October 23, 2006

Mr. Ward L. Rigot, Director and Reactor Supervisor
Dow Chemical Company
1602 Building
Midland, MI 48674

SUBJECT: INITIAL EXAMINATION REPORT NO. 50-264/OL-07-01, DOW CHEMICAL COMPANY RESEARCH REACTOR

Dear Mr. Rigot:

During the week of October 02, 2006, the NRC administered an operator licensing examination at your Dow Chemical Company Research 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. 50-264

Enclosures: 1. Initial Examination Report No. 50-264/OL-07-01
2. Examination and answer key

cc w/encls:
Please see next page

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DISTRIBUTION w/ encls.:
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ADAMS ACCESSION #: ML062910406 **TEMPLATE #:NRR-074**

OFFICE	PRTB:CE	IOLB:LA	PRTB:SC
NAME	PDoyle:tls*	EBarnhill*	JEads:tls*
DATE	10/18/2006	10/23 /2006	10/23 /2006

OFFICIAL RECORD COPY

cc:

Office of the Mayor
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Alex Pollock
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2030/410 Dow Center
Midland, MI 48674

Dr. Kevin Hool, Level 1 Manager,
The Dow Chemical Company
1897 Building
Midland, MI 48667

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.: 50-264/OL-07-01

FACILITY DOCKET NO.: 50-264

FACILITY LICENSE NO.: R-108

FACILITY: Dow Chemical Company

EXAMINATION DATES: October 03, 2006

SUBMITTED BY: _____**/RA/**_____ 10/13/2006
Paul V. Doyle Jr., Chief Examiner Date

SUMMARY:

On October 03, 2006, the NRC administered an Operator Licensing Examination to one Senior Reactor Operator (Instant) candidate. The candidate passed all portions of his 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
   Ward Rigot, Dow Chemical Co., Reactor Supervisor

   The NRC thanked the facility for their support in the administration of the examination, and noted that one question (C.14) had to be deleted due to the answer being on the question page. In addition the examiner noted that the facility has a new cooling system which is not yet in the facility material. The facility told the examiner that they are updating their training material to include all new changes to the facility. The examiner did not note any weaknesses on the part of the candidate significant to be addressed at the exit meeting.

ENCLOSURE 1

OPERATOR LICENSING EXAMINATION

With Answer Key

DOW CHEMICAL TRIGA REACTOR

October 03, 2006

ENCLOSURE 2

Question A.01 [2.0 points, 0.4 each]

The listed isotopes are all potential daughter products due to the radioactive decay of $_{35}Br^{87}$. Identify the type of decay necessary [Alpha (α), Beta plus (β^+), Beta minus (β^-), Gamma (γ) or Neutron (ℕ) emission) to produce each of the isotopes.

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

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

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

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

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

Question A.02 [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.03 [1.0 point]

During a reactor startup, criticality occurred at a lower rod height than the last startup. Which ONE of the following reasons could be the cause?

a. Adding an experiment with positive reactivity.

b. Xe^{135} peaked.

c. Moderator temperature increased.

d. Maintenance on the control rods resulted in a slightly faster rod speed.

Question A.04 [1.0 point]

You are increasing reactor power on a steady +26 second period. How long will it take to increase power by a factor of 1000?

a. 60 seconds (1 minute)

b. 180 seconds (3 minutes)

c. 300 seconds (5 minutes)

d. 480 seconds (8 minutes)

Question A.05 [1.0 point]

Which ONE of the following statements is the definition of **REACTIVITY**?

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

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

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

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

Question A.06 [1.0 point]

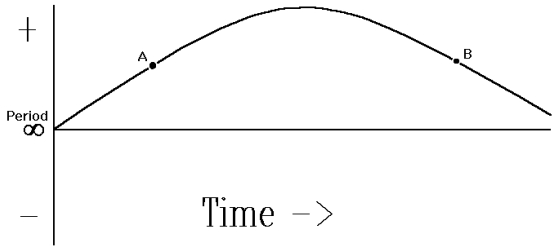
Shown below is a trace of reactor period as a function of time. Between points A and B reactor power is:

a. continually increasing.

b. continually decreasing.

c. increasing, then decreasing.

d. constant.



Question A.07 [1.0 point]

The reactor has been shutdown for 2 weeks. You startup the reactor and raise power to 1 Megawatt. Which ONE of the following correctly describes the movement of the regulating rod for the next three hours?

a. Rods will drive in.

b. Rods will drive out.

c. Rods will initially drive out then start driving back in.

d. Rods will initially drive in then start driving back out.

Question A.08 [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.09 [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.10 [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.11 [1.0 point]

Which ONE of the following describes the characteristics of good moderators and reflectors?

a. High scattering cross-section and low absorption cross-section.

b. Low scattering cross-section and high absorption cross-section.

c. Low scattering cross-section and low absorption cross-section.

d. High scattering cross-section and high absorption cross-section.

Question A.12 [2.0 points, ½ each]

Describe how heat is moved (Conduction (C), Natural Convection (NC), Forced Convection (FC) or Radiation (R) from one medium to the next for each of the following. From the … (Note, each of the choices may be used more than once or not at all.)

a. fuel meat to the cladding

b. cladding to the pool water

c. pool water to the heat exchanger

d. from the cooling tower water to the atmosphere.

Question A.13 [2.0 points, ½ each]

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

a. Total Rod Worth

b. Actual Shutdown Margin

c. Technical Specification Shutdown Margin Limit

d. Excess Reactivity

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

Question A.14 [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.15 [1.0 point]

The term prompt critical refers to:

a. the instantaneous jump in power due to a rod withdrawal

b. a reactor which is supercritical using only prompt neutrons

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

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

Question A.16 [1.0 point]

The 200 MeV worth of energy released by fission is split between the four products listed below. Which ONE of the following is not recoverable (lost to the environment)?

a. Prompt gamma rays

b. Kinetic Energy of the Fission fragments

c. Neutrinos

d. Kinetic Energy of the Fission neutrons

Question A.17 [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 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.02 [1.0 point]

While working on an experiment, you receive the following radiation doses: 100 mrem (β), 25 mrem (γ), and 5 mrem (thermal neutrons). Which ONE of the following is your total dose?

a. 175 mrem

b. 155 mrem

c. 145 mrem

d. 130 mrem

Question B.03 [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.04 [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.05 [1.0 point, 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.06 [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.07 [1.0 point]

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

a. the reactor room (Lab 51-A of the 1602 Building).

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

c. the Dow Chemical campus.

d. the area within a one mile radius of the Dow Chemical Research Reactor.

Question B.08 [2.0 points, ½ each]

Match the reactivity limits listed in column A with their respective technical specification values in column B.

	Column A	Column B
a.	Maximum total absolute reactivity of any individual moveable experiment	$0.50
b.	Maximum reactivity of all in-core experiments	$0.75
c.	Maximum Core Excess	$3.00
d.	Minimum Shutdown Margin	$1.00

Question B.09 [1.0 point]

The Emergency plan specifies three emergency support centers which may be used for different conditions, which ONE of the following locations is the emergency support center to be used for a long period evacuation?

a. Bldg. 1602 conference room

b. congregation area outside bldg. 1602

c. Bldg. 1603 some 300 feet east of Bldg. 1602

d. Bldg. 1607 some 450 feet west of Bldg. 1602

Question B.10 [1.0 point]

Which ONE of the following conditions requires the activation of the Emergency Response Plan?

a. Reactor Room Continuous Air Monitor reading 3000 cpm.

b. Site Boundary G-M Pancake TEDA Charcoal filter reading 2000 cpm.

c. Site Boundary Portable Ion Chamber filter reading 0.5 mrem/hr.

d. Reactor Room Area Monitor reading 1 mrem/hr.

Question B.11 [1.0 point]

No special experiment shall be performed until the proposed experimental procedure has been reviewed and approved by which ONE of the following?

a. Licensed Operator and the Reactor Operations Committee

b. Reactor Supervisor and the Radiation Safety Committee

c. Reactor Supervisor and the Reactor Operations Committee

d. Licensed Operator and the Radiation Safety Committee

Question B.12 [1.0 point]

Which ONE of the following conditions is a violation of DOW technical specifications § 3.4, Coolant System Specifications?

a. Conductivity of the pool water is 2 µmhos/cm averaged over one month.

b. Pool water pH is 5.7.

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

d. Bulk temperature of the coolant is 45°C during reactor operation

Question B.13 [1.0 point]

Which ONE of the following is the safety limit for the fuel element cladding temperature?

a. Less than or equal to 1050°F

b. Less than or equal to 1050°C

c. Less than 500°F

d. Less than 500°C

Question B.14 [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 parameter that assures the integrity of the fuel cladding. The LSSS initiates protective actions to preclude reading the SL.

c. The LSSS is a parameter that assures the integrity of the fuel cladding. The SL initiates protective action to preclude reaching the LSSS.

d. The SL is a maximum setpoint for instrumentation response. The LSSS is the minimum number of channels required to be operable.

Question B.15 [1.0 point]

A small fixed source emits 1 Rem/hr at a distance of 15 ft. If an radiation worker requires 1 minute to shut a valve located 5 feet from this source, HOW MANY times may he/she operate the valve without receiving a dose in excess of the 10 CFR 20 TEDE whole body limit? (Assume this is the ONLY dose received by the radiation worker and the half-life is long enough where decay is negligible.)

a. 20

b. 30

c. 40

d. 50

Question B.16 [1.0 point]

Per the Radiation Safety manual, a radiation worker may be authorized to receive up to a dose of ____ R to save a life.

a. 10

b. 20

c. 100

d. 200

Question B.17 [2.0 points, 0.4 each]

Match the terms in column A with their respective definitions in column B.

a. Radioactivity	1. The thickness of a material which will reduce a gamma flux by a factor of two.
b. Contamination	2. The greatest whole body radiation dose permitted an individual in a given circumstance.
c. Dose	3. An impurity which pollutes or adulterates another substance. In radiological safety, contamination refers to the radioactive materials which are the sources of ionizing radiations.
d. Maximum Permissible Exposure (MPE)	4. The quantity of radiation absorbed per unit mass by the body or by any portion of the body.
e. Half-thickness	5. 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 C.01 [1.0 point]

Which ONE of the following is the reason for the discharge line of the cooling water system terminating 9 feet below the pool water level and having a 45° elbow pipe at the end?

a. Prevents siphoning of the reactor pool should a leak in the system occur.

b. Provides a longer decay time for the short lived radioisotopes.

c. Minimizes the direct flow impingement on the core minimizing metal erosion.

d. Provides turbulent flow within the pool to prevent algae buildup.

Question C.02 [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.

Question C.03 [1.0 point]

The reflector surrounding the reactor uses which ONE of the following materials to reflect neutrons?

a. Beryllium

b. Graphite

c. Polyethylene

d. Zirconium

Question C.04 [1.0 point]

Which ONE of the following neutron flux monitoring channels provides a signal indicating the period of the reactor?

a. Linear Channel

b. Count Rate Channel

c. Log Channel

d. Percent Power Channel

Question C.05 [1.0 point]

In order to minimize the effects of irradiated air from the pneumatic tube (rabbit) system, the …

a. exhaust of the system is located in a fume hood in the Hot Lab.

b. piping is a recirculating loop with a CO_2 purge.

c. piping is a recirculating loop with an N_2 purge.

d. exhaust of the system is located in the facility exhaust stack.

Question C.06 [1.0 point]

Technical Specifications restrict bulk water temperature to less than 60°C because of …

a. pump seal leakage concerns

b. pool water evaporation rate problems

c. ion exchange resin degradation

d. fuel element cladding stress and expansion

Question C.07 [1.0 point]

Which of the following instruments is used to detect High range Beta-Gamma radiation during an emergency condition?

a. Eberline Model E-140

b. Model RO-2

c. CD V - 700 model 6B

d. CD V - 715 model 1B

Question C.08 [1.0 point]

Which ONE of the following Reactor parameters will result in a reactor scram when the set-point is exceeded, but is not required to be operational by DOW Technical Specifications?

a. Reactor water temperature

b. Reactor water level

c. Reactor water radioactivity

d. Reactor water conductivity

Question C.09 [1.0 point]

Which ONE of the following is a safety concern when using a lazy susan specimen container made of polyethylene for long-time activation?

a. Chlorine contamination of the sample

b. Polyethylene contamination of the sample

c. Embrittlement of the sample container

d. Hydrogen gas buildup inside of the container.

Question C.10 [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.11 [1.0 point]

Which ONE of the following methods is used to compensate for gamma radiation in a Compensated Ion Chamber?

a. Pulses smaller than a height (voltage) are stopped by a pulse-height discriminator circuit from entering the instrument channel's amplifier.

b. The chamber contains concentric tubes one of which detects both neutrons and gammas the other only gammas, are wired electronically to subtract the gamma signal, leaving only the signal due to neutrons.

c. The signal travels through a Resistance-Capacitance (RC) circuit, converting the signal to a power change per time period effectively deleting the signal due to gammas.

d. A compensating voltage equal to a predetermined "source gamma level" is fed into the pre-amplifier electronically removing source gammas from the signal. Fission gammas are proportional to reactor power and therefore not compensated for.

Question C.12 [2.0 points, ½ each]

For each of the items listed below, identify whether it is applicable to a fuel element only(FE), a dummy reflector element only (DRE) or could be either (BOTH). (Note choices may be used more than once or not at all.)

a. contains graphite

b. contains zirconium hydride

c. Stainless Steel clad

d. Aluminum clad

Question C.13 [1.0 point]

Which ONE of the following was **NOT** a design consideration for the reactor well when aluminum was selected instead of steel?

a. Improve long-term reliability

b. Minimize effect of activation

c. Maximize radiation shielding

d. Minimize corrosion

~~Question C.14 [1.0 point]~~ Question Deleted (answer given in text of question)

~~Rank the following experimental facilities from highest (1) to lowest neutron flux (4).~~

~~a. Central Thimble (1)~~

~~b. Dummy Fuel Element (2)~~

~~c. Lazy Susan (4)~~

~~d. Pneumatic Transfer System (3)~~

Question C.15 [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.

A.01 a, α; b, $\mathbb{N}$; c, γ; d, β^-; e, β^+
Ref: Standard NRC question.

A.02 d
Ref:

A.03 a
Ref:

A.04 b
Ref: $\ln (P/P_0) \times \text{period} = \text{time}$, $\ln(1000) \times 26 = 6.908 \times 26 = 179.6 \approx 180$ seconds

A.05 b
Ref:

A.06 a
Ref:

A.07 b
Ref:

A.08 a
Ref:

A.09 a
Ref:

A.10 b
Ref:

A.11 a
Ref:

A.12 a, C; b, NC; c, FC; d, FC
Ref:

A.13 a, 7; b, 2; c, 6; d, 5
Ref:

A.14 d
Ref:

A.15 b
Ref:

A.16 c
Ref:

A.17 a

Ref: Burn, Reed Robert, *Introduction to Nuclear Reactor Operations,* © December, 1988, § 3.3.4, pp. 3-20 – 3-23. $\Delta\rho = (K_{eff1} - K_{eff2}) \div (K_{eff1} * K_{eff2})$ $\Delta\rho = (0.9550 - 1.0000) \div (0.9550 * 1.0000)$ $\Delta\rho = -0.0450 \div 0.9550 = -0.0471$ In order to reach critical you must add **+0.0471 ΔK/K**

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

B.02 d
REF: A rem is a rem is a rem.

B.03 a, water; b, air; c, fission product
Ref:

B.04 d
REF: Standard Health Physics Definition.

B.05 a, 4; b, 2; c, 1; d, 3
Ref:

B.06 a, 6; b, 2; c, 2; d, 1
Ref: 10CFR55.59

B.07 a
Ref: Dow TRIGA Research Reactor Emergency Plan, § 5, pg. 11.

B.08 a, $0.75; b, $1.00; c, $3.00; d, $.050
Ref: Technical Specifications 3.1 and 3.8 (2) & (3).

B.09 c
Ref: Dow Chemical TRIGA Emergency Plan

B.10 b
Ref: Dow Chemical Research Reactor Table of EALS, p. 3-37 (3/91 Exam)

B.11 c
Ref: Dow Chemical Chapter 3, § 3.4, p. 3-18 (3/91 Exam)

B.12 c
Ref: Technical Specifications § 3.4, p. 16. (3/91 Exam)

B.13 d
Ref: Technical Specifications § 2.1, p. 6. (3/91 Exam)

B.14 b
Ref: § 2.0 Safety Limits and Limiting Safety System Setpoints, p. 4

B.15 b
Ref: Dose per operation: 1 R/hr × 1/60 hr × $(15\text{ft}/5\text{ ft})^2$ = 9/60 = 0.15 Rem per operation. Limit = 5.0 R/hr. # of operations = 5.0 Rem/0.150Rem/operation = 33.3

B.16 d
Ref: Dow Chemical Radiation Safety, Section 5.1.5, also NRC examination administered 12/1987

B.17 a, 5; b, 3; c, 4; d, 2 e, 1
Ref: Standard NRC Question

C.01 b
Ref: Dow Chemical Chapter 1, § 1.6.1, p. 1-20 (3/91 exam)

C.02 a. 4; b. 3; c. 1; d. 2
Ref: Chapter 1, General Description of DOW TRIGA Research Reactor § 1.5, p. 1-18.

C.03 b
Ref:

C.04 c
Ref:

C.05 a
Ref: SAR § H.6

C.06 c
Ref: TS 3.4

C.07 b
Ref:

C.08 b
Ref: Dow Control Console Manual § 3, p. 3-3 and Technical Specification Tables 3.3A and 3.3B. (3/91 Exam)

C.09 d
Ref: Dow Chemical Chapter 1, § 1.11.1, p. 1-20 (3/91 exam)

C.10 a, 2; b, 3; c, 1; d, 4
Ref: Standard NRC question

C.11 b
Ref: Standard NRC question

C.12 a, BOTH; b, FE; c, FE; d, BOTH
Ref: Modification of question administered December 1987.

C.13 c
Ref: Dow Chemical Chapter 1, § 1.3.2, p. 1-7, also 3/91 Exam

~~C.14 a, 1; b, 2; c, 4; d, 3~~ Question Deleted (answer on question page)
~~Ref:~~

C.15 a
Ref: Standard NRC question.

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

FACILITY: Dow TRIGA Reactor

REACTOR TYPE: TRIGA

DATE ADMINISTERED: 2000/08/07

REGION: III

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	35.0	_____	____	A. Reactor Theory, Thermodynamics and Facility Operating Characteristics
20.00	35.0	_____	____	B. Normal and Emergency Operating Procedures and Radiological Controls
17.00	29.8	_____	____	C. Facility and Radiation Monitoring Systems
57.00		_____	____% 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.01a α β^+ β^- γ $\mathbb{N}$ ___

A.01b α β^+ β^- γ $\mathbb{N}$ ___

A.01c α β^+ β^- γ $\mathbb{N}$ ___

A.01d α β^+ β^- γ $\mathbb{N}$ ___

a.01e α β^+ β^- γ $\mathbb{N}$ ___

A.02 a b c d ___

A.03 a b c d ___

A.04 a b c d ___

A.05 a b c d ___

A.06 a b c d ___

A.07 a b c d ___

A.08 a b c d ___

A.09 a b c d ___

A.10 a b c d ___

A.11 a b c d ___

A.12a C NC FC R ___

A.12b C NC FC R ___

A.12c C NC FC R ___

A.12d C NC FC R ___

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

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

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

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

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.02 a b c d ___

B.03a air water F.P. ___

B.03b air water F.P. ___

B.03c air water F.P. ___

B.04 a b c d ___

B.05a 1 2 3 4 ___

B.05b 1 2 3 4 ___

B.05c 1 2 3 4 ___

B.05d 1 2 3 4 ___

B.06a 1 2 4 6 ___

B.06b 1 2 4 6 ___

B.06c 1 2 4 6 ___

B.06d 1 2 4 6 ___

B.07 a b c d ___

B.08a $0.50 $0.75 $1.00 $3.00 ___

B.08b $0.50 $0.75 $1.00 $3.00 ___

B.08c $0.50 $0.75 $1.00 $3.00 ___

B.08d $0.50 $0.75 $1.00 $3.00 ___

B.09 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.17a 1 2 3 4 5 ___

B.17b 1 2 3 4 5 ___

B.17c 1 2 3 4 5 ___

B.17d 1 2 3 4 5 ___

B.17e 1 2 3 4 5 ___

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.09 a b c d ___

C.10a 1 2 3 4 ___

C.10b 1 2 3 4 ___

C.10c 1 2 3 4 ___

C.10d 1 2 3 4 ___

C.11 a b c d ___

C.12a FE DRE BOTH ___

C.12b FE DRE BOTH ___

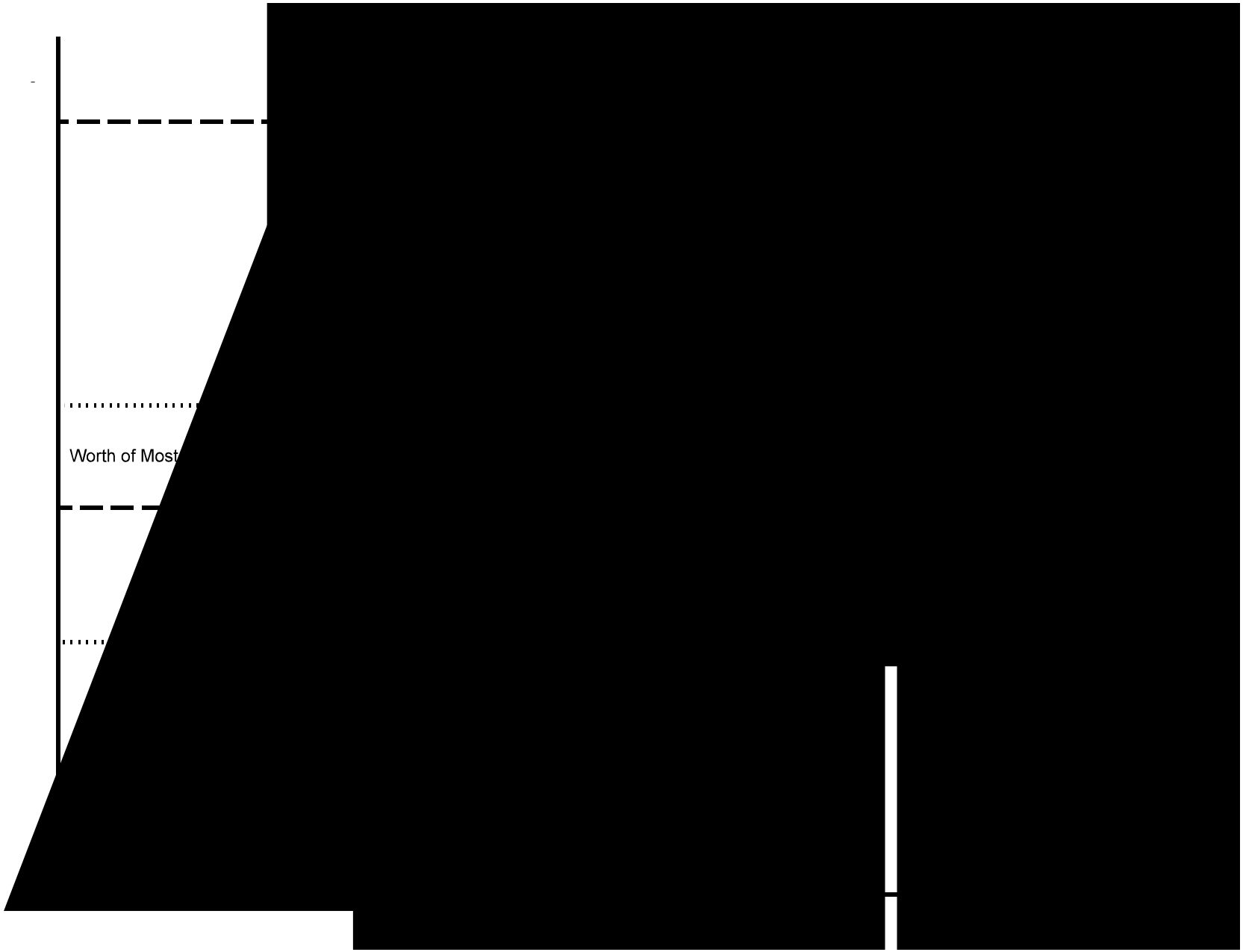
C.12c FE DRE BOTH ___

C.12d FE DRE BOTH ___

C.13 a b c d ___

C.14 a b c d ___

C.15 a b c d ___


Worth of Most