September 2, 2008

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

SUBJECT: INITIAL EXAMINATION REPORT NO. 50-186/OL-08-03, UNIVERSITY OF MISSOURI-COLUMBIA REACTOR

Dear Mr. Butler:

During the week of August 4, 2008, the NRC administered an operator licensing examination at your University of Missouri-Columbia Reactor. The examination was conducted according to NUREG-1478, "Operator Licensing Examiner Standards for Research and Test Reactors," Revision 2. 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 Title 10 of the Code of Federal Regulations Section 2.390, 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 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/

Johnny H. Eads, Jr., Chief
Research and Test Reactors Branch B
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Docket No. 50-186

Enclosures: 1. Initial Examination Report No. 50-186/OL-08-30
2. Written examination with facility comments incorporated

cc without enclosures: See next page

September 2, 2008

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DISTRIBUTION w/ encls.:

PUBLIC	PRTB r/f	RidsNRRDPRPRTA
RidsNRRDPRPRTB	Facility File (CHart) O-13 D-07	

ADAMS ACCESSION #: ML082380956 **TEMPLATE #:NRR-074**

OFFICE	PRTB:CE		IOLB:LA	E	PRTB:SC	
NAME	PDoyle		CHart		JEads	
DATE	08/29/2008		08/29/2008		08/ /2008	

OFFICIAL RECORD COPY

cc:

University of Missouri
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Office of Administration
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Jefferson City, MO 65101

Test, Research, and Training
Reactor Newsletter
University of Florida
202 Nuclear Sciences Center
Gainesville, FL 32611

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

REPORT NO.: 50-186/OL-08-03

FACILITY DOCKET NO.: 50-186

FACILITY LICENSE NO.: R-103

FACILITY: University of Missouri-Columbia Research Reactor (MURR)

EXAMINATION DATES: August 4 – 5, 2008

SUBMITTED BY: /RA/ 8/29/08
Paul V. Doyle Jr., Chief Examiner Date

SUMMARY:
During the week of August 4, 2008, the NRC administered operator licensing examinations to two reactor operator candidates. Both candidates passed all portions of the examination.

REPORT DETAILS

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

2. Results:

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

3. Exit Meeting:
   Paul V. Doyle Jr., Examiner, NRC
   Leslie, Foyto, Reactor Manager, MURR
   Robert Hudson, Assistant Reactor Manager for Training, MURR
   Carl Herbold, Assistant Reactor Manager for Engineering, MURR

The examiner thanked the facility for their support in the administration of examinations. He also reminded facility staff to submit their written examination comments as soon as practical. The facility comments along with NRC resolutions are included as enclosure 2 to this report.

ENCLOSURE 2

FACILITY COMMENTS AND NRC RESOLUTIONS.

Robert A. Hudson
Training Coordinator – Reactor Operations
University of Missouri Research Reactor
Columbia, Mo 65211
HudsonRA@missouri.edu or (573) 882-5318

MURR OPERATIONS

Mr. Doyle,

We have reviewed the written portion of the licensing examination administered at MURR on 8/5/08; and submit the following comments for your consideration:

Question A.06

Which ONE of the following is the definition of REACTIVITY?

Comment: The answer key indicates no answer. Our review indicates the correct answer should be 'B', a measure of the core's deviation from criticality.

Reference: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory

Question A.12

A thin foil target of 10% copper and 90% aluminum is in a thermal neutron beam. Given $\sigma_{a\ Cu}$ = 3.79 barns, $\sigma_{a\ Al}$ = 0.23 barns, $\sigma_{s\ Cu}$ = 7.90 barns, and $\sigma_{s\ Al}$ = 1.49 barns, which ONE of the following reactions has the highest probability of occurring? A neutron …..

Comment: The answer key indicates item '2' to be the correct answer. Our review indicates the correct answer should be 'A', scattering reaction with aluminum (90% x 1.49 = 1.34).

Reference: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory

Question B.01

Which ONE of the following situations would illustrate a time when the reactor is shutdown but ***NOT*** secured?

Comment: The answer key indicates item 'C' to be the correct answer. Our review indicates the correct answer should be 'A', due to work is in progress involving the control rods or control rod drives.

Reference: Technical Specifications – Definitions, 1.20 Reactor Secured
Technical Specifications – Definitions, 1.21 Reactor Shutdown

Question B.15

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).

Comment: The answer key indicates items 'C' and' D' to be Safety Limits (SL). Our review of references indicates the correct answer for both should be Limiting Condition for Operation (LCO).

Reference: Technical Specifications – Limiting Conditions for Operation, Reactivity 3.1.e
Technical Specifications – Limiting Conditions for Operation, Coolant System 3.9.a.1

Question C.08

The reactor has been operating for six days straight at full power when the facility has a complete loss of power. How is damage to the fuel prevented?

Comment: The answer key indicates no answer. Our review indicates the correct answer should be 'B', two air operated valves fail open due to a loss of electrical power, lining up the primary to an in-pool heat exchanger.

Reference: Hazard Summary Report, Addendum 5, Section 2.4.1 – Loss of Commercial Power with the Reactor Operating at 10MW and the Emergency Diesel Fails to Start.

Question C.09

In addition to its primary function to supply gas used for the pressurizer, the N_2 system is used …

Comment: The answer key indicates item 'A' to be the correct answer. Our review indicates there to be NO correct answer. Previous nitrogen system modifications removed the connection to provide backup to the valve operating system.

Reference: Modification Package 92-1 "Valve Operation Air Compressor"

Question C.16

Which ONE of the following conditions will cause Secondary Coolant Pump SP 4 to stop?

Comment: The answer key indicates item 'C' to be the correct answer. Our review indicates there to be NO correct answer. Previous secondary coolant system modifications removed all automatic functions associated with secondary coolant pump SP-4.

Reference: Modification Package 04-5 "Cooling Tower Electrical Upgrade Project"

Question C.17

Identify whether each of the following valves fails OPEN or SHUT?

Comment: The answer key indicates item 'D' to fail OPEN. Our review indicates the DEMIN Inlet Isolation Valve (527E) will fail SHUT. The references used to develop the question do indicate the valve would open; however, the references are incorrect. We are in the process of making the necessary corrections to the references.

Please contact me if you would like additional information or have any questions,

Thank You Again
Rob Hudson

NRC RESOLUTION

Question A.06: Resolution: Added ‘b’ as answer on answer key.

Question A.12: Resolution: Changed answer key from ‘2’ to ‘a’.

Question B.01: Resolution: Changed answer key from ‘c’ to ‘a’.

Question B.15c: Resolution: Changed answer key from ‘SL’ to ‘LCO’.

Question B.15d: Resolution: Changed answer key from ‘SL’ to ‘LCO’.

Question C.08: Resolution: Added ‘b’ as answer on answer key.

Question C.09: Resolution: Question deleted per facility comment.

Question C.16: Resolution: Question deleted per facility comment.

Question C.17: Resolution: Changed answer key from ‘OPEN’ to ‘SHUT’.

OPERATOR LICENSING EXAMINATION

With Corrected Answer Key

UNITED STATES NUCLEAR REGULATORY COMMISSION

UNIVERSITY OF MISSOURI-COLUMBIA

AUGUST 04, 2008

ENCLOSURE 3

QUESTION A.01 [2.0 points, ½ each]

Using the drawing of the Integral Rod Worth Curve provided, identify each of the following reactivity worths.

a. Total Rod Worth	1. B - A
b. Actual Shutdown Margin	2. C - A
c. Technical Specification Shutdown Margin Limit	3. C - B
d. Excess Reactivity	4. D - C
	5. E - C
	6. E - D
	7. E - A

QUESTION A.02 [1.0 point]

Reactor power is rising on a 30 second period. Approximately how long will it take for power to double?

a. 35 seconds

b. 50 seconds

c. 70 seconds

d. 100 seconds

QUESTION A.03 [2 points, ½ each]

Match the description of plant conditions in column A with resulting xenon conditions in column B.

Column A	Column B
a. 4 hours after a power increase from half power to full power	1. Xenon concentration is increasing to a peak
b. 2 hours after a power decrease from full power to half power	2. Xenon concentration is decreasing to a trough
c. 16 hours after a "clean" startup to full power	3. Xenon concentration is approximately zero (reactor is "clean")
d. 72 hours after a shutdown from full power	4. Xenon concentration is "relatively" steady at a "non-zero" value

QUESTION A.04 [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.05 [1.0 point]
The neutron microscopic cross-section for absorption (σ_a) of an isotope generally …

a. increases as neutron energy increases

b. decreases as neutron energy increases

c. increases as target nucleus mass increases

d. decreases as target nucleus mass increases

QUESTION A.06 [1.0 point]
Which ONE of the following statements is the definition of REACTIVITY?

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

b. A measure of the core's deviation from criticality.

c. Equal to 1.00 ΔK/K when the reactor is critical.

d. Equal to 1.00 ΔK/K when the reactor is prompt critical

QUESTION A.07 [2.0 points, ½ 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.08 [1.0 point]
With the reactor on a constant period, which of the following changes in reactor power would take the **LONGEST** time?

a. 5% — from 1% to 6%

b. 15% — from 20% to 35%

c. 20% — from 40% to 60%

d. 25% — from 75% to 100%

QUESTION A.09 [1.0 point]
You are assigned to check the operation of a new nuclear instrumentation channel. You know that the reactor will stabilize with a - 80 second period shortly after shutdown. To check the channel you measure the time for power to decrease by a factor of 10. This time should be approximately…

a. 45 seconds (¾ minute)

b. 90 seconds (1-½ minutes)

c. 135 seconds (2-¼ minutes)

d. 180 seconds (3 minutes)

QUESTION A.10 [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.

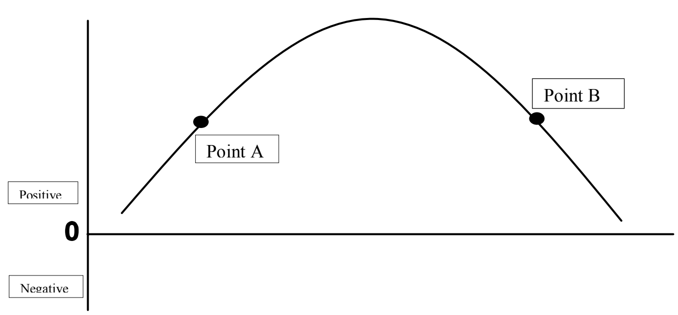
QUESTION A.11 [1.0 point]
Shown below is a trace of reactor period as a function of time. Between points A and B reactor power is:

a. continually increasing.

b. continually decreasing.

c. increasing, then decreasing.

d. constant.



QUESTION A.12 [1.0 point]

A thin foil target of 10% copper and 90% aluminum is in a thermal neutron beam. Given $\sigma_{a\ Cu}$ = 3.79 barns, $\sigma_{a\ Al}$ = 0.23 barns, $\sigma_{s\ Cu}$ = 7.90 barns, and $\sigma_{s\ Al}$ =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.13 [1.0 point]

Which ONE of the reactions below is an example of a **PHOTONEUTRON** source?

a. ${}_1H^2 + {}_0\gamma^0 \rightarrow {}_1H^1 + {}_0n^1$

b. ${}_{92}U^{238} \rightarrow {}_{35}Br^{87} + {}_{57}La^{148} + 3{}_0n^1 + {}_0\gamma^0$

c. ${}_{51}Sb^{123} + {}_0n^1 \rightarrow {}_1H^1 + {}_0\gamma^0$

d. ${}_4Be^9 + {}_2\alpha^4 \rightarrow {}_6C^{12} + {}_0n^1$

QUESTION A.14 [1.0 point]

ELASTIC SCATTERING is the process by which a neutron collides with a nucleus and …

a. recoils with the same kinetic energy it had prior to the collision

b. recoils with less kinetic energy than it had prior to the collision with the nucleus emitting a gamma ray.

c. is absorbed, with the nucleus emitting a gamma ray.

d. recoils with a higher kinetic energy than it had prior to the collision with the nucleus emitting a gamma ray.

QUESTION A.15 [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.16 [1.0 point]
You enter the control room and note that all nuclear instrumentation channels 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.01 [1.0 point]
Which ONE of the following situations would illustrate a time when the reactor is shutdown but ***NOT*** secured?

a. One of the shim rod drives is removed for inspection; the rod is decoupled and is fully inserted into the core, all other shim rods are fully inserted and the console key is in the 'off' position and removed.

b. All shim rods are fully inserted; the console key is in the 'off' position and removed, while fuel is being rearranged in the fuel storage racks.

c. The shim rods are withdrawn to a subcritical position, the core is subcritical by $1.20.

d. An experiment having a reactivity of 50¢ is installed in the central thimble with all shim rods fully inserted and the key removed.

QUESTION B.02 [1.0 point]
You are the reactor operator performing a reactor startup to 10 Mw. New experiments were placed in the beamports during the shutdown. 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.03 [1.0 points, ¼ each]
Match the terms in column A with their respective definitions in column B.

	Column A		Column B
a.	Radioactivity	1.	The thickness of a material which will reduce a gamma flux by a factor of two.
b.	Contamination	2.	An impurity which pollutes or adulterates another substance. In radiological safety, contamination refers to the radioactive materials which are the sources of ionizing radiations.
c.	Dose	3.	The quantity of radiation absorbed per unit mass by the body or by any portion of the body.
d.	Half-thickness	4.	That property of a substance which causes it to emit ionizing radiation. This property is the spontaneous transmutation of the atoms of the substance.

QUESTION B.04 [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.05 [1.0 point]
Many research reactors use different methods to reduce the dose due to N^{16} at the pool top. If the method used keeps the N^{16} ten (10) feet below the surface of the water, and a half-thickness for the N^{16} gamma(s) is one foot for water, then the dose due to N^{16} is reduced (approximately) by a factor of … (Note: Neglect any reduction in dose rate due to half-life.)

a. 20

b. 100

c. 200

d. 1000

QUESTION B.06 [1.0 point, ¼ each]
Match type of radiation (a thru d) with the proper penetrating power (1 thru 4)

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.07 [2.0 points, ½ 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

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

d. At the peak will contain 10 millicuries of Strontium 90 (Sr^{90}).

QUESTION B.08 [1.0 point, ¼ each]
Identify the PRIMARY source (irradiation of air, irradiation of water, or fission product) of EACH of the radioisotopes listed.

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

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

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

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

QUESTION B.09 [1.0 point]
With the exception of routine 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.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 [1.0 point]
Which **ONE** of the following Reactor Emergencies would require you to insert a manual rod run-in as an immediate action?

a. Failure of experimental apparatus

b. High radiation levels

c. Nuclear instrumentation failure

d. Control rod drive failure/stuck rod

QUESTION B.12 [1.0 point]
Which ONE of the following statements correctly describes the relationship between the Safety Limit (SL) and the 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 actions to preclude reading 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.13 [1.0 point]
Monday morning maintenance has been completed. A **Long Form** Startup Checksheet was completed at 08:00 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, and the reactor was shutdown at 19:00. The fan had a loose wire which was quickly found and corrected. Both the off-going and on-coming LSROs agree that systems and instrumentation covered by the **Long Form** startup Checksheet have NOT been adversely affected during the shutdown. Due to the late hour (19:30) the startup will be delayed until after shift change at 20:00 pm. Which ONE of the following statements is correct? Because of the …

a. LSRO determination and the fact that the reactor was shutdown less than 2 hours, you may startup **without** completing a startup checksheet.

b. fact that the time since the the shutdown is less than 2 hours regardless of the LSRO determination, you must perform a **Short Form** startup checksheet prior to startup.

c. fact that the time since the last **Long Form** Startup Checksheet is greater than 8 hours regardless of the LSRO determination, you must perform a **Long Form** Startup Checksheet prior to startup.

d. fact that the last **Long Form** Startup Checksheet was preformed by a different shift crew a new **Long Form** Checksheet must be performed.

QUESTION B.14 [1.0 point]
You are operating the reactor when it scrams (unscheduled). After looking for hours neither you nor the SRO, nor the shift supervisor can find the reason for the scram. Which one of the following conditions must be met to restart the reactor?

a. You may NOT startup the reactor under any conditions until the cause of the scram is found and corrected.

b. You may startup the reactor if authorized by any Senior Reactor Operator.

c. You may startup the reactor if authorized by the designated Shift Supervisor.

d. You may startup the reactor if authorized by the Reactor Manager.

QUESTION B.15 [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. Reactor Inlet Temperature 155°F (Maximum)

b. Primary Coolant Flow, 1625 gpm either Loop (Minimum)

c. The reactor shall be subcritical by a margin at least 0.02 ΔK with any one shim blade fully withdrawn.

d. The reactor shall not be operated … unless the following are operable: The Siphon Break System

QUESTION B.16 [1.0 point]

You initially remove a sample from the pool reading 1 R/hr at 30 cm from the source. You then replace the sample in the pool. An hour later you remove the sample and the reading is now 390 mR/hr at 30 cm. You again replace the sample back in the pool. How much longer should you wait to be able to bring out the sample without generating a high radiation area?

a. ½ hour

b. 1 hour

c. 1½ hours

d. 2 hours

QUESTION B.17 [1.0 point]

Samples irradiated using the pneumatic tube system should be limited to an activity level of …

a. 10 mCi

b. 25 mCi

c. 50 mCi

d. 75 mCi

QUESTION B.18 [1.0 point]

You are relieving the watch. The previous operating crew consisted of a licensed Senior Reactor Operator and a knowledgeable person. Which ONE of the following statements is true?

a. This is a violation of technical specifications.

b. This is allowed by technical specifications, but is not allowed by AP-RO-110 *Operations*.

c. This is allowed by technical specifications, and is allowed by AP-RO-110 *Operations*, during emergencies, for a minimum amount of time.

d. This is unconditionally allowed by both technical specifications, and AP-RO-110 *Operations*.

QUESTION C.01 [2.0 points, ½ each]

Match the purification system conditions listed in column A with their respective causes listed in column B. Each choice is used only once. Higher than normal …

	Column A		Column B
a.	Radiation Level at demineralizer.	1.	Channeling in demineralizer.
b.	Radiation Level downstream of demineralizer.	2.	Fuel element failure.
c.	flow rate through demineralizer.	3.	High temperature in demineralizer system
d.	pressure upstream of demineralizer.	4.	Clogged demineralizer

QUESTION C.02 [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.03 [1.0 point]

Which one of the following correctly describes the operation of a Thermocouple?

a. A bi-metallic strip which winds/unwinds due to different thermal expansion constants for the two metals, one end is fixed and the other moves a lever proportional to the temperature change.

b. a junction of two dissimilar metals, generating a potential (voltage) proportional to temperature changes.

c. a precision wound resistor, placed in a Wheatstone bridge, the resistance of the resistor varies proportionally to temperature changes.

d. a liquid filled container which expands and contracts proportional to temperature changes, one part of which is connected to a lever.

QUESTION C.04 [1.0 point]

Which ONE of the following is the main function performed by the **DISCRIMINATOR** circuit in the Startup Channel?

a. To generate a current signal equal and of opposite polarity as the signal due to gammas generated within the Startup Channel Detector.

b. To filter out small pulses due to gamma interactions, passing only pulses due to neutron events within the Startup Channel Detector.

c. To convert the linear output of the Startup Channel Detector to a logarithmic signal for metering purposes.

d. To convert the logarithmic output of the metering circuit to a δt (delta time) output for period metering purposes.

QUESTION C.05 [1.0 point]
Which **ONE** of the following is a load supplied by the Emergency Generator?

a. Primary Coolant Isolation Valves 507 A/B

b. Reactor Exhaust System Fan EF-14

c. Ventilation Fan SF-1

d. Primary Pump P501A

QUESTION C.06 [1.0 point]
Which **ONE** of the following materials is **NOT** used as a reflector in the reactor?

a. Beryllium

b. D_2O (Heavy Water)

c. Graphite

d. H_2O (Water)

QUESTION C.07 [1.0 point]
Which ONE of the following Nuclear Instrument Channels has an input into the regulating blade auto control circuit?

a. Channel 1

b. Channel 2

c. Wide Range Monitor

d. Channel 6

QUESTION C.08 [1.0 point]
The reactor has been operating for six days straight at full power when the facility has a complete loss of power. How is damage to the fuel prevented?

a. Two thermally (temperature) actuated valves open allowing steam to escape from the primary system, which is quenched in the pool water.

b. Two air operated valves fail open due to loss of electrical power, lining up the primary to an in-pool heat exchanger. Water flow is via natural convection.

c. Two thermally (temperature) actuated valves open, lining up the primary to an in-pool heat exchanger. Water flow is via natural convection.

d. Two motor operated valves (powered off the diesel) open, lining up the primary to an in pool heat exchanger.

QUESTION C.09 [1.0 point]
In addition to its primary function to supply the gas used for the pressurizer, the N_2 system is used …

a. to act as a backup to the air used in the valve operating system.

b. as a cover gas in the pneumatic tube system.

c. as a purge gas for the beam tubes.

d. as a backup to the air used in the antisiphon system.

QUESTION C.10 [1.0 point]
During normal operation a thermal column door open alarm will …

a. have no effect on the operation of the reactor.

b. cause a rod run in.

c. cause a reactor scram.

d. prevent withdrawal of control rods.

QUESTION C.11 [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.12 [1.0 point, ⅓ each]
For each action in Column A select the appropriate pressurizer system setpoint 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.	63 psig
		2.	66.5 psig
b.	Nitrogen makeup valve opens	3.	69.5 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.13 [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.14 [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.15 [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

QUESTION C.16 [1.0 point]
Which ONE of the following conditions will cause Secondary Coolant Pump SP 4 to stop?

a. Secondary coolant pump SP 1 is also running, and you start secondary coolant pump SP 2.

b. Secondary coolant pump SP 1 which is also running, fails.

c. Building Supply Fan SF 1, fails.

d. Building Exhaust Fans EF 13 and 14 both fail.

QUESTION C.17 [2.0 point, ½ each]
Identify whether each of the following valves fails OPEN or SHUT.

a. Pressurizer Drain Valve (527A)

b. Vent Tank Vent Valve (552A)

c. Pressurizer Isolation Valve (527C)

d. Demin Inlet Isolation Valve (527E)

QUESTION C.18 [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.

A.01 a, 7; b, 2; c, ~~6~~1; d, 5 Answer key corrected per examiner review
REF: Standard NRC Question

A.02 c
REF: $P = P_0 e^{t/T}$ —> ln(2) = time ÷ 100 seconds –> time = ln (2) x 100 sec. 0.693 x 100 ≈ 0.7 x 100 ≈ 70 sec.

A.03 a, 2; b, 1; c, 4; d, 3
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, Volume

A.04 c
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, Volume

A.05 b
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, Volume

A.6 b Answer added per facility comment.
Ref:

A.07 a, α, b, n; c, γ; d, β^-
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, Volume

A.08 a.
REF: $P = P_0 e^{t/\tau}$ $\ln(P/P_0) = t/\tau$ Since you are looking for which would take the longest time it is obvious to the most casual of observers that the ratio P/P_0 must be the largest.

A.09 d
REF: $P/P_0 = e^{-T/\tau}$ ln(0.1) = - T(time)/τ(-80sec) Time = ln (0.1) × -80 sec = 184 seconds ≈ 3 minutes

A.10 a, 2; b, 4; c, 1; d, 3
REF: Burn, R., Introduction to Nuclear Reactor Operations, 8 1988, " 3.2.2, p. 3 7

A.11 a
REF: Standard NRC Question[1]

A.12 ~~2~~ a Answer changed per facility comment. 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: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, Volume

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

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

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

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

A.17 b
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, Volume

B.01 ~~c~~ a Answer changed per facility comment
REF: Technical Specifications § 1 *Definitions 1.20 Reactor Secured*.

B.02 d
REF: AP-RO-110 *Conduct of Operations* § 6.6.7.

B.03 a, 4; b, 2; c, 3; d, 1
REF: Standard NRC question

B.04 b
REF: AP-HP-105 *Radiation Work Permits*

B.05 d
REF: Basic Radiological Controls knowledge: "Half-Thickness and Tenth-Thickness". $2^{10} = 1024$

B.06 a, 4; b, 2; c, 1; d, 3
REF: Standard NRC Health Physics Question

B.07 a, DBL; b, NA; c, NSR; d, HEPA
REF: Technical Specification 3.6 (j), (m), (d) and (o).

B.08 a, Water; b, Air; c, Water; d, Fission
REF: Standard NRC question.

B.09 c
REF: EX-RO-105 *Reactor Irradiation Experiments*

B.10 d
REF: Standard Health Physics Definition.

B.11 a
REF: REP-RO-100 Reactor Emergency Procedures: REP 12, REP 4, REP 5 and REP-8

B.12 b
REF:

B.13 a
REF: Rewrite of NRC examination question administered January 1989. Also AP-RO-110, § 6.6.2.

B.14 d
REF: AP-RO-110 § 6.6.8

B.15 a, LSSS; b, LSSS; c, ~~SL~~ LCO; d, ~~SL~~ LCO Answers changed per facility comment
REF:

B.16 c
REF: $I_t = I_0 e^{-\lambda t}$ 390 mR/hr ÷ 1000 mR/hr = $e^{-\lambda 1hr}$ ln(0.39) = -λ * 1 hr. λ = 0.9416 $hour^{-1}$ SOLVING for additional time:
$I_f = I_t e^{-\lambda t}$ 100mR/hr = 390 mR/hr $e^{-0.9416\,(time)}$ ln (0.25) = -0.9163 * time time = 1.4454

B.17 b
REF: SOP VIII.3, *Pneumatic Tube (P-tube) System Irradiations, § 3.2, Sample Limitations*

B.18 c
REF: AP-RO-110, *Operations*

C.01 a, 2; b, 3; c, 1; d, 4
Ref: Standard NRC cleanup loop question.

C.02 a
REF: OP-RO-480, *Secondary Coolant System*, § 6.2 NOTE

C.03 b
REF: Standard NRC question

C.04 b
REF: Standard NRC Question

C.05 b.
REF: Technical Specification 4.5. Training Manual for Reactor Operators pp III-3, III

C.06 b
REF: ***Rewrite*** of December 2007 NRC administered question.

C.07 c
REF: Reactor Operator Training Manual, § II.14, p. II

C.08 b Answer added per facility comment.
REF:

C.09 ~~a~~ Question Deleted per facility Comment
~~REF: MURR Training Manual p. III-10 B III-12~~

C.10 d
REF: Rewrite of facility supplied question, Plant and Radiation Monitoring Systems, #86

C.11 b
REF: Reactor Operator Training Manual, §

C.12 a, 6; b, 2; c, 8
REF: MURR Training Manual for Reactor Operators, Section I.3 pp I

C.13 d
REF: Rewrite of facility supplied question, Plant and Radiation monitoring Systems, #28.

C.14 c
REF: NRC examination administered 2003.

C.15 d
REF: Facility Requalification Examination (11/17/93).

~~C.16 c~~ Question Deleted per facility Comment
~~REF: OP-RO-430 Secondary Coolant System, § 3.4~~

C.17 a, S; b, S; c, S; d, ~~O~~ S Answer changed per facility comment.
REF: Reactor Operator Training Manual, § I.5, Valve Operating System, ¶¶ B.6, 8, , 12

C.18 d
REF: Training Manual for ROs, § II.14 Rod Control System