April 11, 2003

Mr. Ralph A. Butler, Chief Operating Officer
Research Reactor Facility
University of Missouri
Columbia, MO 65211

SUBJECT: INITIAL EXAMINATION REPORT NO. 50-186/OL-03-01, UNIVERSITY OF MISSOURI – COLUMBIA

Dear Mr. Butler:

During the week of March 10, 2003, the NRC administered operator licensing examinations at your University of Missouri – Columbia 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.

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. 50-186

Enclosures: 1. Initial Examination Report No. 50-186/OL-03-01
2. Examination and answer key (with comments incorporated)

cc w/encls:
Please see next page

cc:

University of Missouri
Associate Director
Research Reactor Facility
Columbia, MO 65201

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

Mr. Ron Kucera, Director
Intergovernmental Cooperation
and Special Projects
Missouri Department of Natural Resources
P.O. Box 176
Jefferson City, MO 65102

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

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

REPORT NO.: 50-186/OL-03-01

FACILITY DOCKET NO.: 50-186

FACILITY LICENSE NO.: R-103

FACILITY: University of Missouri – Columbia

EXAMINATION DATES: March 10, 2003

SUBMITTED BY: Paul V. Doyle 3/19/2003
Paul Doyle, Chief Examiner Date

SUMMARY:

On March 10, 2003, the NRC administered operator licensing examinations to 1 Reactor Operator and 1 Senior Reactor Operator (Upgrade) candidates. The Reactor Operator candidate failed section A of the written examination only. The Senior Reactor Operator (Upgrade) passed all portions of the NRC examination.

REPORT DETAILS

1. Examiners:
   Paul Doyle, Chief Examiner

2. Results:

	RO PASS/FAIL	SRO PASS/FAIL	TOTAL PASS/FAIL
Written	0/1	0/0	0/1
Operating Tests	1/0	1/0	2/0
Overall	0/1	1/0	1/1

3. Exit Meeting:
   Paul Doyle, NRC, Examiner
   Michael Dixon, MURR, Assistant Reactor Manager for Operations

The examiner thanked the facility staff for their support in administering the examination. In addition the examiner and the staff discussed recent changes in facility documentation, and agreed to work together to better keep up to date with facility changes.

UNIVERSITY OF MISSOURI–COLUMBIA

With Answer Key

OPERATOR LICENSING EXAMINATION

March 10, 2003

Enclosure 2

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]
When pumping the Liquid Waste tanks to the sanitary sewer, the maximum accumulated activity for nuclides other than H^3 is 2 millicuries for the Lead Senior Reactor Operator to authorize the procedure. The maximum accumulated activity for H^3 is …

a. 5 millicuries

b. 10 millicuries

c. 15 millicuries

d. 20 millicuries

QUESTION B.2 [1.0 point]
Which **ONE** of the following locations is **NOT** an Emergency Command Center per the Emergency Plan?

a. Control Room

b. Research Park Development Building

c. Dalton Cardiovascular Research Center

d. Facility Front Lobby

QUESTION B.3 [1.0 point]
The reactor has been shutdown for the last three hours due to electrical storms, (intermittent loss of power). No shutdown checksheet has been performed. Which **ONE** of the following meets the **MINIMUM** requirements to restart the reactor?

a. You may perform a hot startup with the SRO directing.

b. You may startup after performing a short form Startup Checksheet.

c. You may startup after ensuring the Primary system is on-line per the applicable SOP, then performing a short form Startup Checksheet.

d. You may startup after performing a Full Power Startup Checksheet.

QUESTION B.4 [1.0 point]
Which **ONE** of the following radiation monitors may be placed out of service for two hours for maintenance or calibration, providing no experimental or maintenance activities are conducted which could likely result in the release of unknown quantities of airborne radioactivity.

a. Reactor Bridge Radiation Monitor

b. Reactor Building Exhaust air plenum Radiation Monitor

c. Stack Radiation Monitor

d. Reactor Bridge ALARA Radiation Monitor

QUESTION B.5 [1.0 point]
The Primary System Fuel Failure Monitor has failed. Which **ONE** of the following actions must you take, if any, to comply with Technical Specifications?

a. Immediately SCRAM the reactor.

b. Commence a normal reactor shutdown within 15 minutes.

c. Make arrangements to have the primary coolant sampled once every 4 hours.

d. No actions are required.

QUESTION B.6 [1.0 point]
Which ONE of the following control rod manipulations is **NOT** by procedure?

a. Gang operation of the control rods after criticality to reduce power.

b. Gang operation of the control rods as part of automatic shimming.

c. Simultaneous withdrawal of one control blade and the regulating blade.

d. Gang operation of the controls rods during hot startup.

QUESTION B.7 [1.0 point]
If the reactor is not critical when the upper **ECP** limit is reached, you must:

a. stop and recalculate the ECP prior to further rod withdrawal.

b. shut down the reactor.

c. verify the ECP with a 1/M plot.

d. check the control rod position transmitters.

QUESTION B.8 [1.0 point]
The reactor stack radiation monitor may be taken out of service for maintenance or calibration during reactor operation for a period of up to:

a. 1.0 hour.

b. 2.0 hours.

c. 8.0 hours.

d. 12.0 hours.

QUESTION B.9 [1.0 point]
Two point sources have the ***SAME*** Curie strength. Source A's gammas have an energy of 1 Mev, while Source B's gammas have an energy of 2 Mev. You obtain a measurement from the same GM tube 10 feet from each source. The measured dose rate from Source B is …

a. four times that of Source A.

b. is twice that of Source A.

c. is the same as that of Source A.

d. is half that of Source A.

QUESTION B.10 [1.0 point]
Which **ONE** of the following operations requires the direct supervision (i.e., presence) of a Senior Reactor Operator?

a. Stack monitor operational test.

b. Adjustment of nuclear instrumentation.

c. Start up pool coolant system.

d. Start up primary coolant system.

QUESTION B.11 [1.0 point]
In the event of a high stack monitor readings (in excess of alarm points), the reactor operator should immediately:

a. notify the shift supervisor.

b. scram the reactor.

c. shut down the reactor.

d. reduce power slowly until the alarm clears.

QUESTION B.12 [1.0 point]
According to Technical Specifications, the drop time for each rod shall be measured ____ and one of four blades shall be inspected _____.

a. monthly every six months

b. quarterly every six months

c. quarterly annually

d. every six months annually

QUESTION B.13 [1.0 point]
During refueling, the lowest level of staff who may move fuel **INTO OR OUT OF THE CORE WITHOUT DIRECT SUPERVISION** is …

a. Auxiliary Operator

b. Reactor Operator

c. Senior Reactor Operator

d. Operations Manager

QUESTION B.14 [1.0 point]
How long (by standard practice) must the reactor be secured prior to venting a beam port containing Ar^{41}?

a. 1 hour

b. 12 hours

c. 1 day

d. 2 days

QUESTION B.15 [1.0 point]
A survey instrument with a window probe was used to measure an irradiated experiment. The results were 100 millirem/hr window open and 60 millirem/hr window closed. What was the gamma dose?

a. 100 millirem/hr

b. 60 millirem/hr

c. 40 millirem/hr

d. 140 millirem/hr

QUESTION B.16 [1.0 point]
The NRC has four standard emergency classifications. Which ONE of the four listed below is NOT applicable at MURR?

a. Alert

b. General Emergency

c. Notification of Unusual Event

d. Site Area Emergency

QUESTION B.17 [1.0 point, ¼ each]
Match each of the radioisotopes associated with operating the reactor in column A with its PRIMARY source (irradiation of **AIR** or **WATER**, or **FISSION** product).

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

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

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

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

QUESTION B.18 [1.0 point]
Per the definition in the Emergency Plan, Protective Action Guide(s) is (are) …

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

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

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

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

QUESTION B.19 [1.0 point]
Per SOP I, Section 2 Fuel Handling, when unlatching an element in the reactor _____ on the tool while pushing down on the air operator handle to locked released position.

a. lightly lift up

b. lightly push down

c. quickly jerk up

d. quickly jerk down

QUESTION B.20 [1.0 point]
Which ONE of the following is NOT a responsibility of the Console Operator following a reactor isolation?

a. Verify that the containment building has sealed by the ventilation door and exhaust valve indication lights.

b. Ensure all personnel have evacuated all levels of the containment building.

c. Position himself at the outer airlock allowing only authorized personnel entry.

d. Investigate the cause of the alarm and magnitude of the incident.

QUESTION C.1 [1.0 point]
How is Reactor Coolant temperature controlled?

a. Varying reactor loop flow by varying speed of pumps P501A/B.

b. Varying reactor loop flow by varying the position of butterfly valve 901.

c. Varying secondary loop flow by varying speed of pumps P1, P2 and P3.

d. Varying secondary loop flow by varying the position of butterfly valve S-1.

QUESTION C.2 [1.0 point]
Which ONE of the following is the reason for the 100 gallon holdup tank in the purification system? This tank

a. is part of the regeneration system.

b. allows N^{16} gamma activity to decay off.

c. contains spent resin from the demineralizer units.

d. provides water hammer protection for the purification system.

QUESTION C.3 [1.0 point]
Which ONE of the following Area Radiation Monitoring System (ARMS) channels does NOT cause a building isolation?

a. Air Plenum 2

b. Bridge ALARA

c. Room 114

d. Bridge

QUESTION C.4 [1.0 point]
Which ONE of the following is the correct (temporary) method for maintaining power to critical reactor instrumentation when performing maintenance on the Uninterruptible Power Supply?

a. Close the bypass switch, allowing the batteries to feed a backup UPS.

b. Close the static switch, allowing the batteries to feed a backup UPS.

c. Close the bypass switch, allowing site power to feed the instrumentation.

d. Close the static switch, allowing site power to feed the instrumentation.

QUESTION C.5 [1.0 point]
The ventilation system has two backup doors located in the ventilation supply and return plenums which shut on containment isolation. Which ONE of the following is the method used to shut these doors? The doors are …

a. air motor operated, with their own emergency air supply tanks.

b. motor operated, with air supplied from the emergency air supply system.

c. held open by solenoid, which when deenergized, the door closes via gravity.

d. held open by air pistons, which when vented, the doors close via gravity.

QUESTION C.6 [1.0 point]
The purification system contains a fission product monitor. This monitor detects radiation from fission products collected in …

a. the filter

b. the holdup tank

c. the cation column

d. the anion column

QUESTION C.7 [1.0 point, ⅓ each]
For the setpoint actions in Column A select the appropriate pressurizer system pressure listed in Column B. Pressures in Column B may be used once, more than once or not at all. Only one answer may occupy each space in column A. (Three answers required at 0.333 each)

COLUMN A ACTIONS	COLUMN B SETPOINTS
a. High pressure scram	1. 69.5 psig
	2. 63 psig
b. Nitrogen makeup valve opens	3. 66.5 psig
	4. 70 psig
c. High pressure relief valve lifts	5. 73.5 psig
	6. 77 psig
	7. 80.5 psig
	8. 100 psig

QUESTION C.8 [2.0 points, ⅓ each]
Identify whether each of the following conditions will cause a scram, a rod run-in, a containment isolation (with scram), or no automatic action (If there are two list the one which comes in first):

a. Source Range Monitor Channel 1 Inoperative (at 10 megawatts power)

b. Low Pool Level

c. West Area Radiation Monitor High Radiation Alarm

d. High Off-Gas Activity

e. Low Reflector Differential Pressure

f. Truck Entry Door Seal Deflated

QUESTION C.9 [1.0 point]
Regarding the five control rods …

a. all five are boron carbide clad in aluminum.

b. the shims are boron carbide clad in aluminum, the regulating rod is stainless steel.

c. the shims are boron carbide clad in stainless steel, the regulating rod is aluminum.

d. all five are stainless steel.

QUESTION C.10 [1.0 point]
Starting a Secondary Coolant Pump during reactor startup may cause the reactor to scram due to …

a. low core inlet temperature

b. low core outlet temperature

c. low core discharge pressure

d. low pool temperature

QUESTION C.11 [2.0 points, ⅛ point each]
Identify each of the following valve operator system valve indications as being either via limit switch **(L/S)** on the valve (actual valve position) or air operator **(A/O)** position, and whether the **OPEN** position is **GREEN** or **RED**. (**NOTE**: Two answers should be circled per item.)

a. Pool Loop 6" isolation valve

b. Rx Loop 12" isolation valve

c. Pressurizer, 2" Bypass Drain

d. Pressurizer 1" Supply Valve

e. Reflector Convective Loop Valve

f. Anti-siphon Valve

g. N_2 ½" Exhaust valve.

h. Liquid Level 2" fill

QUESTION C.12 [1.0 point]
Where does the Drain Collection tank overflow, overflow to?

a. "Floor Drain in room 114".

b. Sanitary Sewer

c. Retention Tank #3

d. Reactor Pool

QUESTION C.13 [1.0 point]
The operator wishes to place the reactor in the automatic mode of operation. Which ONE of the following conditions would prevent the operator from doing so?

a. Reactor period, as measured by IRM-2, is 40 seconds.

b. The 60% annunciator alarm for the regulating blade is energized.

c. Reactor period, as measured by IRM-3, is 40 seconds.

d. The Wide Range Monitor selector switch is in the 5 kW black scale position.

QUESTION C.14 [1.0 point]
A Facility Evacuation can be manually initiated from the control console and:

a. the reactor bridge.

b. equipment room 278.

c. the front lobby.

d. equipment room 114.

QUESTION C.15 [1.0 point]
Which Area Radiation Monitors below can cause a Reactor Isolation?

a. Bridge, Bridge ALARA, Fission Product Monitor, Air Plenum 1.

b. Beamport Floor North Wall, Beamport Floor West Wall, Beamport Floor South Wall, Bridge.

c. Bridge, Bridge ALARA, Air Plenum 1, Air Plenum 2.

d. Fission Product Monitor, Air Plenum 1, Air Plenum 2, Bridge ALARA.

QUESTION C.16 [1.0 point]
In the event of a commercial power failure, the diesel engine starts and the emergency generator supplies power to_____. When normal power is restored, the emergency electrical load is shifted back after a time delay of_____.

a. Substation A; ten minutes.

b. Substation B; ten minutes.

c. Substation A; seven seconds.

d. Substation B; seven seconds.

QUESTION C.17 [1.0 point]
Which ONE of the following is NOT a feature of the pneumatic tube system designed to limit the radiation hazard?

a. Speed at which the sample container is transported through the system.

b. When the blower is initially turned on both blowers start simultaneously.

c. Facility exhaust fans operation prevent stagnant air in the vicinity of the rabbit system.

d. Double encapsulation of samples.

QUESTION C.18 [1.0 point]
Which ONE of the following signals does NOT feed into the digital power meter?
a. Pool ΔT

b. Pool Flow

c. Primary Demin Flow

d. Channel 4 Power Level

A.1 a
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory.

A.2 c
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory.

A.3 b
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory.

A.4 a
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory.

A.5 d
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory.

A.6 d
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory.

A.7 b
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory.

A.8 b
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory.

A.9 b
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory.

A.10 b
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory.

A.11 b
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory.

A.12 c
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory.

A.13 d
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory.

A.14 a
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory.

A.15 c
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory.

A.16 c
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory.

A.17 c
$P = P_0 e^{t/\tau}$ 1st find τ. τ = time/(ln(2)) = 42/0.693 = 60.6 sec. Time = $\tau \times \ln(10)$ = 60.6 × 139.5 sec
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory.

A.18 a $0.1 \times 3.79 = .379$ $0.9 \times 0.23 = 0.207$ $0.1 \times 7.9 = 0.79$ $0.9 \times 1.49 = 1.34$
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory.

A.19 a $0.001\ \Delta K/K/\cancel{inch} \times 4.5\ \cancel{inch} \div 9^{\circ}F = 0.001 \div 2 = 0.0005 = 5 \times 10^{-4}\ \Delta K/K/^{\circ}F$
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory.

A.20 b
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory.

B.1 b
REF: Reactor Operator Training Manual, § I.10.2, p. 2, 1st ¶.

B.2 c
REF: SEP-1, §II.2 and 6.

B.3 d
REF: SOP I.4.3.F.1 Startup Checksheet §§ a & b

B.4 c
REF: Technical Specifications, Table in § 3.4(a).

B.5 c
REF: Technical Specifications, § 3.9 Coolant System, pg. 1 of 3.

B.6 c
REF: SOP-I.4.3.D Control Blade Operation, p. SOP/I-5

B.7 b
REF: SOP I.4.3.G.5 p. SOP/I-7

B.8 b
REF: MURR Technical Specifications, Section 3.4.a.

B.9 c
REF: Standard NRC Question (GM tubes detects counts ONLY, they do not detect relative strengths of radiation.)

B.10 b
REF: OP-RO-340

B.11 a
REF: REP-21

B.12 b
REF: Technical Specification 5.3.

B.13 b
REF: SOP II, 2.1.H.

B.14 b
REF: Reactor Operator Training Manual, § I.11 5th ¶.

B.15 b
REF: Instrument reads only gamma with window closed therefore reading with window closed is gamma dose.

B.16 b
REF: Emergency Plan, § 3.0 Classification of Emergency Conditions

B.17 a, water ; b, air; c, water; d, fission
REF: Standard NRC Question. Also chart of the Nuclides.

B.18 c
REF: Emergency Plan, § 9.0 Definitions.

B.19 b
REF: SOP II § 2.0 Fuel Handling

B.20 d
REF: FEP

C.1 d
REF: Reactor Operator Training Manual, § I.2.E, p. I.2.11. 3rd ¶.

C.2 b
REF: Reactor Operator Training Manual, § I.4 Clean-up Systems, p. I.4.1 3rd ¶.

C.3 c
REF: Reactor Operator Training Manual §II.10, p. II.10.1 B.2 Reactor Isolation, p. II.10.3.

C.4 c
REF: Reactor Operator Training Manual § III.3.C.1.3, page II.3.3,

C.5 d
REF: Reactor Operator Training Manual, § II.10.A.4; Page II

C.6 d
REF: Rewrite of facility supplied question, Plant and Radiation monitoring Systems, #28.

C.7 a. 6 b. 3 c. 8
REF: MURR Training Manual for Reactor Operators Section I.3 pp I

C.8 a, scram b, Run-in; c, no auto action; d, no auto action; e, scram; f, run-in
REF: Reactor Operator Training Manual, §

C.9 b
REF: Reactor Operator Training Manual, §

C.10 c
REF: SOP II, § 1.1 NOTE.

C.11 a/b L/S (green), c/d A/O (red), e/f L/S (red) g/h A/O (red)
REF: Reactor Operator Training Manual,

C.12 a
REF: Reactor Operator Training Manual, § I.8. Drain Collection Tank System, p. I.8.1. ¶ B

C.13 d
REF: Training Manual for Reactor Operations, page II

C.14 c
REF: Training Manual for Reactor Operations, page II.10.3.

C.15 c
REF: Training Manual for Reactor Operations, page II.9.2.

C.16 b
REF: Training Manual for Reactor Operations, pages III.2.1, III.2.2.

C.17 b
REF: HSR 8-20 – 8-25. Also NRC Examination Question Bank question 6837

C.18 d
REF: Facility Requalification Examination (11/17/93).