October 29, 2014

Dr. Hyoung K. Lee, Reactor Facility Director
Missouri University of Science
and Technology
Nuclear Engineering
222 Fulton Hall
Rolla, MO 65409-0170

SUBJECT: EXAMINATION REPORT NO. 50-123/OL-15-01, MISSOURI UNIVERSITY OF SCIENCE AND TECHNOLOGY

Dear Dr. Lee:

During the week of September 29, 2014, the NRC administered an operator licensing examination at your Missouri University of Science and Technology Reactor. The examination was 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 internet e-mail Phillip.Young@nrc.gov.

Sincerely,

**/RA/**

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

Docket No. 50-123

Enclosures: 1. Examination Report No. 50-123/OL-15-01
2. Written Examination

cc w/o enclosures:
See next page

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ADAMS ACCESSION #: ML14287A373 TEMPLATE #: NRR-079

| OFFICE | PRTB:CE | IOLB:LA | PROB:BC |
|---|---|---|---|
| NAME | PYoung | CRevelle | KHsueh |
| DATE | 10/14 /14 | 10/21/14 | 10/29/ /14 |

**OFFICIAL RECORD COPY**

cc:

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

Dr. Samuel Frimpong, Chair
Mining and Nuclear Engineering
226 McNutt Hall
Missouri University of Science and Technology
Rolla, MO 65409-0450

Craig Reisner
University of Missouri-Rolla
Nuclear Reactor Facility
1870 Miner Circle
Rolla, MO 65409-0630

Mr. William E. Bonzer, Reactor Manager
Missouri Science and Technology
Nuclear Reactor Facility
250 West 13th Street
Rolla, MO 65409-0630

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

REPORT NO.: 50-123/OL-15-01

FACILITY DOCKET NO.: 50-123

FACILITY LICENSE NO.: R-79

FACILITY: Missouri University of Science and Technology

EXAMINATION DATES: October 1 & 2, 2014

SUBMITTED BY: /RA/ 10/14/2014
Phillip T. Young, Chief Examiner Date

SUMMARY:

During the week of September 29, 2014, the NRC administered operator licensing examinations to one Senior Operator – Instant (SROI) and two new Reactor Operator (RO) and two retake RO applicants. Both retake applicants passed all portions of the examinations. The SROI and Retake RO applicant's passed all portions of the examinations, but the two new RO applicants failed the Section A of the written examination.

REPORT DETAILS

1. Examiners:

Phillip T. Young, Chief Examiner, NRC
Paulette Torres, Examiner Trainee, NRC

2. Results:

| | RO PASS/FAIL | SRO PASS/FAIL | TOTAL PASS/FAIL |
|---|---|---|---|
| Written | 4/2 | 1/0 | 5/2 |
| Operating Tests | 2/0 | 1/0 | 3/0 |
| Overall | 2/2 | 1/0 | 3/2 |

3. Exit Meeting:

Phillip T. Young, NRC, Examiner
Paulette Torres, NRC, Examiner Trainee
Bill Bonzer, Reactor Supervisor, Missouri University of Science and Technology
Craig Reisner, Senior Reactor Operator, Training Coordinator, Missouri University of Science and Technology

The examiner thanked the facility for their cooperation during the examination. No generic issues were identified.

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

| | |
|---|---|
| FACILITY: | Missouri University of Science and Technology (Rolla) |
| REACTOR TYPE: | MTR |
| DATE ADMINISTERED: | 10/01/2014 |
| 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 brackets 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 | % of Candidates Score | Category Value | Category |
|---|---|---|---|---|
| 18.0 | 33.3 | ______ | ____ | A. Reactor Theory, Thermodynamics and Facility Operating Characteristics |
| 18.0 | 33.3 | ______ | ____ | B. Normal and Emergency Operating Procedures and Radiological Controls |
| 18.0 | 33.3 | ______ | ____ | C. Facility and Radiation Monitoring Systems |
| 54.0 | | ______ | ____% FINAL GRADE | TOTALS |

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.

13. When you have completed and turned in you examination, leave the examination area. If you are observed in this area while the examination is still in progress, your license may be denied or revoked.

## EQUATION SHEET's

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$T_{‰} = \frac{0.693}{\lambda}$$

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

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

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

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

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

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

1 Curie = $3.7 \times 10^{10}$ dis/sec

1 kg = 2.21 lbm

1 Horsepower = $2.54 \times 10^3$ BTU/hr

1 Mw = $3.41 \times 10^6$ 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

## Section A Reactor Theory, Thermo, and Facility Characteristics

**Question** A.001 [1.0 point] {1.0}

Control Rod withdrawal predominantly changes $K_{eff}$ by changing the …

a. fast fission factor (ε).
b. thermal utilization factor (f).
c. neutron reproduction factor (η).
d. resonance escape probability (p).

Answer: A.01 b.
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, §

**Question** A.002 [1.0 point] {2.0}

Which ONE of the following isotopes has the largest microscopic cross-section for absorption for thermal neutrons?

a. $U^{235}$
b. $B^{10}$
C. $Sm^{149}$
d. $Xe^{135}$

Answer: A.02 d.
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, §

**Question** A.003 [1.0 point] {3.0}

Which ONE of the following conditions describes a critical reactor?

a. $K_{eff}$ = 1; Δk/k (ρ) = 1
b. $K_{eff}$ = 1; Δk/k (ρ) = 0
c. $K_{eff}$ = 0; Δk/k (ρ) = 1
d. $K_{eff}$ = 0; Δk/k (ρ) = 0

Answer: A.03 b.
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, §

## Section A  Reactor Theory, Thermo, and Facility Characteristics

**Question** A.004 [1.0 point] {4.0}

Initially Nuclear Instrumentation is reading 30 CPS and the reactor has a $K_{eff}$ of 0.90. You add an experiment which causes the Nuclear instrumentation reading to increase to 60 CPS. Which ONE of the following is the new $K_{eff}$?

a. 0.91

b. 0.925

c. 0.95

d. 0.975

Answer: A.04 c.

Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, §

$CR_1/CR_2 = (1\text{-}k_{eff2})/(1 - k_{eff1})$

$(1 - keff_2) = (1 - 0.90) \times 30/60 = 0.1 \times 30/60 = 0.05$

$1\text{-} k_{eff} = 0.05$ or $k_{eff} = 0.95$

**Question** A.005 [1.0 point] {5.0}

What is the kinetic energy range of a thermal neutron?

a. > 1 MeV
b. 100 KeV – 1 MeV
c. 1 eV – 100 KeV
d. < 1 eV

Answer: A.05 d.

Reference: Glasstone, S., Nuclear Reactor Engineering, Kreiger Publishing, Malabar: Florida, 1991. 3rd Edition. pg. 13

**Question** A.006 [1.0 point] {6.0}

Suppose the temperature coefficient of a core is $-2.5 \times 10^{-4}$ ΔK/K/□C and the average control rod worth of the regulating control rod is $5.895 \times 10^{-3}$ ΔK/K/inch. If the temperature <u>INCREASES</u> by 50□C what will the automatic control command the regulating rod to do? Select the answer that is closest to the calculated value.

a. 5.6 inches in
b. 2.1 inches out
c. 0.5 inches in
d. 4.3 inches out

Answer: A.06 b.

Reference: The temperature increase will result in a change in reactivity of: $-2.5 \times 10^{-4}$ ΔK/K/□C × 50□C = $-1.25 \times 10^{-2}$ ΔK/K. Since the temperature rise results in a negative reactivity insertion, the control rod will need to drive out to add positive reactivity. D = ($1.25 \times 10^{-2}$ ΔK/K)

÷ ($5.895 \times 10^{-3}$ ΔK/K/inch) = 2.12 inches

## Section A Reactor Theory, Thermo, and Facility Characteristics

## Section A Reactor Theory, Thermo, and Facility Characteristics

**Question** A.007 [1.0 point] {7.0}

Which one of the following is the definition of the FAST FISSION FACTOR?

a. The ratio of the number of neutrons produced by fast fission to the number produced by thermal fission.
b. The ratio of the number of neutrons produced by thermal fission to the number produced by fast fission.
c. The ratio of the number of neutrons produced by fast fission to the number produced by fast and thermal fission.
d. The ratio of the number of neutrons produced by fast and thermal fission to the number produced by thermal fission.

Answer: A.07 d.
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, §

**Question** A.008 [1.0 point] {8.0}

The number of neutrons passing through a one square centimeter of target material per second is the definition of which one of the following?

a. Neutron Flux (nv)
b. Neutron Density (nd)
c. Neutron Population (np)
d. Neutron Impact Potential (nip)

Answer: A.08 a.
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, §

**Question** A.009 [1.0 point] {9.0}

Reactor Power increases from 15 watts to 65 watts in 30 seconds. The period of the reactor is:

a. 7 seconds
b. 14 seconds
c. 21 seconds
d. 28 seconds

Answer: A.09 c.
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, §
$P = P_0 e^{t/\tau}$, $\ln(65/15) = 30sec/\tau$ $\tau = (30 sec)/(\ln 4.3333) = 20.456$

## Section A Reactor Theory, Thermo, and Facility Characteristics

**Question** A.010 [1.0 point] {10.0}
A reactor is subcritical with a Keff of 0.955. A positive reactivity of 3.5% delta k/k is inserted into the core. At this point, the reactor is:

a. supercritical.
b. exactly critical.
c. subcritical.
d. prompt critical.

Answer: A.10 c.
Reference: Burn, Introduction to Nuclear Reactor Operations, Page 3-20.
Initial Reactivity = (K-1)/K = (0.955 -1)/0.955 = - 0.047 delta k/k
After reactivity insertion, net reactivity = - 0.047 + 0.035 = - 0.012 delta k/k

**Question** A.011 [1.0 point] {11.0}
During the time when reactor power increases, the delayed neutron fraction, β:

a. remains unchanged.
b. increases because prompt neutrons are being produced at a faster rate.
c. increases because delayed neutron precursors are being produced at a faster rate.
d. decreases because delayed neutrons are being produced from precursors that were formed at a lower power level.

Answer: A.11 d.
Reference: Burn, Introduction to Nuclear Reactor Operations, Page 4-8.

**Question** A.012 [1.0 point] {12.0}
Which ONE of the following statements describes the difference between Differential Rod Worth (DRW) and Integral Rod Worth (IRW)?

a. DRW relates the worth of the rod per increment of movement to rod position. IRW relates the total reactivity added by the rod to rod position.
b. DRW relates the time rate of reactivity change to rod position. IRW relates the total reactivity in the core to the time rate of reactivity change.
c. IRW relates the worth of the rod per increment of movement to rod position. DRW relates the total reactivity added by the rod to rod position.
d. IRW is the slope of the DRW at a given rod position.

Answer: A.12 a.
Reference: Burn, Introduction to Nuclear Reactor Operations, Pages 7-1 thru 7-5.

**Question** A.013 [1.0 point] {13.0}
Two different neutron sources were used during two reactor startups. The source used in the first startup emits ten times as many neutrons as the source used in the second startup. Assume all other factors are the same for the second startup. Which ONE of the following states the expected result at criticality?

a. Neutron flux will be higher for the first startup.
b. Neutron flux will be higher for the second startup.
c. The first startup will result in a higher rod position (rods further out of the core).
d. The second startup will result in a higher rod position (rods further out of the core).

Answer: A. 13 a.
Reference: Burn, Introduction to Nuclear Reactor Operations, Pages 5-14 thru 5-19.

**Question** A.014 [1.0 point] {14.0}
When performing rod calibrations, many facilities pull the rod out a given increment, then measure the time for reactor power to double (doubling time), then calculate the reactor period. If the doubling time is 42 seconds, what is the reactor period?

a. 29 sec
b. 42 sec
c. 61 sec
d. 84 sec

Answer: A.14 c.
Reference: ln (2) = -time/τ τ = time/(ln(2)) = 60.59 ≈ 61 seconds

**Question** A.015 [1.0 point] {15.0}
Which ONE of the following statements concerning reactor poisons is NOT true?

a. During reactor operation, Xenon concentration is dependent on reactor power level.
b. Following shutdown, Samarium concentration will increase to some value then stabilize.
c. During reactor operation, Samarium concentration is independent of reactor power level.
d. Following shutdown, Xenon concentration will initially increase to some value then decrease exponentially.

Answer: A.15 c.
Reference: Reactor Theory (Nuclear Parameters), Enabling Objectives 4.1 through 4.15

**Question** A.016 [1.0 point] {16.0}
Which ONE of the following is an example of alpha decay?

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

Answer: A.16 a.
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, §

**Question** A.017 [1.0 point] {17.0}
Which ONE of the following describes the term prompt jump?

a. The instantaneous change in power level due to withdrawing a control rod.
b. A reactor which has attained criticality on prompt neutrons alone.
c. A reactor which is critical using both prompt and delayed neutrons.
d. A negative reactivity insertion which is less than Keff.

Answer: A.017 a.
Reference: Burn, Introduction to Nuclear Reactor Operations, Page 4-21.

**Question** A.018 [1.0 point] {18.0}
Which ONE of the following describes the difference between a moderator and reflector?

a. A reflector increases the fast non-leakage factor and a moderator increases the thermal utilization factor.
b. A reflector increases the neutron production factor and a moderator increases the fast fission factor.
c. A reflector decreases the thermal utilization factor and a moderator increases the fast fission factor.
d. A reflector decreases the neutron production factor and a moderator decreases the fast nonleakage factor.

Answer: A.18 a.
Reference: Burn, Introduction to Nuclear Reactor Operations, Page 3-16.

## Section B Normal/Emergency Procedures & Radiological Controls

**Question** B.001 [1.0 point] {1.0}
The reactor parameter which is protected by a Safety Limit is:
a. fuel element cladding temperature.
b. fuel element temperature.
c. primary coolant flow rate.
d. reactor power level.

Answer: B.01 a.
Reference: Technical Specifications, Section 2.1.

**Question** B.002 [1.0 point] {2.0}
A radiation survey of an area reveals a general radiation reading of 1 mrem/hr. There is, however, a small section of pipe (point source) which reads 10 mrem/hr at one (1) meter. Which ONE of the following defines the posting requirements for the area in accordance with 10CFR20?
a. "CAUTION RADIATION AREA."
b. "CAUTION RADIOACTIVE MATERIAL."
c. "CAUTION HIGH RADIATION AREA."
d. "GRAVE DANGER, VERY HIGH RADIATION AREA."

Answer: B.02 c.
Reference: 10 CFR 20.1003 $DR1/D1^2 = DR2/D2^2$
10 mR/hr at 1 meter = 111 mR/hr at 30 cm.

**Question** B.003 [1.0 point] {3.0}
To maintain an active Reactor Operator or Senior Reactor Operator license, the functions of an operator or senior operator must be actively performed for at least:
a. one hour per month.
b. three hours per calendar quarter.
c. four hours per calendar quarter.
d. twelve hours per year.

Answer: B.03 c.
Reference: 10 CFR 55.53.

**Question** B.004 [1.0 point] {4.0}
You (a licensed Reactor Operator) and a Senior Reactor Operator (SRO) are operating the reactor on the weekend. No one else is available. In order to meet Technical Specifications requirements if you are on the console the SRO must be …

a. within the Reactor Building.
b. within the reactor control room.
c. within the confines of the Campus.
d. within 15 minutes' walk of the Reactor Facility.

Answer: B.04 a.
Reference: SOP 101, General Operating Procedures, § B.2

**Question** B.005 [1.0 point] {5.0}
Because the regulating rod may move without operator action (Auto control) it is limited to a total reactivity worth of less than …

a. 0.03% Δk/k
b. 0.07% Δk/k
c. 0.3% Δk/k
d. 0.7% Δk/k

Answer: B.05 d.
Reference: Technical Specifications § 3.1, specification (5).

**Question** B.006 [1.0 point] {6.0}
Which one of the following is the definition of Total Effective Dose Equivalent (TEDE) as specified in 10 CFR Part 20?

a. The sum of thyroid dose and external dose.
b. The sum of the external deep dose and the organ dose.
c. The sum of the deep dose equivalent and the committed effective dose equivalent.
d. The dose that your whole body is received from the source, but excluded from the deep dose.

Answer: B.06 c.
Reference: 10 CFR 20.1003.

**Question** B.007 [1.0 point] {7.0}
During the emergency, who has responsibility for determining the appropriate emergency classification and procedures?

a. Chair Mining and Nuclear.
b. Senior Reactor Operator.
c. Reactor Manager.
d. Reactor Director.

Answer: B.07 d.
Reference: Emergency Plan FIGURE 2. Emergency Organizational Chart for the Missouri S&T Reactor

**Question** B.008 [1.0 point] {8.0}
According to Technical Specification 3.7.1 “Experiments worth more than ______ delta k/k shall be inserted or removed with the reactor shutdown."

a. 0.05
b. 0.4
c. 1.2
d. 1.5

Answer: B.08 b.
Reference: Technical Specification 3.7.1 (c)

**Question** B.009 [1.0 point] {9.0}
Per the Emergency Plan, “If an emergency situation requires personnel to search for and remove injured person(s) or entry is necessary to prevent conditions that would probably injure numbers of people, a planned emergency exposure to the whole body could be allowed up to ____ to save a life.”

a. 25 rem
b. 50 rem
c. 75 rem
d. 100 rem

Answer: B.09 c.
Reference: Emergency Plan § 7.4.6, page 18.

**Question** B.010 [1.0 point] {10.0}
The MINIMUM pool temperature for operation of the reactor is …

a. 12.8□C (55□F)
b. 15.5□C (60□F)
c. 18.3□C (65□F)
d. 21.1□C (70□F)

Answer: B.10 b.
Reference: Technical Specifications § 3.3.3

**Question** B.011 [1.0 point] {11.0}
In accordance with SOP 101, who is the only person authorized to use an interlock bypass key?

a. The licensed reactor operator at the console.
b. The Senior Operator on duty.
c. Reactor Manager.
d. Reactor Director.

Answer: B.11 b.
Reference: SOP 101, General Operational Procedures – B.9

**Question** B.012 [1.0 point] {12.0}
"A channel test of each of the reactor safety system channels shall be performed before each day's operation or before each operation expected to extend more than one day, except for the bridge motion monitor which shall be done weekly." This is an example of a"

a. safety limit.
b. limiting safety system setting.
c. limiting condition for operation.
d. surveillance requirement.

Answer: B.12 d.
Reference: Technical Specifications, Section 4.2.2.

**Question** B.013 [1.0 point] {13.0}
The Quality Factor is used to convert …
a. dose in rads to dose equivalent in rems.
b. dose in rems to dose equivalent in rads.
c. contamination in rads to contamination equivalent in rems
d. contamination in rems to contamination equivalent in rads

Answer: B.13 a.
Reference: 10CFR20.1004.

**Question** B.014 [1.0 point] {14.0}
Which ONE of the following types of experiments shall **NOT** be irradiated at MSTR?
a. The secured experiments have a worth of - 1.00 % Δk/k.
b. Experiments containing 15 milligrams of explosive materials.
c. Fueled experiments in the amount which generates a power of 50 watts.
d. Experiments having moving parts have a continuous insertion rate of 0.01 % Δk/k per second.

Answer: B.14 c.
Reference: Technical Specifications § 3.7.2

**Question** B.015 [1.0 point] {15.0}
A radioactive source reads 35 Rem/hr on contact. Five hours later, the same source reads 1.5 Rem/hr. How long is the time for the source to decay from a reading of 35 Rem/hr to 100 mRem/hr?
a. 6.5 hours.
b. 7.5 hours.
c. 8.5 hours.
d. 9.5 hours.

Answer: B.15 d.
Reference:

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

1.5 rem/hr =35 rem/hr* e –λ(5hr)
Ln(1.5/35) = -λ*5 --> λ=0.623; solve for t: Ln(.1/35)=-0.623 *t  t=9.4 hours

**Question** B.016 [1.0 point] {16.0}
Given that the following emergency conditions occur at the MST reactor facility:
(a) Low level of coolant alarms
(b) Particulate monitor alarms
(c) Radiation levels at the site boundary indicate 100 mRem for one hour.

Which ONE of the following is the appropriate Emergency Classification?
a. Notification of Unusual Event.
b. Alert.
c. Site Area Emergency.
d. General Emergency.

Answer: B.16 c.
Reference: Emergency Plan, Table I

**Question** B.017 [1.0 point] {17.0}
A radioactive material is **DECAYING** at a rate of 30% per hour. Determine its half-life?
a. 1.5 hours.
b. 2.0 hours.
c. 2.5 hours.
d. 3.0 hours.

Answer: B.17 b.
Reference:

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

30% is decayed, so 70% is still there
70% =100%* e –λ(1hr)
Ln(70/100) = -λ*1 -->λ=0.356 t1/2=Ln(2)/ λ -->.693/.356 t=1.94 hours

**Question** B.018 [1.0 point] {18.0}
During a reactor startup, the reactor operator calculates that the maximum excess reactivity for reference core conditions is 1.6 % Δk/k. For this excess reactivity, which ONE of the following is the best action?
a. Continue to operate because the excess reactivity is within TS limit.
b. Increase power to 200 kW to verify the minimum excess reactivity.
c. Shutdown the reactor; immediately report the result to NRC due to excess being above TS limit.
d. Continue operation, but immediately report the result to the supervisor since the excess reactivity is exceeding TS limit.

Answer: B.18 c.
Reference: Technical Specifications § 3.1 and 6.6.1

**Question** C.001 [1.0 point] (1.0)
The Ventilation system consists of three fans mounted on the Reactor Building roof. On a Building Evacuation Alarm from the Reactor Bridge Radiation Area Monitor,

a. Verify all three fans will secure automatically.
b. All three fans must be secured by the Reactor Operator.
c. The two normal exhaust fans will secure automatically, the emergency exhaust fan will start automatically.
d. The Reactor Operator must secure the two normal exhaust fans and start the emergency exhaust fan.

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

**Question** C.002 [1.0 point] (2.0)
Which ONE of the following is the method used to minimize mechanical shock to the Shim/Safety control rods on a scram?
a. A small spring located at the bottom of the rod.
b. An electrical-mechanical brake energizes when the rod down limit switch is energized.
c. A piston (part of the connecting rod) drives air out of a dashpot as the rod nears the bottom of travel.
d. A piston attached to the upper end of the rod enters a special damping cylinder as the rod approaches the full insert position.

Answer: C.02 d.
Reference: SAR § 3.2.3, p. 3-13

**Question** C.003 [1.0 points, 0.167 each] (3.0)
Match each of the following situations {a. through g.} with the correct protective action {items 1 through 4}. Items 1 through 4 may be used more than once.

| Situations: | Protective Actions: |
|---|---|
| a. Period < 15 seconds | 1. Scram |
| b. Log N and Period Amp. Not Operative | 2. Rundown |
| c. Effluent Pool Demineralizer Conductivity high | 3. Rod Withdrawal Prohibit |
| d. High Neutron Flux in Beam Room | 4. Operator Response |
| e. Safety Rods Below Shim Range | |
| f. Reg rod on insert limit in auto control | |

Answer: C.03 a. = 2; b. = 1; c. = 4; d. = 4; e. = 3; f. = 2
Reference: SAR, Table 7.1-Nuclear Instrumentation Channel Description and Table 7.2-Reactor Instrumentation Protective Actions

## Section C Facility and Radiation Monitoring Systems

**Question** C.004 [1.0 point, ¼ each] (4.0)
Match each of the radiation monitors in column A with its associated actions in Column B.

| Column A | Column B |
|---|---|
| a. Demineralizer RAM | 1. Indication Only |
| b. Experiment Room RAM | 2. Indication and Runback Only |
| c. Reactor Bridge RAM | 3. Indication, Runback and Evacuation. |
| d. CAM | |

Answer: C.04 a. = 2; b. = 2; c. = 3; d. = 1
Reference: Technical Specifications Table 3.1 and SAR Table 7.2

**Question** C.005 [1.0 point] (5.0)
Each shim/safety rods consists of a grooved,

a. hafnium rod.
b. boron-carbide rod.
c. boral (boron and aluminum alloy) rod.
d. boron stainless steel rod.

Answer: C.05 d.
Reference: SAR, Table 4.1-General Design Characteristics of the MSTR

**Question** C.006 [1.0 point] (6.0)
Which ONE of the listed radioisotopes is best detected by the Continuous Air Monitor?

a. Xe136
b. Rb88
c. Ar41
d. N16

Answer: C.06 b.
Reference: Designed to detect particulate NOT gaseous radioactivity.

**Question** C.007 [1.0 point] (7.0)
On receipt of a scram signal, with the regulating rod controlling in AUTO, the regulating rod will:

a. remain at its position at the time of the scram.
b. receive a rod run-in signal and be driven into the core.
c. be magnetically decoupled from the drive, and drop into the core via gravity.
d. receive a mismatch signal and be driven out of the core attempting to maintain power stable.

Answer: C.07 a.
Reference: SAR § 4.2.2

**Question** C.008 [1.0 point] (8.0)
During a loss of coolant accident the purification system may be used to refill the pool at a rate of …
a. 10 gpm
b. 20 gpm
c. 30 gpm
d. 40 gpm

Answer: C.08 c.
Reference: SOP: 301 - POOL WATER SYSTEM

**Question** C.009 [1.0 point] (9.0)
Which ONE of the following types of detector is utilized in the continuous air monitoring system?
a. Ionization chamber.
b. Scintillation detector.
c. Geiger-Mueller tube.
d. Proportional counter.

Answer: C.09 c.
Reference: SAR, 7.4 - Radiation Monitoring System

**Question** C.010 [1.0 point] (10.0)
Which ONE accident below is designated as the Maximum Hypothetical Accident for the UMRR?
a. Loss of coolant accident.
b. Failure of a fueled experiment.
c. Fuel element handling accident.
d. Failure of a movable experiment.

Answer: C.10 b.
Reference: SAR, page 9-19.

**Question** C.011 [1.0 point] (11.0)
Which ONE of the following methods is used to compensate for gamma radiation in a Fission Chamber?

a. A compensating voltage equal to a predetermined "source gamma level" is fed into the pre-amplifier electronically removing source gammas from the signal. Fission gammas are proportional to reactor power and therefore not compensated for.
b. The chamber contains concentric tubes one of which detects both neutrons and gammas the other only gammas, are wired electronically to subtract the gamma signal, leaving only the signal due to neutrons.
c. The signal travels through a Resistance-Capacitance (RC) circuit, converting the signal to a power change per time period effectively deleting the signal due to gammas.
d. Pulses smaller than a height (voltage) are stopped by a pulse-height discriminator circuit from entering the instrument channel's amplifier.

Answer: C.11 d.
Reference: Standard NRC Question

**Question** C.012 [1.0 point] (12.0)
A neutron flux will activate isotopes in air. This is the reason that $N_2$ gas is used to drive the rabbit into and out of the core. The primary isotope we worry about in irradiating air is …

a. N16 (O16 (n,p) N16).
b. C14 (C13 (n, γ) C14).
c. Ar41 (Ar40 (n, γ) Ar41).
d. H2 (H1 (n, γ) H2).

Answer: C.12 c.
Reference: SAR, 10.2.3

**Question** C.013 [1.0 point] (13.0)
Compensating voltage to the compensated ion chambers is lost while the reactor is operating. As a result, the power level indication will:

a. increase or decrease, depending on the power level.
b. remain unchanged.
c. decrease.
d. increase.

Answer: C.13 d.
Reference: When compensation voltage is lost, detector reads both the neutron & gamma signals.

**Question** C.014 [1.0 point] (14.0)
Which ONE of the following describes the action of the shim-safety rod drive system following a reactor scram?

a. The magnet remains in its present position until driven in.
b. The scram signal automatically causes the magnet to be driven in.
c. Activation of the INSERT LIMIT microswitch initiates the down motion of the magnet.
d. Deactivation of the contact-actuated microswitch initiates the down motion of the magnet.

Answer: C.14 a.
Reference: SAR, 4.2 and 7.2

**Question** C.015 [1.0 point] (15.0)
Which ONE of the following is the method used to determine the control rod worth at MSTR?

a. Thermal Power calibration.
b. Negative Period.
c. Positive Period.
d. Rod Drop.

Answer: C.15 d.
Reference: SOP 109

## Section C Facility and Radiation Monitoring Systems

**Question** C.016 [1.0 point] (16.0)
Per MSTR Technical Specifications, the minimum resistivity of the MSTR pool water shall be greater than ______ megohm-cm when the fuel elements are in the reactor pool.

a. 0.2
b. 0.5
c. 2.0
d. 5.0

Answer: C.16 a.
Reference: TS 3.3

**Question** C.017 [1.0 point] (17.0)
Exposing a check source to the particulate detector to verify whether it is operable is considered to be:

a. a channel test.
b. a channel check.
c. a channel calibration.
d. a channel verification.

Answer: C.17 b.
Reference: TS, Definition

**Question** C.018 [1.0 point] (18.0)
What is the minimum level of management who may authorize removing or installing reactor thermocouples?

a. SRO on call.
b. SRO on duty.
c. Reactor Manager.
d. Reactor Director.

Answer: C.18 b.
Reference: SOP 806