October 16, 2002

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

SUBJECT: RETAKE EXAMINATION REPORT NO. 50-123/OL-02-02, UNIVERSITY OF MISSOURI–ROLLA

Dear Dr. Tokuhiro:

During the week of September 16, 2002, the NRC administered an operator licensing retake examination at your University of Missouri–Rolla Reactor. The examination was conducted according to NUREG-1478, "Non-Power Reactor Operator Licensing Examiner Standards," Revision 1.

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/

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-02-02
2. Facility comments with NRC resolution
3. Examination and answer key (RO/SRO)

cc w/encls:
Please see next page

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MMendonca	Facility File (EBarnhill) O-6 D-17	

ADAMS ACCESSION #: ML022820762 **TEMPLATE #:NRR-074**

OFFICE	RORP:CE		IEHB:LA	E	RORP:SC	
NAME	PDoyle:rdr		EBarnhill		PMadden	
DATE	10 / 12 /2002		10 / 16 /2002		10 / 16 /2002	

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

REPORT NO.: 50-123/OL-02-02

FACILITY DOCKET NO.: 50-123

FACILITY LICENSE NO.: R-79

FACILITY: University of Missouri–Rolla

EXAMINATION DATES: September 19 and 20, 2002

SUBMITTED BY: _____***/RA/***_____ 10/11/2002
Paul Doyle, Chief Examiner Date

SUMMARY:

The NRC prepared written operator licensing examinations for four Reactor Operator candidates who had failed the NRC examinations administered March, 2002. Two candidates took Section A only, one candidate took Section B only, and one candidate took Sections A and C only. One candidate failed section A of the retake examination.

REPORT DETAILS

1. Examiner:
   Paul Doyle, Chief Examiner

2. Results:

	RO PASS/FAIL	SRO PASS/FAIL	TOTAL PASS/FAIL
Written	3/1	0/0	3/1
Operating Tests	0/0	0/0	0/0
Overall	3/1	0/0	3/1

ENCLOSURE 1

UNIVERSITY OF MISSOURI–ROLLA

With Answer Key

OPERATOR LICENSING EXAMINATION

Week of September 16, 2002

Enclosure 2

QUESTION A.1 [1.0 point]
Which one of the following statements correctly describes the property of a **GOOD MODERATOR**?

a. It slows down fast neutrons to thermal energy levels via a large number of collisions.

b. It reduces gamma radiation to thermal energy levels via a small number of collisions.

c. It slows down fast neutrons to thermal energy levels via a small number of collisions.

d. It reduces gamma radiation to thermal energy levels via a large number of collisions.

QUESTION A.2 [1.0 point]
Which ONE of the following is an example of β^+ decay?

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

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

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

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

QUESTION A.3 [1.0 point]
The reactor is at a power of 1 watt, with a 30 second stable period. How long will it take for power to reach 500 watts?

a. 186 seconds

b. 140 seconds

c. 124 seconds

d. 81 seconds

QUESTION A.4 [1.0 point]
The reactor is subcritical with a K_{eff} of 0.96 and 30 counts per second indicated. After a fuel element is removed the count rate drops to 10 counts per second. No other changes have occurred. What is the K_{eff} of the core with the fuel element removed?

a. 0.9733

b. 0.8800

c. 0.8400

d. 0.8000

QUESTION A.5 [1.0 point]
Which of the following statements correctly describe the influence of **DELAYED NEUTRONS** on the neutron life cycle? Delayed neutrons …

a. increase the time required for PU^{239} to moderate the fission process.

b. decrease the time required for the neutron population to change between generations.

c. increase the time required for the neutron population to change between generations.

d. decrease the amount of reflection possible with a steel reflector.

QUESTION A.6 [2.0 points, ½ each]
Match each term in column A with the correct definition in column B.

Column A	Column B
a. Prompt Neutron	1. A neutron in equilibrium with its surroundings.
b. Fast Neutron	2. A neutron born directly from fission.
c. Thermal Neutron	3. A neutron born due to decay of a fission product.
d. Delayed Neutron	4. A neutron at an energy level greater than its surroundings.

QUESTION A.7 [1.0 point]
Why is the stable negative period following a scram always the same value, regardless of initial power level? The rate of power change is dependent on the …

a. mean lifetime of the longest lived delayed precursor.

b. constant decay rate of prompt neutrons.

c. mean lifetime of the shortest lived delayed neutron precursor.

d. constant decay rate of prompt gamma emitters.

QUESTION A.8 [1.0 point]
During a Critical Experiment "1/M" data is required to be taken. What does the 1/M represent?

a. The inverse of the moderator coefficient of reactivity.

b. The inverse of core total U^{235} mass.

c. The inverse migration length of neutrons of varying energies.

d. The inverse multiplication of the count rate between generations.

QUESTION A.9 [1.0 point]
Which one of the following correctly describes the relationship between differential rod worth (DRW) and integral rod worth (IRW)?

a. DRW is the slope of the IRW curve at a given location.

b. DRW is the area under the IRW curve at a given location.

c. DRW is the square root of the IRW curve at a given location.

d. There is no relationship between DRW and IRW.

QUESTION A.10 [1.0 point]
What is the period that would cause reactor power to double in 40 seconds?

a. 3.7 seconds

b. 27.7 seconds

c. 57.7 seconds

d. 80.0 seconds

QUESTION A.11 [1.0 point]
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.

QUESTION A.12 [1.0 point]
The term "reactivity" may be described as…

a. a measure of the core's fuel depletion.

b. negative when K_{eff} is greater than 1.0.

c. a measure of the core's deviation from criticality.

d. being equal to 0.0050 $\Delta K/K$ when the reactor is prompt critical.

QUESTION A.13 [1.0 point]
Delayed neutrons comprise approximately what percent of all neutrons produced in the reactor?

a. 0.65%

b. 1.3%

c. 6.5%

d. 13%

QUESTION A.14 [1.0 point]
Which of the following factors has the **LEAST** effect on rod worth?

a. number and location of adjacent rods.

b. temperature of the moderator.

c. temperature of the fuel.

d. core age.

QUESTION A.15 [1.0 point]
Given the following data, which **ONE** of the following is the closest to the half life of the material?

TIME	***ACTIVITY***
0	2400 cps
10 min.	1757 cps
20 min.	1286 cps
30 min.	941 cps
60 min.	369 cps

a. 11 minutes

b. 22 minutes

c. 44 minutes

d. 51 minutes

QUESTION A.16 [1.0 point]
Which ONE of the following is correct with regard to criticality?

a. Critical rod height does NOT depend on how fast control rods are withdrawn.

b. Critical rod height dictates the reactor power level when criticality is first achieved.

c. The slower the approach to criticality, the lower the reactor power level will be when reaching criticality.

d. The reactivity of the reactor increases towards infinity during the approach to criticality.

QUESTION A.17 [1.0 point]
What is the PRINCIPAL source of heat in the reactor after shutdown?

a. Cosmic radiation causing fission

b. Decay of fission products

c. Spontaneous fission within the core

d. Stored energy from the reactor and core materials

QUESTION A.18 [1.0 point]
Which one of the following factors is most easily varied by the reactor operator?

a. reproduction factor

b. fast fission factor

c. fast non-leakage probability

d. thermal utilization factor

QUESTION A.19 [1.0 point]
β and β_{eff} both describe the total fraction of delayed neutrons. The difference between the two is that β_{eff} is …

a. smaller than β since delayed neutrons are born at lower energy levels than prompt neutrons.

b. larger thanβ since delayed neutrons are born at lower energy levels than prompt neutrons.

c. smaller than β since delayed neutrons are born at higher energy levels than prompt neutrons.

d. larger thanβ since delayed neutrons are born at higher energy levels than prompt neutrons.

QUESTION B.1 [1.0 point]
Which ONE of the following is the lowest level of management who has the authority to extend a Radiation Work Permit?

a. Reactor Manager

b. Reactor Director

c. Any licensed Senior Reactor Operator

d. Any licensed Reactor Operator

QUESTION B.2 [2.0 points, ½ each]
Identify each of the following reactor plant limitations as a Safety Limit (SL), Limiting Safety System Setting (LSSS) or a Limiting Condition for Operation (LCO). (Choices may be used more than once or not at all.)

a. Excess reactivity above the reference core condition will be no more than 1.5% Δk/k.

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

c. The regulating rod shall be worth no more than 0.7% Δk/k in reactivity

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

QUESTION B.3 [1.0 point]
Before you removed a control rod for inspection or maintenance you must remove fuel elements to insure the loading is below …

a. 25% of a critical mass when all rods are removed.

b. 40% of a critical mass when all rods are removed.

c. 50% of a critical mass when all rods are removed.

d. 75% of a critical mass when all rods are removed.

QUESTION B.4 [2.0 points, ½ each]
Match the 10CFR20 values for Quality Factor in Column B with their respective types of radiation in Column A. (Note: Values in column B may be used more than once or not at all.)

	Column A	Column B
a.	Alpha (α)	1
b.	Beta (β)	2
c.	Gamma (γ)	5
d.	Neutron (unknown energy)	10
		20

QUESTION B.5 [2.0 points, ½ each]
Identify the correct number (1 through 20) which correctly defines the maximum period between testing intervals per the Technical Specifications definitions.

a. Weekly: ___ days

b. Monthly: ___ weeks

c. Quarterly: ___ months

d. Annually: ___ months

QUESTION B.6 [1.0 point]
Which one of the following describes the Emergency Planning Zone (EPZ) for the UMRR? The EPZ …

a. is the area that enclosed by the walls of the reactor facility.

b. specifies contamination levels of airborne, radiological dose or dose rates that may be used as thresholds for establishing emergency classes.

c. is the geographical area that is beyond the site boundary where the Reactor Director has direct authority over all activities.

d. lies within the site boundary and is bounded by a 150 meter radius from the UMRR exhaust stack.

QUESTION B.7 [1.0 point, ½ each]
Common radioisotopes associated with research reactors are N^{16}, and Ar^{41}. The half-life for each is (seconds (sec), minutes (min) hours (hr) or years (yr)).

a. N^{16} is 7 _____.

b. Ar^{41} is 1.9 _____.

QUESTION B.8 [2.0 points, ½ each]
Match type of radiation (1 thru 4) with the proper penetrating power (a thru d)

a. Gamma	1. Stopped by thin sheet of paper
b. Beta	2. Stopped by thin sheet of metal
c. Alpha	3. Best shielded by light material
d. Neutron	4. Best shielded by dense material

QUESTION B.9 [1.0 point]
An experiment is removed from the reactor with a radiation level of 10R/hr at 1 foot. The radioisotope has a half-life of 120 seconds. Approximately how long must you let the experiment decay before the radiation level has decreased by a factor of 1000?

a. 600 seconds (ten minutes)

b. 1200 seconds (twenty minutes)

c. 6000 seconds (1hour 40 minutes)

d. 12000 seconds (3 hours 20 minutes)

QUESTION B.10 [2.0 points, $^{2}/_{5}$ each]
Match the Control Channel in column A with its respective rundown setpoint in column B.

Control Channel	Setpoint
a. Linear power (%)	1. 15
b. Reactor period (seconds)	2. 20
c. Low CIC voltage (%)	3. 80
d. Radiation Monitors (mR/hr)	4. 120
e. Log power	

QUESTION B.11 [1.0 point]
A maximum allowable excess reactivity is specified in the Technical Specifications

a. 0.75% ΔK/K

b. 1.5% ΔK/K

c. 3.0% ΔK/K

d. 3.5% ΔK/K

QUESTION B.12 [1.0 point]
Which ONE of the following is the lowest level of management who may authorize starting or stopping of a ventilation fan?

a. Reactor Manager

b. Reactor Director

c. Any licensed Senior Reactor Operator

d. Any licensed Reactor Operator

QUESTION B.13 [1.0 point]
Which ONE of the following **MAY** be placed in a designated Radwatse can?

a. Wastes which have come in contact with radioactive material, but have no detectable reactivity when frisked.

b. Radioactive waste which reads greater than 5 mrem/hr at one foot.

c. Free-standing liquids

d. Sharp Objects

QUESTION B.14 [1.0 point]
An accessible area with a radiation level of 50 mR/hr should be posted as a:

a. restricted area

b. radiation area

c. high radiation area

d. very high radiation area

QUESTION B.15 [1.0 point]
Which ONE of the following is the exposure you would expect (approximately) two feet from a point source containing 5 curies of Co^{60}.

a. 190 mR/hr

b. 1.9 R/hr

c. 19 R/hr

d. 190 R/hr

QUESTION C.1 [1.0 point]
Which ONE of the following is a feature of the pneumatic sample transfer system designed to reduce overall radiation.

a. The receiver is lined with lead.

b. Exiting gases are vented directly to the facility exhaust system.

c. Rabbit tubes are curved through the pool water to prevent radiation streaming

d. The rabbit termination in the reactor is lined with cadmium to reduce neutron flux.

QUESTION C.2 [1.0 point]
Which ONE of the following is the reason that primary temperature is maintained below 48.9°C (120°F)? This temperature is based upon …

a. a jump in the diffusion of N^{16} from the pool.

b. the bath temperature coefficient changes from negative to positive.

c. the purification system filter melts.

d. the upper limit of the effective temperature range for the ion exchange resin.

QUESTION C.3 [2.0 points, ⅓ each]
For the following situations (a through f), state the correct Protective Action (Scram, Rundown, Rod Withdrawal Prohibit, Safety Rod Withdrawal Prohibit, or Operator Response)

a. Period < 30 seconds

b. Bridge Motion

c. Log N and Period Amplifier Not Operative

d. Effluent Pool Demineralizer Conductivity high

e. High Neutron Flux in Beam Room

f. Safety Rods Below Shim Range

QUESTION C.4 [1.0 point]
Which ONE of the following is the type of sensor(s) used to measure the pool water temperature.

a. Thermocouple (junction of two dissimilar metals, potential (voltage) varies with temperature)

b. Resistance Temperature Detector (precision wound platinum wire, resistance varies with temperature).

c. Liquid filled Ball (volume varies with temperature).

d. Mercury Thermometer (external circuit converts to electrical output).

QUESTION C.5 [2.0 points, ⅓ each]
From Figure 14, attached, MATCH the correct items (a through f):

a. Control Element

b. Magnet

c. Rod Drive Assembly

d. Magnetic Guide Tube

e. Control Rod Stop Assembly

f. Extension Tube Assembly

QUESTION C.6 [2.0 points, $^2/_7$ each]
From Figure 11, Identify the following seven components of the reactor core.

a.	A	1.	Grid plate
b.	B	2.	Fuel element
c.	C	3.	Control rod element
d.	D	4.	Isotope production element
e.	E	5.	Core access element
f.	F	6.	Fission chamber
g.	G	7.	Ionization chamber or CIC

QUESTION C.7 [1.0 point]
Which ONE of the following prevents damage to a control element when it drops due to a scram?

a. dash pot assembly

b. spring assembly

c. electro-mechanical brake assembly

d. oil-filled shock-absorber assembly

QUESTION C.8 [1.0 point]
N_2 gas is used in the pneumatic tube system to minimize the production of …

a. H^3

b. N^{16}

c. Ar^{41}

d. Xe^{131}

QUESTION C.9 [2.0 points, ¼ each]
Identify each of the characteristics listed below as belonging to the Shim/Safety Rods or the Regulating Rod.

a. Scrams

b. Doesn't Scram

c. Stainless Steel

d. Boron-steel

e. Tubular

f. Grooved Rod

g. Auto Control

h. No Auto Control
REF: S

QUESTION C.10 [1.0 point]
Which ONE of the following areas/locations is ***NOT*** monitored by the Radiation Area Monitoring System?

a. On the reactor bridge to monitor the reactor pool.

b. Near the demineralizer.

c. Area near the thermal column and beam ports.

d. Area near the Control Panel

QUESTION C.11 [1.0 point]
The automatic controller will shift from automatic to manual, without operator action, anytime the difference between power level and demand exceeds the ± __% variation limit.

a. 1

b. 2

c. 5

d. 10

QUESTION C.12 [1.0 point]
All of the Nuclear Instrumentation channels listed below have a rod withdrawal prohibit if its respective recorder is off ***EXCEPT*** the …

a. Log Count Rate Channel

b. Log Power Channel

c. Period recorder Channel

d. Linear Power Channel

QUESTION C.13 [2.0 points, ½ each]
Match the purification system functions in column A with the purification component listed in column B

Column A	Column B
a. remove floating dust, bug larvae, etc.	1. Demineralizer (Ion Exchanger)
b. remove dissolved impurities	2. Skimmer
c. remove suspended solids	3. Filter
d. maintain pH	

QUESTION C.14 [1.0 point]
The Ventilation system consists of three fans mounted on the Reactor Building roof. Which ONE of the following statements correctly describes the action on receipt of a Building Evacuation Alarm from the Reactor Bridge Radiation Area Monitor?

a. 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.

QUESTION C.15 [1.0 point
Inadvertent movement of the reactor bridge will result in …

a. illumination of a status light only.

b. a rod rundown.

c. a reactor scram.

d. an evacuation alarm

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

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

A.3 a $N/N_0 = e^{t/T}$ $500 = e^{t/T}$ $\ln 500 = t/30$ $t = 6.21 \times 30 = 186$ seconds
REF: Burn, R., *Introduction to Nuclear Reactor Operations*, © 1988, §

A.4 b
$CR_1/CR_2 = [1 - K_{eff2}]/[1 - K_{eff1}]$ $30/10 = [1 - K_{eff}]/[1 - 0.96]$ $1 - K_{eff} = 3 \times 0.04 = 0.12$ $K_{eff} = 0.88$
REF: Burn, R., *Introduction to Nuclear Reactor Operations*, © 1988, §

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

A.6 a, 2; b, 4; c, 1; d, 3
REF: Burn, R., *Introduction to Nuclear Reactor Operations*, © 1988, §

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

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

A.9 a
REF: Burn, R., *Introduction to Nuclear Reactor Operations*, © 1988, § p.7-5

A.10 c $P = P^0 e^{t/T}$ $\ln(P/P_0) = t/T$ $T = t/\ln(P/P_0)$ $T = 30 \text{ sec}/(\ln(2)) = 30/0.693 = 57.7$ sec
REF: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, § p. 4-4.

A.11 b
REF: Burn, R., *Introduction to Nuclear Reactor Operations*, © 1988, § pp. 8-5 thru 8-15

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

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

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

A.15 b 1285 is close to ½ activity, so time should be close. Also, $A = A_0 e^{-\lambda t}$ so:
$\ln(1286/2400) = -\lambda(20 \text{ min})$ $\lambda = -(\ln(1286/2400))/20\text{min} = -0.0312$ min
$t = \ln(½)/-0.0312 = 22.19$
REF: Burn, R., *Introduction to Nuclear Reactor Operations*, © 1988, §

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

A.17 b
REF: Burn, R., *Introduction to Nuclear Reactor Operations*, © 1988, §

A.18 d
REF: Burn, R., *Introduction to Nuclear Reactor Operations*, © 1988, §

A.19 b
REF: Burn, R., *Introduction to Nuclear Reactor Operations*, © 1988, §

B.1 a (b and a both have authority, a is less senior.)
REF: SOP 615 pg 2

B.2 a, LCO; b, LSSS; c, LCO; d, SL
REF: Technical Specifications §§ 2.1, 2.2 and 3.1

B.3 c
REF: Facility SOP 302

B.4 a, 20; b, 1; c, 1; d, 10
REF: 10CFR20

B.5 a, 10; b, 6; c, 4; d, 15
REF: Technical Specifications

B.6 a
REF: Emergency Plan, § 6.0 *Emergency Planning Zone*

B.7 a, sec; b, hr
REF: Standard NRC Question

B.8 a. 4 b. 2 c. 1 d. 3
REF: Standard NRC Question

B.9 b
REF: Standard NRC question 1/1000 ≈ ½10

B.10 a, 4; b, 1; c, 3; d, 2; e, 4
REF: Facility Technical Specification Table 3.1

B.11 b
REF: Technical Specifications, § x.x

B.12 c
REF: Facility Technical Specification 3.5, SOP 104

B.13 a
REF: SOP 600 § 12, p. 2.

B.14 b
REF: 10CFR20.1003

B.15 c R/hr = $6CiE/d^2$ R/hr = $(6 \times 5 \text{ curies} \times 2.5MeV)/(2 \text{ feet})^2 = 75/4 = 18.75$ R/hr ≈ 19 R/hr
REF: Standard NRC question.

C.1 c
REF: Facility SAR 4.3 (Rewrite of NRC question administered March 1998).

C.2 d
REF: SAR § 5.2, p. 5-3.

C.3 a. RWP b. Scram c. Scram d. Op Response e. Op Response f. RWP
REF: SAR 3-40, Table IX

C.4 a
REF: SAR pg 3-35

C.5 a. 3 b. 4 c. 6 d. 2 e. 5 f. 1
REF: SAR Figure 14, pg. 3-15

C.6 a, 2; b, 3; c, 4; d, 5; e, 7; f, 6; g, 1
REF: Facility SAR Figure 11

C.7 a
REF: Rewrite of Examination question administered August 1985.

C.8 c
REF: Standard NRC Question

C.9 a, Shim/Safety; b, Regulating; c, Regulating; d, Shim/Safety;
e, Regulating; f, Shim/Safety; g, Regulating; h, Shim/Safety

C.10 d
REF: SAR 3-45

C.11 b
REF: SAR 3-36

C.12 d
REF: SAR 3.5.1, 3.5.2, 3.5.3 and Table IX

C.13 a, 2; b, 1; c, 3; d, 1
REF: SAR § 5.2, pp. 5-1 – 5-3, also Figure 22, p. 5-4.

C.14 b
REF: SAR § 3.6.2, Radiation Monitoring System pp. 3-46 and 3-47.

C.15 c
REF: SAR § 3.2.6, p. 3.19.