U.S. NUCLEAR REGULATORY COMMISSION

REGION III

Report No(s). 50-123/OL-85-01

Docket(s) No. 50-123

Licensee: University of Missouri - Rolla
Nuclear Reactor
Rolla, Missouri 65401-0249

Facility Name: University of Missouri - Rolla

Examination Administered At: Rolla, Missouri

Examination Conducted: August 27 and 30, 1985

Examiner(s): E. Plettner — 9/12/85 Date

E. Plettner

Approved By: D. I. McMillen, Chief, Operator Licensing Section — 9/12/85 Date

D. I. McMillen

Examination Summary

Examination administered on August 27 and 30, 1985 (Report No(s). 50-123/OL-85-01)
The written examination was administered on August 27, 1985, and the oral examination was conducted on August 30, 1985.
Results: One candidate successfully completed the examination.

REPORT DETAILS

1. Examiners

   E. Plettner, Region III Chief Examiner

2. Examination Review Meeting

   Examination review was conducted by E. Plettner with Dr. A. Bolon after the oral exam was given on August 30, 1985. Facility comments were for the most part editorial and have been incorporated in the examination and answer key attached.

3. Exit Meeting

   At the conclusion of the site visit E. Plettner met with Dr. A. Bolon to discuss the results of the examination. The individual who clearly passed the oral was identified in the meeting.

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U.S. NUCLEAR REGULATORY COMMISSION
REACTOR OPERATOR LICENSE EXAMINATION

Facility University of Missouri Rolla

Reactor Type Pool

Date Administered August 27, 1985

Examiner E. Plettner

Applicant _____

Instructions to Applicant:

Use separate paper for the answers; staple question sheet on top of the answer sheets. Points for each question are indicated in parenthesis after the question. The passing grade requires at least 70% in each category and a final grade of at least 70%.

Category Value	% of Total	Applicant's Score	% of Cat. Value	
16.0	16.0	_____	_____	A. Principles of Reactor Operation
16.0	16.0	_____	_____	B. Features of Facility Design
13.5	13.5	_____	_____	C. General Operating Characteristics
15.0	15.0	_____	_____	D. Instruments and Controls
13.5	13.5	_____	_____	E. Safety and Emergency Systems
13.0	13.0	_____	_____	F. Standard and Emergency Operating Procedures
13.0	13.0	_____	_____	G. Radiation Control and Safety
100		_____		

Final Grade _____%

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

_____
Applicant's Signature

A. QUESTIONS - Principles of Reactor Operation

A.01 Define

a. Prompt Critical (1.0)
b. Subcritical Multiplication (1.0)

A.02 Reactor power increases from 15 watts to 65 watts in 30 seconds. The period of the reactor is: (1.0)

a. 6.9 seconds
b. 13.6 seconds
c. 20.5 seconds
d. 130 seconds

A.03 Explain the production and removal mechanisms for Xe-135 and Sa-149. (3.0)

A.04 Why does your reactor need a neutron source? (Two required for full credit) (2.0)

A.05 What are four reasons why excess reactivity is placed in the core of your reactor? (2.0)

A.06 What is the source of decay heat in reactor? (2.0)

A.07 In each of the following cases indicate the preferred characteristics for a moderator. Briefly explain why for each answer.

a. Absorb neutrons or scatter neutrons (1.0)
b. Have a high atomic weight or low atomic weight (1.0)

A.08 What does Beta effective refer to in an operating reactor? (1.0)

A.09 Which of the following is a true statement concerning radioactive decay? Remember the atomic number is the number of protons and the mass number is the number of neutrons plus protons. (1.0)

a. When an element decays by beta emission, the new element will have increased in atomic number by one and the mass number will remain the same as the original element.

b. When an element decays by alpha emission, the new element will have decreased in atomic number and mass number by two, from the original element.

c. When an element decays by neutron emission the new element will have increased in atomic number by one and decreased in mass number by one, from the original element.

d. When an element decays by gamma emission, the new element will have increased in atomic number by one and the mass number will remain the same as the original element.

END OF SECTION A

B. QUESTIONS - Features of Facility Design

B.01 Fill in the blanks on the drawing provided. (3.0)

B.02 Match the following: (2.5)

___	1. mixed resin bed ion exchanger	a.	Maintains pool purity at 500,000 ohm/cc and reduces corrosion and leaking.
___	2. core access element	b.	Permits a neutron startup source to be inserted into the core.
___	3. beam hole	c.	Reduces fuel element corrosion and prevents build up impurities.
___	4. pool water purification	d.	Has a cadmium lining to prevent sample activation by thermal neutrons.
___	5. isotope production element	e.	Has a curved aluminum tube which prevents neutron or gamma streaming.
		f.	Has a stainless steel lining to prevent radioactive contamination of samples.

B.03 Your facility has a special clutch on the shim/safety rods. What two actions are provided by this special clutch? (2.0)

B.04 True or False

An inadvertent movement of the reactor bridge causes the reactor to be scrammed. (1.0)

B.05 Describe or draw the normal flow path of water in the UMRR pool water system. Include any instrumentation that is included in the flow path. (3.0)

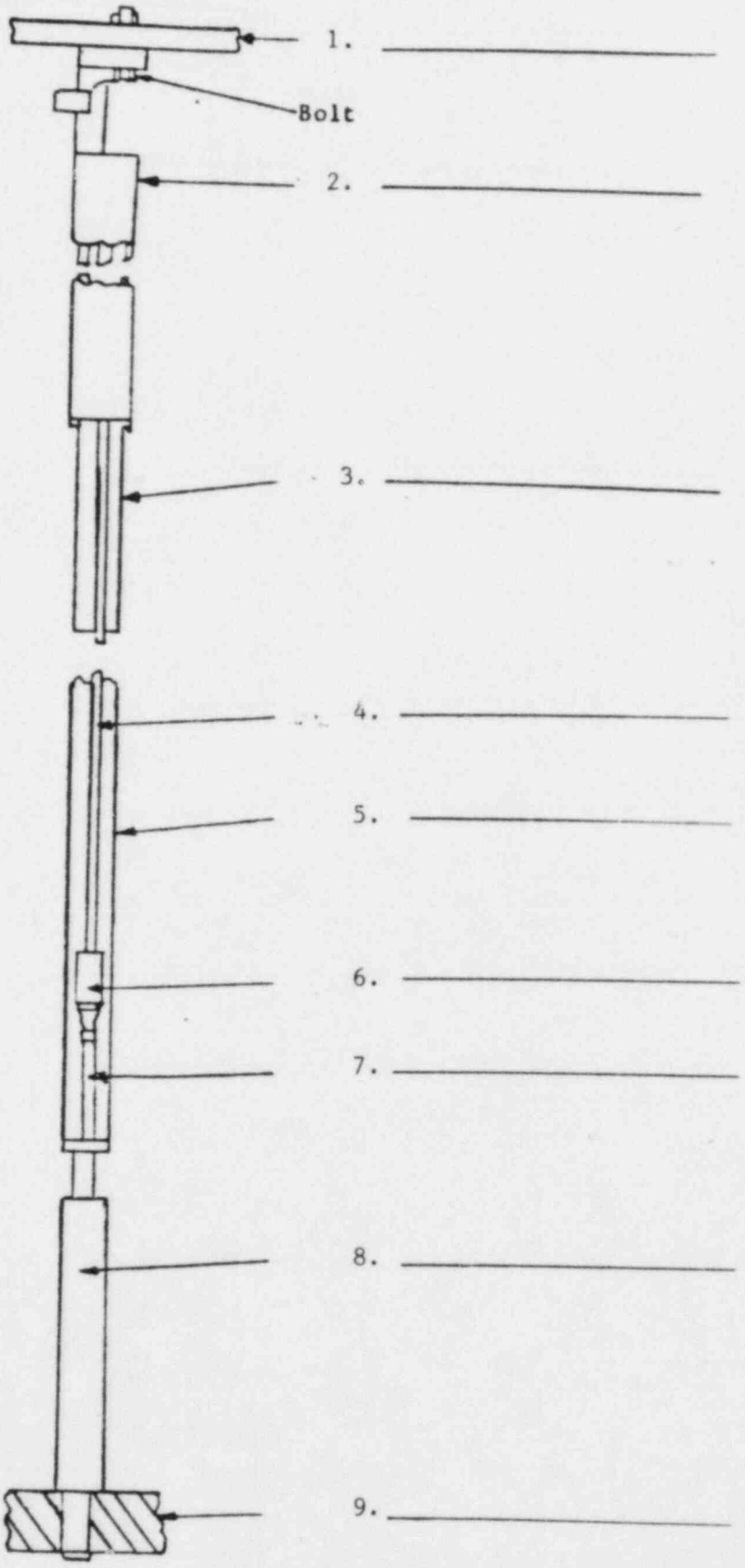
B.06 What are three functions of the liquid water hold up system at the UMRR? (1.5)

B.07 What is the design parameter for each of the following? (2.0)

a. Water level in the core
b. Drive speed of shim/safety rod
c. Maximum inlet core temperature
d. Drive speed of regulatory rod

B.08 Each rabbit system consists of two stainless steel tubes. What purpose does each tube serve? (1.0)

END OF SECTION B



B.01 Control rod drive system.

C. QUESTIONS - General Operating Characteristics

C.01 The reactor shall not be operated unless certain control channels are operable. List five of the required channels. (2.5)

C.02 The chart provided shows a trace of the Ln of power level versus time following a scram. Explain the reason for the shape of the power curve for the portions indicated as (a) and (b). (2.0)

C.03 What indication/conditions do you have at the console that the reactor is critical during your startup? (2.0)

C.04 List the reactor parameters that can initiate an automatic scram at UMRR. (2.0)

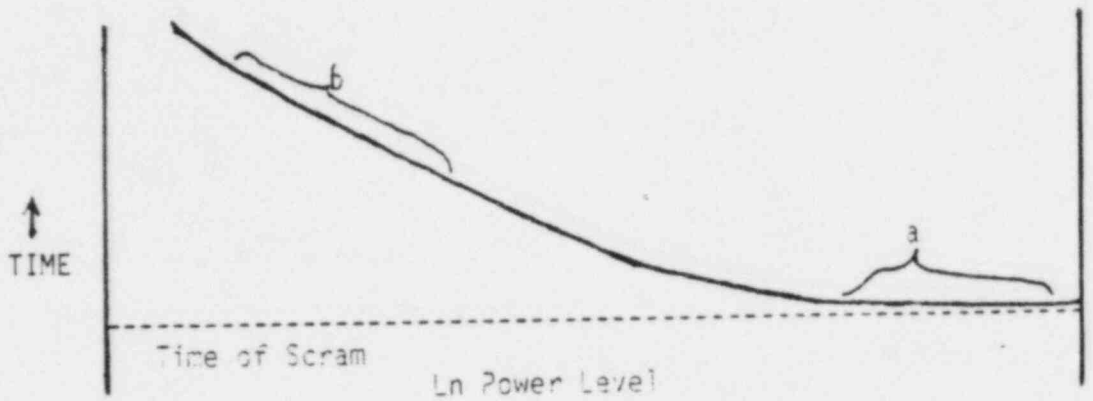
C.05 For the UMRR tabulate the following

a. Maximum excess reactivity loaded into core for normal operation and for control rod calibration. (2.0)
b. Thermal power safety limit (1.0)
c. Shim/safety rod drop times (1.0)

C.06 A reactor is exactly critical. Control rods are then withdrawn to insert .0005 Delta-k/k (assume Beta 0.007, Lambda=.1/sec) Show all work. (1.0)

a. What is resulting stable period?

END OF SECTION C


b
a
TIME
Time of Scram
Ln Power Level

D. QUESTIONS - Instruments and Control

D.01 What two signals for the reactor interlock system are derived from the log count rate recorder. (2.0)

D.02 What will cause the automatic controller to shift from automatic to manual without operator action? (1.0)

D.03 There are a number of built-in engineered protective action levels at UMRR. What are these levels and describe what each level does? (3.0)

D.04 What does "open on failure" relay contacts mean? (1.0)

D.05 What are the three areas/locations monitored by the Radiation Area Monitoring System? (3.0)

D.06 a. What is the number of temperature detectors and their approximate location? (2.0)

b. What if any protective feature is associated with water temperature? (1.0)

D.07 What is the range of the linear Power Channel at UMRR? (1.0)

D.08 True or False

All four control rods can be moved simultaneously by means of the joy stick. (1.0)

END OF SECTION D

E. QUESTIONS - Safety and Emergency Systems

E.01 The Reactor Protection system has two redundant circuits for scramming the reactor. Name each circuit and describe what each circuit does when the scram signal is received. (2.0)

E.02 What five situations in the reactor protective system may be key bypassed? (2.5)

E.03 How is the exposure due to N-16 production at UMRR reduced to a maximum radiation level of 3mr/hr? (1.0)

E.04 The function of the fire protection system is to give warning of fire or smoke within the reactor building.

a. What types of detectors/sensors are used by the system? (1.0)
b. Where are the hand pull stations located at the UMRR facility? (1.0)

E.05 What are four of the six situations that will cause a rundown? (2.0)

E.06 Why is a fire hose kept near the pool? (1.0)

E.07 What four items of confinement/containment must be operable before the reactor can be operated? (2.0)

E.08 True or False (1.0)

There is no emergency power supply in the reactor building in the event of a power failure.

END OF SECTION E

F. QUESTIONS - Standard and Emergency Operating ?rocedures

F.01 What are the staffing conditions that shall be met when the reactor is operating? (2.0)

F.02 True or False (1.0)

a. The visitor to escort ratio will not exceed 25 to 1. (1.0)
b. The visitor must remain in audible and visual contact with their escort at all times. (1.0)

F.03 When is nitrogen diffuser operation required? (1.0)

F.04 When can the regulatory rod be placed in Automatic Control? (1.0)

F.05 What are the actions of a Rector operator in the event of a building emergency and the SRO is not available? (assume at power operations.) (3.0)

F.06 The reactor can be operated without magnet contact lights. (1.0)

a. What must the operator perform in order to operate the reactor?

b. What is the excess reactivity limit under this condition? (1.0)

F.07 What are four examples of emergency conditions at UMRR as as listed in SOP 501. (2.0)

END OF SECTION F

G. QUESTIONS - Radiation Control and Safety

G.01 Define or explain the following:

a. Dose (1.0)
b. Contamination (1.0)
c. Rad (1.0)
d. Dead Time (1.0)
e. Half Value Layer (Half Thickness) (1.0)

G.02 During any calendar quarter what according to 10 CFR 20

a. Is the maximum whole body dose an individual can receive? (1.0)
b. Is the maximum whole body dose an individual under 18 year of age can receive? (1.0)

G.03 A highly radioactive component must be carried out of the containment. Discuss how the three (3) basic principles of exposure control should be used to minimize radiation doses to individual workers. Give a practical example to apply each of the principles. (3.0)

G.04 A radiological survey acquired 12 feet from a concentrated quantity of deionizer resin indicates a radiation level of 300 mr/hr. (2.0)

At what distance would you expect "High Radiation" conditions to exist? (Show all work)

G.05 How is external exposure monitored for staff personnel at UMRR? (1.0)

END OF SECTION G

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ANSWERS - A. Principles of Reactor Operation

A.01 a. The reactor is critical on prompt neutrons, alone, an uncontrollable condition for a reactor. (1.0)

b. The multiplication of source neutrons by fuel in a reactor with Keff less than 1. (1.0)

A.02 c.

Reference: Standard Nuclear Principles (1.0)

A.03 a. Xe is a daughter of I which is a daughter of Te (a fission prod). Xe also is a direct fission product. It can be removed by decay to cesium or "burnup" by absorbing a thermal neutron. (1.5)

b Sa is a daughter is promethium (formed by fission and also a daughter of neudymium). It can be removed by "burnup," but Sa is stable. (1.5)

Reference: Standard Nuclear Principles

A.04 a. To have a minimum count level above background to insure instrumentation is working correctly. (1.0)

b. Can monitor subcritical multiplication and reactivity change in the core. (1.0)

Reference: UMRR Tech Spec 14

A.05 Poisons, burnup, coefficient, experiments. (ea. @ 0.5)

Reference: UMRR SER 4-9

A.06 Attenuation of the beta and gamma from fission products in reactor materials. (2.0)

Reference: Standard Nuclear Principles

A.07 a. Scatter, so neutrons are lowered in energy rather than lost. (1.0)

b. Low atomic weight so that fewer scattering collisions are required. (1.0)

Reference: Standard Nuclear Principles

A.08 Refers to fraction of delayed neutrons under equilibrium conditions (1.0)

Reference: Standard Nuclear Principles

A.09 a

Reference: Standard Nuclear Principles

END OF SECTION A

ANSWERS - B. Features of Facility Design

B.01 See drawing provided (2.5)

Reference: UMRR SAR 3-15

B.02 1. c
2. e
3. f
4. a
5. b

Reference: UMRR SAR

B.03 a. To prevent excessive loading of the drive (1.0)
b. To insure that the force available to insert the shim rod is always greater than the withdrawal force. (1.0)

Reference: UMRR SAR 3-16

B.04 True (1.0)

Reference: UMRR SAR 3-19

B.05 Normal flow path is (each @ .3)

a. from skimmer on surface
b. to pump
c. past a pressure gauge
d. through a filter ← through a conductivity cell
e. ~~past a pressure gauge~~
f. through a flow meter
g. through an ion bed
h. through a conductivity cell
i. through the rotameter
j. back to the pool

Reference: UMRR Figure 22

B.06 Holding of ion exchanger regeneration liquids for

a sampling (0.5)
b. decay (0.5)
c. disposal after activity is below PC (0.5)

Reference: UMRR SAR 5-5

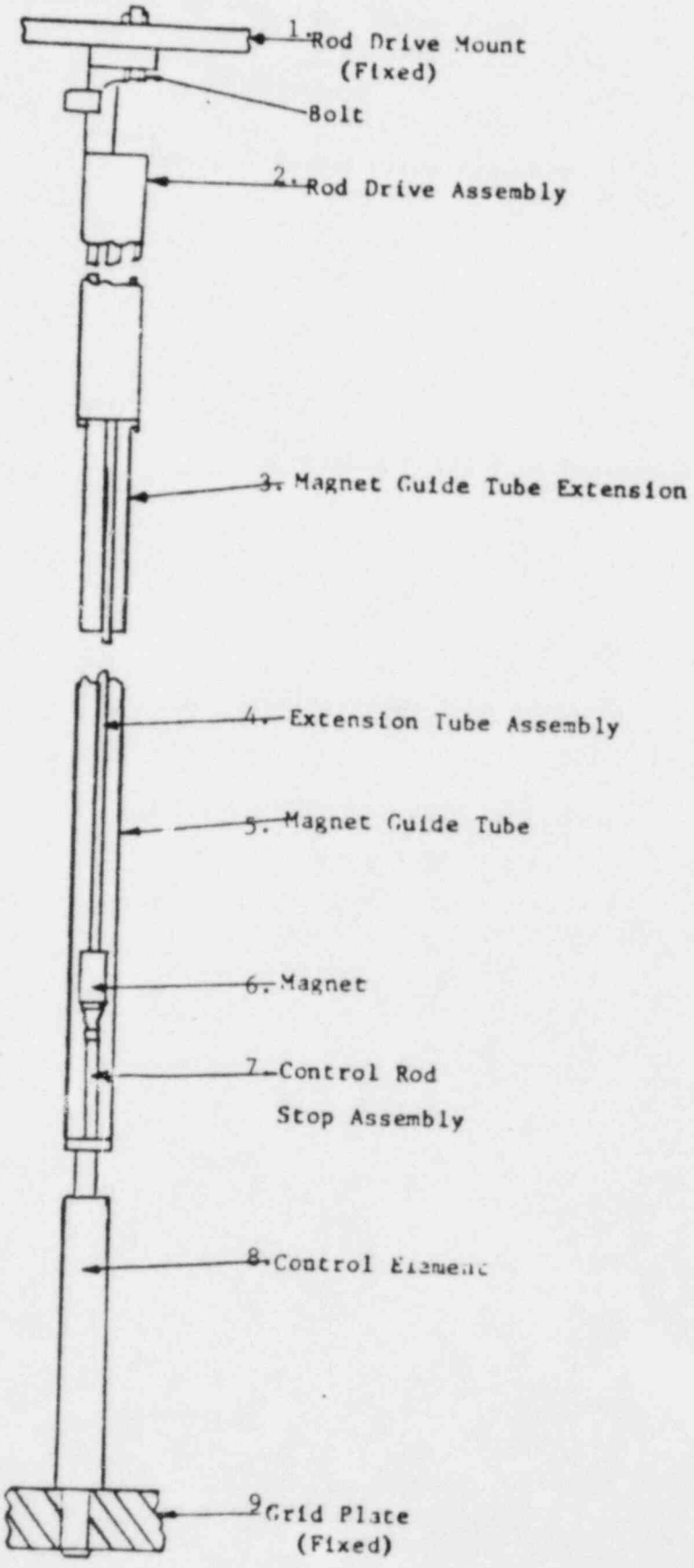

Figure 14. Control rod drive system.

B.07 a 16 feet (0.5)
b 6 in/min (0.5)
c 140° F or 135°F (0.5)
d 24 in/min (0.5)

Reference: UMRR SAR 3-2
UMRR Tech Spec 17

B.08 a. One tube is the sample tube (0.5)
b. One tube provides the pressure differential (0.5)

Reference: UMRR SAR 4-5

END OF SECTION B

ANSWERS - C. General Operating Characteristics

C.01 a. linear power demand
b. Low Compensating Ion chamber voltage
c. Log Power
d. Reactor Period < 30 sec
e. Reg. Rod on insert limit in auto
f. Radiation area monitors
g. Pool water temperature
h. Startup count rate
i. Reactor period < 15 sec
j. Recorder off

Any five @ (0.5) each

Reference: UMRR Tech Spec Table 3.1

C.02 a. Prompt drop as the prompt neutrons are absorbed by the control rods. (1.0)

b. Decay of the longest half-life delayed neutron precursor controls power decrease on an approximate 80 second period. (1.0)

Reference: Standard Nuclear Principles

C.03 a. Log count rate recorder shows a steady increase in power (1.0)
b. No shim rod withdrawal or movement (1.0)

Reference: UMRR SOP 103-7

C.04 a. high reactor power (0.5)
b. short reactor period (0.5)
c. bridge movement (0.5)
d. log N and period amplifier inoperative (0.5)

Reference:

C.05 a. 1.5 delta k/k; normal operation (1.0)
3.5 delta k/k; control rod calibration (1.0)
b. no greater than 300 kwt (1.0)
c. less than 600 m/sec (1.0)

Reference: UMRR Tech Specification 10, 8, 16

C.06 a tau 130 sec. Lamda-eff Delta-k/k .1(.0005) (1.0)

Reference: Standard Nuclear Principles

END OF SECTION C

ANSWERS - D. Instruments and Control

D.01 a. minimum count rate greater than 2 counts per second. (1.0)
b. Prevents control rod movement if log count rate recorder is not turned on. (1.0)

Reference: UMRR SAR 3-32

D.02 Anytime the power level exceeds the plus or minus 2% variation limit. (1.0

Reference: UMRR SAR 3-36

D.03 a. Lowest level is audible and visual alarm annunciation (1.0)
b. Middle level prohibits any further rod withdrawal (1.0)
c. Highest level results in reactor shutdown either by rundown or scram (1.0)

Reference: UMRR SAR 3-39

D.04 Any scram signal or component failure will result in de-energizing the scram relay. (1.0)

Reference: UMRR SAR 3-42

D.05 a. On the reactor bridge to monitor the reactor pool. (1.0)
b. Near the demineralizer (1.0)
c. Area near the thermal column and beam ports. (1.0)

Reference: UMRR SAR 3-45

D.06 a. 2 inlet located just below the core (1.0)
b. 1 outlet located five feet above the core (1.0)

Reference: UMRR SAR 3-34, 35

D.07 a. 6 times 10 to the minus fourth to 2 times 10 to the sixth watts. (1.0)

Reference: UMRR SAR 3-33

D.08 False (1.0)

Reference: UMRR SAR 3-35

END OF SECTION D

ANSWERS - E. Safety and Emergency Systems

E.01 a. Master circuit (.25) provides a fast scram by applying cutoff bias directly to the grids of the magnet amplifiers (.75).

b. Slave circuit (.25) provides back-up scram by cutting off the AC power supply to the magnet amplifiers (.75).

Reference: UMRR SAR 3-37

E.02 a. High radiation (0.5)
b. Period <30 seconds (0.5)
c. Log count rate <2 cps (0.5)
d. Safety rods below shim range (0.5)
e. Safety rods below shim range and ~~reg~~ reg rod > Both on the same key switch (0.5)
above insert limit

Reference: UMRR SAR Table IX 3-40

E.03 Two water pumps are used to direct surface water downward to the top of the reactor core. (1.0)

Reference: UMRR SAR 3-44

E.04 a. Heat sensors (0.5) smoke detector (0.5)
b. By the security door (0.5) by the emergency exit at the demineralizer lever (0.5).

Reference: UMRR SAR 5-8

E.05 a. 120% Demand
b. Period <15 seconds
c. Reg rod on insert limit in auto control
d. Low CIC voltage
e. 120% full power
f. High radiation
(Any four at (0.5) each)

Reference: UMRR Table IX 3-40

E.06 As an auxiliary measure in case of the loss of pool water. It can be connected to a nearby fire hydrant and water can be added to the pool. (1.0)

Reference: UMRR SAR 9-6

E.07 a. Reactor building bay door (0.5)
b. Ventilation intake duct lower (0.5)
c. Ventilation exhaust duct lower (0.5)
d. Personnel security door (0.5)

Reference: UMRR Tech Spec 18

E.08 False Battery supply for fire system (1.0)

Reference: UMRR SAR 5-8

END OF SECTION E

ANSWERS - F. Standard and Emergency Operating Procedures

F.01 a. At least two persons (one of whom is an SRO) shall be present in the reactor building. (1.0)

b. A licensed RO or SRO shall be present in the control room. (1.0)

Reference: UMRR Tech Spec 39

F.02 a. False
b. True

Reference: UMRR SOP 208

F.03 For reactor power greater than 20 kilowatts. (1.0)

Reference: UMRR SOP 103 B.7

F.04 When the linear recorder reaches approximately 98% and the "green" auto permit light comes on. (1.0)

Reference: UMRR SOP 103 C.11

F.05 a. Scram the reactor (0.5)
b. Remove the magnet power key (0.5)
c. Obtain radiation instruments (0.5)
d. Turn off the exhaust fan (0.5)
e. Obtain the keys to the physics building (0.5)
f. Evacuate the building himself (0.5)

Reference: UMRR SOP 501 C.2

F.06 a. Check by audible or visual means the necessary functions that the magnet contact light perform automatically. (1.0)
b. Less than 1.5% (1.0)

Reference: UMRR SOP 305

F.07 a. Spill of radioactive material.
b. Insufficient shielding of an experiment utilizing the reactor.
c. Rupture of a sample container which may constitute an air contamination hazard.
d. Fire or chemical explosion.
e. Reactor malfunction.

Any four at (0.5) each

Reference: UMRR SOP 501 A.

END OF SECTION F

ANSWERS - G. Radiation Control and Safety

G.01 a. Dose - The quantity of radiation absorbed per unit mass by the body or any portion of the body. (1.0)

b. Contamination - The deposition of radioactivity material in any place where it is not desired, particularly if its presence is harmful to personnel. (1.0)

c. Rad - A measure of the dose of any ionizing radiation to body tissues in terms of the energy absorbed per unit mass of tissue. 100 ergs/g tissue. (1.0)

d. Dead Time - The time when a detector operating in the Geiger-Mueller region of the curve is insensitive to incoming radiation due to the process causing the anode to be engulfed by position ions. (1.0)

e. Half Value Layer - A term used to represent shielding. A half value layer of material, HVL, reduces the intensity of incident radiation by a factor of 2. Also called half thickness. (1.0)

Reference: Standard Radiological Principles

G.02 a. 1.25 rem (1.0)

b. .125 rem (1.0)

Reference: 10 CFR 20.201 and 20.104

G.03 Time: Preplanning, procedures, rehearsing, rotating people. (1.0)

Distance: Remote handling tools (1.0)

Shielding: Materials like lead, steel or concrete (1.0)

Reference: 10 CFR 20

G.04 $R_1 = 300$ mr/hr
$D_1 = 12$ ft
$R_2 = 100$ mr/hr (2.0)

$$R_2 D^2_2 = R_1 D_1^2$$

$$D^2_2 = \frac{R_1 D_1^2}{R_2} = \frac{300 \times (12)2}{100}$$

$$D^2_2 = 432 \text{ ft}^2$$

$$D_2 = 20.78 \text{ ft}$$

Reference: Standard Radiation Principles

G.05 a. Film badges (0.5)
b. Thermoluminescent dosimeters or pocket chamber dosimeters (0.5)

Reference: UMRR SAR 7-6

END OF SECTION G