20.0)
Reactor is in Mode I operation. A calculation of the secondary heat balance of 11 MW. Which ONE of the following is your proper action?

a. You may continue the reactor operation and start investigating the result
b. You reduce the reactor power to Mode II operation and recalculate the heat balance r
c. You may continue the reactor operation and inform the result to Lead Senior Reactor Operator

d. You immediately shut down the reactor and inform the result to Lead Senior Reactor Operator

Answer: C.20 d.
Reference: SOP AP-RO-110, Section 6.7

(*** End of Examination ***)

Section C - Plant and Rad Monitoring Systems