September 10, 2008

Dr. Gunter Kegel, Director
Nuclear Radiation Laboratory
University of Massachusetts — Lowell
One University Avenue
Lowell, MA 01854

SUBJECT: INITIAL EXAMINATION REPORT NO. 50-223/OL-08-01, UNIVERSITY OF MASSACHUSETTS-LOWELL

Dear Dr. Kegel:

During the week of August 25, 2008, the NRC administered an operator licensing examination at your University of Massachusetts- Lowell Research 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. 50-223

Enclosures: 1. Initial Examination Report No. 50-223/OL-08-01
2. Facility Comments on Written examination with NRC resolution
3. Written Examination with comments incorporated

cc without enclosures:
Please see next page

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ADAMS ACCESSION #: ML082530395 **TEMPLATE #:NRR-074**

OFFICE	PRTB:CE		IOLB:LA	E	PRTB:SC	
NAME	PDoyle/PIsaac for		CHart cah		JEads jhe	
DATE	09/09/2008		9/10/08		9/10/08	

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cc:

Mayor of Lowell
City Hall
Lowell, MA 01852

Mr. Leo Bobek
Reactor Supervisor
University of Massachusetts - Lowell
One University Avenue
Lowell, MA 01854

Department of Environmental Protection
One Winter Street
Boston, MA 02108

Director
Radiation Control Program
Department of Public Health
90 Washington Street
Dorchester, MA 02121

Nuclear Preparedness Manager
Massachusetts Emergency Management Agency
400 Worcester Road
Framingham, MA 01702-5399

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.: 50-223/OL-08-01

FACILITY DOCKET NO.: 50-223

FACILITY LICENSE NO.: R-125

FACILITY: University of Massachusetts-Lowell Research Reactor

EXAMINATION DATES: August 25 – 26, 2008

SUBMITTED BY: **/RA/** August 29, 2008
Paul V. Doyle Jr., Chief Examiner Date

SUMMARY:

During the week of August 25, 2008 the NRC administered operator licensing examinations to two reactor operator candidates at the University of Massachusetts-Lowell Research Reactor. Both candidates passed all portions of their examinations.

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., NRC, Examiner
   Leo Bobek, University of Massachusetts-Lowell, Reactor Supervisor

During the exit meeting the examiner thanked Mr. Bobek for his support in the administration of the examination and Mr. Bobek presented his comments on the written examination which is included as Enclosure 2 to this Examination Report.

ENCLOSURE 2

FACILITY COMMENTS

AND

NRC RESOLUTIONS

University of Massachusetts
UMASS Lowell

Pinanski Building
One University Avenue
Lowell, Massachusetts 01854
tel: 978.934.3365
fax. 978.934.4067
e-mail: Leo_Bobek@uml.edu

Leo M. Bobek
Reactor Supervisor

RADIATION LABORATORY

August 25, 2008

Mr. Paul Doyle
M/S 0-12 G-15
USNRC
Washington, D.C. 20555

Dear Mr.Doyle:

Thank you for performing the licensing examination during the week of August 25.

Regarding the written portion of the examination, the following comments are submitted for your review:

Question A.12: The answer sheet indicates the answer is "2". The answer should indicate (a) - "scattering reaction with aluminum".

Question B.4: All the answers as provided are true and each is specified in the procedure.

Question B.12: Answer key is correct. There is a typo in answer (b). "Reading" should be changed to "reaching".

If you should require additional information, please let me know. Thank you again for your efforts in providing this examination.

Sincerely,

Leo M. Bobek

NRC RESOLUTIONS

All comments accepted as written. Examination included as Enclosure 3 incorporates all comments.

OPERATOR LICENSING EXAMINATION

With Answer Key

UNIVERSITY OF MASSACHUSETTS-LOWELL

AUGUST 25, 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

b. Actual Shutdown Margin

c. Technical Specification Shutdown Margin Limit

d. Excess Reactivity

1. B - A
2. C - A
3. C - B
4. D - C
5. E - C
6. E - D
7. E - A

QUESTION A.02 [1.0 point]

Reactor power is rising on a 100 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]

A reactor contains three safety rods and a control rod. Which one of the following would result in a determination of the excess reactivity of this reactor?

a. The reactor is critical at a low power level, with all safety rods full out and the control rod at some position. The reactivity remaining in the control rod (i.e. its rod worth from its present position to full out) is the excess reactivity.

b. The reactor is shutdown. Two safety rods are withdrawn until the reactor becomes critical. The total rod worth withdrawn is the excess reactivity.

c. The reactor is at full power. The total worth of all rods withdrawn is the excess reactivity.

d. The reactor is at full power. The total worth remaining in all the safety rods and the control rod (i.e. their worth from their present positions to full out) is the excess reactivity.

QUESTION A.07 [1.0 point]

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]

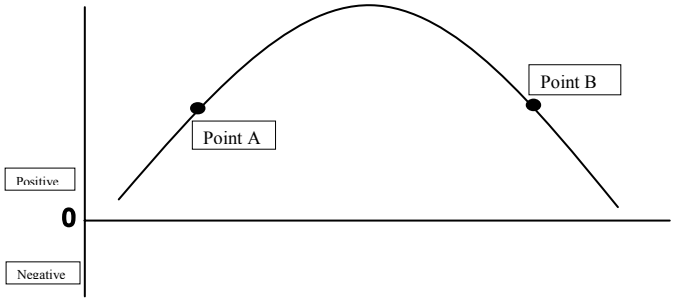
Shown below is a trace of reactor period as a function of time. Between points A and B reactor power is:

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 A.17 [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 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]

According to EO-7 Stuck Rod of Safety Blade, which ONE of the following is the console operator's primary responsibility?

a. Maintain power level constant.

b. To unstick the stuck rod.

c. To run the unstuck blades and regulating rod in.

d. To determine the cause of the stuck rod.

QUESTION B.03 [2.0 points, ½ 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.
e. 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] Question Deleted per facility comment.

~~Which ONE of the following statements concerning crane operations is NOT true?~~

~~a. Loads may NOT be lifted over the stall pool.~~

~~b. Fuel shipping casks may be lowered into the bulk pool provided the gate is in place in the stall pool.~~

~~c. Loads may be attached to the load block hook using slings.~~

~~d. Side pulls (dragging) is not allowed.~~

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 [2.0 points, ½ 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 NRC approval, or is Not Authorized (NA).

a. Corrosive Materials

b. The surface temperature of a submerged experiment exceeds 90°C (194°F)

c. A newly installed experiment significantly affects critical rod height.

d. Less than 25 mg of nitroglycerine. Out-of-core test indicate that, with the containment provided, no damage to the explosive containers, the reactor or the reactor components shall occur upon detonation of the explosive.

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]

According to the Safety Analysis Report (SAR), which ONE of the following locations has the potential of generating the greatest amount of Ar^{41}?

a. Thermal Column Case Vent

b. Beam Port

c. Pneumatic Tube

d. Primary Coolant (Pool)

QUESTION B.10 [1.0 point]

The **CURIE** content of a radioactive source is a measure of

a. the number of radioactive atoms in the source.

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

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

d. the number of nuclear disintegrations per unit time.

QUESTION B.11 [2.0 points, ½ each]

Identify the modes [Forced Convection (above 0.1 Mw) (FC), Natural Convection (NC), Cross-Pool flow pattern (CP) or Down-Comer flow pattern (DC), or all modes (ALL)] for which each of the following scrams is required to be operational. (Modes may be used more than once or not at all.)

a. Pool level 2'3" above centerline of core.

b. Either Coolant Riser Gate or Downcomer Gate opens

c. Coolant Inlet Temperature 108□F

d. Manual Scram button

QUESTION B.12 [1.0 point] Part b corrected per facility comment

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~~ 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.13 [1.0 point]

Which ONE of the following is the maximum reactivity of a rabbit sample which may be inserted by someone who does NOT have an operator (RO or SRO) license?

a. 0.01 % Δk/k

b. 0.02 % Δk/k

c. 0.10 % Δk/k

d. 0.20 % Δk/k

QUESTION B.14 [1.0 point]

Which **ONE** of the following conditions regarding experiments is not allowed under **ANY** condition? The experiment …

a. contains cryogenic liquids.

b. contains 2.1 milligrams of explosive material

c. causes a reduction in the reading for the startup channel.

d. causes the outside temperature of a submerged material to reach 90°C (176°F)

QUESTION B.15 [1.0 point]

Which ONE of the following is the definition of Committed Dose Equivalent?

a. The sum of the deep dose and the committed effective dose equivalent.

b. The dose equivalent that the whole body receives from sources outside the body.

c. The sum of external deep dose equivalent and the organ dose equivalent.

d. The 50 year dose equivalent to an organ or tissue resulting from an intake of radioactive material.

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 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 [2.0 point, ⅓ each]

Identify whether the following scrams are ENABLED or DISABLED after placing the Power Level selector switch (7S5) in the "0.10 MW" position.

a. Primary low flow.

b. Pool high temperature

c. Core inlet high temperature.

d. Bridge Movement

e. Coolant gates open. (Riser and downcomer).

f. Thermal Column Door

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]

Using the drawing of the primary system provided, which ONE of the following valves will cause a scram if the valve is opened (moved off closed seat)?

a. P-1

b. P-9

c. P-11

d. P-12

QUESTION C.06 [1.0 point]

Which one of the following combinations of detector alarms would cause you to activate the "Limited Radiation Emergency Alarm"?

a. Stack Monitor (A) and Bridge Monitor (K).

b. Reactor Constant Air Monitor (C) and Fission Product Monitor (E).

c. Facilities Exhaust Monitor (F) and Pump Room Monitor (P).

d. Bridge Monitor (K) and Control Room Monitor (R).

QUESTION C.07 [1.0 point]

The baffles in the holdup tank are designed to allow which two isotopes time to decay?

a. ${}_1H^3$ and ${}_6C^{14}$

b. ${}_1H^3$ and ${}_7N^{16}$

c. ${}_6C^{14}$ and ${}_8O^{19}$

d. ${}_7N^{16}$ and ${}_8O^{19}$

QUESTION C.08 [1.0 point]

After placing the ***MASTER SWITCH*** in the **ON** position, a warning bell sounds. Which ONE of the following is the correct method for resetting the alarms on the *SCAM PANEL* for this condition?

a. Press the ***SCRAM RESET*** button then the ***ANNUN RESET*** button.

b. Place the ***MASTER SWITCH*** in the **TEST** position, then back to the **ON** position.

c. Wait approximately 10 seconds for the warning bell to stop, then press the ***SCAM RESET*** button.

d. Press the ***ANNUN RESET*** button, then the ***ANNUN ACKN*** button on the *SCAM PANEL.*

QUESTION C.09 [2.0 points, ½ each]

Match each of the control blade rod withdrawal interlocks (column A) with its corresponding set point (column B).

Column A	Column B
a. Low source count rate - ___ cps.	3
b. Short Period - ___ seconds.	5
c. Low flux - ___ %	7
d. Time delay block after "reactor startup" - ___ seconds.	10
	15
	20
	30

QUESTION C.10 [1.0 point]

The purpose of the thermal column is to …

a. enhance heat transfer characteristics of the core.

b. enhance natural convection flow.

c. provide a thermal temperature rise for experiments.

d. provide a thermal neutron flux for experiments.

QUESTION C.11 [1.0 point]

You are performing a reactor shutdown and notice that the source range instrument does not come on scale until **AFTER** the intermediate range instrumentation went off-scale low. Select the cause for the lack of overlap.

a. Source range high voltage is de-energized.

b. Source range high voltage is set too high.

c. Intermediate range compensating voltage is set too low.

d. Intermediate range compensating voltage is set too high.

QUESTION C.12 [2.0 points, ½ each]

Match each of the electrical loads listed in column A with its electrical source listed in column B. (Each load has only one answer. Items in column may be used more than once or not at all.)

Column A	Column B
a. Secondary Pump	1. Motor Control Center #l;
b. Pneumatic tube system blower	2. Motor Control Center #2;
c. Exhaust Blower EF-12	3. PPL-R1
d. Emergency Exhaust EF-14	4. ELPL-Rl

QUESTION C.13 [1.0 point]

Fan EF-14 has an extra component in the bank of filters in its suction. Which ONE of the following is the extra filter component? (NOTE: A diagram of the ventilation system is in the handout.)

a. Carbon filter

b. HEPA filter

c. Absolute Filter

d. Roughing Filter

QUESTION C.14 [1.0 point]

Fans 3, 4, 5 and 6 are all rated at 600 cpm except… (NOTE: A diagram of the ventilation system is in the handout.)

a. # 3, Thermal Column/Beamports & Medical Embedment Drain line vent

b. # 4, Pneumatic Tubes Exhaust

c. # 5, Hot Cell

d. # 6, Gamma Cave

QUESTION C.15 [1.0 point]

You are instructed to place the core in the #1 position and align the core for minimum vibration (induced by flow). Select the position and mode of cooling for the core.

	Position	**Flow Alignment**
a.	Bulk Pool	downcomer mode
b.	Stall Pool	cross-stall mode
c.	Bulk Pool	cross-stall mode
d.	Stall Pool	downcomer mode

QUESTION C.16 [1.0 point]

Which ONE of the following is the reason that city water is brought into an open tank?

a. To allow for off-gassing prior to feeding the water into the makeup demineralizer.

b. to allow for addition of chemicals prior to feeding the water into the makeup demineralizer

c. to create a physical break so that potentially contaminated primary water does NOT have a flow path back into the city water system.

d. to allow sediment to settle on the bottom of the tank prior to feeding the water into the makeup demineralizer.

A.01 a, 7; b, 2; c, ~~6~~ 1; d, 5 Answer 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.06 a
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, Vol.

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)/τ(-80sec) Time (t) = ln (0.1) × -80 sec = 184 seconds ≈ 3 minutes

A.10 a, 2; b, 4; c, 1; d, 3
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, Volume

A.11 a
REF: Standard NRC Question

A.12 ~~2~~ a Answer corrected per facility comment.
$0.1 \times 3.79 = 0.379$ $0.9 \times 0.23 = 0.207$ $0.1 \times 7.9 = 0.79$ $0.9 \times 1.49 = 1.34$
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, 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
REF: Technical Specifications § 1 *Definitions 1.18 Reactor Secured & 1.19 Reactor Shutdown*.

B.02 c
REF: EO-7, also NRC Exams administered 8/3/88 & 11/16/98

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

B.04 a Question Deleted per facility comment.
REF: NRC Exam 1/27/98 and SP-21.

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, NSR; c, NA; d, NRC
REF: Technical Specification 3.6 *Limitations of Experiments*

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

B.09 b
REF: SAR pp. 3-18 and 7-2.

B.10 d
REF: Standard Health Physics Definition.

B.11 a, NC; b, DC; c, FC; ALL
REF: T.S. § 3.3, table

B.12 b
REF:

B.13 b
REF: RO-4, §§ 4.1.5 & 4.1.6.

B.14 c
REF: T.S. § 3.6, specifications 3, 5, 7 and 8.

B.15 d
REF: 10CFR20.1003 Definitions

B.16 c
REF: $I_t = I_0 e^{-\lambda t}$ 390 mR/hr ÷ 1000 mR/hr = $e^{-\lambda 1 hr}$ $\ln(0.39) = -\lambda * 1$ hr. $\lambda = 0.9416$ 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 * t t = 1.4454

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

C.02 a, D; b, E; c, D; d, E; e, D; f, E;
REF: ULR Technical Specifications, § 3.3. R.0.9 "Reactor and Control System Checkout Procedures", 9.2.2.(d).

C.03 b
REF: Standard NRC question

C.04 b
REF: Standard NRC Question

C.05 d
REF: Study Guide for Key Access and Intro. to Operator Training, Primary System.

C.06 d
REF: U. Mass — Lowell, FSAR Appendix 10.

C.07 d
REF: Study Guide for Key Access and Intro. To Operator Training, § covering primary system and NRC exam administered September, 1997.

C.08 a
REF: RO-9, Step 3.25, p. RO-9-4. Also NRC exam administered March, 1994.

C.09 a, 3; b, 15; c, 5; d, 10
REF: USAR, § 4.4.9 and table 4.4. R.0.9 "Reactor and Control System Checkout Procedures".

C.10 d
REF: USAR, § 4.3.1, *Thermal Column*

C.11 d
REF: Procedure RO-9, *Reactor and Control System Checkout Procedures,* steps 3.17 & 4.11.

C.12 a, 2; b, 1; c, 2; d, 4;
REF: Study Guide for Key Access and Introduction to Operator Training “Electrical System”, Figure 3.5.

C.13 a
REF: Study Guide for Key Access and Introduction to Operator Training, figure 3.5, Ventilation schematic.

C.14 b
REF: Study Guide for Key Access and Introduction to Operator Training, Containment/Ventilation System, ¶ 5.

C.15 b
REF: USAR, § 4.2.2, *Primary Coolant Systems*

C.16 c
REF: NRC question administered 2002