December 7, 2001

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-02-01

Dear Dr. Kegel:

During the week of November 12, 2001, the NRC administered operator licensing examinations at your University of Massachusetts – Lowell Reactor. The examinations were conducted according to NUREG-1478, "Non-Power Reactor Operator Licensing Examiner Standards," Revision 1. Examination questions and preliminary findings were discussed with those members of your staff identified in the enclosed report at the conclusion of the examination.

In accordance with 10 CFR 2.790 of the Commission's regulations, a copy of this letter and the enclosures will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records (PARS) component of NRC's document system (ADAMS). ADAMS is accessible from the NRC Web site at (the Public Electronic Reading Room) http://www.nrc.gov/NRC/ADAMS/indesx.html. The NRC is forwarding the individual grades to you in a separate letter which will not be released publicly. Should you have any questions concerning this examination, please contact Paul Doyle at (301)415-1058 or pvd@nrc.gov .

Sincerely,

/RA by Patrick M. Madden Acting for/

Eugene I. Imbro, Acting Branch Chief
Operational Experience and Non-Power Reactors Branch
Division of Regulatory Improvement Programs
Office of Nuclear Reactor Regulation

Docket No. 50-223

Enclosures:
1. Initial Examination Report No. 50-223/OL-02-01
2. Facility comments with NRC resolution
3. Examination and answer key (RO/SRO)

cc w/encls:
Please see next page

cc:

Mayor of Lowell
City Hall
Lowell, MA 01852

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

Office of the Attorney General
Environmental Protection Division
19th Floor
One Ashburton Place
Boston, MA 02108

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

REPORT NO.: 50-223/OL-02-01

FACILITY DOCKET NO.: 50-223

FACILITY LICENSE NO.: R-125

FACILITY: University of Massachusetts – Lowell

EXAMINATION DATES: November 13-14, 2001

SUBMITTED BY: ___________/RA/________________ __11/21/2001_
Paul Doyle, Chief Examiner Date

SUMMARY:

The NRC administered operator licensing examinations to two reactor operator candidates. One candidate decided to withdraw from the examination after taking the written portion of the examination, but prior to taking the operating test, and therefore failed all portions of the examination. The other candidate passed all portions of the examination.

REPORT DETAILS

1. Examiners:
Paul Doyle, Chief Examiner

2. Results:

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

3. Exit Meeting:
Paul Doyle, NRC, Examiner
Leo Bobek, University of Massachusetts-Lowell, Reactor Supervisor

Mr. Bobek presented Mr. Doyle with preliminary written exam comments, which he later E-mailed to Mr. Doyle. Mr. Doyle told Mr. Bobek that he must submit a letter on facility letterhead formally informing the NRC of the decision by one of the candidates to withdraw from the examination, which Mr. Bobek sent via fax on 11/20/2001.

Facility Comments on November 2001 Written Examination

Paul:

Here are Nov. 14 2001 exam comments:

A.9) There is no correct answer given the question for 7% dk/k.

B.8) The correct answer is A (T.S. 3.4.3*)

B.11) The answers should be A-test, B-check

B.15) The answers are given in terms of dose rate instead of dose and may have confused the candidates.

Best Regards,

Leo M. Bobek
Radiation Laboratory
University of Massachusetts Lowell
One University Avenue
Lowell, MA 01854
ph: 978-934-3365
fax: 978-934-4067

NRC Resolution:

All comments accepted as written. Question A.9 deleted because of no correct answer. Questions B.8 and B.11 answer key corrected (typographical errors). Question B.15 no change to answer.

UNIVERSITY OF MASSACHUSETTS-LOWELL

With Answer Key

UNITED STATES NUCLEAR REGULATORY COMMISSION

OPERATOR LICENSING
EXAMINATION
November 13, 2001

ENCLOSURE 2

QUESTION A.1 [2.0 points, 0.5 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.2 [1.0 point]
You enter the control room and note that all nuclear instrumentation show a steady neutron level, and no rods are in motion. Which ONE of the following conditions CANNOT be true?

a. The reactor is critical.

b. The reactor is subcritical.

c. The reactor is supercritical.

d. The neutron source has been removed from the core.

QUESTION A.3 [1.0 point]
Which ONE of the following describes the **MAJOR** processes contributing to the **PRODUCTION** and **DEPLETION** of Xenon respectively in a **STEADY-STATE OPERATING** reactor?

	Production	Depletion
a.	Radioactive decay of Iodine	Radioactive Decay
b.	Radioactive decay of Iodine	Neutron Absorption
c.	Directly from fission	Radioactive Decay
d.	Directly from fission	Neutron Absorption

QUESTION A.4 [1.0 point]
Which factor of the Six Factor formula is most easily varied by the reactor operator?

a. Thermal Utilization Factor (f)

b. Reproduction Factor (η)

c. Fast Fission Factor (ε)

d. Fast Non-Leakage Factor ($\mathfrak{L}_f$)

QUESTION A.5 [1.0 point]
Which ONE of the following is an example of neutron decay?

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

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

c. ${}_{35}Br^{87} \rightarrow {}_{34}Se^{86}$

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

QUESTION A.6 [1.0 point]
Which ONE of the following explains the response of a **SUBCRITICAL** reactor to equal insertions of positive reactivity as the reactor approaches criticality?

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

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

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

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

QUESTION A.7 [1.0 point]
Several processes occur that may increase or decrease the available number of neutrons. SELECT from the following the six-factor formula term that describes an INCREASE in the number of neutrons during the cycle.

a. Thermal utilization factor (f).

b. Resonance escape probability (p).

c. Thermal non-leakage probability ($\mathcal{L}_{th}$).

d. Reproduction factor (η).

QUESTION A.8 [1.0 point]
Core excess reactivity changes with…

a. Fuel burnup

b. Control Rod Height

c. Neutron Level

d. Reactor Power Level

QUESTION A.9 [1.0 point] Question deleted per facility comment.
~~K_{eff} for the reactor is 0.98. If you place an experiment worth +7%ΔK/K into the core, what will the new K_{eff} be?~~

~~a. 0.987~~

~~b. 0.993~~

~~c. 1.003~~

~~d. 1.03~~

QUESTION A.10[1.0 point]
WHICH ONE of the following is the **MAJOR** source of energy released during fission?

a. Kinetic energy of the fission neutrons.

b. Kinetic energy of the fission fragments.

c. Decay of the fission fragments.

d. Prompt gamma rays.

QUESTION A.11[1.0 point]
You perform two startups with exactly the same core characteristics. During the first startup you proceed straight to criticality. During the second startup you receive a phone call after starting to pull rods, but before reaching criticality. How will this increase in time before reaching criticality affect reactor critical conditions? For the second startup …

a. rod height will be lower, reactor power will be lower.

b. rod height will be the same, reactor power will be the same.

c. rod height will be the same, reactor power will be higher.

d. rod height will be higher, reactor power will be higher.

QUESTION A.12[1.0 point]
The term "prompt jump" refers to:

a. the instantaneous change in power due to raising a control rod.

b. a reactor which has attained criticality on prompt neutrons alone.

c. a reactor which is critical using both prompt and delayed neutrons.

d. a negative reactivity insertion which is less than β_{eff}.

QUESTION A.13[1.0 point]
An experimenter makes an error loading a rabbit sample. Injection of the sample results in a 100 millisecond period. If the scram which causes the reactor to shutdown is set at 1.25 MW and the scram delay time is 0.1 seconds, **WHICH ONE** of the following is the peak power of the reactor at shutdown.

a. 1.25 MW

b. 2.5 MW

c. 3.4 MW

d. 12.5 MW

QUESTION A.14[1.0 point]
All four control rods are worth 11.4% ΔK/K. Core excess is 4.2% ΔK/K. Regulating rod worth is 0.6% ΔK/K. If the regulating rod is stuck in the fully out position, calculate the actual (NOT TECHNICAL SPECIFICATION) Shutdown Margin. (Ignore temperature and poisons.)

a. 2.5% ΔK/K

b. 3.3% ΔK/K

c. 6.6% ΔK/K

d. 7.8% ΔK/K

QUESTION A.15[1.0 point]
With the reactor on a constant positive period, which ONE of the following power changes will take the SHORTEST time?

a. 5% power, from 1% to 6% power

b. 10% power, from 10% to 20% power

c. 15% power, from 20% to 35% power

d. 20% power, from 40% to 60% power

QUESTION A.16[1.0 point]
Regarding the Am-Be neutron source: The decay of Americium produces _____ which are absorbed by the Beryllium producing the reaction _______

a. Alphas; $_4Be^9$ (α,n) $_6C^{12}$

b. Betas; $_4Be^9$ (β,n) $3Li^8$

c. Gammas; $_4Be^9$ (γ,n) $2(_2He^4)$

d. Neutrons (from Spontaneous fission); $_4Be^9$ (n,2n) $_4Be^8$

QUESTION A.17[1.0 point]
Which one of the following statements is the definition of "reactivity"? Reactivity is …

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

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

c. equal to $.70 when the reactor is prompt critical.

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

QUESTION A.18[1.0 point]
Given the following conditions which one of the following reactions has the highest probability of occurrence? A beam of thermal neutrons is aimed at a thin foil target made of 10% copper and 90% aluminum.

$\sigma_{a\ Cu}$ = 3.79 barns $\sigma_{a\ Al}$ = 0.23 barns
$\sigma_{s\ Cu}$ = 7.90 barns $\sigma_{s\ Al}$ = 1.49 barns

a. A neutron absorption in copper

b. A neutron absorption in aluminum

c. A neutron scattering reaction with copper

d. A neutron scattering reaction with aluminum

QUESTION A.19[1.0 point]
Which one of the following figures most closely depicts the reactivity versus time plot for xenon for the following series of evolutions: (See attached figures on last page of handout for choice selections.) (Note use $1/10^{th}$ of values in figures.)

TIME	EVOLUTION
1-2	1 Megawatt startup, clean core; Operation at 1 Megawatt for 24 hours;
3	Shutdown for 15 hours;
4	Startup and operation at 5 Mw for 12 hours.

a. a

b. b

c. c

d. d

QUESTION B.1 [1.0 point]
Which ONE of the following types of experiments is required to be doubly encapsulated? Experiments which contain …

a. explosive materials.

b. fissionable materials

c. corrosive materials

d. compounds highly reactive with water.

QUESTION B.2 [2.0 points, 0.5 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 [1.0 point]
Which ONE of the following is the 10 CFR 20 definition of TOTAL EFFECTIVE DOSE EQUIVALENT (TEDE)?

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

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

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

d. The dose to a specific organ or tissue resulting from an intake of radioactive material.

QUESTION B.4 [1.0 point]
Two inches of shielding reduce the gamma exposure in a beam of radiation from 400 mR/hr to 200 mR/hr. If you add an additional four inches of shielding what will be the new radiation level? (Assume all reading are the same distance from the source.)

a. 25 mR/hr

b. 50 mR/hr

c. 75 mr/hr

d. 100 mr/hr

QUESTION B.5 [1.0 point]
According to Technical Specification 3.4.1.a "A moveable experiment shall have a reactivity worth less than or equal to …

a. 0.05% Δk/k

b. 0.1% Δk/k

c. 0.5% Δk/k

d. 1.0% Δk/k

QUESTION B.6 [1.0 point]
Which ONE of the following is the definition of ***Emergency Action Level***?

a. a condition that calls for immediate action, beyond the scope of normal operating procedures, to avoid an accident or to mitigate the consequences of one.

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

c. classes of accidents grouped by severity level for which predetermined emergency measures should be taken or considered.

d. a document that provides the basis for actions to cope with an emergency. It outlines the objectives to be met by the emergency procedures and defines the authority and responsibilities to achieve such objectives.

QUESTION B.7 [1.0 point]
The control rod drop and drive times were last determined on July 31, 2001. Which one of the following dates is the latest the maintenance may be performed again without exceeding a Technical Specifications requirement?

a. Feb. 14, 2002

b. Jul. 31, 2002

c. Oct. 31, 2002

d. Jan. 31, 2003

QUESTION B.8 [1.0 point]
Upon discovery that no Area Radiation Monitors on the experimental levels are operable, you may continue steady-state operation providing you replace the inoperable monitor with a portable gamma-sensitive monitor having its own alarm within ________ discovery of the condition.

a. 15 minutes

b. 30 minutes

c. an hour

d. eight hours

QUESTION B.9 [2.0 points, 0.5 each]
Match the 10CFR55 requirements for maintaining an active operator license in column A with the corresponding time period from column B.

	Column A	Column B
a.	Renew License	1 year
b.	Medical Exam	2 years
c.	Pass Requalification Written Examination	4 years
d.	Pass Requalification Operating Test	6 years

QUESTION B.10 [1.0 point]
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.11 [2.0 points, 0.5 each]
Identify each of the following actions as either a channel **CHECK**, a channel **TEST**, or a channel **CAL**ibration.

a. Prior to startup you place a known radioactive source near a radiation detector, noting meter movement and alarm function operation.

b. During startup you compare all of your nuclear instrumentation channels ensuring they track together.

c. At power, you perform a heat balance (calorimetric) and determine you must adjust Nuclear Instrumentation readings.

d. During a reactor shutdown you note a -80 second period on Nuclear Instrumentation.

QUESTION B.12 [2.0 points, 0.5 each]
Identify each of the following as either a Safety Limit (**SL**) a Limiting Safety System Setting (**LSSS**) or a Limiting Condition for Operation (**LCO**).

a. The minimum coolant flow rate shall be 1170 GPM (Forced Convection Mode).

b. Maximum excess reactivity shall be 4.7% Δk/k.

c. The True value of pool water level shall not be less than 24.25 feet above the centerline of the core. (Forced Convection Mode).

d. During steady-state operation a minimum of two Reactor Power Level (Linear N) Channels shall be operable.

QUESTION B.13 [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.14 [1.0 point]
Which ONE of the following is the lowest level of permission required to restart the reactor following violation of a Safety Limit?

a. Licensed Senior Operator on call.

b. Reactor Supervisor

c. Facility Director

d. Nuclear Regulatory Commission

QUESTION B.15 [1.0 point]
While working in a radiation area, you note that your pocket dosimeter reads off-scale and immediately leave the area. You had been working for 2 hours at 8 feet from a source reading 2400 mr/hr at a foot. Which one of the following is the estimated dose you received?

a. 600 mr/~~hr~~

b. 300 mr/~~hr~~

c. 75 mr/~~hr~~

d. 37½ mr/~~hr~~

QUESTION B.16 [1.0 point]
During an emergency responsibility for authorizing re-entry into the reactor building or portions thereof belongs to the …

a. Console Operator

b. Senior Reactor Operator

c. Emergency Director

d. Radiation Safety Officer

QUESTION C.1 [1.0 point]
Which one of the following scrams is disabled by placing the range switch (7S5) in the 0.10 MW position?

A. Coolant Gate Open (Riser).

B. High Voltage Failure

C. Pool Level

D. Containment Air Leak Doors Open

QUESTION C.2 [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.

QUESTION C.3 [2.0 points, 0.5 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-RI

QUESTION C.4 [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.5[1.0 point]
Which ONE of the following is ***NOT*** a Rod Withdrawal Interlock?

A. Low source count rate < 3 cps

B. High flux - 110%

C. Short Period - 15 seconds

D. Source Range Signal/noise ratio of 2

QUESTION C.6[1.0 point]
WHICH ONE of the following detectors is used primarily to measure **N^{16}** release to the environment?

a. NONE, N^{16} has too short a half-life to require environmental monitoring.

b. Stack Gas Monitor

c. Stack Particulate Monitor

d. Bridge Area Monitor

QUESTION C.7[1.0 point]
WHICH ONE of the following poisons is used in all of the control elements?

a. Borated Graphite

b. Boron-Aluminum Alloy (Boral)

c. Hafnium

d. Stainless Steel.

QUESTION C.8[1.0 point]
Which ONE of the following contaminants is the Demineralizer most efficient at removing from pool water?

a. oil

b. Ar^{41}

c. I^{135}

d. mosquito larvae

QUESTION C.9 [1.0 point]
An experimenter drops and breaks open a sample vial in a laboratory room. He immediately runs out of the room and closes the door. You are called in to assist in the cleanup. **Prior** to opening the door you would take a reading using a(n)

a. Ion Chamber portable radiation detector to determine the radiation field strength.

b. Geiger-Müller portable radiation detector to determine the radiation field strength.

c. Ion Chamber portable radiation detector to determine whether contamination is present.

d. Geiger-Müller portable radiation detector to determine whether contamination is present.

QUESTION C.10 [1.0 point]
Which ONE of the following is the actual design feature which prevents siphoning of pool water on a failure of the primary/purification system?

a. The suction and return line each contain a siphon break valve and stand-pipe.

b. All primary system pipes end three feet below the water surface.

c. ½ inch holes are located in each water pipe about a foot below the water surface.

d. The suction and return line each contain a valve which will inject service air into the loop.

QUESTION C.11 [1.0 point]
Which ONE of the following methods is used to determine if there is a leak in the heat exchanger?

a. Routine checks of the secondary coolant for Na^{24}.

b. Pool level will decrease due to leakage into the secondary.

c. Decrease in secondary makeup, due to water from primary.

d. Routine checks of the secondary coolant for O^{19}.

QUESTION C.12 [1.0 point]
Which one of the following ventilation valves will ***FAIL OPEN*** on a loss of service air?

A. G, Sanitary System Vent Isolation Valve

B. D, Emergency Exhaust Isolation Valve

C. F, Ventilation Supply Bypass Valve

D. H, Acid Vent (Basement)

QUESTION C.13 [2.0 points, 0.5 each]
Match the Radiation Detection Systems in Column A with its corresponding detector type from Column B. (Items in column B may be used more than once or not at all.)

Column A	Column B
A. Continuous Air Monitors	1. Proportional Counter
B. Stack Effluent Monitor (Gaseous)	2. Geiger-Müeller
C. Stack Effluent Monitor (Particulate)	3. Scintillation
D. Bridge Area Radiation Monitor	4. Ion Chamber

QUESTION C.14 [1.0 point]
The reactor is operating at 1 Megawatt, when the ***SECONDARY*** coolant pump trips on overload. Assuming NO OPERATOR ACTION, which ONE of the following trips would most likely cause a reactor scram?

A. High Flux

B. Short Period

C. High Coolant Inlet Temperature

D. Low Secondary Flow

QUESTION C.15 [1.0 point]
Which ONE of the following loads is supplied from the air compressor located on the intermediate level inside the reactor building?

a. Air lock doors.

b. Thermal column door.

c. Pneumatic tube system.

d. Containment isolation valves.

QUESTION C.16 [1.0 point]
The "TEST" position of the Master Switch allows:

a. insertion of scram signals without deenergizing the scram magnets.

b. control power and lamp indication operability testing.

c. control blade drive motion without energizing the scram magnets.

d. control blade drive motion with energized scram magnets

QUESTION C.17 [1.0 point]
Which ONE of the following safety system protective functions (Scrams) is NOT bypassed when the Power Level Selector Switch is in the 0.1 Mwatt position?

a. High temperature Primary Coolant leaving core

b. Primary coolant low flow rate

c. Bridge Low Power Position

d. Low Pool Water Level

QUESTION C.18 [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 its closed seat)?

a. P-1

b. P-9

c. P-11

d. P-12

A.1 a, 2; b, 4; c, 1; d, 3
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 2.5.1 & 3.2.2

A.2 c
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 5.3, conclusions on p. 5-7.

A.3 b
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 8.1

A.4 a
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 6.4

A.5 b
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 2.4.6

A.6 b
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 5.3

A.7 d
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 3.3 Example 3.3(a)

A.8 a
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 6.2.1

~~A.9 a~~ Deleted per facility comment
~~REF:~~
~~SDM = $(1-k_{eff})/k_{eff}$ = (1-0.98)/0.98 = 0.02/0.99 = 0.02041 or a reactivity worth (ρ) of -0.02041. Adding +0.007 reactivity will result in a SDM of 0.02041 + 0.007 = or -0.01341 ΔK/K~~
~~K_{eff} = 1/(1+SDM) = 1/(1 + 0.01341) = 0.987~~

A.10 b
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, Table 3.2

A.11 c
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 5.3

A.12 a
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 4.7

A.13 c
REF: $P = P_0 e^{t/\tau}$, P = 1.25 Mwatt × $e^{0.1/0.1}$ = 1.25 × e = 3.3979

A.14 c
REF: (11.4% - 4.2% - 0.6%)ΔK/K = 6.6% ΔK/K)

A.15 d
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 4.3 Eq. 4-7

A.16 a
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 5.2, also Chart of the Nuclides.

A.17 b
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 3.3.4, p. 3-21.

A.18 d
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 2.5.1, pp. 2-36 — 2-43.

A.19 a
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 8.4

B.1 c
REF: Technical Specification 3.4.2.a

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

B.3 a
REF: 10 CFR 20.1003 Definitions

B.4 b
REF: Basic Radiological Controls knowledge: “Half-Thickness and Tenth-Thickness".

B.5 b
REF: Technical Specification 3.1.9, Table.

B.6 b
REF: Emergency Plan, § 2.0 Definitions, p. 6.

B.7 c
REFERENCE T.S. §§ 4.1.2 and 1.26.b (15 months)

B.8 ~~d~~ a Answer changed per facility comment.
REF: Technical Specifications 3.4.3.

B.9 a, 6; b, 2; c, 2; d, 1
REF: 10CFR55.

B.10 a, Water; b, Air; c, Water; d, Fission
REF: Standard NRC question

B.11 a, ~~Check~~ Test; b, ~~Test~~ Check; c, Cal; d, Check Answer changed per facility comment.
REF: Technical Specification 1.2.3-5.

B.12 a, LSSS; b, LCO; c, SL; d, LCO
REF: Technical Specifications §§ 2.1, 2.2.3, 3.1.1 and 3.2.4 (table).

B.13 d
REF: Standard Health Physics Definition.

B.14 d
REF: Technical Specification 6.5 1st ¶

B.15 c
REF: NRC question administered Jan. 1987 $D_1 d_1^2 = D_2 d_2^2$ (D is Dose rate, d is distance)
$D_1 (8^2) = 2400 (1^2)$ $D_1 = 2400/64 = 37½$ mr/hr DOSE = Dose Rate x time 37½ mr/hr 2 hr = 75 mr

B.16 c
REF: Emergency Plan § 3.4

C.1 a
REF: U. Mass. Lowell Reactor, RO-9 Reactor and Control System Checkout, § 9.2.2(d)

C.2 c
REF: Makeup Drawing.

C.3 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.4 b
REF: NRC Exam administered 09/23/1996

C.5 d
REF: U. Mass. Lowell Reactor RO-9 System Checkout Procedures

C.6 a
REF: Standard NRC Question.

C.7 b
REF: Study Guide for Key Access and Intro to Operator Training "Introduction to the UML Reactor" ¶ 5

C.8 c
REF: SAR § 4.2.5

C.9 a
REF: Standard NRC Question

C.10 a
REF: SAR § 4.2.2 Primary Coolant System, 5th ¶.

C.11 a
REF: Study Guide for Key Access and Introduction to Operator Training "Secondary Cooling System" ¶ 8.

C.12 c
REF: U. Mass. Lowell Reactor, FSAR, § 3.4.2.2

C.13 a, 2; b, 2; c, 3; d, 4
REF: NRC Examination Bank Question asked March, 1993.

C.14 c
REF: Modification of NRC Examination bank question administered August 1988.

C.15 a
REF: ULR SAR, § 6.2, p 6-5.

C.16 c
REF: U. Mass — Lowell, FSAR Table 4.3.

C.17 d
REF: U. Mass — Lowell Technical Specifications § 3.3. R.0.9 "Reactor and Control System Checkout Procedures", 9.2.2.(d).

C.18 d
REF: Study Guide for Key Access and Intro. to Operator Training, Primary System.

U. S. NUCLEAR REGULATORY COMMISSION
NON-POWER INITIAL REACTOR LICENSE EXAMINATION

FACILITY: University of Massachusetts- Lowell

REACTOR TYPE: GE Pool

DATE ADMINISTERED: 2001/11/13

CANDIDATE: ______________________________

INSTRUCTIONS TO CANDIDATE:
Answers are to be written on the answer sheet provided. Attach the answer sheets to the examination. Points for each question are indicated in brackets for each question. A 70% in each section is required to pass the examination. Examinations will be picked up three (3) hours after the examination starts.

Category Value	% of Total	% of Candidates Score	Category Value	Category
20.00	33.3	______	____	A. Reactor Theory, Thermodynamics and Facility Operating Characteristics
20.00	33.3	______	____	B. Normal and Emergency Operating Procedures and Radiological Controls
20.00	33.3	______	____	C. Facility and Radiation Monitoring Systems
60.00		______	____% FINAL GRADE	TOTALS

All work done on this examination is my own. I have neither given nor received aid.

____
Candidate's Signature

NRC RULES AND GUIDELINES FOR LICENSE EXAMINATIONS

During the administration of this examination the following rules apply:

1. Cheating on the examination means an automatic denial of your application and could result in more severe penalties.

2. After the examination has been completed, you must sign the statement on the cover sheet indicating that the work is your own and you have neither received nor given assistance in completing the examination. This must be done after you complete the examination.

3. Restroom trips are to be limited and only one candidate at a time may leave. You must avoid all contacts with anyone outside the examination room to avoid even the appearance or possibility of cheating.

4. Use black ink or dark pencil <u>only</u> to facilitate legible reproductions.

5. Print your name in the blank provided in the upper right-hand corner of the examination cover sheet and each answer sheet.

6. Mark your answers on the answer sheet provided. USE ONLY THE PAPER PROVIDED AND DO NOT WRITE ON THE BACK SIDE OF THE PAGE.

7. The point value for each question is indicated in [brackets] after the question.

8. If the intent of a question is unclear, ask questions of the examiner only.

9. When turning in your examination, assemble the completed examination with examination questions, examination aids and answer sheets. In addition turn in all scrap paper.

10. Ensure all information you wish to have evaluated as part of your answer is on your answer sheet. Scrap paper will be disposed of immediately following the examination.

11. To pass the examination you must achieve a grade of 70 percent or greater in each category.

12. There is a time limit of three (3) hours for completion of the examination.

13. When you have completed and turned in you examination, leave the examination area. If you are observed in this area while the examination is still in progress, your license may be denied or revoked.

$$\dot{Q} = \dot{m}c_p \Delta T = \dot{m} \Delta H = UA \Delta T$$

$$P_{max} = \frac{(\rho-\beta)^2}{2\alpha(k)\ell}$$

$$\ell^* = 1 \times 10^{-4} \text{ seconds}$$

$$\lambda_{eff} = 0.1 \text{ seconds}^{-1}$$

$$SCR = \frac{S}{-\rho} \approx \frac{S}{1-K_{eff}}$$

$$CR_1(1-K_{eff_1}) = CR_2(1-K_{eff_2})$$
$$CR_1(-\rho_1) = CR_2(-\rho_2)$$

$$SUR = 26.06\left[\frac{\lambda_{eff}\rho}{\beta-\rho}\right]$$

$$M = \frac{1-K_{eff_0}}{1-K_{eff_1}}$$

$$M = \frac{1}{1-K_{eff}} = \frac{CR_1}{CR_2}$$

$$P = P_0 \, 10^{SUR(t)}$$

$$P = P_0 \, e^{\frac{t}{T}}$$

$$P = \frac{\beta(1-\rho)}{\beta-\rho} P_0$$

$$SDM = \frac{(1-K_{eff})}{K_{eff}}$$

$$T = \frac{\ell^*}{\rho - \bar{\beta}}$$

$$T = \frac{\ell^*}{\rho} + \left[\frac{\bar{\beta}-\rho}{\lambda_{eff}\rho}\right]$$

$$\Delta\rho = \frac{K_{eff_2}-K_{eff_1}}{k_{eff_1} \times K_{eff_2}}$$

$$T_{½} = \frac{0.693}{\lambda}$$

$$\rho = \frac{(K_{eff}-1)}{K_{eff}}$$

$$DR = DR_0 \, e^{-\lambda t}$$

$$DR = \frac{6CiE(n)}{R^2}$$

$$DR_1 d_1^2 = DR_2 d_2^2$$

DR – Rem, Ci – curies, E – Mev, R – feet

$$\frac{(\rho_2-\beta)^2}{Peak_2} = \frac{(\rho_1-\beta)^2}{Peak_1}$$

1 Curie = 3.7 x 10^{10} dis/sec

1 kg = 2.21 lbm

1 Horsepower = 2.54 x 10^3 BTU/hr

1 Mw = 3.41 x 10^6 BTU/hr

1 BTU = 778 ft-lbf

°F = 9/5 °C + 32

1 gal (H_2O) ≈ 8 lbm

°C = 5/9 (°F - 32)

c_P = 1.0 BTU/hr/lbm/°F

c_p = 1 cal/sec/gm/°C

A.1a 1 2 3 4 ___

A.1b 1 2 3 4 ___

A.1c 1 2 3 4 ___

A.1d 1 2 3 4 ___

A.2 a b c d ___

A.3 a b c d ___

A.4 a b c d ___

A.5 a b c d ___

A.6 a b c d ___

A.7 a b c d ___

A.8 a b c d ___

A.9 a b c d ___

A.10 a b c d ___

A.11 a b c d ___

A.12 a b c d ___

A.13 a b c d ___

A.14 a b c d ___

A.15 a b c d ___

A.16 a b c d ___

A.17 a b c d ___

A.18 a b c d ___

A.19 a b c d ___

B.1 a b c d ___

B.2a 1 2 5 10 20 ___

B.2b 1 2 5 10 20 ___

B.2c 1 2 5 10 20 ___

B.2d 1 2 5 10 20 ___

B.3 a b c d ___

B.4 a b c d ___

B.5 a b c d ___

B.6 a b c d ___

B.7 a b c d ___

B.8 a b c d ___

B.9a 1 2 4 6 ___

B.9b 1 2 4 6 ___

B.9c 1 2 4 6 ___

B.9d 1 2 4 6 ___

B.10a Air Water Fission Product _____

B.10b Air Water Fission Product _____

B.10c Air Water Fission Product _____

B.10d Air Water Fission Product _____

B.11a Check Test Cal ____

B.11b Check Test Cal ____

B.11c Check Test Cal ____

B.11d Check Test Cal ____

B.12a SL LSSS LCO ____

B.12b SL LSSS LCO ____

B.12c SL LSSS LCO ____

B.12d SL LSSS LCO ____

B.13 a b c d ___

B.14 a b c d ___

B.15 a b c d ___

B.16 a b c d ___

C.1 a b c d ___

C.2 a b c d ___

C.3a 1 2 3 4 ___

C.3b 1 2 3 4 ___

C.3c 1 2 3 4 ___

C.3d 1 2 3 4 ___

C.4 a b c d ___

C.5 a b c d ___

C.6 a b c d ___

C.7 a b c d ___

C.8 a b c d ___

C.9 a b c d ___

C.10 a b c d ___

C.11 a b c d ___

C.12 a b c d ___

C.13a 1 2 3 4 ___

C.13b 1 2 3 4 ___

C.13c 1 2 3 4 ___

C.13d 1 2 3 4 ___

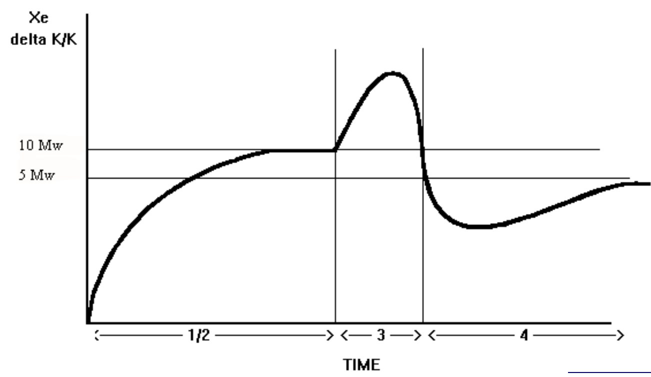
C.14 a b c d ___

C.15 a b c d ___

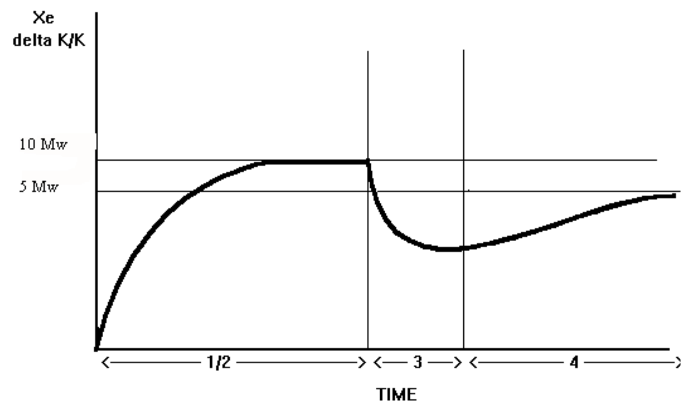
C.16 a b c d ___

C.17 a b c d ___

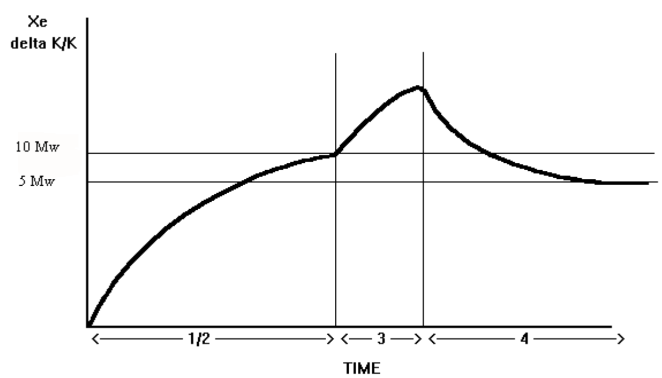
C.18 a b c d ___


Xe
delta K/K
10 Mw
5 Mw
1/2
3
4
TIME

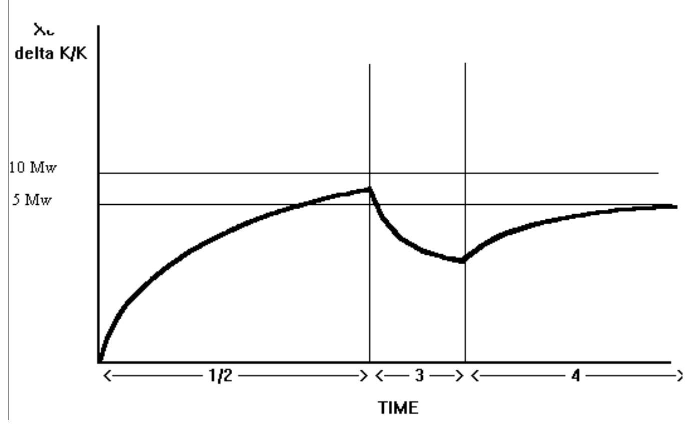
a


Xe
delta K/K
10 Mw
5 Mw
1/2
3
4
TIME

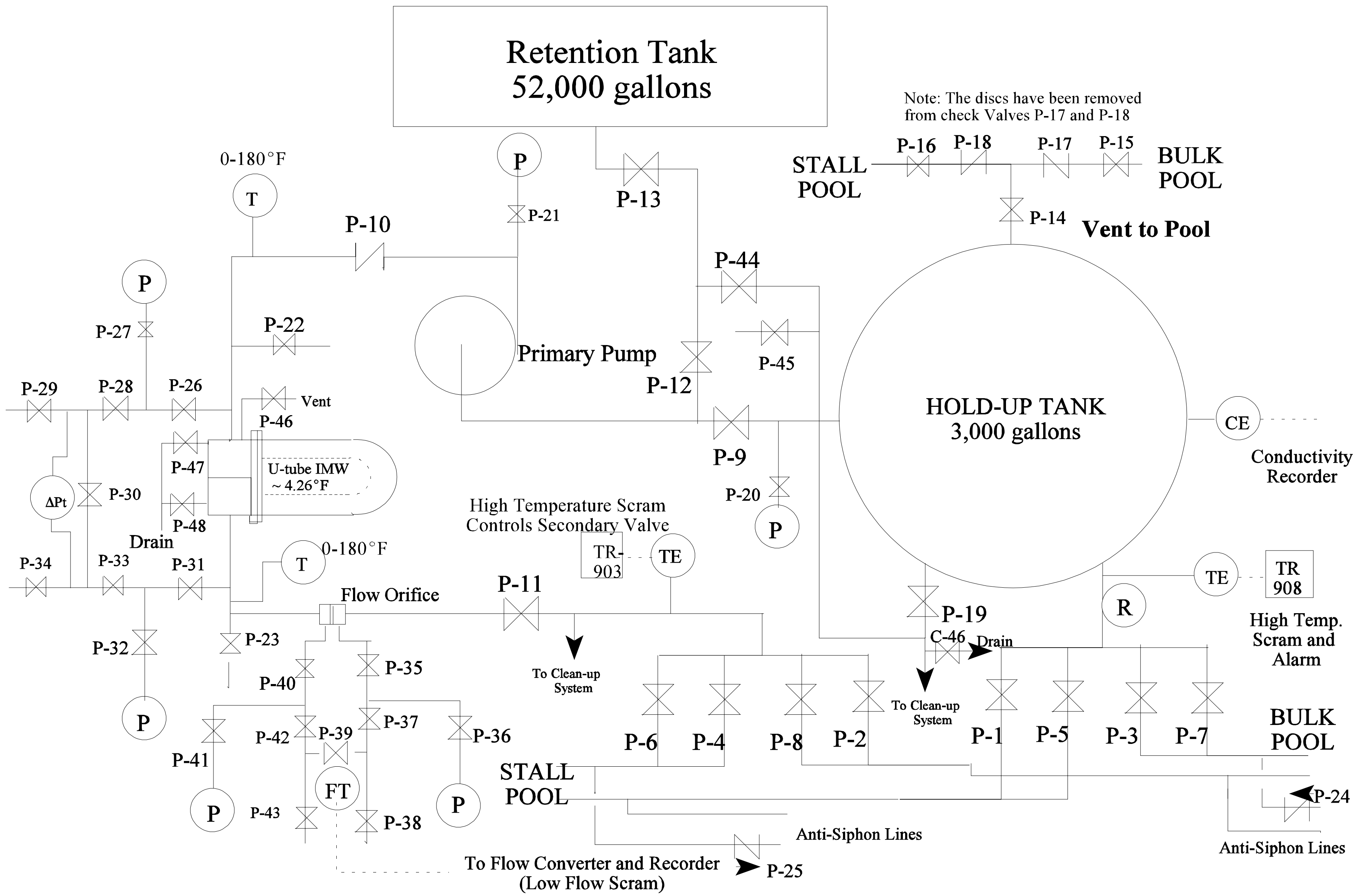
b


Xe
delta K/K
10 Mw
5 Mw
1/2
3
4
TIME

c


delta K/K
10 Mw
5 Mw
1/2
3
4
TIME

d



Retention Tank
52,000 gallons
Note: The discs have been removed
from check Valves P-17 and P-18
STALL POOL
BULK POOL
Vent to Pool
HOLD-UP TANK
3,000 gallons
Primary Pump
CE
Conductivity Recorder
TE
TR 908
High Temp. Scram and Alarm
R
High Temperature Scram
Controls Secondary Valve
TR-903
U-tube IMW
~ 4.26°F
0-180°F
Flow Orifice
To Clean-up System
Drain
Vent
FT
ΔPt
Anti-Siphon Lines
To Flow Converter and Recorder
(Low Flow Scram)
C-46
P-1
P-2
P-3
P-4
P-5
P-6
P-7
P-8
P-9
P-10
P-11
P-12
P-13
P-14
P-15
P-16
P-17
P-18
P-19
P-20
P-21
P-22
P-23
P-24
P-25
P-26
P-27
P-28
P-29
P-30
P-31
P-32
P-33
P-34
P-35
P-36
P-37
P-38
P-39
P-40
P-41
P-42
P-43
P-44
P-45
P-46
P-47
P-48