October 20, 2006

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

SUBJECT: RETAKE EXAMINATION REPORT NO. 50-223/OL-06-01, UNIVERSITY OF MASSACHUSETTS – LOWELL

Dear Dr. Kegel:

During the week of July 03, 2006, the NRC administered an operator licensing retake examination at your University of Massachusetts – Lowell Reactor. The examination was conducted according to NUREG-1478, "Non-Power Reactor Operator Licensing Examiner Standards," Revision 1.

In accordance with 10 CFR 2.390 of the Commission's regulations, a copy of this letter and the enclosures will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records (PARS) component of NRC's 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 at or via internet E-mail at @nrc.gov.

Sincerely,

/RA/

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

Docket No. 50-223

Enclosures: 1. Retake Examination Report No. 50-223/OL-06-01
2. Examination and answer key

cc w/encls:
Please see next page

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PUBLIC RNRP R&TR r/f JEads Facility File (EBarnhill) O-6 F-2 MMendonca

ADAMS ACCESSION #: ML062910365 **TEMPLATE #:NRR-074**

OFFICE	PRTB:CE	IOLB:LA	PRTB:BC
NAME	PDoyle:tls*	EBarnhill*	JEads:tls*
DATE	10/18/2006	10/20/2006	10/20/2006

OFFICIAL RECORD COPY

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

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

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

REPORT NO.: 50-223/OL-03-01

FACILITY DOCKET NO.: 50-223

FACILITY LICENSE NO.: R-125

FACILITY: University of Massachusetts – Lowell

EXAMINATION DATES: July 07, 2006

SUBMITTED BY: _____**/RA/**___ 10/112006___
Paul V. Doyle Jr., Chief Examiner Date

SUMMARY:

The NRC prepared a retake written examination for a candidate who failed sections A and C of the written examination administered September 2005. The examination was mailed to the facility, and the facility management administered the examination to the candidate.

REPORT DETAILS

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

2. Results:

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

3. Exit Meeting:

   Due to the fact that the examination was mailed to the facility there was no exit meeting.

ENCLOSURE 1

OPERATOR LICENSING EXAMINATION

With Answer Key

UNIVERSITY OF MASSACHUSETTS-LOWELL

Week of June 19, 2006

Retake of Sections A and C

Enclosure 2

QUESTION A.01 [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.02 [2.0 points, ½ each]

A fissile material is one which will fission upon the absorption of a THERMAL neutron. A fertile material is one which upon absorption of a neutron becomes a fissile material. Identify each of the listed isotopes as either fissile or fertile.

a. Th^{232}

b. U^{235}

c. U^{238}

d. Pu^{239}

QUESTION A.03 [1.0 point]

The reactor supervisor tells you that the K_{eff} for the reactor is 0.955. How much reactivity must you add to the reactor to reach criticality?

a. +0.0471

b. +0.0450

c. -0.0471

d. -0.0450

QUESTION A.04 [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.05 [1.0 point]

What is the kinetic energy range of a thermal neutron?

a. > 1 MeV

b. 100 KeV – 1 MeV

c. 1 eV – 100 KeV

d. < 1 eV

QUESTION A.06 [1.0 point]

When performing rod calibrations, many facilities pull the rod out a given increment, then measure the time for reactor power to double (doubling time), then calculate the reactor period. If the doubling time is 42 seconds, what is the reactor period?

a. 29 sec

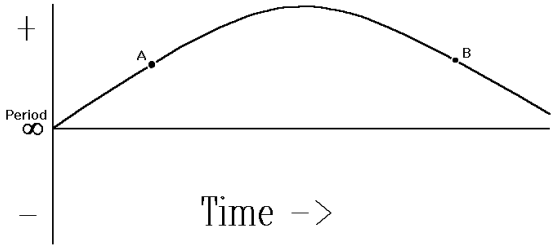
b. 42 sec

c. 61 sec

d. 84 sec

QUESTION A.07 [1.0 point]

Shown to the right 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, the decreasing.

d. constant.

QUESTION A.08 [1.0 point]

The term "*reactivity*" may be described as …

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

b. negative when K_{eff} is greater than 1.0.

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

d. equal to $.50 when the reactor is prompt critical.

QUESTION A.09 [1.0 point]

Given the data in the table to the right, which ONE of the following is the closest to the half-life of the material?

TIME	ACTIVITY
0 minutes	2400 cps
10 minutes	1757 cps
20 minutes	1286 cps
30 minutes	941 cps
60 minutes	369 cps

a. 11 minutes

b. 22 minutes

c. 44 minutes

d. 51 minutes

QUESTION A.10 [1.0 point]

Which ONE of the following is the definition of the term "*Cross-Section*?"

a. The probability that a neutron will be captured by a nucleus.

b. The most likely energy at which a charge particle will be captured.

c. The length a charged particle travels past the nucleus before being captured.

d. The area of the nucleus including the electron cloud.

QUESTION A.11 [1.0 point]

The number of neutrons passing through a square centimeter 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.12 [1.0 point]

The difference between a moderator and a reflector is that a reflector …

a. increases the fast non-leakage factor and a moderator increases the thermal utilization factor.

b. increases the neutron production factor and a moderator increase the fast fission factor.

c. increases the neutron production factor, and a moderator decreases the thermal utilization factor.

d. decreases the fast non-leakage factor, and a moderator increases the thermal utilization factor.

QUESTION A.13 [1.0 point]

The delayed neutron precursor (β) for U^{235} is 0.0065. However, when calculating reactor parameters you use β_{eff} with a value of ~0.0070. Why is β_{eff} larger than β?

a. Delayed neutrons are born at higher energies than prompt neutrons resulting in a greater worth for the neutrons.

b. Delayed neutrons are born at lower energies than prompt neutrons resulting in less leakage during slowdown to thermal energies.

c. The fuel also contains U^{238} which has a relatively large β for fast fission.

d. U238 in the core becomes Pu^{239} (by neutron absorption), which has a higher β for fission

QUESTION A.14 [1.0 point]

The Fast Fission Factor (ε) is defined as "The ratio of the number of neutrons produced by …

a. fast fission to the number produced by thermal fission.

b. thermal fission to the number produced by fast fission.

c. fast and thermal fission to the number produced by thermal fission.

d. fast fission to the number produced by fast and thermal fission

QUESTION A.15 [1.0 point]

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

a. Uranium (U^{238})

b. Carbon (C^{12})

c. Deuterium (H^{2})

d. Hydrogen (H^{1})

QUESTION A.16 [1.0 point]

Which one of the following is the primary reason a neutron source is installed in the core?

a. To allow for testing and irradiation of experiments when the reactor is shutdown.

b. To supply the neutrons required to start the chain reaction for subsequent reactor startups.

c. To provide a neutron level high enough to be monitored for a controlled reactor startup.

d. To increase the excess reactivity of the reactor which reduces the frequency for refueling.

QUESTION A.17 [1.0 point]

INELASTIC 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. is absorbed, with the nucleus emitting a gamma ray, and the neutron with a lower kinetic energy.

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.18 [1.0 point]

The neutron microscopic cross-section for absorption σ_a 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 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 [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-Rl

QUESTION C.3 [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.4 [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.5 [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.6 [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.7 [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.8 [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.9 [2.0 points, 0.5 each]

Match the Radiation Detection Systems in Column A with its corresponding detector type from Column B.

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.10 [2.0 points, 0.33 each]

Using the drawing of the primary system provided, if the reactor is in position 1, with the coolant system in the cross-stall mode (preferred line-up). Identify the position of the valves listed (**O**pen, **C**losed, **T**hrottled).

a. P-1

b. P-2

c. P-3

d. P-4

e. P-9

f. P-11

QUESTION C.11 [2.0 points, ¼ each]

Using the drawing of the ventilation system provided, give the status of the following valves (OPEN, SHUT) and fans (ON, OFF) upon receipt of a GRVS signal.

a. Valve A

b. Valve B

c. Valve C

d. Fans 3 through 6

e. Valve E

f. Valve F

g. Fan EF-12

h. Fan AC-2

QUESTION C.12 [1.0 point]

Fan EF-14 and valve D operate independently of a GRVS signal. For which of the listed conditions below, would fan EF-14 be operating? Containment Pressure =

a. +0.6 inches H_2O

b. +0.3 inches H_2O

c. -0.3 inches H_2O

d. -0.6 inches H_2O

QUESTION C.13 [2.0 points, ⅓ each]

Using Figure C.13, match each of the core locations listed in column A with its correct component from column B.

Column A (Grid Position)	Column B
a. A1	1. Proportional Counter
b. A2	2. Compensated Ion Chamber
c. A5	3. Startup Source
d. B4	4. Graphite Reflector Element
e. D9	5. Fuel Element
f. G9	6. Irradiation Basket
	7. Servo Control Element (Regulating rod)

QUESTION C.14 [1.0 point]

Which ONE of the following describes how the signal for regulating rod position indication is generated?

a. A series of magnetic switches which respond to lead screw position.

b. A tachometer that counts the revolutions of the lead screw.

c. A series of limit switches that are actuated by the ball bearing screw assembly.

d. A mechanical position transmitter that is chain driven by the drive motor

QUESTION C.15 [1.0 point]

The purpose of the filter in the reactor pool cleanup system is to …

a. prevent demineralizer resin fines from entering the pool.

b. prevent larger particles from plugging the demineralizer resin.

c. remove crud from the coolant limiting the radiation levels associated with the demineralizer.

d. remove particles that could clog the cleanup system pump seals..

QUESTION C.16 [1.0 point]

Which ONE of the following is an ***"ELECTRONIC"*** scram?

a. High flux

b. High temperature primary coolant

c. Seismic

d. Low pool water level

QUESTION C.17 [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.

A.01 c
REF: Standard NRC Question

A.02 a, fertile; b, fissile; c, fertile; d, fissile
REF: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, § 3.2 p. 3-2 Example 3.2(a)

A.03 a
REF: $\Delta\rho = (K_{eff1} - K_{eff2}) \div (K_{eff1} * K_{eff2})$ $\Delta\rho = (0.9550 - 1.0000) \div (0.9550 * 1.0000)$ $\Delta\rho = -0.0450 \div 0.9550 = -0.0471$

A.04 a, 2; b, 4; c, 1; d, 3
REF: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, §§ 2.5.1 and 3.2.2

A.05 d
REF: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, § 2.5.1.

A.06 c
REF: $\ln(2) = -\text{time}/\tau$ $\tau = \text{time}/(\ln(2)) = 60.59 \approx 61$ seconds

A.07 a
REF: Standard NRC Question

A.08 c
REF: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, § 3.3.4

A.09 b
REF: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, § 2.4.5

A.10 a
REF: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, § 2.5

A.11 c
REF: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, § 2.6.1

A.12 a diff between moderator & reflector
REF: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, §

A.13 b
REF: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, §

A.14 c
REF: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, § 3.3.1

A.15 d
REF: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, § 2.5.3

A.16 c
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1982, § 5.2 (b), p. 5-4.

A.17 b
REF: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, § 2.4.5, Example 2.4.5(c)

A.18 b
REF: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, § 2.5, Example 2.5.1(b)

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

C.2 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.3 d
REF: U. Mass. Lowell Reactor RO-9 System Checkout Procedures

C.4 a
REF: Standard NRC Question.

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

C.6 c
REF: U. Mass. Lowell Reactor, FSAR, § 3.4.2.2

C.7 c
REF: U. Mass — Lowell, FSAR Table 4.3.

C.8 c
REF: Modification of NRC Examination bank question administered August 1988.

C.9 a, 2; b, 2; c, 3; d, 4
REF: NRC Examination Question administered September, 1996.

C.10 a, Open; b, Open; c, Closed; d, Closed; e, Open; f, Throttled
REF: SAR § 4.2.2, also, Training Handout section on Primary System, and drawing.

C.11 a, SHUT; b, SHUT; c, SHUT; d, OFF; e, SHUT; f, OPEN; g, OFF; h, ON
REF:

C.12 b
REF: Training Handout Section on Containment/Ventilation, last page.

C.13 a, 2; b, 4; c, 3; d, 5; e, 7; f, 1
REF:: SAR Figure 4.1, Core Arrangement

C.14 d
REF: ULR SAR, §4.1.8, p 4-11; Figures 4.6 and 4.7. C.14

C.15 a
REF: ULR SAR, §4.2.5, p 4-29.

C.16 a
REF: ULR SAR, §4.4.15.2, p 4-74.

C.17 a
REF: ULR SAR, § 6.2, p 6-5.

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

FACILITY: University of Massachusetts- Lowell

REACTOR TYPE: GE Pool

DATE ADMINISTERED: 2006/06/_____

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	47.6	_____	____	A. Reactor Theory, Thermodynamics and Facility Operating Characteristics
22.00	52.4	_____	____	C. Facility and Radiation Monitoring Systems
42.00		_____	____% 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 only 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.

EQUATION SHEET

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$T_{½} = \frac{0.693}{\lambda}$$

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

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

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

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

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.01 a b c d ___

A.02a fertile fissile ___

A.02b fertile fissile ___

A.02c fertile fissile ___

A.02d fertile fissile ___

A.03 a b c d ___

A.04a 1 2 3 4 ___

A.04b 1 2 3 4 ___

A.04c 1 2 3 4 ___

A.04d 1 2 3 4 ___

A.05 a b c d ___

A.06 a b c d ___

A.07 a b c d ___

A.06 a b c d ___

A.09 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 ___

C.01 a b c d ___

C.02a 1 2 3 4 ___

C.02b 1 2 3 4 ___

C.02c 1 2 3 4 ___

C.02d 1 2 3 4 ___

C.03 a b c d ___

C.04 a b c d ___

C.05 a b c d ___

C.06 a b c d ___

C.07 a b c d ___

C.08 a b c d ___

C.09a 1 2 3 4 ___

C.09b 1 2 3 4 ___

C.09c 1 2 3 4 ___

C.09d 1 2 3 4 ___

C.10a O C T ___

C.10b O C T ___

C.10c O C T ___

C.10d O C T ___

C.10e O C T ___

C.10f O C T ___

C.10a Open Shut On Off ___

C.10b Open Shut On Off ___

C.11c Open Shut On Off ___

C.11d Open Shut On Off ___

C.11e Open Shut On Off ___

C.11f Open Shut On Off ___

C.11g Open Shut On Off ___

C.11h Open Shut On Off ___

C.12 a b c d ___

C.13a 1 2 3 4 5 6 7 ___

C.13b 1 2 3 4 5 6 7 ___

C.13c 1 2 3 4 5 6 7 ___

C.13d 1 2 3 4 5 6 7 ___

C.13e 1 2 3 4 5 6 7 ___

C.13f 1 2 3 4 5 6 7 ___

C.14 a b c d ___

C.15 a b c d ___

C.16 a b c d ___

C.17 a b c d ___

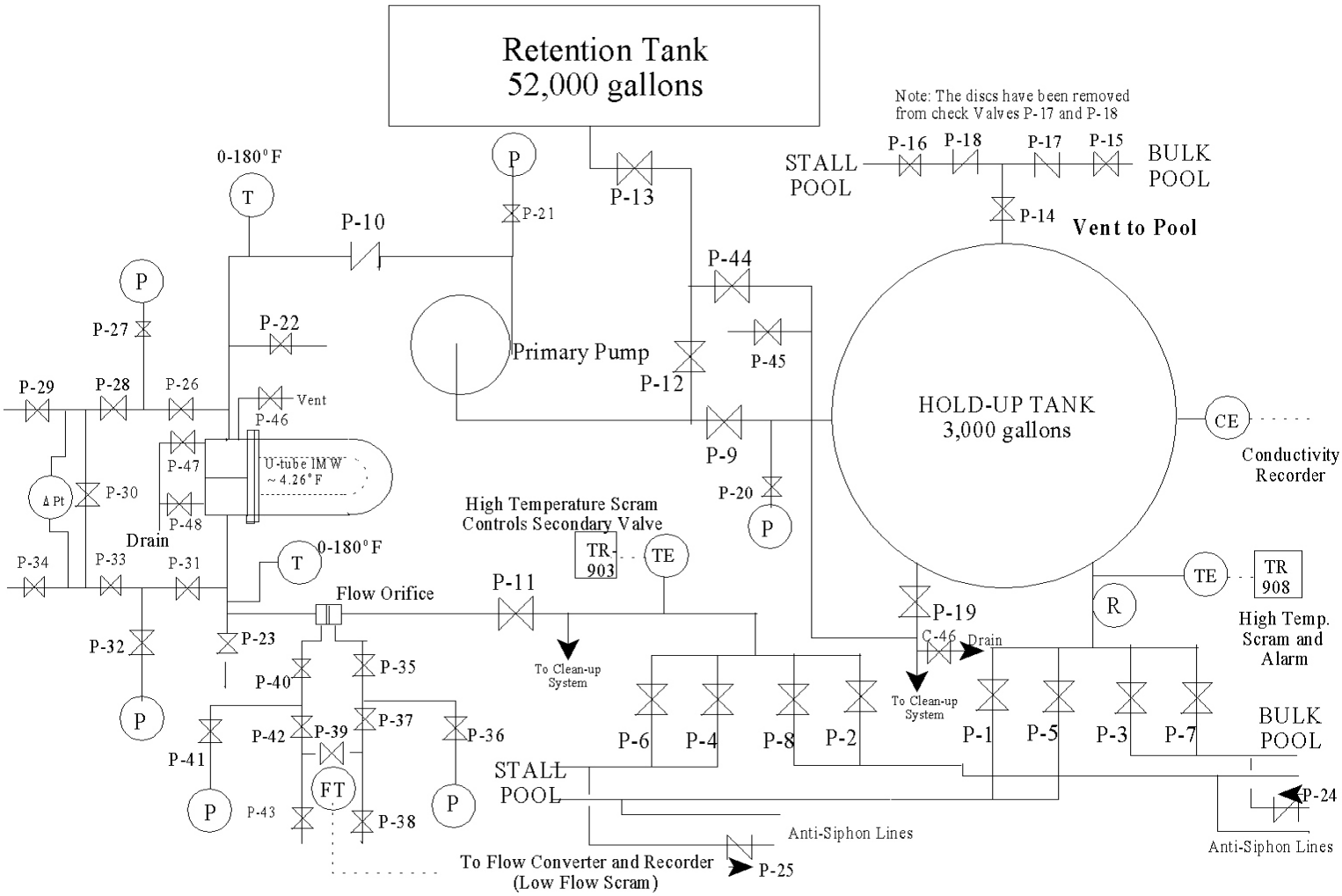

Retention Tank
52,000 gallons
Note: The discs have been removed
from check Valves P-17 and P-18
STALL
POOL
P-16
P-18
P-17
P-15
BULK
POOL
P-14
Vent to Pool
0-180°F
T
P
P-21
P-13
P-10
P-44
P-45
P-27
P-22
Primary Pump
P-12
HOLD-UP TANK
3,000 gallons
CE
Conductivity
Recorder
P-29
P-28
P-26
Vent
P-46
P-47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

Figure C.10

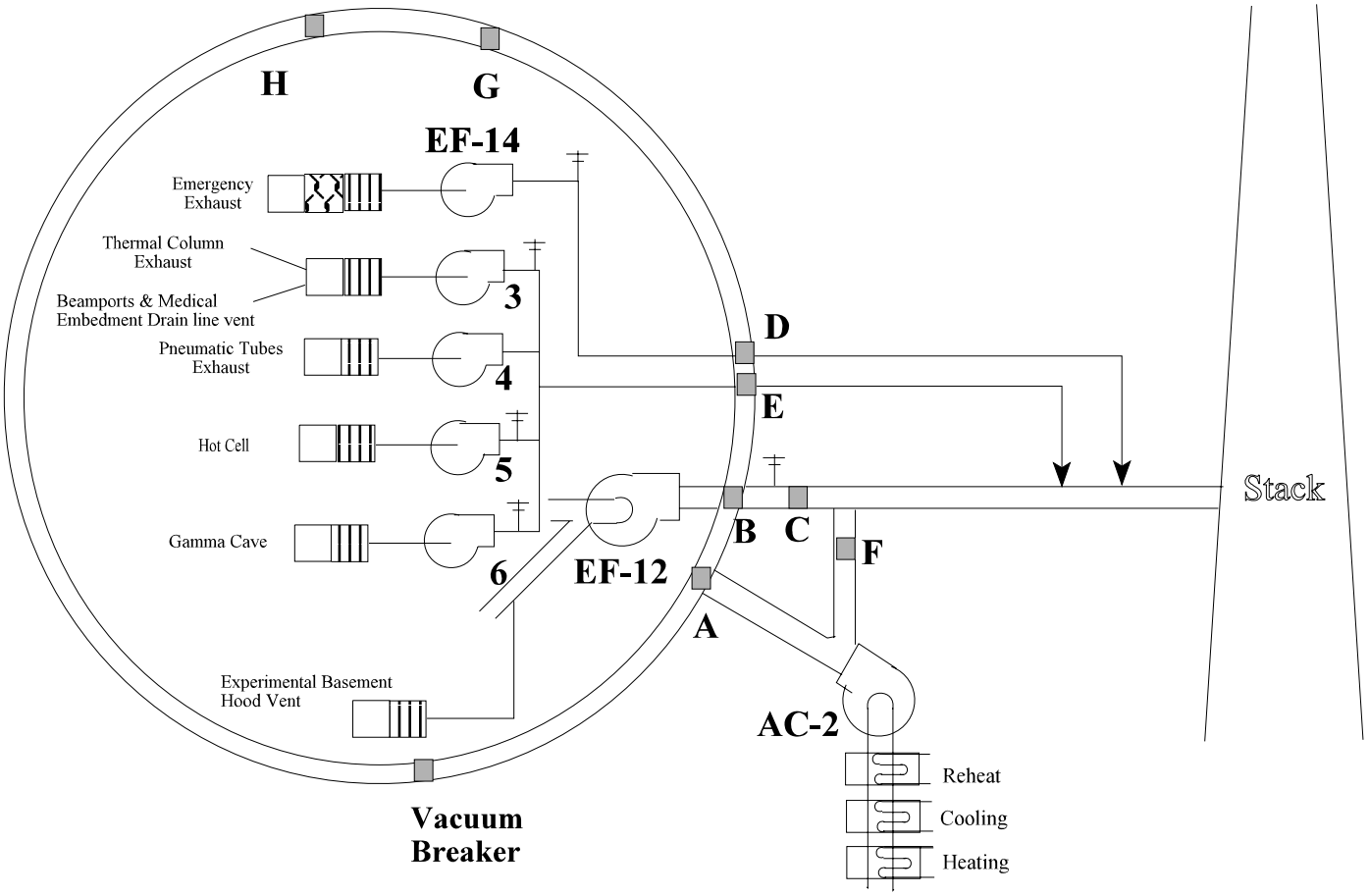

H
G
EF-14
Emergency Exhaust
Thermal Column Exhaust
Beamports & Medical Embedment Drain line vent
Pneumatic Tubes Exhaust
Hot Cell
Gamma Cave
3
4
5
6
EF-12
D
E
B
C
F
A
Stack
AC-2
Reheat
Cooling
Heating
Experimental Basement Hood Vent
Vacuum Breaker

Figure C.11

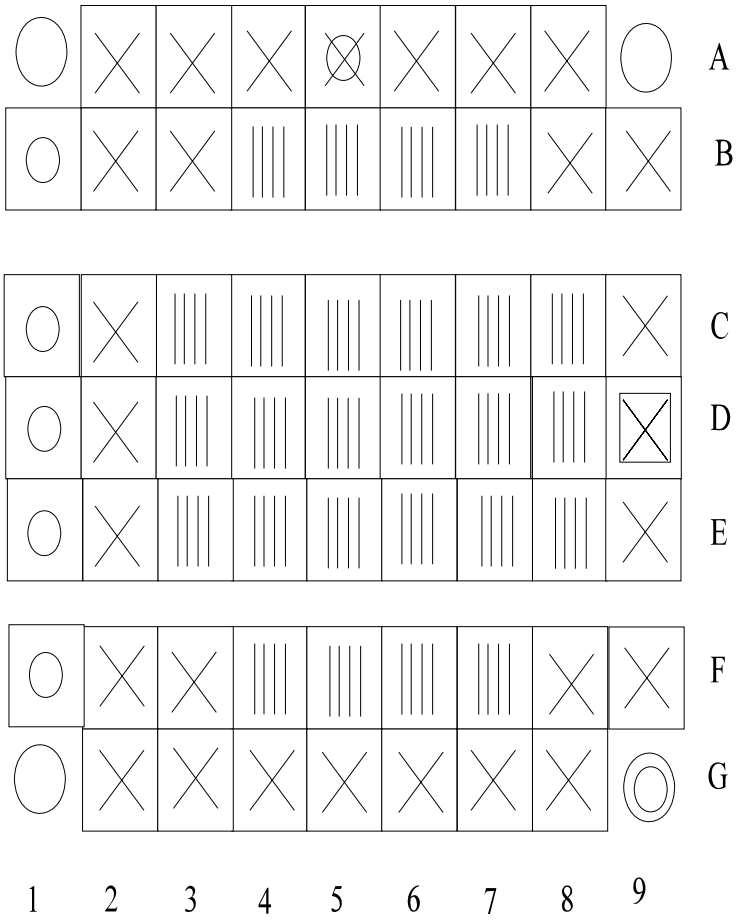


Figure C-13