March 10, 2005

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

SUBJECT: INITIAL EXAMINATION REPORT NO. 50-186/OL-05-01, University of Missouri – Columbia

Dear Mr. Butler:

During the week of February 14, 2005, 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 2.390 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 Agencywide Documents Access and Management System (ADAMS). ADAMS is accessible from the NRC Web site at (the Public Electronic Reading Room) http://www.nrc.gov/reading-rm/adams.html. The NRC is forwarding the individual grades to you in a separate letter which will not be released publicly. Should you have any questions concerning this examination, please contact Mr. Paul V. Doyle Jr. at (301) 415-1058 or via internet e-mail pvd@nrc.gov.

Sincerely,

/RA/

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

Docket No. 50-186

Enclosures: 1. Initial Examination Report No. 50-186/OL-05-01
2. Examination and answer key with facility comments incorporated.

cc w/encls: Please see next page

March 10, 2005

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

SUBJECT: INITIAL EXAMINATION REPORT NO. 50-186/OL-05-01, UNIVERSITY OF MISSOURI - COLUMBIA

Dear Mr. Butler:

During the week of February 14, 2005, 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.

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OFFICE	RNRP:CE		IROB:LA	E	RNRP:SC	
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U. S. NUCLEAR REGULATORY COMMISSION
OPERATOR LICENSING INITIAL EXAMINATION REPORT

REPORT NO.: 50-186/OL-05-1

FACILITY DOCKET NO.: 50-186

FACILITY LICENSE NO.: R-103

FACILITY: University of Missouri – Columbia

EXAMINATION DATES: February 14 - 15, 2005

SUBMITTED BY: /RA/ 2/22/2005
Paul V. Doyle Jr., Chief Examiner Date

SUMMARY:

During the week of February 14, 2005, the NRC administered operator licensing examinations to one Reactor Operator and two Senior Reactor Operator (Upgrade) candidates. All three candidates passed all portions of their respective examinations.

REPORT DETAILS

1. Examiners:
   Paul V. Doyle Jr., Chief Examiner

2. Results:

	RO PASS/FAIL	SRO PASS/FAIL	TOTAL PASS/FAIL
Written	1/0	0/0	1/0
Operating Tests	1/0	2/0	3/0
Overall	1/0	2/0	3/0

3. Exit Meeting:
   Paul V. Doyle Jr., NRC, Examiner
   Robert Hudson, Training Coordinator, MURR
   Michael Dixon, Assistant Reactor Manager, Operations

   During the exit meeting the examiner thanked the facility for their support in the administration of the examination. The examiner stated that he did not note any generic weaknesses on the part of the candidates. The facility staff mentioned some changes which would enhance the written examination, and promised to update some references sent to the examiner. All enhancements to the examination have been incorporated into the copy included with this report.

ENCLOSURE 1

OPERATOR LICENSING EXAMINATION
With Answer Key

UNITED STATES NUCLEAR REGULATORY COMMISSION

UNIVERSITY OF MISSOURI-COLUMBIA
February 15, 2005

Enclosure 2

QUESTION A.1 [2.0 points, 0.5 each]
The listed isotopes are all potential daughter products due to the radioactive decay of $_{35}Br^{87}$. Identify the type of decay necessary (Alpha, Beta, Gamma or Neutron emission) to produce each of the isotopes.

a. $_{33}As^{83}$

b. $_{35}Br^{86}$

c. $_{35}Br^{87}$

d. $_{36}Kr^{87}$

QUESTION A.2 [1.0 point]
What is the kinetic energy range of a thermal neutron?

a. > 1 MeV

b. 100 KeV – 1 MeV

c. 1 eV – 100 KeV

d. < 1 eV

QUESTION A.3 [1.0 point]
Suppose the temperature coefficient of a core is -2.5×10^{-4})K/K/°C and the average control rod worth of the regulating control rod is 5.895×10^{-3})K/K/inch. If the temperature INCREASES by 50°C what will the automatic control command the regulating rod to do? Select the answer that is closest to the calculated value.

a. 5.6 inches in

b. 2.1 inches out

c. 0.5 inches in

d. 4.3 inches out

QUESTION A.4 [1.0 point]
Which ONE of the following is the major source of energy released during fission?

a. Absorption of prompt gamma rays

b. Slowing down of fission fragments

c. Neutrino interactions

d. Fission neutron scattering

QUESTION A.5 [1.0 point]

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

a. The ratio of the number of neutrons produced by fast fission to the number produced by thermal fission

b. The ratio of the number of neutrons produced by thermal fission to the number produced by fast fission

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

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

QUESTION A.6 [1.0 point]

In a reactor at full power, the thermal neutron flux (N) is 2.5×10^{12} neutrons/cm^2/sec. and the macroscopic fission cross-section G_f is 0.1 cm^{-1}. The fission reaction rate is:

a. 2.5×10^{11} fissions/sec.

b. 2.5×10^{13} fissions/sec.

c. 2.5×10^{11} fissions/cm^3/sec.

d. 2.5×10^{13} fissions/cm^3/sec.

QUESTION A.7 [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? Each insertion causes a …

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

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

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

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

QUESTION A.8 [1.0 point]

Which ONE of the following atoms will cause a neutron to lose the most energy in an elastic collision?

a. Uranium^{238}

b. Carbon^{12}

c. Hydrogen^{2}

d. Hydrogen^{1}

QUESTION A.9 [1.0 point]

A thin foil target of 10% copper and 90% aluminum is in a thermal neutron beam. Given $F_{a\ Cu}$ = 3.79 barns, $F_{a\ Al}$ = 0.23 barns, $F_{s\ Cu}$ = 7.90 barns, and $F_{s\ Al}$ =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.10 [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.11 [1.0 point]

The delayed neutron precursor $ for U^{235} is 0.0065. However, when calculating reactor parameters you use the *effective* delayed neutron precursor $\$_{eff}$ with a value of ~0.0070. Which ONE of the following is the correct reason that $\$_{eff}$ is larger than $?

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 $ for fast fission.

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

QUESTION A.12 [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.13 [1.0 point]
Which ONE of the following isotopes will cause a neutron to lose the most energy in an ELASTIC scattering reaction?

a. O^{16}

b. C^{12}

c. Be^{9}

d. H^{1}

QUESTION A.14 [1.0 point]
Which ONE of the following describes the ***MAJOR*** contributors to the production and depletion of Xenon respectively in the core shortly (less than an hour) after ***SHUTDOWN***

	Production	***Depletion***
a.	Radioactive decay of Iodine	Radioactive Decay
b.	Radioactive decay of Iodine	Neutron Absorption
c.	Directly from fission due to delayed neutrons	Radioactive Decay
d.	Directly from fission due to delayed neutrons	Neutron Absorption

QUESTION A.15 [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 of 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.16 [1.0 point]
Several processes within the core increase or decrease the number of neutrons in a generation. Which ONE of the following six-factor terms describes a process which results in an INCREASE in the number of neutrons during the cycle?

a. Thermal Utilization Factor (f)

b. Resonance Escape Probability (p)

c. Thermal Non-Leakage Probability (‹$_{TH}$)

d. Reproduction Factor (0)

QUESTION A.17 [1.0 point]
Which **ONE** of the following is the correct reason burnable poison is added to the core?

a. To minimize the effects of a rod withdrawal accident.

b. To increase the power achievable for a given core size.

c. To allow addition of additional fuel to compensate for burnup.

d. To decrease the effects of Xenon and Samarium on the core.

QUESTION A.18 [1.0 point]
As a reactor continues to operate over time, for a **CONSTANT** power level, the average **THERMAL** neutron flux…

a. decreases, due to the increase in fission product poisons.

b. decreases, because the fuel is being depleted.

c. increases, in order to compensate for fuel depletion.

d. remains the same

QUESTION A.19 [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 (B.1) [1.0 point]
Which ONE of the following statements correctly describes the relationship between a Safety Limit (SL) and a Limiting Safety System Setting (LSSS)?

a. The SL is a maximum operationally limiting value that prevents exceeding the LSSS during normal operations.

b. The SL is a parameter that assures the integrity of the fuel cladding. The LSSS initiates protective action to preclude reaching the SL.

c. The LSSS is a parameter that assures the integrity of the fuel cladding. The SL initiates protective action to preclude reaching the LSSS.

d. The SL is a maximum setpoint for instrumentation response. The LSSS is the minimum number of channels required to be operable.

QUESTION (B.2) [2.0 points, ½ point each]
Match the type of radiation in column A with its associated Quality Factor (10CFR20) from column B.

Column A	Column B
a. alpha	1
b. beta	2
c. gamma	5
d. neutron (unknown energy)	10
	20

QUESTION B.3 [2.0 points, a point each]
Match each of the Technical Specification Limits in column A with its corresponding value in column B. (Each limit has only one answer, values in Column B may be used more once, more than once or not at all.)

Column A	Column B
a. Minimum Shutdown Margin	0.0980) K
b. Each secured Removable Experiment	0.0200) K
c. Core Excess Reactivity	0.0060) K
d. Absolute Value of all experiments in Center test hole	0.0025) K
e. Movable parts of any individual experiments	0.0010) K
f. Each Unsecured Experiment	

QUESTION (B.4) [1.0 point]
You are the reactor operator performing a reactor startup to 10 Mw. During the shutdown 4 new experiments were placed in a beamport which could result in an undefined radiation hazard. At what power levels during the startup (besides criticality) are you required to inform the health physics technician monitoring the experiments?

a. 5 Kws, 0.5 Mws, 5 Mws

b. 50 Kws, 2.5 Mws, 10 Mws

c. 5 Kws, 2.5 Mws, 5 Mws

d. 50 Kws, 5 Mws, 10 Mws

QUESTION (B.5) [1.0 point]
The on-duty shift consists of you (Licensed Reactor Operator) the Lead Senior Reactor Operator (LSRO) and a Reactor Operator Trainee (Knowledgeable Person). You receive a message concerning an emergency in your family. What actions should you take before you leave?

a. Shutdown the reactor in accordance with ______.

b. Wait for another Reactor Operator to arrive before you leave.

c. Turn over the watch to the Shift Supervisor who may operate the reactor with the trainee present in the control room.

d. Turn over the watch to the trainee, who may operate the reactor under the direction of the Shift Supervisor.

QUESTION (B.6) [1.0 point]
How long before a Radiation Work Permit expires (no extension)?

a. 8 hours

b. 24 hours

c. 48 hours

d. one week

QUESTION (B.7) [1.0 point]
Technical Specifications require the facility to test the operability of the Pool Fill system …

a. Weekly

b. Monthly

c. Semiannually

d. Annually

QUESTION (B.8) [1.0 point]
When is the reactor licensee authorized to take reasonable action that departs from a license condition or a technical specification?

a. The licensee is never allowed to violate any NRC authorized operating limits.

b. The licensee can depart from technical specifications for calibration purposes.

c. The licensee is authorized to do whatever is necessary to protect public health and safety in an emergency.

d. The license holder can do anything deemed necessary for normal operations, so long as the licensee notifies the NRC within an hour after the action.

QUESTION (B.9) [1.0 point, ¼ each]
Identify whether each of the following experiments has no special requirements (NSR), requires Double encapsulation (DBL), requires venting through HEPA and charcoal filters to the stack (HEPA) or is Not Authorized (NA).

a. Corrosive Materials

b. Cryogenic Materials (in pool experiment)

c. At the peak will contain 3 milligrams of explosive material.

d. At the peak will contain 100 millicuries of Strontium 90 (Sr^{90}).

QUESTION (B.10) [1.0 point]
The reflector high and low differential pressure scram:

a. assures adequate cooling of the fuel and flux trap region.

b. provides a backup to the primary low pressure scram.

c. provides a backup to the primary coolant low flow scram.

d. provides a backup to the pool coolant low flow scram.

QUESTION (B.11) [1.0 point]
According to the Technical Specifications, which **ONE** of the following conditions is **NOT** permissible when the reactor is operating?

a. Above 100 kW, the maximum distance between the highest and lowest shim blade = 1 inch.

b. A fueled experiment containing 300 millicuries of I^{135}.

c. Emergency generator is out of service for one hour for maintenance.

d. Core excess reactivity = 0.006) k/k.

QUESTION (B.12) [1.0 point]
With the exception of routine silicon sample handling, when moving radioactive material around the pool, Health Physics personnel are required to be present when the dose rate exceeds:

a. 50 mR/hr.

b. 75 mR/hr.

c. 100 mR/hr.

d. 200 mR/hr.

QUESTION (B.13) [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.14) [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.15) [1.0 point]
During startup of the Primary coolant system, per procedure you start the pumps at 63 psig. After starting the second pump, the pumps cycle then on. Per procedure you should …

a. continue the system startup.

b. stop both pumps, and inform the Lead Senior Reactor Operator.

c. stop both pumps, wait for primary pressure to increase greater than 66 psig, then restart the pumps.

d. continue the system startup, after informing the Lead Senior Reactor Operator.

QUESTION (B.16) [1.0 point]

Which ONE of the following is NOT a requirement of OP-RO-531 *Primary and Pool Sample Station*?

a. The primary must be sampled daily for H^3.

b. If the primary system fuel failure detector is out of service the primary must be sampled every 4 hours.

c. Do not operate if I^{131} concentration exceeds 5×10^{-3} μCi/ml

d. HP coverage is required if abnormal fission product activity is present.

QUESTION (B.17) [1.0 point, ¼ 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.18) [1.0 point]

Monday morning maintenance has been completed. A full power pre-startup checksheet was completed at 09:00 am. The new trainees have been performing startups and shutdowns all day for NRC examinations. All equipment has been operating properly. Following the completion of exams, a cooling tower fan failed. It was a loose wire which was quickly corrected. Due to the late hour (19:30) the startup following the examinations will start after shift change at 20:00 pm. Which ONE of the following statements is correct? Because the …

a. cooling tower equipment is not part of a short form pre-startup checksheet, and it is less than 12 hours since the last full power startup checksheet, you may startup after successfully completing a short form pre-startup checksheet.

b. cooling tower equipment is part of a short form pre-startup checksheet, regardless of the time you must perform a full power startup checksheet prior to startup.

c. time since the last full power startup checksheet is greater than 8 hours regardless of wether the cooling tower equipment is part of a short form pre-startup checksheet, you must perform a full power startup checksheet prior to startup.

d. last full power startup checksheet was preformed during a different shift a new full power check sheet must be performed regardless of time or equipment malfunctions.

QUESTION C.1 [1.0 point]
Which ONE statement below describes the operation of the three-way solenoid valves in the Valve Operating System? When the solenoid valve is …

a. energized, the vent side of the valve closes, directing air pressure to the isolation valve operator.

b. deenergized, the vent side of the valve closes, directing air pressure to the isolation valve operator.

c. energized, the vent side of the valve opens, directing air pressure to the isolation valve operator.

d. deenergized, the vent side of the valve opens, directing air pressure to the isolation valve operator.

QUESTION C.2 [1.0 point]
Containment building isolation is accomplished by closing two butterfly valves, 16A and 16B, in the main exhaust line. Which ONE of the following describes the operation of these valves?

	Valve 16A	**Valve 16B**
a.	air open, air close	air open, spring close.
b.	air open, spring close	air open, air close.
c.	motor-operated (open and close)	air open, air close.
d.	air open, spring close	motor-operated (open and close)

QUESTION C.3 [1.0 point]
What type of sensor is used to detect the position of the "rabbit" in the core?

a. photo-electric cell

b. magnetic switch

c. micro switch

d. reed switch

QUESTION C.4 [1.0 point]
How long after shutdown must the Primary system be in operation?

a. 5 minutes

b. 10 minutes

c. 15 minutes

d. 30 minutes.

QUESTION C.5 [1.0 point]
Which ONE of the following describes the response of the regulating blade to a reactor scram signal?

a. It's electromagnetic clutch deenergizes and the rod falls into the core via the force of gravity.

b. The rod will be driven into the core.

c. The rod will withdraw in an attempt to compensate for the shim blades insertion.

d. The rod will remain in its position.

QUESTION C.6 [1.0 point]
Which ONE of the following conditions is NOT a Nuclear Instrument Anomaly?

a. SRM high voltage supply is low.

b. ~~IRM selector switch not in OPERATE position.~~

c. ~~WRM selector switch not in OPERATE position.~~

Note: These two distractors must be rewritten as changes to the equipment have resulted in the drawers no longer having these switches.

d. PRM at 120% power.

QUESTION C.7 [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.8 [1.0 point]
Which ONE of the Radiation Monitors is used to track radioactive Argon, Neon and Krypton to the environment?

a. Bridge ALARA

b. Stack Gas

c. Stack Particulate

d. Stack Iodine

QUESTION C.9 [1.0 point]
What is the purpose of the ventilation ducts built in to the pool wall? These ducts are designed to remove …

a. H^3

b. N^{16}

c. Ar^{41}

d. I^{131}

QUESTION C.10 [1.0 point]

Which ONE of the following Nuclear Instrument Channels has an input into the regulating blade auto control circuit.

a. Channel 1 (Source Range Monitor)

b. Channel 2 (Intermediate Range (Log-N))

c. ~~Channel 4 (~~Wide Range Monitor~~)~~ Note: Wide Range Monitor is no longer called Channel 4. This is however the correct answer.

d. Channel 6 (Power Range Monitor)

QUESTION C.11 [1.0 point]

Which ONE of the following conditions is required for proper operation of the Antisiphon system?

a. System pressure must be greater than 10 psig.

b. System pressure must be greater than 27 psig.

c. System water level must be more than 10 inches above the antisiphon valves.

d. System water level must be more than 6 inches above the antisiphon valves.

QUESTION C.12 [2.0 points, a each]

Match each of the beamports in column A with the correct characteristics in Column B

	Column A Beamport	Column B Characteristic
a.	A	6" radial (6R)
b.	B	6" tangential (6T)
c.	C	4" radial (4R)
d.	D	4" tangential (4T)
e.	E	
f.	F	

QUESTION C.13 [1.0 point]

The normal (green) lamp on an Area Radiation Monitor is out. This is an indication of …

a. too low a voltage to the detector.

b. the Sr^{90} test source is missing

c. too many pulses to the detector (saturation).

d. the signal due to the Sr^{90} test source is verified correct.

QUESTION C.14 [1.0 point]
Which ONE of the following alarms on the control panel is NOT associated with the startup interlock?

a. Channel 1 Low Count rate

b. Nuclear Instrument Anomaly

c. Thermal Column Door Open

d. Jumper Board in Use

QUESTION C.15 [2.0 points, ¼ each]
Match the channel in column A with the correct detector in column B.

	Column A		Column B
a.	Fission Product Monitor	1.	Geiger Müeller
b.	Secondary Coolant Monitor	2.	Scintillation Detector
c.	Stack Gas Monitor	3.	GeLi Detector
d.	Stack Particulate Monitor	4.	BF_3 Ion Chamber Detector
e.	Stack Iodine Monitor		
f.	Bridge ARMS		
g.	Exhaust Plenum 1		
h.	Room 114 ARMS		

QUESTION C.16 [2.0 points, 0.4 each]
Indicate whether each of the following reactivity coefficients are positive or negative for the indicated locations.

a. Void Coefficient of the Flux Trap

b. Void Coefficient of the Core

c. Temperature Coefficient of the Core

d. Temperature Coefficient of the Pool

e. Temperature Coefficient of the Flux Trap

QUESTION C.17 [1.0 point]
Mechanical strain when shifting Cooling Tower Fans from fast to slow speed is minimized by …

a. a delay timer allowing the fan to coast down (about 20 seconds), before the slow speed windings energize.

b. a large torsion spring designed to absorb the shock of energizing the slow speed windings.

c. the use of special fan belts designed to absorb the shock of energizing the slow speed windings.

d. a directed spray of coolant aiding in the slowing down of the fans.

QUESTION C.18 [1.0 point]
Just prior to withdrawing control rods with all process control systems on line, the Master Control Switch (1S1) is taken from the **ON** position to the **OFF** position. Which **ONE** of the following conditions will result?

a. All systems will shut down.

b. All systems will remain running, but without automatic operation.

c. The system is mechanically interlocked and you cannot move 1S1 to the off position with all systems running.

d. All systems will remain running with all automatic functions operable.

A.1 a, alpha; b, neutron; c, gamma; d, Beta
Ref: Reference 1, Volume 1, Module 1, *Modes of Radioactive Decay*, pp. 22–29.

A.2 d
Ref: Reference 1, Volume 1, Module 2, *Neutron Moderation*, p. 23.

A.3 b
REF: The temperature increase will result in a change in reactivity of: -2.5×10^{-4}) K/K/°C × 50°C = -1.25×10^{-2}) K/K. Since the temperature rise results in a negative reactivity insertion, the control rod will need to drive out to add positive reactivity. D = (1.25×10^{-2}) K/K) ÷ (5.895×10^{-3}) K/K/inch) = 2.12 inches. Reference 1, Volume 2, Module 3, *Reactivity Coefficients,* p. 48.

A.4 b
Ref: Reference 1, Volume 1, Module 1, *Energy Release from Fission*, p. 56.

A.5 c
Ref: Reference 1, Volume 2, Module 3, *Neutron Life Cycle*, p. 3.

A.6 c
Ref: Reference 1, Volume 1, Module 2 *Reaction Rate*, p. 18.

A.7 b
Ref: Reference 1, Volume 2, Module 4, *Subcritical Multiplication*, p. 1.

A.8 d
Ref: Reference 1, Volume 1, Module 2, *Interaction of Radiation with Matter*, p. 65.

A.9 a 0.1 × 3.79 = 0.379 0.9 × 0.23 = 0.207 0.1 × 7.9 = 0.79 0.9 × 1.49 = 1.34
Ref: Reference 1, Volume 1, Module 2

A.10 a
Ref: This term is NOT defined in reference 1, but is a Technical Specification Requirement.

A.11 b
Ref: Reference 1, Volume 2, Module 4, *Effective Delayed Neutron Fraction*, p. xx

A.12 a
Ref: Reflectors are not discussed in reference 1, however, the MURR is extremely dependent on the presence of its reflectors. This question is from the NRC Examination Question Bank.

A.13 d
Ref: Reference 1, Volume 1, Module 2, *Nuclear Cross-Sections and Neutron Flux*, p. 5.

A.14 a
Ref: Reference 1, Volume 2, Module 3, *Production and Removal of Xenon*, p. 35

A.15 b
Ref: Reference 1, Volume 1, Module 2, *Reactor Operation*, p. 31.

A.16 d
Ref: Reference 1, Volume 2, Module 3, *Neutron Life Cycles*, pp. 3–9.

A.17 c
Ref: Reference 1, Volume 2, Module 3, *Fixed Burnable Poisons*, o, 30.

A.18 c
Ref: Standard NRC Question

A.19 c
Ref: Standard NRC Question

Reference 1: *DOE FUNDAMENTALS HANDBOOK, Nuclear Physics and Reactor Theory, DOE-hdbk-1019/193*

B.1 b
REF: T.S. § A *Definitions*

B.2 a, 20 b, 1 c, 1 d, 10
REF: 10CFR20.100x

B.3 a, 0.02; b, 0.006; c, 0.098; d, 0.006; e, 0.001; f, 0.0025
REF: Technical Specifications § 3.1 Reactivity Specifications e, f, g, h, i, and j.

B.4 d
REF: AP-RO-110, Conduct of Operations § 6.6.7.b, p. 16.

B.5 c
REF: AP-RO-110, Conduct of Operations § 6.5,3,d, p. 10.

B.6 b
REF: Reference AP-HP-105 NOT PROVIDED. Question is from Examination Bank.

B.7 c
Ref: Technical Specifications § 5.6 *Auxiliary Systems*.

B.8 c
Ref: 10 CFR 50.54(x)

B.9 a, DBL; b, NA; c, NSR; d, HEPA
Ref: Technical Specification 3.8. j, m, d and o.

B.10 d
REF: MURR Technical Specifications, Section 3.3.a bases.

B.11 c
REF: MURR Technical Specifications, Section 3.10.a.

B.12 c
REF: MURR Technical Specifications, Section 3.2.c.

B.13 b
REF: OP-RO-340

B.14 a
REF: REP-21

B.15 c
REF: OP-RO-410, *Primary Coolant System.*

B.16 a
REF: OP-RO-531, Primary and Pool Sample Station

B.17 a. 4 b. 2 c. 1 d. 3
REF: Standard NRC Question

B.18 c
REF: Rewrite of NRC examination question administered January 1989. Also SOP/I-5. NOTE This SOP/I-5 is no longer in use.

C.1 a
REF: Training Manual for Reactor Operations, page I.5.1.

C.2 b
REF: Training Manual for Reactor Operations, page I.11.2.

C.3 a
REF: Facility Requalification Examination (11/17/93)

C.4 c
REF: OP-RO-410, *Primary Coolant System*, § 6.0 Caution

C.5 d
REF: Training Manual for ROs, § II.14 *Rod Control System*

C.6 d
REF: Training Manual for Reactor Operations, page II.5.2.

C.7 b
REF: Reactor Operator Training Manual, § I.4 Clean-up Systems, p. I.4.1 3rd ¶

C.8 b
REF: Reactor Operator Training Manual § II.

C.9 a
REF: Reactor Operator Training Manual, § I.11, Containment Building Exhaust System p. I.11.1, 2nd ¶.

C.10 c
REF: Reactor Operator Training Manual, § II.14, p. II

C.11 b
REF:

C.12 a, 4R; b, 6R; c, 6T; d, 4T; e, 6R; f, 4R
REF: Rewrite of facility supplied question, Plant and Radiation Monitoring Systems, #32.

C.13 a
REF: RO Training Manual § II.

C.14 d
REF: Drawing # 79, HSR § 9.5 Startup Interlocks, Training Manual for ROs § II.14.A Rod Control System/Shim-Safety Rod Control, p. II

C.15 a, 2; b, 2; c, 2; d, 2; e, 2; f, 1; g, 1; h, 4
REF: MURR Facility prepared Requalification Examination administered 11/93. Note: this question has a new answer key, additional information will be provided to the NRC to reflect updated facility equipment.

C.16 a. positive b. negative c. negative d. positive e. positive
REF: MURR Hazards Summary Report, p. 4-14.,SOP/VIII-7 Critical Parameters List

C.17 a
REF: OP-RO-480, *Secondary Coolant System*, § 6.2 NOTE.

C.18 d
REF: MURR Facility prepared Requalification Examination administered 11/93.