May 7, 2003

Dr. Akiro T. Tokuhiro, Reactor Director
226 Fulton Hall
University of Missouri–Rolla
Rolla, MO 65409-0170

SUBJECT: INITIAL EXAMINATION REPORT NO. 50-123/OL-03-01, UNIVERSITY OF MISSOURI–ROLLA

Dear Dr. Tokuhiro:

During the week of March 10, 2003, the NRC administered operator licensing examinations at your University of Missouri–Rolla Reactor. The examinations were conducted according to NUREG-1478, "Non-Power Reactor Operator Licensing Examiner Standards," Revision 1. Examination questions and preliminary findings were discussed with those members of your staff identified in the enclosed report at the conclusion of the examination. Included with those preliminary findings, the examiners noted weaknesses in some parts of your training program. Specifically, it was noted that improvements could be made in evaluating the candidates knowledge and understanding of the reactor's Technical Specifications and the physical and operational aspects of the related reactor systems. These concerns are listed in detail in the exit meeting minutes on page 2 of the report.

In accordance with 10 CFR 2.790 of the Commission's regulations, 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 document system (ADAMS). ADAMS is accessible from the NRC Web site at (the Public Electronic Reading Room) http://www.nrc.gov/NRC/ADAMS/indesx.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 Paul Doyle at (301) 415-1058 or via internet E-mail at pvd@nrc.gov.

Sincerely,

/RA by Alexander Adams, Jr. Acting for/

Patrick M. Madden, Section Chief
Research and Test Reactors Section
Operating Reactor Improvements Program
Division of Regulatory Improvement Programs
Office of Nuclear Reactor Regulation

Docket No. 50-123

Enclosures:
1. Initial Examination Report No. 50-123/OL-03-01
2. Facility comments with NRC resolution
3. Examination and answer key (RO/SRO)

cc w/encls.:

Please see next page

cc:

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

Dr. Lee W. Saperstein, Dean
School of Mines and Metallurgy
305 McNutt Hall
University of Missouri-Rolla
Rolla, MO 65401

Dr. Akira T. Tokuhiro, Reactor Director
University of Missouri-Rolla
Department of Nuclear Engineering
226 Fulton Hall
1870 Miner Circle
Rolla, MO 65409-0170

William E. Bonzer, Reactor Manager
University of Missouri-Rolla
Nuclear Reactor Facility
1870 Miner Circle
Rolla, MO 65409-0630

Mr. Tim Daniel
Homeland Security
Suite 760
P.O. Box 809
Jefferson City, MO 65102

May 7, 2003

Dr. Akiro T. Tokuhiro, Reactor Director
226 Fulton Hall
University of Missouri–Rolla
Rolla, MO 65409-0170

SUBJECT: INITIAL EXAMINATION REPORT NO. 50-123/OL-03-01, UNIVERSITY OF MISSOURI–ROLLA

Dear Dr. Tokuhiro:

During the week of March 10, 2003, the NRC administered operator licensing examinations at your University of Missouri–Rolla Reactor. The examinations were conducted according to NUREG-1478, "Non-Power Reactor Operator Licensing Examiner Standards," Revision 1. Examination questions and preliminary findings were discussed with those members of your staff identified in the enclosed report at the conclusion of the examination. Included with those preliminary findings, the examiners noted weaknesses in some parts of your training program. Specifically, it was noted that improvements could be made in evaluating the candidates knowledge and understanding of the reactor's Technical Specifications and the physical and operational aspects of the related reactor systems. These concerns are listed in detail in the exit meeting minutes on page 2 of the report. .

In accordance with 10 CFR 2.790 of the Commission's regulations, 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 document system (ADAMS). ADAMS is accessible from the NRC Web site at (the Public Electronic Reading Room) http://www.nrc.gov/NRC/ADAMS/indesx.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 Paul Doyle at (301) 415-1058 or via internet E-mail at pvd@nrc.gov.

Sincerely,

/RA by Alexander Adams, Jr. Acting for/

Patrick M. Madden, Section Chief
Research and Test Reactors Section
Operating Reactor Improvements Program
Division of Regulatory Improvement Programs
Office of Nuclear Reactor Regulation

Docket No. 50-123

Enclosures:
1. Initial Examination Report No. 50-123/OL-03-01
2. Facility comments with NRC resolution
3. Examination and answer key (RO/SRO)

cc w/encls.:
Please see next page

DISTRIBUTION w/encls.:

PUBLIC	RORP R&TR r/f	PMadden
MMendonca	Facility File (EBarnhill) O6-D17	

ADAMS Accession No. ML031000309 **TEMPLATE No. NRR-074**

OFFICE	RORP:CE		IEHB:LA	E	RORP:SC	
NAME	PDoyle		EBarnhill		PMadden	
DATE	04/ 07 /2002		04/ 17 /2002		05/ 07 /2002	

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

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

REPORT NO.: 50-123/OL-03-01

FACILITY DOCKET NO.: 50-123

FACILITY LICENSE NO.: R-79

FACILITY: University of Missouri–Rolla

EXAMINATION DATES: March 10-13, 2003

SUBMITTED BY: ___________/RA/__________________ ___04/07/2003__
Paul Doyle, Chief Examiner Date

SUMMARY:

During the week of March 10, 2003, the NRC administered operator licensing examinations to 12 Reactor Operator and 3 Senior Reactor Operator (Upgrade) license candidates. One Reactor Operator candidate failed Section A of the written examination only. One Reactor Operator candidate failed section C of the written examination only. One Reactor Operator candidate failed all sections of the written examination only. One Reactor Operator failed all three sections of the written examination and the operating test. Two Reactor Operator candidates failed the Operating Test only. The other six reactor operator candidates and the three senior reactor operator candidates passed all sections of their respective NRC administered examinations.

REPORT DETAILS

1. Examiners: Paul Doyle, Chief Examiner, Patrick J. Isaac, Examiner

2. Results:

	RO PASS/FAIL	SRO PASS/FAIL	TOTAL PASS/FAIL
Written	8/4	N/A	8/4
Operating Tests	9/3	3/0	12/3
Overall	6/6	3/0	9/6

3. Exit Meeting:
Paul V. Doyle Jr., NRC, Chief Examiner
Patrick J. Isaac, NRC, Examiner
Daniel Estel, Training Coordinator, University of Missouri-Rolla Reactor (UMRR)
William Bonzer, Reactor Manager, UMRR
Akira Tokuhiro, Reactor Director, UMRR

During the exit meeting the examiners thanked the facility staff for their support in the administration of examinations. Both examiners mentioned to the licensee's staff that they noticed a common weakness in the candidates' knowledge of facility administrative requirements, particularly in understanding of the reactor Technical Specifications. The examiners noted that the licensee should improve the program's ability to evaluate a potential candidate's knowledge and understanding of the reactor's Technical Specifications and identify those conditions where remedial training may be needed.

In addition, the examiners noted that some individuals had knowledge deficiencies which were related to the physical and operational aspects of the facility and the reactor and should have been detected by a licensee administered individual candidate "walk-through" evaluation. The licensee stated that, for the most part, candidate evaluations were done with multiple candidates. The examiners noted that it is difficult to ascertain weaknesses in a candidate's operational knowledge and understanding when the walk-through evaluations are done with multiple candidates.

(Direct copy of E-mail)
Mr. Paul Doyle,

We are presenting our review of the written operator licensing examination given at the University of Missouri - Rolla Nuclear Reactor Facility during the evening of March 10, 2003. We have reviewed the test and received comments from trainees after they completed the test that we wish to respond to. The following questions have answers that we would like you to address.

A.19 A typo in the answer sheet list "b" as the answer, it should changed to "a".

B.8 Section b. "Pass a Requalification Written Examination" is listed for 2 years, this is correct. The UMRR requalification plan lists the requalification written examination to be taken each calendar year. We request answers 1 and 2 years as correct answers.

B.9 N-16 should have answers water and air as both being correct. The irradiated O-16 creating the N-16 may be originating from water H2O or dissolved air that is in the water.

B.12 The "Quarterly" interval does not have a correct number listed in the numbers provided, which were (6, 7½, 9, 10, 14,15, 18, or 30). The correct answer for Quarterly is 4 months as listed in TS definitions on page 7. Section c of B.12 should be remove from the test.

B.15 An uncompensated Geiger-Muller detector may show an increased dose rate reading with higher energy gammas due to its efficiency being higher at higher energies. Answers "b" and "c" should be allowed as correct answers.

C.1 A typo in the answer sheet for F list "10" it should be "5".

C.11 A correct answer is not listed and the question should be removed from the examination. The shim/safety rods are made of solid boron steel (SAR page3-11) and the regulating rod is a hollow stainless steel tube (SAR page 3-13).

C.17 Answers "a" and "c" should be listed as correct, both are accurate. The SAR refers to the location of the conductivity cells (figure 22, page 5-4) and also states the purity of the pool water is maintained at a specific resistance greater than 500 kOhm-cm (page 5-3 of the SAR).

Sincerely,

Dan Estel
UMRR Training Coordinator

William Bonzer
UMRR Manager

NRC Comment Resolution

A.19: Agree with facility comment. Answer key changed to recognize “a” as correct answer.

B.8b. Agree with facility comment. Answer key changed to recognize “1” as a second correct answer.

B.9 Disagree with facility comment. By far the majority of Oxygen atoms near the fuel plates is due to water, not due to air entrained within the water. In addition any air in any experimental facilities is far enough away from the fuel that the flux for high energy neutrons is negligible. Oxygen is an extremely stable element, and it is only very high energy neutrons which are capable of causing the n,p reaction which produces N^{16}. This is why we worry about Ar^{41} and not N^{16} if air is used instead of N_2 in the pneumatic tube system.

B.12.c Agree with facility comment. Answer key modified to delete part c of question b.12, and the value of each part changed to ⅓.

B.15 Disagree with facility comment as written. The examiner did not expect the candidates to take into account detector efficiency. However, that being said, for gamma ray energies in the 1.0 to 2.0 MeV range, the detector efficiency for a lead cathode Geiger counter increases from about 0.9% to about 1.4%, for a copper cathode, Geiger counter efficiency increases from about 0.7% to about 1.3%, and for an aluminum cathode Geiger counter efficiency increases from about 0.75% to about 1.4%. Therefore, the examiner will modify the answer key to add “b” as a second correct answer for this examination. In the future, this question will be rewritten to state: ignore detector efficiency.[1]

C.1 Agree with facility comment as written. Answer key changed to recognize “5” as correct answer.

C.11 Agree with facility comment as written. Question deleted.

C.17 Agree with facility comment as written. Although at most facilities the reason for having two conductivity probes is to more easily determine when the ion bed is depleted, this is NOT part of the SAR at U. Missouri-Rolla. Therefore the answer key will be modified to add “a” as a correct answer for this question.

1 Reference: Glenn F. Knoll, *Radiation Detection and Measurement*, © 1979, John Wiley and Sons, Inc. Figure 7-9. The efficiency of G-M tubes for gamma rays normally incident on the Cathode. [From W. K. Sinclair, Ch.5 in Radiation Dosimetry, (G.J. Hine and G. L. Brownell, eds.). Copyright 1956 by Academic Press.]

UNIVERSITY OF MISSOURI-ROLLA

With Answer Key

UNITED STATES NUCLEAR REGULATORY COMMISSION

OPERATOR LICENSING EXAMINATION

Week of March 10, 2003

Enclosure 3

QUESTION A.1 [1.0 point]
Core excess reactivity changes with …

a. fuel element burnup

b. control rod height

c. neutron energy level

d. reactor power level

QUESTION A.2 [1.0 point]
You enter the control room and note that all nuclear instrumentation show a steady neutron level, and no rods are in motion. Which ONE of the following conditions CANNOT be true?

a. The reactor is critical.

b. The reactor is subcritical.

c. The reactor is supercritical.

d. The neutron source has been removed from the core.

QUESTION A.3 [1.0 point]
The delayed neutron precursor (β) for U^{235} is 0.0065. However, when calculating reactor parameters you use β_{eff} with a value of ~0.0070. Why is β_{eff} larger than β?

a. Delayed neutrons are born at higher energies than prompt neutrons resulting in a greater worth for the neutrons.

b. Delayed neutrons are born at lower energies than prompt neutrons resulting in less leakage during slowdown to thermal energies.

c. The fuel also contains U^{238} which has a relatively large β for fast fission.

d. U^{238} in the core becomes Pu^{239} (by neutron absorption), which has a higher β for fission.

QUESTION A.4 [1.0 point]
The difference between a moderator and a reflector is that a reflector …

a. increases the fast non-leakage factor and a moderator increases the thermal utilization factor.

b. increases the neutron production factor and a moderator increases the fast fission factor.

c. increases the neutron production factor and a moderator decreases the thermal utilization factor.

d. decreases the fast non-leakage factor and a moderator increases the thermal utilization factor.

QUESTION A.5 [1.0 point]
Which of the following atoms will cause a neutron to lose the most energy during an elastic scattering reaction?

a. O^{16}

b. C^{12}

c. U^{235}

d. H^1

QUESTION A.6 [1.0 point]
Which ONE of the following is the MAJOR source of energy released during fission? Kinetic Energy of the…

a. prompt gamma rays.

b. capture gammas.

c. Beta particles.

d. fission fragments.

QUESTION A.7 [1.0 point]
Which ONE of the following describes the **MAJOR** contributor to the production and depletion of Xenon respectively in a **STEADY-STATE OPERATING** reactor?

	Production	Depletion
a.	Radioactive decay of Iodine	Radioactive Decay
b.	Radioactive decay of Iodine	Neutron Absorption
c.	Directly from fission	Radioactive Decay
d.	Directly from fission	Neutron Absorption

QUESTION A.8 [1.0 point]
Which ONE of the following is an example of neutron decay?

a. ${}_{35}Br^{87} \rightarrow 33As^{83}$

b. ${}_{35}Br^{87} \rightarrow {}_{35}Br^{86}$

c. ${}_{35}Br^{87} \rightarrow {}_{34}Se^{86}$

d. ${}_{35}Br^{87} \rightarrow {}_{36}Kr^{87}$

QUESTION A.9 [1.0 point]
Which ONE of the following is the reason for the -80 second period following a reactor scram?

a. The ability of U^{235} to fission source neutrons.

b. The half-life to the longest-lived group of delayed neutron precursors is 55 seconds.

c. The amount of negative reactivity added on a scram is greater than the shutdown margin.

d. The Doppler effect, which adds positive reactivity due to the temperature decrease following a scram.

QUESTION A.10 [1.0 point]
Which ONE of the following explains the response of a SUBCRITICAL reactor to equal insertions of positive reactivity as the reactor approaches criticality?

a. Each insertion causes a **SMALLER** increase in the neutron flux resulting in a **LONGER** time to stabilize.

b. Each insertion causes a **LARGER** increase in the neutron flux resulting in a **LONGER** time to stabilize.

c. Each insertion causes a **SMALLER** increase in the neutron flux resulting in a **SHORTER** time to stabilize.

d. Each insertion causes a **LARGER** increase in the neutron flux resulting in a **SHORTER** time to stabilize.

QUESTION A.11 [1.0 point]
K_{eff} for the reactor is 0.85. If you place an experiment worth +17.6% into the core, what will the new K_{eff} be?

a. 0.995

b. 0.9995

c. 1.005

d. 1.05

QUESTION A.12 [1.0 point]
Which ONE of the following is the reason for an installed neutron source within the core? A startup without an installed neutron source …

a. is impossible as there would be no neutrons available to start up the reactor.

b. would be very slow due to the long time to build up neutron population from so low a level.

c. could result in a very short period due to the reactor going critical before neutron population built up high enough to be read on nuclear instrumentation.

d. can be compensated for by adjusting the compensating voltage on the source range detector.

QUESTION A.13 [1.0 point]
Several processes occur that may increase or decrease the available number of neutrons. SELECT from the following the six-factor formula term that describes an INCREASE in the number of neutrons during the cycle.

a. Thermal utilization factor.

b. Resonance escape probability.

c. Thermal non-leakage probability.

d. Reproduction factor.

QUESTION A.14 [1.0 point]
The term "prompt jump" refers to:

a. the instantaneous change in power due to raising 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 β_{eff}.

QUESTION A.15 [1.0 point]
By definition, an exactly critical reactor can be made prompt critical by adding positive reactivity equal to …

a. the shutdown margin

b. the K_{excess} margin

c. the β_{eff} value

d. 1.0 %ΔK/K.

QUESTION A.16 [1.0 point]
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 Population (np)

b. Neutron Impact Potential (nip)

c. Neutron Flux (nv)

d. Neutron Density (nd)

QUESTION A.17 [1.0 point]
Reactor power doubles in 42 seconds. Based on the period associated with this transient, how long will it take for reactor power to increase by a factor of 10?

a. 80 seconds

b. 110 seconds

c. 140 seconds

d. 170 seconds

QUESTION A.18 [1.0 point]
A thin foil target of 10% copper and 90% aluminum is in a thermal neutron beam. Given σ_a Cu = 3.79 barns, σ_a Al = 0.23 barns, σ_s Cu = 7.90 barns, and σ_s Al =1.49 barns, which ONE of the following reactions has the highest probability of occurring? A neutron …

a. scattering reaction with aluminum

b. scattering reaction with copper

c. absorption in aluminum

d. absorption in copper

QUESTION A.19 [1.0 point]
Regulating rod worth for a reactor is 0.001 ΔK/K/inch. Moderator temperature **INCREASES** by 9°F, and the regulating rod moves 4½ inches inward to compensate. The moderator temperature coefficient α_{Tmod} is …

a. $+5 \times 10^{-4}$ ΔK/K/°F

b. -5×10^{-4} ΔK/K/°F

c. $+2 \times 10^{-5}$ ΔK/K/°F

d. -2×10^{-5} ΔK/K/°F

QUESTION A.20 [1.0 point]
K_{eff} is K_{∞} times …

a. the fast fission factor (ε)

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

c. the reproduction factor (η)

d. the resonance escape probability (p)

QUESTION B.1 [1.0 point]
The lowest level of Reactor Staff who may authorize key bypass of control channel automatic functions is the …

a. Licensed Console Operator

b. Senior Reactor Operator On Duty

c. Reactor Manager

d. Reactor Director

QUESTION B.2 [1.0 point]
The two (2) copies of the Standard Operating Procedures which are considered ***<u>"Controlled Copies"</u>*** are the Control Room Copy and the …

a. Reactor Manager's copy in the Beam Room Area

b. Reactor Director's copy in his office 219 Fulton Hall

c. Reactor Manager's copy in the Office Reception Area

d. Reactor Director's copy in the Basement of the Physics Building

QUESTION B.3 [2.0 points, ½ point each]
Identify each of the following as either a Safety Limit (SL), Limiting Safety System Setting (LSSS) or a Limiting Condition for Operation (LCO).

a. The free-drop time for each of 'the three shim/safety rods must be less than 600 msec.

b. The reactor thermal power shall be no greater than 300 kWt, or 150% of full power

c. The temperature of fuel element cladding shall be less than 580°C (1067°F).

d. The resistivity of the pool water shall be greater than 0.2 megohm-cm as long as there are fuel elements in the pool.

QUESTION B.4 [1.0 point]
According to SOP 104, "*Reactor Power Changes and Stable Operations*", at least one diffuser pump should be turned on for operations above …

a. 1 Kilowatt

b. 2 Kilowatts

c. 10 Kilowatts

d. 20 Kilowatts

QUESTION B.5 [1.0 point]
Which ONE of the following is the definition of a ***CHANNEL TEST***?

a. the combination of sensor, line, amplifier, and output devices which are connected for the purpose of measuring the value of a parameter

b. an adjustment of the channel such that it output corresponds with acceptable accuracy to known values of the parameter which the channel measures. Calibration shall encompass the entire channel, Including equipment actuation, alarm, or 'trip and shall be deemed to include a channel test

c. a qualitative verification of acceptable performance by observation of channel behavior.' This verification, where possible, shall Include comparison of the channel with other Independent channels or systems measuring the same variable.

d. the Introduction of a signal Into the channel for verification that It Is operable.

QUESTION B.6 [1.0 point]
The reactor will be shutdown and the SRO on Duty notified if ***"TURNAROUND"*** is not observed on the Safety Channels and the Power Range of the Log and Linear Channel by the time the reactor reaches …

a. 1 Kilowatt

b. 5 Kilowatts

c. 10 Kilowatts

d. 20 Kilowatts

QUESTION B.7 [1.0 point]
Two inches of shielding reduce the gamma exposure in a beam of radiation from 400 mR/hr to 100 mR/hr. If you add an **additional** **four** inches of shielding what will be the new radiation level? (Assume all reading are the same distance from the source.)

a. 6.25 mR/hr

b. 12.5 mR/hr

c. 25 mr/hr

d. 100 mr/hr

QUESTION B.8 [2.0 points, ½ point each]
10 CFR 55 contains requirements associated with your operator or senior operator license. Match each of the requirements listed in column A with it's appropriate time period in column B. (Note: Periods from column B may be used more than once or not at all.)

	Column A (Requirements)	Column B (Years)
a.	License Expires	1
b.	Pass a Requalification Written Examination	2
c.	Pass a Requalification Operating Test	4
d.	Medical Examination Required	6

QUESTION B.9 [2.0 points, ½ each]
Identify each of the radioisotopes in column A with its PRIMARY source (irradiation of air, irradiation of water, or is a fission product).

a. $_{1}H^{3}$

b. $_{18}Ar^{41}$

c. $_{7}N^{16}$

d. $_{54}Xe^{135}$

QUESTION B.10[1.0 point]
The CURIE content of a radioactive source is a measure of

a. the number of radioactive atoms in the source.

b. the amount of energy emitted per unit time by the source

c. the amount of damage to soft body tissue per unit time.

d. the number of nuclear disintegrations per unit time.

QUESTION B.11[2.0 points, ½ each]
Match the Condition listed in column A with the corresponding reactivity limit in column B. (Each

	Column A	***Column B***
a.	Maximum worth of Regulating Rod	0.4% ΔK/K
b.	Total Reactivity worth of all experiments	0.7% ΔK/K
c.	Maximum worth of an ***Unsecured Experiment***	1.2% ΔK/K
d.	Maximum Excess reactivity above the reference core condition (normal)	1.5% ΔK/K

QUESTION B.12[1.0 point, ¼ each]
Identify the correct number (6, 7½, 9, 10, 14, 15 18 or 30) which correctly defines the maximum period between testing intervals per each of the Technical Specifications definitions.

a. Weekly: ___ days

b. Monthly: ___ weeks

c. Quarterly: ___ months

d. Annually: ___ months

QUESTION B.13[1.0 point]
Which ONE of the following conditions is an Reportable Occurrence per the Technical Specification definition?

a. Operation of the reactor with the Reactor Period scram set at 4 seconds.

b. Operation of the reactor with a secured experiment worth 0.25% ΔK/K.

c. A rabbit sample injects 0.3% Δk/k reactivity when anticipated was 0.1% Δk/k.

d. Operation with a pool level of 19 ft. above the top of the core.

QUESTION B.14[1.0 point]
A radiation survey instrument was used to measure an irradiated experiment. The results were 0.1 mrem/hr, read 10 minutes following removal from the core. If the half life of the sample is 1 minute. What was the dose rate, at the time the sample was initially removed from the core?

a. 10 rem/hr

b. 1 rem/hr

c. 100mrem/hr

d. 10 mrem/hr

QUESTION B.15[1.0 point]
Consider two point sources, each having the ***SAME*** curie strength. Source A's gammas have an energy of 1.0 MeV, while Source B's gammas have an energy of 2.0 MeV. Using a **Geiger-Müller** detector the reading from source B will be …

a. four times that of source A.

b. twice that of source A.

c. the same.

d. half that of source A.

QUESTION B.16[1.0 point]
According to both the Safety Analysis Report and UMR Reactor Standard Operating Procedure 650, when performing a swipe contamination survey, activities below ____ are reported as “no contamination evident.”

a. 100 μCi/100 cm^2

b. 10 μCi/100 cm^2

c. 1 μCi/100 cm^2

d. 100 pCi/100 cm^2

QUESTION C.1 [2.0 points, ¼ each]
Using the drawing of the purification system provided, identify the components (a through h) with the correct name from Column B. (Note only one answer per item, not all choices in column B are used.)

	Column A		Column B
a.	A	1.	Demineralizer (Ion Bed)
b.	B	2.	Filter
c.	C	3.	Conductivity Cell
d.	D	4.	Pressure Gage
e.	E	5.	Rotameter
f.	F	6.	Normally Closed Valve
g.	G	7.	Normally Open Valve
h.	H	8.	Raw Water Supply Tank
		9.	Discharge Tank

QUESTION C.2 [1.0 point]
Which ONE of the following is ***NOT*** a feature of the Pneumatic Sample Transfer system designed to reduce overall radiation levels in the facility?

a. The tube has a slight curve through the pool (preventing a beam of radiation directly from the core).

b. Exhaust of the system is sent through a high efficiency filter (Reduces the amount of radioactive particles released to the atmosphere).

c. The tubes are lined with Cadmium (reduces the fast neutron flux at the surface of the pool).

d. N_2 gas is used to move the rabbit (reduces the generation of gaseous radioisotopes).

QUESTION C.3 [1.0 point]
Which ONE of the following is used when the reactor is operating to reduce the buildup of Ar^{41} in the reactor bay?

a. Operation of the ventilation system, which releases the Ar^{41} through the stack.

b. Diffuser pumps which decrease the release of Ar^{41} from the pool.

c. Purification system via the ion bed.

d. None required due to the relatively short half-life of Ar^{41} (seven seconds).

QUESTION C.4 [1.0 point]
The purification pump is located on the intermediate basement level of the facility, well below the top of the pool. What design characteristic of the system prevents draining the pool on a pipe failure downstream of the pump?

a. On low pump torque, due to low discharge pressure, a circuit automatically stops the pump.

b. A vacuum break in the purification piping about 16 feet above the top of the core.

c. On high pump current a circuit automatically stops the pump.

d. On low pump discharge pressure, a circuit automatically stops the pump.

QUESTION C.5 [1.0 point]
Which part of the shim/safety rod assembly is responsible for ensuring that the rod receives more torque for inserting the rod than for withdrawing the rod?

a. Dashpot Assembly

b. Slip Clutch Assembly

c. Magnet Assembly

d. Linear Actuator

QUESTION C.6 [1.0 point]
A significant amount of N^{16} is generated in the core. In order to minimize the dose at the top of the pool, the facility utilizes

a. a ventilation system at the side of the pool to whisk away N^{16} gases.

b. two “diffuser pumps” which pump the N^{16} laden water to the bottom of the tank.

c. two “diffuser pumps” which by forcing water downwards slow the rise of N^{16} thus maintaining a layer of water as a shield.

d. the purification system which removes the N^{16} via the ion bed.

QUESTION C.7 [2.0 points, ⅓ each]
Identify the correct protective action (SCRAM, RUNDOWN, rod withdrawal PROHIBIT, or OPERATOR response for each of the following situations …

a. Log Count Rate < 2 counts

b. Period < 5 seconds

c. Interlock Bypassed

d. Basement Sump Level High

e. Core Inlet Water Temperature 135°

f. 120% Full Power

QUESTION C.8 [1.0 point]
Which ONE of the following is the actual design feature which prevents siphoning of pool water on a failure of the purification system?

a. A valve upstream of the primary pump will shut automatically.

b. A valve downstream of the primary pump will shut automatically.

c. "Vacuum breaks" are located in the system which prevent draining the pool below about 16 feet above the core.

d. The Emergency Fill system will automatically maintain pool level.

QUESTION C.9 [1.0 point]
On a scram which ONE of the following correctly describes the positions of the regulating rods and the shim/safety magnets. The regulating rod will …

a. remain where it was for the scram and the shim/safety magnets will drive in.

b. drive in and the shim/safety magnets will drive in.

c. drive in and the shim/safety magnets will remain where they were for the scram.

d. remain where it was for the scram and the shim/safety magnets will remain where they were for the scram.

QUESTION C.10 [2.0 points, ½ each]
Match the radiation detection equipment in column A, with its primary use in column B.

Column A	Column B
a. Ion Chamber portable radiation detector	1. To measure total dose received by a visitor.
b. Geiger-Müller portable radiation detector	2. To detect the presence of contamination.
c. Film Badge	3. To measure radiation field strength.
d. Pocket Dosimeter.	4. To measure total dose received by a radiation worker.

~~QUESTION C.11 [1.0 point]~~ Question deleted per facility comment.
~~Which ONE of the following correctly describes the control elements in use at the UMR reactor?~~

	~~Shim/Safety~~	~~Regulating~~
~~a.~~	~~solid boral rod~~	~~hollow boron steel tube~~
~~b.~~	~~hollow boral tube~~	~~solid boron steel rod~~
~~c.~~	~~solid boron steel rod~~	~~hollow boral tube~~
~~d.~~	~~hollow boron steel tube~~	~~solid boral rod~~

QUESTION C.12 [1.0 point]
Why is one of the pneumatic tube system core termini (plural of terminus), lined with cadmium?

a. Reduce effect of gammas on the sample.

b. Reduce the effect of Fast Neutrons on the sample

c. Reduce the effect of Thermal Neutrons on the sample.

d. Increase the effect of high energy betas on the sample.

QUESTION C.13 [1.0 point]
The fission chamber is lined with a thin layer of ___ to interact with the neutrons and generate a pulse.

a. U^{235}

b. B^{10}

c. Be^{8}

d. Th^{232}

QUESTION C.14 [1.0 point]
Which ONE of the following has a battery backup so that even on a loss of power it will cause an alarm at the campus police station?

a. Pool Low Level

b. All three Radiation Area Monitors

c. Continuous Air Monitor

d. Fire Alarm System

QUESTION C.15 [1.0 point, ¼ each]
Match each of the radiation monitors in column A with its associated actions in 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	

QUESTION C.16 [1.0 point]
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

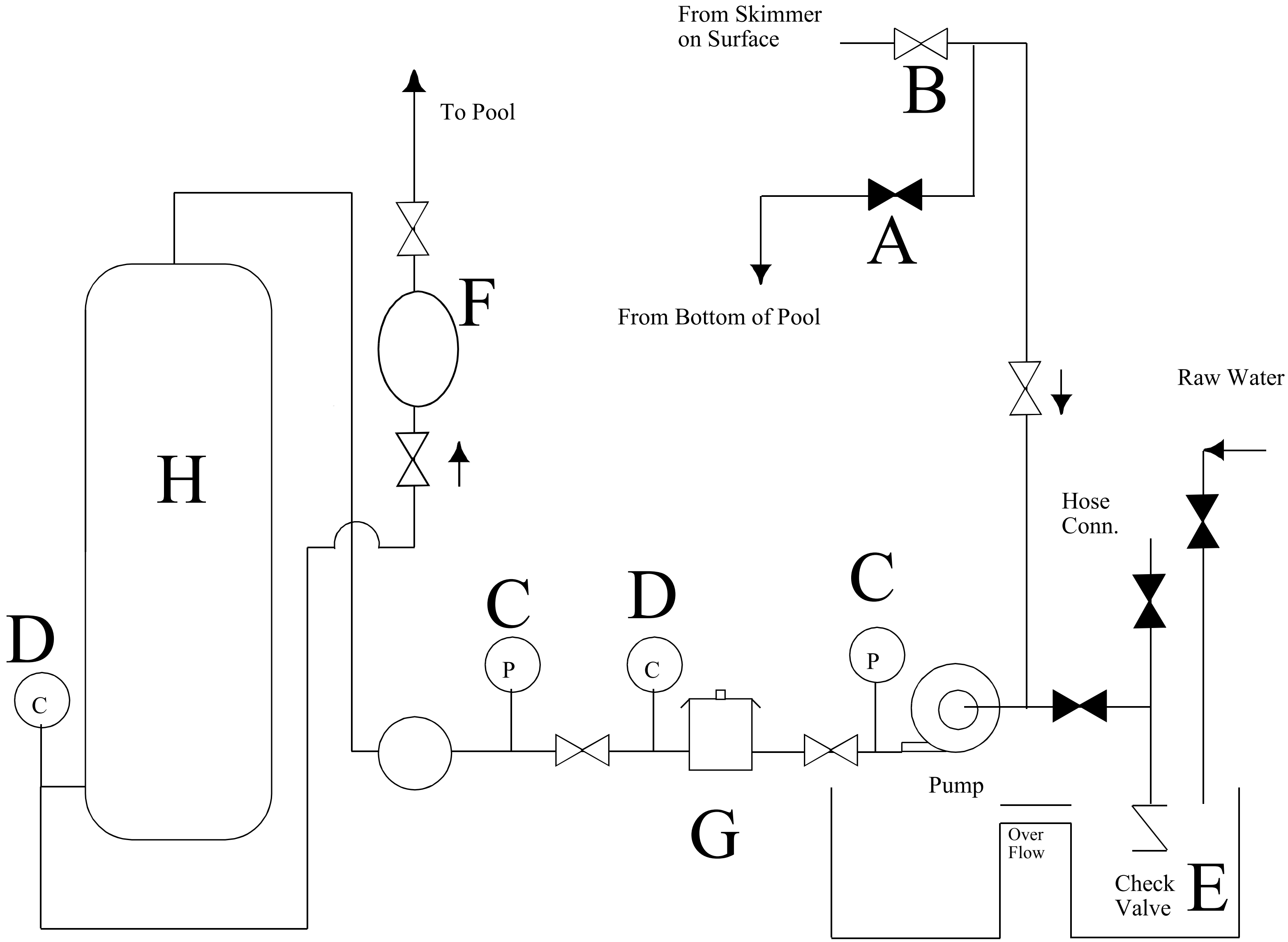
QUESTION C.17 [1.0 point]
The. Which ONE of the following is the reason that the Purification System has two conductivity cells?

a. One is to determine the conductivity of the pool, the other is to determine the conductivity of water being added to the pool.

b. The second one is strictly a backup to the first.

c. The readings from the two conductivity cells are compared to determine the end of life (need to regenerate) the ion bed.

d. One is to determine the conductivity of the pool, the other is to determine the conductivity of the raw water in the supply tank.


From Skimmer
on Surface
B
To Pool
A
F
From Bottom of Pool
Raw Water
H
Hose
Conn.
C
D
C
D
C
P
C
P
C
G
Pump
Over
Flow
Check
Valve
E

A.1 a
REF: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, §

A.2 c
REF: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, §

A.3 b
REF: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, §

A.4 a
REF: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, §

A.5 d
REF: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, §

A.6 d
REF: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, §

A.7 b
REF: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, §

A.8 b
REF: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, §

A.9 b
REF: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, §

A.10 b
REF: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, §

A.11 b
REF: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, §

A.12 c
REF: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, §

A.13 d
REF: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, §

A.14 a
REF: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, §

A.15 c
REF: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, §

A.16 c
REF: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, §

A.17 c
$P = P_0 e^{t/\tau}$ 1st find τ. $\tau = \text{time}/(\ln(2)) = 42/0.693 = 60.6$ sec. Time = $\tau \times \ln(10) = 60.6 \times 139.5$ sec
REF: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, §

A.18 a
0.1 × 3.79 = .379 0.9 × 0.23 = 0.207 0.1 × 7.9 = 0.79 0.9 × 1.49 = 1.34
REF: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, §

A.19 ~~b~~ a Answer changed per facility comment.
0.001 ΔK/K/~~inch~~ × 4.5 ~~inch~~ ÷ 9°F = 0.001 ÷ 2 = 0.0005 = 5×10^{-4} ΔK/K/°F
REF: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, §

A.20 b
REF: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, §

B.1 b
REF: SOP 101, § B.8.

B.2 c
REF: SOP 100 § B.2.

B.3 a, LCO; b, LSSS; c, SL; d, LCO
REF: T.S. §§a-3.2.3; b-2.2; c-2.1.b; d-3.3(2)

B.4 d
REF: SOP 104, § B.3.

B.5 d
REF: Technical Specification Definitions

B.6 c
REF: SOP 104, § B.2.

B.7 a
REF: Nuclear Power Plant Health Physics and Radiation Protection, Research Reactor Version©1988, § 1.2.3 "Half-Thickness and Tenth-Thickness" $(½)^6 = {}^1/_{64} = {}^{400}/_{64}$ = 50/8 = 25/4 = 6.26

B.8 a, 6; b, 2 or 1; c, 1; d, 2 Second correct answer for part b added per facility comment.
REF: 10CFR55

B.9 a, water; b, air; c, water; d, fission product
REF: Typical NRC Question (Chart of the Nuclides

B.10 d
REF: Standard Health Physics Definition.

B.11 a, 0.7% ΔK/K; b, 1.2% ΔK/K; c, 0.4% ΔK/K; d, 1.5% ΔK/K
REF: Technical Specifications 3.1.1, 3.1.4, 3.7.1.2 and 3.7.1.4 3.7.1

B.12 a, 10; b, 6; ~~c, 7-½;~~ d, 15 Part c deleted per facility comment.
REF: Emergency Plan, § 8.1, *Emergency Support Center, p. 21.*

B.13 a
REF: Technical Specifications,

B.14 c
REF: Ten half-lives implies that dose was reduced by (½)10 = 1/1024 ≈ 1/1000. Initially, the reading would be about 1000 times larger 0.1 mrem × 1000 = 100 mrem.

B.15 c or b, Second correct answer added per facility comment.
REFERENCE T.S. §§ 1.3 Definitions, p. 7, and 4.2.1 Specification (1), p. 27.

B.16 d
REFERENCE SAR 7.2.2(d) p. 7-7.

C.1 a, 6; b, 7; c, 4; d, 3; e, 8; f, ~~10~~ 5 answer changed per facility comment; g, 2; h, 1
REF: SAR § 5.2, pp. 5-1 – 5-3, also Figure 22, p. 5-4.

C.2 c
REF: SAR § 4.3, p. 4-5.

C.3 a
REF: SAR §

C.4 b
REF: SOP 309 § B.2

C.5 b
REF: SAR § 3.2.3

C.6 c
REF: SAR §

C.7 a, Prohibit; b, Scram; c, Operator; d, Operator; e, Prohibit; f, Rundown
REF: SAR 3-40, Table IX

C.8 c
REF: SOP 309 *Response to a Coolant System Leak*

C.9 d
REF: SAR, § 3.4.7, p. 3-28.

C.10 a, 3; b, 2; c, 4; d, 1
REF: Standard NRC question.

~~C.11 d~~ Question deleted per facility comment.
~~REF: SAR § 3.2.3, p. 3-11.~~

C.12 c
REF: SAR § 4.3

C.13 a
REF: SAR

C.14 d
REF: SAR § 5.5

C.15 a, 2; b, 2; c, 3; d, 1
REF: Facility Technical Specifications Table 3.3, and SAR § 3.6.2, pp., 3-46 – 3-38.

C.16 c
REF: SAR § 5.2

C.17 c or a; second answer added per facility comment.
REF: SAR §