January 5, 2007

Dr. Steven R. Reese, Director
Oregon State University
Radiation Center, A100
Corvallis, OR 97331-5903

SUBJECT: INITIAL EXAMINATION REPORT NO. 50-243/OL-07-01, OREGON STATE UNIVERSITY

Dear Dr. Reese:

During the week of December 11, 2006, the NRC administered an operator licensing examination at your Oregon State University Reactor. The examination was conducted according to NUREG-1478, "Non-Power Reactor Operator Licensing Examiner Standards," Revision 1. Examination questions and preliminary findings were discussed with those members of your staff identified in the enclosed report at the conclusion of the examination.

In accordance with 10 CFR 2.390 of the Commission's regulations, a copy of this letter and the enclosures will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records (PARS) component of NRC's Agencywide Documents Access and Management System (ADAMS). ADAMS is accessible from the NRC Web site at (the Public Electronic Reading Room) http://www.nrc.gov/reading-rm/adams.html. The NRC is forwarding the individual grades to you in a separate letter which will not be released publicly. Should you have any questions concerning this examination, please contact Mr. Paul V. Doyle Jr. at (301) 415-1058 or via internet e-mail pvd@nrc.gov.

Sincerely,

/RA/

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

Docket No. 50-243

Enclosures: 1. Initial Examination Report No. 50-243/OL-07-01
2. Examination and answer key

cc w/encls:
Please see next page

Dr. Steven R. Reese, Director
Oregon State University
Radiation Center, A100
Corvallis, OR 97331-5903

January 5, 2007

SUBJECT: INITIAL EXAMINATION REPORT NO. 50-243/OL-07-01, OREGON STATE UNIVERSITY

Dear Dr. Reese:

During the week of December 11, 2006, the NRC administered an operator licensing examination at your Oregon State University Reactor. The examination was conducted according to NUREG-1478, "Non-Power Reactor Operator Licensing Examiner Standards," Revision 1. Examination questions and preliminary findings were discussed with those members of your staff identified in the enclosed report at the conclusion of the examination.

In accordance with 10 CFR 2.390 of the Commission's regulations, a copy of this letter and the enclosures will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records (PARS) component of NRC's Agencywide Documents Access and Management System (ADAMS). ADAMS is accessible from the NRC Web site at (the Public Electronic Reading Room) http://www.nrc.gov/reading-rm/adams.html. The NRC is forwarding the individual grades to you in a separate letter which will not be released publicly. Should you have any questions concerning this examination, please contact Mr. Paul V. Doyle Jr. at (301) 415-1058 or via internet e-mail pvd@nrc.gov.

Sincerely,

/RA/

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

Docket No. 50-243

Enclosures: 1. Initial Examination Report No. 50-243/OL-07-1
2. Examination and answer key

cc w/encls:
Please see next page

DISTRIBUTION w/ encls.:
PUBLIC PRTB r/f JEads
AAdams Facility File (EBarnhill) O-6 F-2

ADAMS ACCESSION #: ML070030418 **TEMPLATE #:NRR-074**

OFFICE	PRTB:CE		IOLB:LA	E	PRTB:SC	
NAME	PDoyle:cah		EBarnhill		JEads	
DATE	01/03/2007		01/04 /2007		01/05/2007	

OFFICIAL RECORD COPY

cc:

Mayor of the City of Corvallis
Corvallis, OR 97331

David Stewart-Smith
Oregon Office of Energy
625 Marion Street, N.E.
Salem, OR 97310

George Holdren, Interim Vice Provost
for Research
Oregon State University
Administrative Services Bldg., Room A-312
Corvallis, OR 97331-5904

Dr. John Ringle, Chairman
Reactor Operations Committee
Oregon State University
100 Radiation Center
Corvallis, OR 97331-5904

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.: 50-243/OL-07-01

FACILITY DOCKET NO.: 50-243

FACILITY LICENSE NO.: R-160

FACILITY: Oregon State University

EXAMINATION DATES: December 11, 2006

SUBMITTED BY: _____**/RA/**_____ 01/03/2007
Paul V. Doyle Jr., Chief Examiner Date

SUMMARY:

On December 11, 2006, the NRC administered an examination to a Senior Reactor Operator (Instant) [SRO(I)] license candidate for the Oregon State University TRIGA research reactor. The SRO(I) candidate was well prepared and passed all portions of the administered examination.

REPORT DETAILS

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

2. Results:

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

3. Exit Meeting:
   Paul V. Doyle Jr., NRC, Examiner
   Stephen Reese, Oregon State University, Radiation Center Director
   Gary Wachs, Oregon State University, Reactor Supervisor
   Michael Hartman, Oregon State University, Reactor Administrator

   The NRC examiner thanked the facility staff for their support in the administration of the examinations. The examiner noted that the candidate was well prepared and that there were no signs of any weaknesses. The facility submitted their comments which identified two typographic errors. All corrections have been entered into the copy of the examination included with this report.

OPERATOR LICENSING EXAMINATION

With Answer Key

OREGON STATE UNIVERSITY

Week of December 11, 2006

QUESTION A.01 [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.02 [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.03 [1.0 point]
During a fuel loading of the core, as the reactor approaches criticality, the value of 1/M:

a. Increases toward one

b. Decreases toward one

c. Increases toward infinity

d. Decreases toward zero

QUESTION A.04 [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.05 [2.0 points]

Given a mother isotope of $(_{35}Br^{87})^{*}$, identify each of the daughter isotopes as a result of α, β^{+}, β^{-}, γ, or n, decay.

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

b. $_{34}Se^{87}$

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

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

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

QUESTION A.06 [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?

a. 11 minutes

b. 22 minutes

c. 44 minutes

d. 51 minutes

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

QUESTION A.07 [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.08 [1.0 point]

Using the graphs provided in the handout. Choose the ONE which most closely depicts the reactivity versus time plot for xenon for the following evolution. Bring the reactor to 100% power (clean core) and operate for four days (96 hours). Shutdown the reactor for 15 hours. Bring the reactor to 50% power for a day (24 hours).

a. A

b. B

c. C

d. D

QUESTION A.09 [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.10 [1.0 point]

K_{eff} is K_{∞} times …

a. the fast fission factor (ε)

b. the total non-leakage probability ($\mathcal{L}_f \times \mathcal{L}_{th}$)

c. the reproduction factor (η)

d. the resonance escape probability (p)

QUESTION A.11 [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.12 [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.13 [1.0 point]

Which of the following power manipulations would take the longest to complete assuming the same period is maintained?

a. 1 Kilowatt: from 1 kW to 2 kW

b. 1.5 Kilowatts: from 2 kW to 3.5 kW

c. 2 Kilowatts: from 3.5 kW to 5.5 kW

d. 2.5 Kilowatts: from 5.5 kW to 8 kW

QUESTION A.14 [1.0 point]

Which one of the following statements details the effect of fuel temperature on core operating characteristics? As fuel temperature …

a. increases, doppler peaks will become higher.

b. decreases, resonance escape probability will increase.

c. decreases, U^{238} will absorb more neutrons.

d. increases, the fast non-leakage probability will decrease.

QUESTION A.15 [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.16 [1.0 point]

Given an average rod reactivity worth of 0.1%/inch, and $\alpha_{T\text{prompt}}$ of -0.005%Δk/°C. If fuel temperature were to increase by 150°C, how far and in what direction would you have to move the rod to compensate?

a. 7.5 inches, inward

b. 0.75 inches, inward

c. 7.5 inches, outward

d. 0.75 inches, outward

QUESTION A.17 [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 B.01 [1.0 point]

You note that 1 cm of a material (used as a shield) reduces the radiation level from a given source by a factor of 2. If you add another nine cm of the material (for a total of 10 cm), you would expect the radiation level to be reduced by a factor of approximately ____ over no shielding. (Note: Ignore dose decrease due to distance, and decay.)

a. 20

b. 100

c. 200

d. 1,000

QUESTION B.2 [1.0 point, ⅓ each]

Identify the source for the listed radioisotopes. Irradiation of air, water, or fission product.

a. N^{16}

b. Ar^{41}

c. Xe^{188}

QUESTION B.03 [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.04 [2.0 points, ½ each]

Match type of radiation (1 thru 4) with the proper penetrating power (a thru d)

a. Gamma	1. Stopped by thin sheet of paper
b. Beta	2. Stopped by thin sheet of metal
c. Alpha	3. Best shielded by light (e.g., hydrogenous) material
d. Neutron	4. Best shielded by dense material

QUESTION B.05 [2.0 points, ½ 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.06 [1.0 point]

The Emergency Response Plan defines ***"Emergency Planning Zone (EPZ)"*** as …

a. within the walls of the reactor bay (Room D104).

b. the area within a 100 meter radius of the reactor core centerline.

c. within the walls of the Reactor Building.

d. within the walls of the Radiation Center.

QUESTION B.07 [1.0 point]

Which ONE of the following is the safety limit for a TRIGA-FLIP fuel element temperature? The temperature shall not exceed …

a. 3780°F (2100°C)

b. 2100°F (1150°C)

c. 1830°F (1000°C)

d. 1000°F (540°C)

QUESTION B.08 [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 prevent exceeding the LSSS during normal operations.

b. The SL is a limit on important process variables that assures the integrity of the fuel cladding. The LSSS initiates protective actions to preclude reaching the SL.

c. The LSSS is a limit on important process variables 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.09 [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.
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.10 [1.0 point]

What is the minimum level of permission to restart the reactor following an unplanned automatic scram?

a. Any Senior Reactor Operator's initials in the log book.

b. The Reactor Supervisor's (or his alternate's) verbal agreement.

c. The Reactor Supervisor's (or his alternate's) initials in the log book.

d. The Facility Director's verbal agreement.

QUESTION B.11 [1.0 point]

The Reactor Operator on duty is responsible for authorizing individuals to use the crane. The crane bridge is not allowed in the southern half of the bay if reactor power is greater than _____.

a. 300 watts

b. 3 Kwatts

c. 30 Kwatts

d. 300 Kwatts

QUESTION B.12 [1.0 point]

Which ONE of the following conditions is a violation of technical specifications § 3.7.2, *Reactor Pool Water*?

a. Conductivity of the pool water is 3µmhos/cm

b. Pool water pH is 4.8.

c. Radioactivity in the pool water is 0.2 µCi/ml

d. Bulk temperature of the coolant is 131°F (55°C) during reactor operation

QUESTION B.13 [1.0 point]

10CFR50.54(x) states: *"A licensee may take reasonable action that departs from a license condition or a technical specification (contained in a license issued under this part) in an emergency when this action is immediately needed to protect the public health and safety and no action consistent with license conditions and technical specifications that can provide adequate or equivalent protection is immediately apparent.* 10CFR50.54(y) states that the minimum level of management which may authorize this action is …

a. any Reactor Operator licensed at facility

b. any Senior Reactor Operator licensed at facility

c. Facility Manager (or equivalent at facility).

d. NRC Project Manager

QUESTION B.14 [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.15 [1.0 point]

Which ONE of the following statements concerning emergency exposure limits is correct? "For lifesaving situations, a total effective dose of up to ____ is permissible without authorization, due to the implied urgency of the situation".

a. 5 rem

b. 10 rem

c. 25 rem

d. 50 rem

QUESTION B.16 [1.0 point]

According to Technical Specification 3.8.a, Non-secured experiments shall have a reactivity worth less than ___ .

a. $.25

b. $.50

c. $.75

d. $1.0

QUESTION B.17 [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.18 [1.0 point]

Which ONE of the following Emergency classifications is NOT used at the Oregon State University TRIGA reactor?

a. Personnel and Operational Event

b. Notification of Unusual Event

c. Alert

d. General Emergency

QUESTION C.01 [1.0 point]

Which ONE of the following is the method used to minimize mechanical shock to the standard control rods on a scram?

a. A small spring located at the bottom of the rod.

b. A piston, (part of the connecting rod) drives water out of a dashpot as the rod nears the bottom of its travel.

c. An electrical-mechanical brake energizes when the rod down limit switch is energized.

d. A piston (part of the connecting rod) drives air out of a dashpot as the rod nears the bottom of travel.

QUESTION C.02 [1.0 point]

WHICH ONE of the following detectors is used primarily to measure Ar^{41} released to the environment?

a. NONE, Ar^{41} has too short a half-life to require environmental monitoring.

b. Stack Gas Monitor

c. Air Particulate Monitor

d. Area Radiation Monitor above pool

QUESTION C.03 [2.0, ½ each]

Match each beam port in column A with its corresponding description in column B.

	Column A (Beam Port)		Column B (Description)
a.	#1	1.	Radial, terminating at outer edge of reflector assembly
b.	#2	2.	Radial, terminating at inner surface of reflector assembly
c.	#3	3.	Same as 1, with cylindrical void in reflector graphite.
d.	#4	4.	Tangential to the outer edge of the core.

QUESTION C.04 [1.0 point]

On a pipe rupture, according to OSTROP 7, you are to stop the pumps and shut some valves. If you are unable to shut the valves, what design feature prevents siphoning of the reactor tank water?

a. vacuum breaker located on the shell side of the heat exchanger.

b. primary system pipes only go down six inches below the normal water surface.

c. holes located in each water pipe about 22 inches below the normal water surface.

d. holes located in each water pipe about 6 inches below the normal water surface.

QUESTION C.05 [1.0 point]

Which ONE of the valve lineups listed below will result in sending a "rabbit" INTO the core? (Use drawing provided with handout.)

	OPEN	SHUT
a.	A & B	C & D
b.	C & D	A & B
c.	A & C	B & D
d.	B & D	A & C

QUESTION C.06 [2.0 points, ⅓ each]

Identify whether the equipment listed remains energized (**ALWAYS ON**), reenergizes after emergency generator starts [20 seconds] (**EMERGENCY** Powered) or remains deenergized (**NO POWER**) following a loss of normal AC power to the facility.

a. Argon Fan

b. Public Address System

c. Fire Alarm System

d. Stack Monitor Pump

e. Cypher Locks

f. Rabbit Fan

QUESTION C.07 [1.0 point]

The rabbit system uses air to send samples into and out of the reactor core. Which ONE of the following is the largest radiological problem associated with using air?

a. ${}_{6}C^{14}$

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

c. ${}_{8}O^{18}$

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

QUESTION C.08 [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.

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

QUESTION C.09 [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.10 [1.0 point]

Why is Erbium added to TRIGA-FLIP fuel?

a. to improve the overall heat transfer coefficient, which is necessary due to higher temperatures generated when pulsing FLIP fuel.

b. to act as both a burnable poison, (allowing more fuel to be added), and as a resonance absorber, (enhancing prompt negative temperature coefficient).

c. to act as a burnable poison only (allowing more fuel to be added).

d. to act as a resonance absorber only, (enhancing prompt negative temperature coefficient).

QUESTION C.11 [2.0 points, ½ each]

Match the throttling valve listed in column A with the parameter (pressure of flow rate) that it is set to maintain.
Use the drawing of the Primary and Purification Systems provided for reference.

	Valve		Parameter Maintained
a.	DV-4	1.	~ 50 psig
b.	DV-16	2.	~ 10 gpm
c.	PV-6	3.	~ 50 gpm
d.	PV-7	4.	~ 440 gpm

QUESTION C.12 [1.0 point]

Identify which row (A through G) each of the following core components is in.

a. Source

b. Central Thimble

c. Instrumented Fuel Element

d. Transient Rod

e. Safety Rod

f. Rabbit Terminus

QUESTION C.13 [1.0 point]

The neutron absorbing part of the standard control rods are …

a. hafnium impregnated with aluminum oxide.

b. boron-carbide impregnated with hafnium

c. graphite impregnated with boron carbide.

d. aluminum impregnated with boron carbide.

QUESTION C.14 [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 Log-N Channel Detector.

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

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

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

QUESTION C.15 [2.0 points, ½ each]

Match the control rod drive mechanism part from column "A" with the correct function in column "B".

	COLUMN A		COLUMN B
a.	Piston	1.	Provide rod bottom indication.
b.	Potentiometer	2.	Provide rod full withdrawn indication.
c.	Spring-loaded Pull Rod	3.	Provide rod position indication when the electromagnet engages the armature.
d.	Push Rod	4.	Works with dash pot to slow rod near bottom of its travel.

A.01 c
REF:

A.02 c
REF:

A.03 d
REF:

A.04 a
REF:

A.05 a, α; b, β^+; c, n; d, γ; e, β^-
REF: STD NRC question.

A.06 b
REF:

A.07 c
REF: ln (2) = -time/τ τ = time/(ln(2)) = 60.59 ≈ 61 seconds

A.08 a
REF:

A.09 b
REF:

A.10 b
REF:

A.11 a, 2; b, 4; c, 1; d, 3
REF:

A.12 c
REF:

A.13 a
REF:

A.14 b
REF:

A.15 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.16 c
REF: -0.00005Δk/~~°C~~ × +150~~°C~~ = -0.0075 Δk of reactivity added. To compensate, must add +0.0075 Δk. +0.0075Δk ÷ 0.001 Δk/inch = 7.5 inches in the positive or outward direction.

A.17 a, 7; b, 2; c, 6; d, 5
REF: Standard NRC Question

B.01 d
REF: $2^{10} = 1{,}024 \approx 1{,}000$

B.02 a, water; b, air; c, fission product
REF: Standard NRC question

B.03 d
REF: Standard NRC definition

B.04 a, 4; b, 2; c, 1; d, 3
REF: Standard NRC question

B.05 a, 6; b, 2; c, 2; d, 1
REF: Technical Specifications § 1.31

B.06 c
REF: Emergency Response Plan § 6.0 *Emergency Planning Zone.*

B.07 b
REF: Technical Specifications § 2.1, p. 6.

B.08 b
REF: Technical Specifications §§ 1.22 and 1.23 Safety Limits and Limiting Safety System Settings, p. 4

B.09 a, 4; b, 2; c, 3; d, 1
REF: Technical Specifications, 2.2, 3.3.a, 3.6.d and 3.2.2 (Table 2)

B.10 c
REF: OSTROP 4, § VIII AUTOMATIC SCRAMS, step C, p. 12, also NRC exam administered 02/1998

B.11 d
REF: OSTROP 23, § III.B, p. 2, also NRC exam administered 02/1998

B.12 d; a and b are violations of the limits of OSTROP 7,
REF: Technical Specifications § 3.7.2, OSTROP 7

B.13 b
REF: 10CFR50.54(y)

B.14 a
REF: 10 CFR 20.1003 *Definititions*

B.15 c
REF: Emergency Plan § 7.4.1 p. 7-17.

B.16 d
REF: Technical Specification 3.8.a, p. 15.

B.17 b
REF: Emergency Plan, § 2.0 *Definitions*, p. 2-1.

B.18 d
REF: Emergency Plan §4.0 Emergency Classification System pp. 4-1 – 4-4.

C.01 b
REF: Oregon State Training Manual Volume 1, *Control Rod Drives*, p. 50.

C.02 b
REF: Per telcon with G. Wachs.

C.03 a, 3; b, 1; c, 4, d, 2
REF: OSU Training Volume 1, *Beam Port Facilities,* p. 91, also 1998 NRC exam

C.04 c
REF: OSTROP 7, *Operating Procedures for Reactor Water Systems*, § I.G, last paragraph, p. 4, also 1998 NRC examination

C.05 c
REF: OSTR Training Manual, Vol I, fig. 1.40 Standard Rabbit System Schematic, p. 71, also 1996 NRC Exam

C.06 **a, NO POWER; b, ALWAYS ON; c, EMERGENCY; d, EMERGENCY; e, EMERGENCY; f, NO POWER**
REF: OSTROP 22.0 Emergency Power System, Figures 22.1, and 22.2, also 1996 NRC Examination

C.07 d
REF: Standard NRC question.

C.08 a, 2; b, 3; c, 1; d, 4
REF: Standard NRC Question

C.09 b
REF: Standard NRC question.

C.10 b
REF: Standard NRC question of FLIP fuel

C.11 a, 1; b, 2; c, 4; d, 3
REF: OSTROP 7 *Operating Procedcures for Reactor Water Systems*

C.12 a, G; b, A; c, B; d, C; e, D; f, G
REF: Oregon State Training Material Operator Reference Data, Last Figure.

C.13 c
REF: Oregon State Training Manual Vo0lume 1, *Standard Control Rods*, p. 42.

C.14 b
REF: OSTR Training Manual Vol. 2, § IIIA, page 13. Also NRC examination administered October, 1996.

C.15 a. 4; b. 3; c. 1; d. 2
REF: Chapter 1, General Description of TRIGA Research Reactor

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

FACILITY: Oregon State University

REACTOR TYPE: TRIGA (Pulsing)

DATE ADMINISTERED: 2007/12/11

CANDIDATE: _____

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

Category Value	% of Total	Candidate Score	%of Category Value	Category
20	33	_____	_____	A. Reactor Theory, Thermodynamics, and Facility Operating Characteristics
20	33	_____	_____	B. Normal and Emergency Operating Procedures and Radiological Controls
20	33	_____	_____	C. Plant and Radiation Monitoring Systems
60		_____	_____	TOTALS
		FINAL GRADE		

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 answer sheets.

10. Ensure all information you wish to have evaluated as part of your answer is on your answer sheet.

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

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

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

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

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

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

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

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

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

$$T_{½} = \frac{0.693}{\lambda}$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Fuch's Pulse Model Equations (Estimates)

$$T_{max} = T_0\frac{2(\rho-\beta)}{\alpha}{}^{\circ}C \qquad P_{max} = \frac{(\rho-\beta)^2}{2\alpha(k)I}MW \qquad E_{tot} = \frac{2(\rho-\beta)}{k(\alpha)}MWS$$

$l = 39 \times 10^{-6}$ sec. $\alpha = 1.26 \times 10^{-4}\Delta k/k/^{\circ}C$ $k = 9.6$

---

1 Curie = 3.7×10^{10} dis/sec

1 Horsepower = 2.54×10^3 BTU/hr

1 BTU = 778 ft-lbf

1 gal (H_2O) ≈ 8 lbm

c_P = 1.0 BTU/hr/lbm/°F

1 kg = 2.21 lbm

1 Mw = 3.41×10^6 BTU/hr

°F = 9/5 °C + 32

°C = 5/9 (°F - 32)

c_p = 1 cal/sec/gm/°C

A.01 a b c d ___

A.02 a b c d ___

A.03 a b c d ___

A.04 a b c d ___

A.05a α β^+ β^- γ n ___

A.05b α β^+ β^- γ n ___

A.05c α β^+ β^- γ n ___

A.05d α β^+ β^- γ n ___

A.05e α β^+ β^- γ n ___

A.06 a b c d ___

A.07 a b c d ___

A.08a a b c d ___

A.08b a b c d ___

A.08c a b c d ___

A.08d a b c d ___

A.09 a b c d ___

A.10 a b c d ___

A.11a 1 2 3 4 ___

A.11b 1 2 3 4 ___

A.11c 1 2 3 4 ___

A.11d 1 2 3 4 ___

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 ___

B.01 a b c d ___

B.02a air water F.P. ___

B.02b air water F.P. ___

B.02c air water F.P. ___

B.03 a b c d ___

B.04a 1 2 3 4 ___

B.04b 1 2 3 4 ___

B.04c 1 2 3 4 ___

B.04d 1 2 3 4 ___

B.05a 1 2 4 6 ___

B.05b 1 2 4 6 ___

B.05c 1 2 4 6 ___

B.05d 1 2 4 6 ___

B.06 a b c d ___

B.07 a b c d ___

B.08 a b c d ___

B.09a a b c d ___

B.09b a b c d ___

B.09c a b c d ___

B.09d a b c d ___

B.10 a b c d ___

B.11 a b c d ___

B.12 a b c d ___

B.13 a b c d ___

B.14 a b c d ___

B.15 a b c d ___

B.16 a b c d ___

B.17 a b c d ___

B.18 a b c d ___

C.01 a b c d ___

C.02 a b c d ___

C.03a 1 2 3 4 ___

C.03b 1 2 3 4 ___

C.03c 1 2 3 4 ___

C.03d 1 2 3 4 ___

C.04 a b c d ___

C.05 a b c d ___

C.06a ALWAYS ON EMERGENCY NO POWER ___

C.06b ALWAYS ON EMERGENCY NO POWER ___

C.06c ALWAYS ON EMERGENCY NO POWER ___

C.06d ALWAYS ON EMERGENCY NO POWER ___

C.06e ALWAYS ON EMERGENCY NO POWER ___

C.06f ALWAYS ON EMERGENCY NO POWER ___

C.07 a b c d ___

C.08a 1 2 3 4 ___

C.08b 1 2 3 4 ___

C.08c 1 2 3 4 ___

C.08d 1 2 3 4 ___

C.09 a b c d ___

C.10 a b c d ___

C.11a 1 2 3 4 ___

C.11b 1 2 3 4 ___

C.11c 1 2 3 4 ___

C.11d 1 2 3 4 ___

C.12a a b c d ___

C.12b a b c d ___

C.12c a b c d ___

C.12d a b c d ___

C.12e a b c d ___

C.12f a b c d ___

C.13 a b c d ___

C.14 a b c d ___

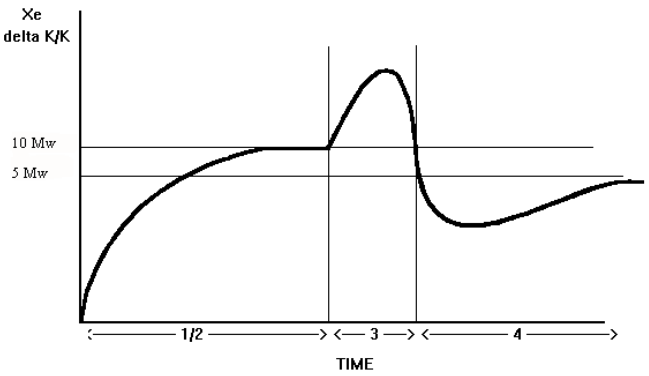
C.15a 1 2 3 4 ___

C.15b 1 2 3 4 ___

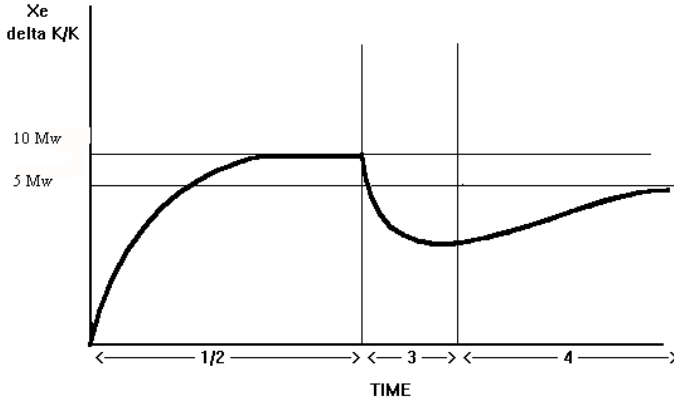
C.15c 1 2 3 4 ___

C.15d 1 2 3 4 ___

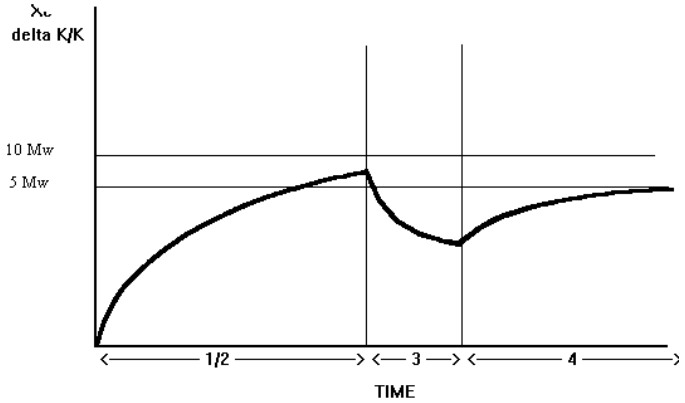
Figure for Question A.08



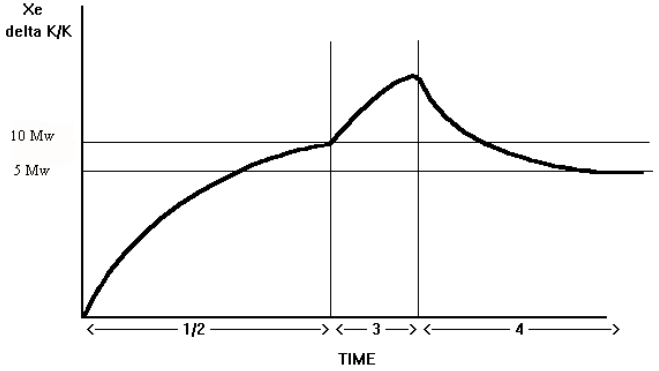
a



b



c



d

Figure for Question A.17

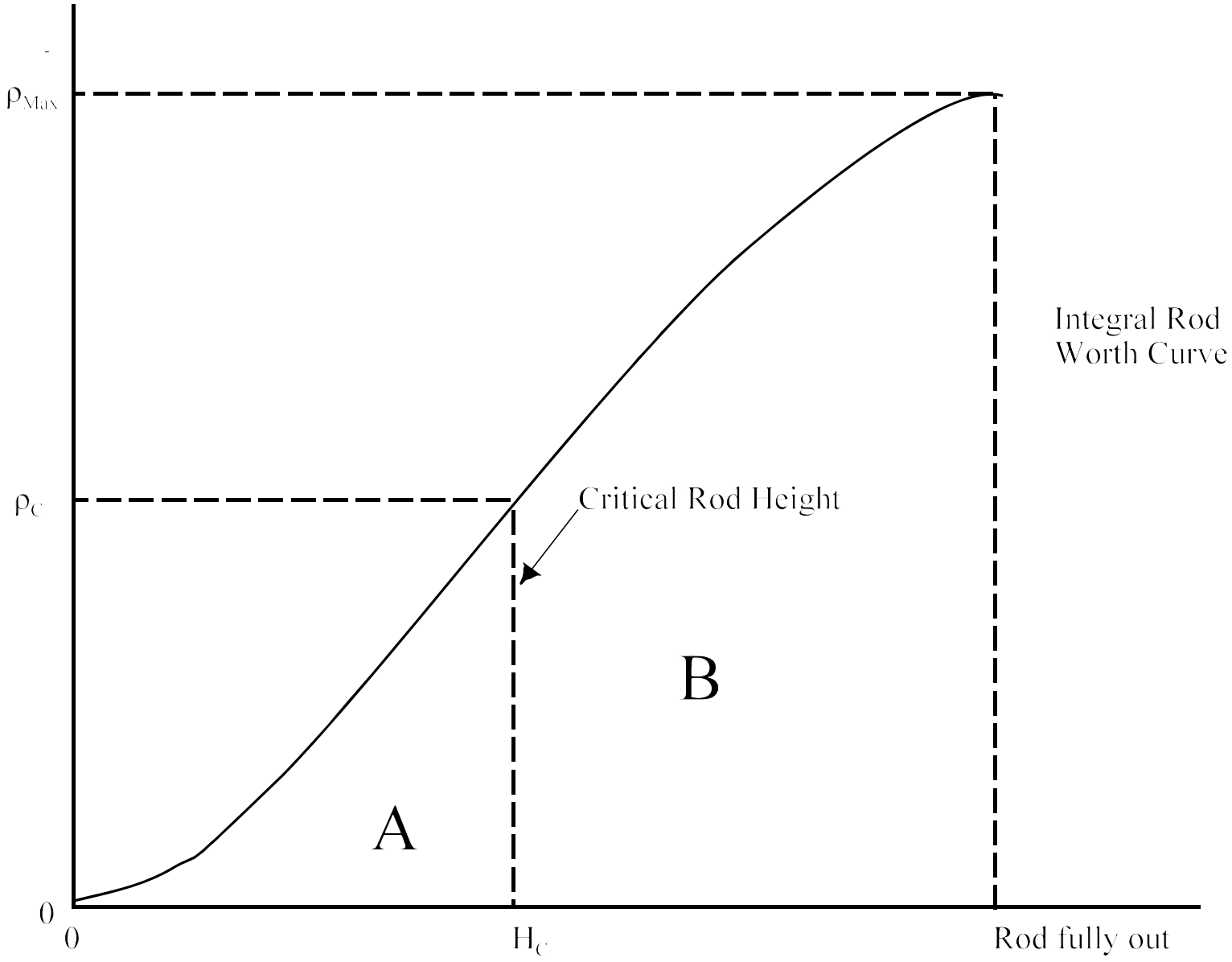
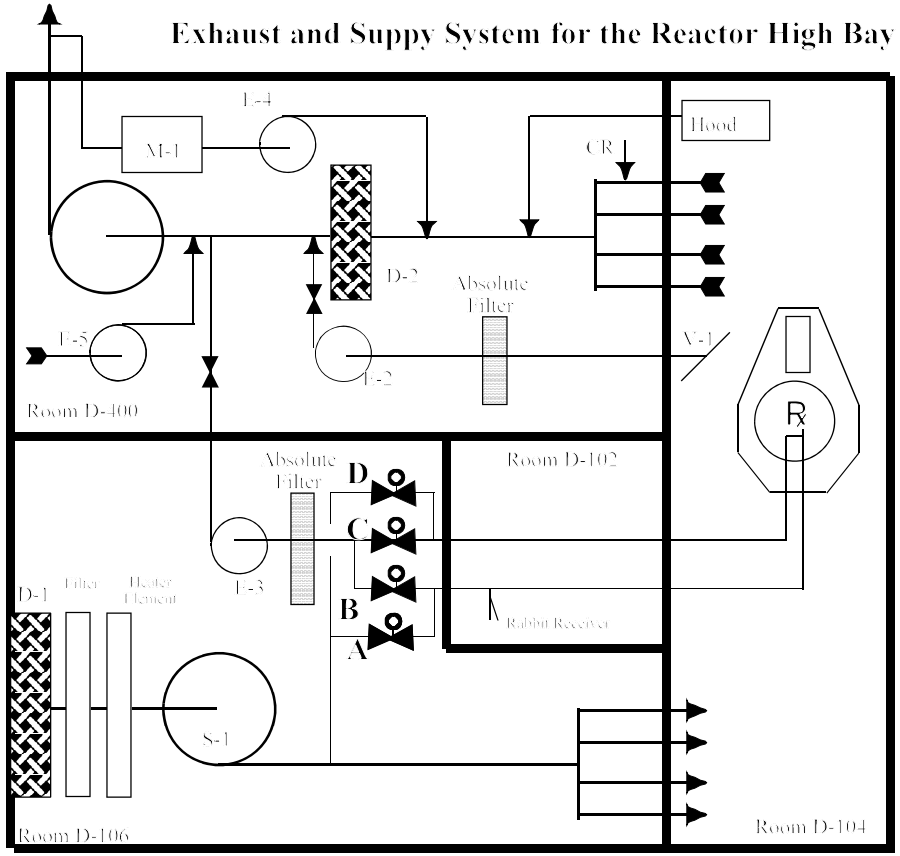


Figure for Question C.05



SYMBOL	FUNCTION
S-1	Suppy fan for Room D-104 (12,000 CFM)
E-1	Exhaust fan for Room D-104 (12,000 CFM)
E-2	Argon Exhaust fan (~5 CFM)
E-3	Pneumatic system exhaust (135 CFM)
E-4	Stack Gas and Particulate monitor blower (8 CFM)
E-5	Contaminated water drain vent fan
D-1	Suppy Damper
D-2	Static pressure control damper
M-1	Stack Gas and Particulate radiation monitor
V-1	Argon 41 manifold
CR	Cadmium rabbit discharge line into reactor bay ventillation exhaust duct

Figure for Question C.11