August 24, 2000

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

SUBJECT: INITIAL EXAMINATION REPORT NO. 50-264/OL-00-01

Dear Mr. Rigot:

During the week of August 7, 2000, the NRC administered an initial examination to an employee of your facility who had applied for a license to operate your Dow Chemical Company Reactor. The examination was conducted in accordance with NUREG-1478, "Non-Power Reactor Operator Licensing Examiner Standards," Revision 1. At the conclusion of the examination, the examination questions and preliminary findings were discussed with those members of your staff identified in the enclosed report.

In accordance with 10 CFR 2.790 of the NRC's "Rules of Practice" a copy of this letter and its 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/index.html. The NRC is forwarding the individual grades to your staff in a separate letter which will not be released publicly. If you have any questions concerning the examination, please contact Paul Doyle at (301) 415-1058 or E-mail at pvd@nrc.gov.

Sincerely,

/RA/
Ledyard B. Marsh, Chief
Events Assessment, Generic Communications
and Non-Power Reactors Branch
Division of Regulatory Improvement Programs
Office of Nuclear Reactor Regulation

Docket No. 50-264

Enclosures:
1. Initial Examination Report No. 50-264/OL-00-01
2. Examination and answer key (RO/SRO)

cc w/encls:
Please see next page

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DATE	08/23/2000		08/ /2000		08/ /2000	

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cc:

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Midland, Michigan 48640

Office of the Governor
Room 1 - Capitol Building
Lansing, Michigan 48913

Stan Dombrowski
Chair, Radiation Safety Committee
Dow North America
1803 Building
Midland, Michigan 48667

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

REPORT NO.: 50-264/OL-00-01

FACILITY DOCKET NO.: 50-264

FACILITY LICENSE NO.: R-108

FACILITY: Dow Chemical Company

EXAMINATION DATES: August 8, 2000

EXAMINER: Paul Doyle, Chief Examiner

SUBMITTED BY: ***/RA/*** 08/24/2000
Paul Doyle, Chief Examiner Date

SUMMARY:

The NRC administered an Operator Licensing Examination to one Senior Reactor Operator (Instant) candidate. The candidate passed the examination.

REPORT DETAILS

1. Examiner: Paul Doyle, 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 Doyle, NRC, Examiner
Ward Rigot, Reactor Supervisor, Dow Chemical TRIGA Reactor.

Mr. Doyle thanked Mr. Rigot for the facility's support in administering the examination, and encouraged him to submit any comment to the written examination as soon as possible to expedite issuing the results.

N.B.: Per telephone call, the facility had no comments on the written.

DOW CHEMICAL TRIGA REACTOR

With Answer Key

UNITED STATES NUCLEAR REGULATORY COMMISSION

OPERATOR LICENSING
EXAMINATION
August 8, 2000

ENCLOSURE 2

QUESTION A.1 [2.0 points, 0.5 each]
Match each term in column A with the correct definition in column B.

	Column A		Column B
a.	Prompt Neutron	1.	A neutron in equilibrium with its surroundings.
b.	Fast Neutron	2.	A neutron born directly from fission.
c.	Thermal Neutron	3.	A neutron born due to decay of a fission product.
d.	Delayed Neutron	4.	A neutron at an energy level greater than its surroundings.

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

a. The reactor is critical.

b. The reactor is subcritical.

c. The reactor is supercritical.

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

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

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

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

a. Thermal Utilization Factor (f)

b. Reproduction Factor (η)

c. Fast Fission Factor (β)

d. Fast Non-Leakage Factor (L_f)

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

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

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

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

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

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

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

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

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

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

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

a. Thermal utilization factor (f).

b. Resonance escape probability (p).

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

d. Reproduction factor (η).

QUESTION A.8 [1.0 point]
Which ONE of the following atoms will cause a neutron to lose the most energy in an elastic collision?

a. Uranium^{238}

b. Carbon^{12}

c. Hydrogen^{2}

d. Hydrogen^{1}

QUESTION A.9 [1.0 point]
K_{eff} for the reactor is 0.98. If you place an experiment worth +$1.00 into the core, what will the new K_{eff} be?

a. 0.982

b. 0.987

c. 1.013

d. 1.018

QUESTION A.10 [1.0 point]
About two minutes following a reactor scram, period has stabilized, and is decreasing at a CONSTANT rate. If reactor power is 10^{-5}% full power what will the power be in three minutes.

a. 5×10^{-6} % full power

b. 2×10^{-6} % full power

c. 10^{-6} % full power

d. 5×10^{-7} % full power

QUESTION A.11 [1.0 point]
The frequency on the local power grid increases from 60 Hz to 66 Hz. This results in all of the control rod drives running 10% faster. How will this change in rod speed effect reactor critical conditions compared to normal rod speed?

a. Rod height will be lower, Power will be lower.

b. Rod height will be higher, Power will be higher

c. Rod height will be the same, Power will be lower.

d. Rod height will be the same, Power will be the same.

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

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

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

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

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

QUESTION A.13 [1.0 point]
The source was removed from an operating reactor. Later, the source was reinstalled and the Reactor Operator noted reactor power increasing LINEARLY. What was the condition of the reactor when the source was inserted? (Assume source has no reactivity worth, and no other changes in reactor parameters.) The reactor was …

a. very subcritical

b. slightly subcritical

c. exactly critical

d. slightly supercritical

QUESTION A.14 [1.0 point]
Which one of the following is the definition of the FAST FISSION FACTOR?

a. The ratio of the number of neutrons produced by fast fission to the number produced by thermal fission

b. The ratio of the number of neutrons produced by thermal fission to the number produced by fast fission

c. The ratio of the number of neutrons produced by fast and thermal fission to the number produced by thermal fission

d. The ratio of the number of neutrons produced by fast fission to the number produced by fast and thermal fission

QUESTION A.15 [1.0 point]
In a reactor at full power, the thermal neutron flux (β) is 2.5×10^{12} neutrons/cm^2/sec. and the macroscopic fission cross-section Σ_f is 0.1 cm^{-1}. The fission reaction rate is:

a. 2.5×10^{11} fissions/sec.

b. 2.5×10^{13} fissions/sec.

c. 2.5×10^{11} fissions/cm^3/sec.

d. 2.5×10^{13} fissions/cm^3/sec.

QUESTION A.16 [1.0 point]
A characteristic peculiar to TRIGA fuel is that it has a relatively large (and quickly acting) …

a. pressure coefficient.

b. void coefficient.

c. bath temperature coefficient.

d. fuel temperature coefficient.

QUESTION A.17 [1.0 point]
For a TRIGA reactor a “Rule of thumb” for increasing power is that power will increase by ___ for every cent of reactivity added.

a. 125 watts

b. 250 watts

c. 1.25 kilowatts

d. 2.50 kilowatts

QUESTION A.18 [1.0 point]
The number of neutrons in one cubic centimeter multiplied by their average velocity 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.19 [1.0 point]
Which ONE of the following is the correct reason that delayed neutrons enhance control of the reactor?

a. There are more delayed neutrons than prompt neutrons.

b. Delayed neutrons increase the average neutron generation time.

c. Delayed neutrons are born at higher energies than prompt neutrons and therefore have a greater effect.

d. Delayed neutrons take longer to reach thermal equilibrium.

QUESTION B.1 [2.0 points, 0.5 each]
Identify each of the following as either a Safety Limit (**SL**), a Limiting Safety System Setting (**LSSS**) or a Limiting Condition for Operation (**LCO**)

a. The temperature in any fuel element shall not exceed 500°C under any conditions of operation.

b. … shall not exceed 300kw as measured by the calibrated power channels.

c. The excess reactivity measured at less than 10 watts in the reference core with or without experiments in place shall not be greater than $3.00.

d. Conductivity of the bulk pool water shall be no higher than 5×10^{-6} mhos/cm average over one month.

QUESTION B.2 [2.0 points, 0.5 each]
Identify each of the following as either a CHANNEL **CHECK**, a CHANNEL **TEST** or a CHANNEL **CAL**IBRATION.

a. Dipping a temperature detector in ice water and verifying the channel reads 32°F (0°F)

b. Verifying proper overlap between Nuclear Instrumentation Channels during startup.

c. After receiving an alarm on an Area Radiation Monitor, you verify the reading with a hand-held meter.

d. Performing a reactor pool water rate-of-temperature-rise measurement, then adjusting the detectors to correct readout.

QUESTION B.3 [2.0 points, 0.5 each]
Match the radiation reading from column A with its corresponding radiation area classification (per 10 CFR 20) listed in column B.

COLUMN A	COLUMN B
a. 10 mRem/hr	1. Unrestricted Area
b. 150 mRem/hr	2. Radiation Area
c. 10 Rem/hr	3. High Radiation Area
d. 550 Rem/hr	4. Very High Radiation Area

QUESTION B.4 [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.5 [1.0 point]
The ***Quality Factor*** is used to convert …

a. dose in rads to dose equivalent in rems.

b. dose in rems to dose equivalent in rads.

c. contamination in rads to contamination equivalent in rems

d. contamination in rems to contamination equivalent in rads.

QUESTION B.6 [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 dose 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.7 [1.0 point]
Two inches of shielding reduce the gamma exposure in a beam of radiation from 400 mR/hr to 200 mR/hr. If you add an additional four inches of shielding what will be the new radiation level? (Assume all readings are the same distance from the source.)

a. 25 mR/hr

b. 50 mR/hr

c. 75 mr/hr

d. 100 mr/hr

QUESTION B.8 [1.0 point]
The Dow TRIGA Research Reactor Requalification Program requires each licensed operator to operate the reactor at least once every 120 days and perform a minimum of ten reactivity manipulations each calendar year. 10CFR55 states …the licensee shall perform the functions of an operator or senior operator for a minimum of ___ hours per calendar quarter.

a. 2

b. 4

c. 6

d. 8

QUESTION B.9 [1.0 point]
Which ONE of the following statements concerning emergency exposure limits is correct?
The Dow standard for radiation exposure of emergency workers is ___ for life-saving situations …

a. 5 rem

b. 10 rem

c. 25 rem

d. 50 rem

QUESTION B.10 [1.0 point]
Technical Specification 5.4 requires "all fuel and fueled devices not in the core shall be stored in such a way that K_{eff} is less than …

a. 0.80

b. 0.85

c. 0.90

d. 0.95

QUESTION B.11 [1.0 point]
According to Technical Specification 3.7.3 experiments having worths of greater than ___ shall be securely located or fastened to prevent inadvertent movement during reactor operation.

a. $.25

b. $.50

c. $.75

d. $1.0

QUESTION B.12 [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.13 [1.0 point]
In case of an emergency the **NORMAL** Emergency Support Center (evacuation not required) is…

a. the conference room in the 1602 building

b. congregation area outside the building.

c. 1603 building

d. reactor control room.

QUESTION B.14 [1.0 point]
Which ONE of the following Emergency classifications is NOT used at the Dow TRIGA reactor?

a. Unclassified Event

b. Notification of Unusual Event

c. Alert

d. General Emergency

QUESTION B.15 [1.0 point]
A small radioactive source is to be stored in the reactor building. The source reads 2 R/hr at 1 foot. Assuming no shielding is to be used, a Radiation Area barrier would have to be erected from the source at least a distance of approximately:

a. 400 feet

b. 40 feet

c. 20 feet

d. 10 feet

QUESTION B.16 [1.0 point]
The control rod drive withdrawal speeds were last measured on July 31, 1999. Which one of the following dates is the latest the maintenance may be performed again without exceeding a Technical Specifications requirement?

a. Nov. 30, 1999

b. Feb. 14, 2000

c. Oct. 31, 2000

d. Jan 31, 2001

QUESTION B.17 [1.0 point]
Following a spill continue decontaminating an area until the contamination level is less than or equal to

a. 10 dpm/100 cm^2

b. 50 dpm/100 cm^2

c. 100 dpm/100 cm^2

d. 500 dpm/100 cm^2

QUESTION C.1 [2.0 points, ½ each]
Match the purification system functions in column A with the purification component listed in column B

Column A	Column B
a. remove floating dust, bug larvae, etc.	1. Demineralizer (Ion Exchanger)
b. remove dissolved impurities	2. Skimmer
c. remove suspended solids	3. Filter
d. maintain pH	

QUESTION C.2 [1.0 point]
The gas used to move pneumatic tube "rabbit" samples into and out of the reactor is …

a. H

b. Air

c. CO_2

d. N_2

QUESTION C.3 [1.0 point, ½ each]
Match the detector type in column B with the proper reactor channel in column A.

a. NM1000	1. Fission Chamber
b. NPP1000	2. BF_3 Counter
	3. Compensated Ion Chamber
	4. Uncompensated Ion Chamber

QUESTION C.4 [1.0 point]
Which ONE of the following is the reason that primary temperature is maintained below 50°C? Above this temperature the …

a. diffusion of N^{16} from the pool increases dramatically.

b. bath temperature coefficient changes from negative to positive.

c. the purification system filter melts.

d. the demineralizer resin start to break down.

QUESTION C.5 [1.0 point]
Which ONE of the following is the actual method used to determine rod position from 0 to 100%?

a. A logic circuit receives input from two sensors which count 100 pulses per revolution along with detecting direction, converting these signals to rod position.

b. A ten-turn potentiometer, driven by the rod drive motor, generates a signal proportional to rod position.

c. As the rod moves up and down, the magnet opens and closes a series of 100s of limits switches which generate a signal which is converted to rod position.

d. As the rod moves, it move into or out of a coil, generating a signal proportional to rod position.

QUESTION C.6 [1.0 point]
Which ONE of the following is the method used to minimize mechanical shock to the 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.7 [1.0 point]
During reactor operation, a leak develops in the primary to secondary heat exchanger. Which ONE of the following conditions correctly describes how the system will react?

a. Pool level will increase due to leakage from the secondary.

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

c. Pool level will remain the same due to automatic makeup, secondary flow into the sewer will increase.

d. Pool level will remain constant due to isolation of the secondary following detection of radioisotopes.

QUESTION C.8 [1.0 point]
Which ONE of the following is the actual design feature which prevents siphoning of pool water on a failure of the primary/purification system?

a. A Vacuum breaker valve is located upstream of the primary pump.

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

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

d. A vacuum breaker valve is located downstream of the primary pump.

QUESTION C.9 [1.0 point]
Fill in the blank: In the event of failure of the pool cooling system, the heat capacity of the reactor pool is sufficient to cool the reactor for _____, with the reactor operating at 300 Kilowatts.

a. about 2 Minutes

b. about 2 Hours

c. about 2 Days

d. about 2 Weeks

QUESTION C.10 [1.0 point]
An experimenter drops and breaks open a sample vial in a laboratory room. He immediately runs out of the room and closes the door. You are called in to assist in the cleanup. Prior to opening the door you would take a reading using a(n)

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

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

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

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

QUESTION C.11 [1.0 point]
The control rods are aluminum tubes containing a mixture of

a. hafnium and aluminum oxide.

b. boron-carbide and hafnium

c. boron-carbide and aluminum oxide.

d. boron-carbide and stainless-steel

QUESTION C.12 [1.0 point]
Flow through the demineralizer loop is limited to 10 gallons per minute. This limit is to

a. prevent blowing resin out of the demineralizer thereby clogging the filter.

b. creating channels through the demineralizer reducing efficiency.

c. overpressurization of the demineralizer.

d. blowing the upstream filter into the demineralizer.

QUESTION C.13 [1.0 point]
A sample placed in which ONE of the following positions will have the greatest effect on core reactivity?

a. Lazy Susan

b. Pneumatic Transfer system

c. Hollow Element Assembly

d. Central Thimble

QUESTION C.14 [1.0 point]
The purpose of the graphite slugs located at the top and bottom of each fuel rod is …

a. absorb neutrons, thereby reducing neutron embrittlement of the upper and lower guide plates.

b. absorb neutrons, thereby reducing neutron leakage from the core.

c. reflect neutrons, thereby reducing neutron leakage from the core.

d. couple neutrons from the core to the nuclear instrumentation, decreasing shadowing effects.

QUESTION C.15 [1.0 point]
The ventilation system is designed so that:

a. the reactor room is at a higher pressure than the atmosphere.

b. the reactor room is at a lower pressure than the adjacent laboratory.

c. the reactor building is equal to atmospheric pressure.

d. the reactor room and the adjacent laboratory are always at the same pressure.

QUESTION C.16 [1.0 point]
Loss of power to which ONE of the following reactor systems will cause an alarm at the Dow Security Dispatcher?

a. Area Radiation Monitor

b. Continuous Air Monitor

c. NM1000

d. Water Radioactivity Monitor

QUESTION C.17 [1.0 point, – each]
Identify the heat transfer mechanism (**Rad**iation, **F**orced **C**onvection, **N**atural **C**onvection or **Con**duction) for each of the following:

a. Cooling the Core

b. Cooling the Pool

c. Heat Transfer across the Heat Exchanger Tubes

QUESTION C.18 [1.0 point]
Which ONE of the following parameters is NOT measured in the Primary Cooling/Purification System Loops?

a. Temperature

b. Flow Rate

c. Conductivity

d. pH

QUESTION C.19 [1.0 point, ¼ each]
Identify whether the Nuclear Indication listed below is provided by the NM1000, NP1000 or BOTH.

a. Log Power

b. Period

c. % Power

d. Linear Power

A.1 a, 2; b, 4; c, 1; d, 3
REF: Dow Chemical Chapter 6, § 6.1.10, p. 6-7 and 6.2.5, p. 6-18.

A.2 c
REF: Standard NRC question

A.3 b
REF: Dow Chemical Chapter 6, § 6.3.11, pp. 6-44–6-51.

A.4 a
REF: Dow Chemical Chapter 6, § 6.1.5 through 6.1.8, pp. 6-4–6-5.

A.5 b
REF: Standard NRC question

A.6 b
REF: Dow Chemical Chapter 6, § 6.2.3, pp. 6-13–6-16.

A.7 d
REF: Dow Chemical Chapter 6, § 6.1.5, through 6.1.9 pp. 6-7–6-8.

A.8 d
REF: Dow Chemical Chapter 6, § 6.1.10, p. 6-7.

A.9 b
REF: Dow Chemical Chapter 6, §
SDM = $(1-k_{eff})/k_{eff}$ = (1-0.98)/0.98 = 0.02/0.99 = 0.02041 or 0.02041/.0075 = $2.72, or a reactivity worth (β) of -$2.72. Adding +$1.00 reactivity will result in a SDM of $2.72 - $1.00 = $1.72, or .0129081 βK/K
K_{eff} = 1/(1+SDM) = 1/(1 + 0.0129081) = 0.987

A.10 c
REF: $P = P_0\, e^{-T/\beta} = 10^{-5} \times e^{(-180sec/80sec)} = 10^{-5} \times e^{-2.25} = 0.1054 \times 10^{-5} = 1.054 \times 10^{-6}$

A.11 c
REF: Dow Chemical Chapter 6, § 6.2.2, pp. 6-12–6-16.

A.12 a
REF: Dow Chemical Chapter 6, § 6.2.8, pP. 6-23–6-28.

A.13 c
REF: Dow Chemical Chapter 6, § 6.2.2, pp. 6-12–6-16.

A.14 c
REF: Dow Chemical Chapter 6, § 6.1.5, p. 6-4.

A.15 c

REF: Standard NRC question. $R = \beta \Sigma_f = (2.5 \times 10^{12}) \times 0.1 = 2.5 \times 10^{11}$

A.16 d
REF: Dow Chemical Chapter 6, § 6.3.4, p. 6-38.

A.17 c
REF: Dow Chemical Chapter 6, § 6.3.7, p. 6-45.

A.18 c
REF: Dow Chemical Chapter 6, § 6.1.1, p. 6-2.

A.19 b
REF: Dow Chemical Chapter 6, § 6.2.5, pp. 6-18.

B.1 a, SL; b, LSSS; c, LCO; d, LCO
REF: Technical Specifications §§ 2.1, 2.2, 3.1.2 and 3.8

B.2 a, test; b, check; c, check; d, cal
REF: Technical Specifications § 1.3.

B.3 a, 2; b, 3; c, 3; d, 4
REF: 10 CFR 20.1003, Definitions

B.4 b
REF: 10CFR50.54(y)

B.5 a
REF: 10CFR20.1004.

B.6 a
REF: 10 CFR 20.1003 *Definititions*

B.7 b
REF: Nuclear Power Plant Health Physics and Radiation Protection, Research Reactor Version©1988, § 9.2.3 "Half-Thickness and Tenth-Thickness"

B.8 b
REF: 10CFR55.53(e) last sentence.

B.9 c
REF: Emergency Plan last ¶ of § 6.Emergency Response on p. 14.

B.10 a
REF: Technical Specification 5.4

B.11 c
REF: Technical Specification 3.7.3

B.12 b
REF: Emergency Plan, § b. Definitions, p. 2.

B.13 a
REF: Emergency Plan, § 7.a, p. 14

B.14 d
REF: Emergency Plan §3. Emergency Classifications pp. 8 and 9.

B.15 c
REF:

$$\frac{DR_1}{X_2^2} = \frac{DR_2}{X_1^2} X_2^2 = \frac{DR_1}{DR_2} X_1^2 \qquad X_2^2 = \frac{2000}{5} \times 1^2 = 400 ft^2 X_2 = 20 f$$

B.16 c
REFERENCE T.S. § 4.2.1

B.17 b
REFERENCE Radioactive Material Loose Isotope Procedures, § 2 RAM Decontamination, p3.

C.1 a, 2; b, 1; c, 3; d, 1
REF: Instruction Manual for the DOW TRIGA Research Reactor § 1.6.2, pp. 1-20 & 1-21.

C.2 b
REF: Instruction Manual for the DOW TRIGA Research Reactor § 1.11.2, pp. 1-27 & 1-28.

C.3 a, 1; b, 4
REF: Instruction Manual for the DOW TRIGA Research Reactor § 2.4, pp. 2-17 & 2-18.

C.4 d
REF: Instruction Manual for the DOW TRIGA Research Reactor § 1.6.2, pp. 1-21

(C.5) b
REF: Instruction Manual for the DOW TRIGA Research Reactor § 1.5.3, pp. 1-16

C.6 b
REF: Instruction Manual for the DOW TRIGA Research Reactor § 1.5.3, pp. 1-16

C.7 a
REF: Instruction Manual for the DOW TRIGA Research Reactor § 1.6.1, pp. 1-20

C.8 c
REF: Instruction Manual for the DOW TRIGA Research Reactor § 1.6.1, pp. 1-20

C.9 b
REF: Instruction Manual for the DOW TRIGA Research Reactor § 4.2.1, pp. 4-14

$$Power(kilowatt) = \frac{\Delta Temperature}{\Delta Time \times 0.0499} \qquad Time = \frac{\Delta Temperature}{300 \times 0.0499} = \frac{29}{14.97} = 1.94$$

C.10 a
REF: Standard NRC question.

C.11 c
REF: Instruction Manual for the DOW TRIGA Research Reactor § 1.5.1, pp. 1-16

C.12 b
REF: Instruction Manual for the DOW TRIGA Research Reactor § 1.6.2, pp. 1-21

C.13 d
REF: Instruction Manual for the DOW TRIGA Research Reactor § 1.11.5, pp. 1-29

C.14 c
REF: Instruction Manual for the DOW TRIGA Research Reactor § 1.4.1, pp. 1-8

C.15 b
REF: Instruction Manual for the DOW TRIGA Research Reactor § 1.10, pp. 1-25

C.16 b

REF: Emergency Plan § 1, 2nd ¶, 5th sentence.

C.17 a, NC; b, FC; c, Con
REF: Instruction Manual for the DOW TRIGA Research Reactor §

C.18 d
REF: Instruction Manual for the DOW TRIGA Research Reactor §

C.19 a, NM1000; b, NM1000; c, BOTH; d, NM1000
REF: Operation and Maintenance Manual Microprocessor Based Instrumentation and Control System for the ICI Tracerco TRIGA Reactor, Figure

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	33.3	_____	____	A. Reactor Theory, Thermodynamics and Facility Operating Characteristics
20.00	33.3	_____	____	B. Normal and Emergency Operating Procedures and Radiological Controls
20.00	33.3	_____	____	C. Facility and Radiation Monitoring Systems
60.00		_____	____% FINAL GRADE	TOTALS

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

_____
Candidate's Signature

NRC RULES AND GUIDELINES FOR LICENSE EXAMINATIONS

During the administration of this examination the following rules apply:

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

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

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

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

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

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

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

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

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

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

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

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

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

EQUATION SHEET

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

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

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

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

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

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

$$CR_1(-\beta_1) = CR_2(-\beta_2)$$

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

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

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

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

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

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

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

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

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

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

$$T_{½} = \frac{0.693}{\beta}$$

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

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

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

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

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

$$\frac{(\beta_2-\beta)^2}{Peak_2} = \frac{(\beta_1-\beta)^2}{Peak_1}$$

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

1 kg = 2.21 lbm

1 Horsepower = 2.54 x 10^3 BTU/hr

1 Mw = 3.41 x 10^6 BTU/hr

1 BTU = 778 ft-lbf

°F = 9/5 °C + 32

1 gal (H_2O) ≈ 8 lbm

°C = 5/9 (°F - 32)

c_P = 1.0 BTU/hr/lbm/°F

c_p = 1 cal/sec/gm/°C

A.1a 1 2 3 4 ___

A.1b 1 2 3 4 ___

A.1c 1 2 3 4 ___

A.1d 1 2 3 4 ___

A.2 a b c d ___

A.3 a b c d ___

A.4 a b c d ___

A.5 a b c d ___

A.6 a b c d ___

A.7 a b c d ___

A.8 a b c d ___

A.9 a b c d ___

A.10 a b c d ___

A.11 a b c d ___

A.12 a b c d ___

A.13 a b c d ___

A.14 a b c d ___

A.15 a b c d ___

A.16 a b c d ___

A.17 a b c d ___

A.18 a b c d ___

A.19 a b c d ___

B.1a SL LSSS LCO ___

B.1b SL LSSS LCO ___

B.1c SL LSSS LCO ___

B.1d SL LSSS LCO ___

B.2a Check Test Cal ___

B.2b Check Test Cal ___

B.2c Check Test Cal ___

B.2d Check Test Cal ___

B.3a 1 2 3 4 ___

B.3b 1 2 3 4 ___

B.3c 1 2 3 4 ___

B.3d 1 2 3 4 ___

B.4 a b c d ___

B.5 a b c d ___

B.6 a b c d ___

B.7 a b c d ___

B.8 a b c d ___

B.9 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 ___

C.1a 1 2 3 ___

C.1b 1 2 3 ___

C.1c 1 2 3 ___

C.1d 1 2 3 ___

C.2 a b c d ___

C.3a 1 2 3 4 ___

C.3b 1 2 3 4 ___

C.4 a b c d ___

C.5 a b c d ___

C.6 a b c d ___

C.7 a b c d ___

C.8 a b c d ___

C.9 a b c d ___

C.10 a b c d ___

C.11 a b c d ___

C.12 a b c d ___

C.13 a b c d ___

C.14 a b c d ___

C.15 a b c d ___

C.16 a b c d ___

C.17a Rad FC NC Con ___

C.17b Rad FC NC Con ___

C.17c Rad FC NC Con ___

C.18 a b c d ___

C.19a NM1000 NP1000 Both ___

C.19b NM1000 NP1000 Both ___

C.19c NM1000 NP1000 Both ___

C.19d NM1000 NP1000 Both ___