U. S. NUCLEAR REGULATORY COMMISSION REGION I
OPERATOR LICENSING EXAMINATION REPORT

EXAMINATION REPORT NO. 50-054/85-05 (OL)

FACILITY DOCKET NO. 50-054

LICENSEE: Cintichem, Inc.
P. O. Box 326
Tuxedo, New York 10987

FACILITY: Cintichem, Inc.

EXAMINATION DATES: October 9 and 10, 1985

CHIEF EXAMINER: Noel Dudley — 11-8-85
Noel Dudley, Reactor Engineer Examiner — Date

REVIEWED BY: R M Keller — 11/12/85
Robert M. Keller, Chief — Date
Projects Section 1C

APPROVED BY: H B Kister — 11/12/85
Harry B. Kister, Chief — Date
Projects Branch No. 1

SUMMARY: A licensing examination was administered to one RO candidate. He passed both the written and oral examinations.

REPORT DETAILS

TYPE OF EXAMS: Replacement

EXAM RESULTS:

	RO Pass/Fail
Written Exam	1/0
Oral Exam	1/0
Overall	1/0

1. CHIEF EXAMINER AT SITE: R. G. Clark, PNL

2. OTHER EXAMINERS: None

3. Summary of generic strengths or deficiencies noted on oral exams:

   Candidate demonstrated a weakness in knowledge of area monitors.

4. Summary of generic strengths or deficiencies noted from grading of written exams:

   Candidate's knowledge of Principles of Reactor Power Operation was weak but acceptable.

   Facility did not provide adequate or appropriate reference material for preparation of the examination. The licensee expended a large portion of the examination review session attempting to find references to justify expansion of responses in the answer key. As a result, the examiner felt that, in some cases, the answers provided by the reviewers were less appropriate than the answers supplied by the candidate.

5. Personnel Present at Exit Interview:

   NRC Contractor Personnel

   R. G. Clark, PNL

Facility Personnel

W. G. Ruzicka, Manager, Nuclear Operations
S. E. Lupinski, Training Coordinator
R. A. Strack, Reactor Supervisor

6. Summary of NRC Comments made at exit interview:

The candidate clearly passed the oral examination.

Facility supplied questions and answers had not been received by the examiner.

7. CHANGES MADE TO WRITTEN EXAM:

The following changes were made to the questions prior to the exam:

Question B.5 p. 5	remove words by pass
C.6 p. 9	or changed to on
C.7 p. 9	insert word best in part b.
D.4 p. 10	change and to any
G.6 p. 20	add and briefly tell why at end of question (answer expects this addition)
G.8 p. 21	change the word the to two. Give two limitations.

Answers enlarged as a result of inadequate reference material submitted.

A.1 Add as an alternate Answer:

- photoneutron source

$${}_{1}D^{2} + {}_{o}\gamma^{o} \text{------} {}_{o}n^{1} = {}_{1}H^{1}$$

A.2 Add as a factor:

- Relative short half-life as an option

B.2 Add as an option:

- Due to press difference

C.5 References provided by facility:

- Tables on RM-04-2 or RM-03-2

D.1 For correctness, the last line of the answer should read:

- direction, thus overcoming the compensating current that is in excess of gamma current from the CIC.

D.2 Answer shall state:

- Can cover a wide range of flux changes, without switching.

E.4 Answers should be:

- For 3' limit: To always assure NPSH for primary pump.
- For 7' limit: To assure adequate volume in hold-up tank that gravity flow of coolant through the core occurs after primary pump lost.

Facility was unable to supply references for these answers.

F.2 No change made. All suggested addition to answer were correct, but insignificant.

Attachment:

1. Written Examination and Answer Key (RO)

MASTER

Attachment 1

U.S. NUCLEAR REGULATORY COMMISSION

REACTOR OPERATOR LICENSE EXAMINATION

Facility: Cintichem

Reactor Type: Test

Date Administered: October 9, 1985

Examiner: R. G. Clark

Candidate: ______________________

INSTRUCTIONS TO APPLICANT:

Print your name on the line above marked "Candidate." The grade points available for each question are indicated within parentheses after each question. The passing grade is at least 70% in each of the seven (7) categories. Use separate paper for your answers and write on only one (1) side of the paper, unless a specific question instructs you otherwise. Staple this question package to your answer sheets. The examination questions and answers will be picked up six (6) hours after the examination was started. Read the statement at the bottom of this page. When you have finished this examination, affirm the statement by signing your name.

Category Value	% of Total	Candidate's Score	% of Cat. Value	Category
17.5	17.5			A. Principles of Reactor Power Operation
12.0	12.0			B. Features of Facility Design
15.0	15.0			C. General Operating Characteristics
15.0	15.0			D. Instruments and Controls
16.0	16.0			E. Safety and Emergency Systems
11.5	11.5			F. Standard and Emergency Operating Procedures
13.0	13.0			G. Radiation Control and Safety
100.0				TOTALS

Final Grade ________ %

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

____

Candidate's Signature

A. PRINCIPLES OF REACTOR POWER OPERATION (17.5)

Points Available

QUESTION A.1

Give the nuclear reactions that produce neutrons from the source at the Cintichem Research Reactor. (1.0)

ANSWER A.1

$_4Be^9 + {}_0\gamma^0 \longrightarrow {}_4Be^8 + {}_0n^1$ OR (+1.0) This source recently removed from reactor.

O/K $_1H^2 + {}_0\gamma^0 \longrightarrow {}_0n^1 + {}_1H^1$ Now depending on

Reference(s)

1. Principles of Reactor Operation, p. A-7.
2. Nuclear Energy Hdbk Etherington 1958 pp 2-3, 2-27.

QUESTION A.2

Give two (2) reasons why Xe-135 has such a significant effect on reactor operation. (2.0)

ANSWER A.2

Because of its high fission product yield **(+1.0)**.
Because of its very large thermal cross-section **(+1.0)**.

O/K Because of its relatively short half life

Reference(s)

1. NUS, Vol. 3, p. 10, 2-1.
2. Nuc Engr Hdbk, Etherington p 6-29

- Section A continued on next page -

Points
Available

QUESTION A.3

Answer TRUE or FALSE and briefly justify your answer.

a. The time it takes to achieve peak Xe conditions following a shutdown is independent of the equilibrium power level prior to shutdown. (1.0)

b. The equilibrium Xe-135 concentration at 50% (2.5 MW) power is about half the Xe-135 concentration at 100% power. (1.0)

ANSWER A.3

a. FALSE - The lower the equilibrium power, the earlier the Xenon peaks.

b. FALSE - It is about 70% as high as at 100% due to higher burn-out factor of Xe-135 at 100% power.

(+1.0 each)

Reference(s)

1. NUS, Vol. 3, pp. 10.2-2, 10.2-3 and 10.2-4.

- Section A continued on next page -

Points Available

QUESTION A.4

Why is excess reactivity added to a reactor greater than that necessary for a critical mass? Give three (3) reasons. (3.0)

ANSWER A.4

[Any three (3)]

1. To overcome negative power coefficients.
2. To overcome neutron losses due to poisons and leakage.
3. To give operating flexibility i.e., increase to power at a reasonable rate.
4. To compensate for fuel burnup.
5. To accommodate negative reactivity of experiments.

(+1.0 each, +3.0 maximum)

Reference(s)

1. Training Manual (TM), Section J, Specific Operating Characteristics, pp. 10, 11.
2. NUS, Vol. 3, Section 11., p. 11.1-3.

- Section A continued on next page -

Points
Available

QUESTION A.5

Given the following,

$K\beta$ = multiplication factor for delayed neutrons
$K(1-\beta)$ = multiplication factor for prompt neutrons
β_{eff} = 0.008 for Cintichem Research Reactor

Give the maximum safe multiplication factor that can be tolerated in this reactor, and briefly explain why. (2.0)

ANSWER A.5

Less than 1.008. **(+1.0)**

Because at these multiplication factors the rate of increase is controlled only by the rate of emission of delayed neutrons. **(+1.0)**

Reference(s)

1. Training Manual (TM), Section H, p. H-7

- Section A continued on next page -

Points Available

QUESTION A.6

How does β differ from β_{eff} (larger/smaller) in the Cintichem Research Reactor and briefly explain why? (2.5)

ANSWER A.6

β_{eff} is larger **(+1.0)**. The essence of this statement. Delayed neutrons are born with lower energies (hence, fewer fast fissions), greater thermalization, less fast neutron escape. Resulting in more thermal neutrons present. Hence β_{eff} is larger. **(+1.5)**

Reference(s)

1. NUS, Vol. 3, p. 5.3-3.
2. Console Exercise #1, p. N-1, Par. 2.
3. Console Exercise #3, p. N-4, Par. 4.

- Section A continued on next page -

Points
Available

QUESTIONS A.7

What reactivity (e) is associated with the following values of k_{eff}?

a. $k_{eff} = 1$
$e = ?$ (0.5)

b. $k_{eff} = 1.001$
$e = ?$ (0.5)

c. $k_{eff} = 0.995$
$e = ?$ (0.5)

ANSWER A.7

a. $e = 0$
b. $e = 0.001$
c. $e = -0.005$

(+0.5 each)

Reference(s)

1. Training Manual (TM), Section H, p. H-7.

- Section A continued on next page -

Points
Available

QUESTION A.8

Select the best answer (a., b., c., or d.)

From the initial count until the reactor is critical during a start-up, how many doublings of the count usually occur until criticality is achieved? (0.5)

(a.) 3
(b.) 5
(c.) 7
(d.) 10

ANSWER A.8

(b.) **(+0.5)**

Reference(s)

1. Training Manual (TM), Section N, Console Exercises, p. N-2.

QUESTION A.9

The effectiveness of a control rod (disregarding its material or construction) depends largely upon what factors? Name two (2). (2.0)

ANSWER A.9

a. Position in the core. **(+1.0)**
b. Neutron flux at the location of the rod. **(+1.0)**

Reference(s)

1. Training Manual (TM), Section N, Console Exercises, p. N-5.

- Section A continued on next page -

Points Available

QUESTION A.10

If reactor power steadily increases from 1 MW to about 2.72 MW in 100 seconds, what is the approximate period? (1.0)

$P = P_0 e^{t/\tau}$.

ANSWER A.10

100 sec **(+1.0)**

Reference(s)

1. NUS, Vol. 3, p. 6.3-1.

- End of Section A -

B. FEATURES OF FACILITY DESIGN (12.0)

Points Available

QUESTION B.1

a. In the reactor cooling system, rank in order of elevation, the following components, i.e., which is highest, next highest, etc. (2.0)

1. Heat Exchanger (bottom)
2. Reactor Stall (pool surface)
3. Hold-up Tank (bottom)
4. Storage Tank (bottom)

b. Briefly explain why a difference (if any) exists in elevation and size of the above. (1.0)

ANSWER B.1

a. 4. Storage Tank (highest)
   2. Reactor Surface
   1. Heat Exchanger
   3. Hold-up Tank (lowest)

   (+0.5 each)

b. To provide an adequate supply of coolant under all conditions **(+0.5)** and to assure that the pool cannot be drained inadvertently to drop the pool level below the core **(+0.5)**.

Reference(s)

1. Drawing 101586A - Flow Diagram-Reactor Cooling.
2. Training Manual, Section B, p. B-8

- Section B continued on next page -

Points Available

QUESTION B.2

If a tube leak develops in the heat exchanger, state in which direction the leakage occurs and why. (1.5)

ANSWER B.2

From the tube to the shell **(+0.5)**; to prevent the primary water from contaminating the secondary **(+1.0)**. OR

APPROVED DUE TO PRESS DIFF BETWEEN SYSTEMS (0.5) (1.0) MAX.

Reference(s)

1. Training Manual (TM), Features of Facility Design, p. B-8.

- Section B continued on next page -

Points Available

QUESTION B.3

Give (a) the important design feature and (b) the important components that result in the ability of the ventilation system to maintain a negative pressure in the reactor building, considering that the supply capacity is 19,000 CFM, the hot lab fan capacity is 30,000 CFM, and the reactor building exhaust fan capacity is 20,000 CFM. (2.0)

ANSWER B.3

For credit, the answers must contain the essence of the following:

a. The hot lab exhausts directly to the stack, which doesn't affect the reactor building. **(+0.5)** OR EXHAUST SYSTEM CAPACITY EXCEEDS SUPPLY SYSTEM CAPACITY.

ADDED

b. Ventilation supply valves **(+0.5)**, ventillation exhaust valves **(+0.5)**, and a negative pressure control valve **(+0.5)** can be adjusted to result in the reactor building pressure being less than atmospheric.

Reference(s)

1. Training Manual (TM), Features of Facility Design, Figure B-11.
2. FACILITY MODIFICATION FM 74-07

- Section B continued on next page -

Points
Available

QUESTION B.4

The continuous overflow gutter located on both sides of the pool is a gravity drain system open to the atmosphere.

a. How is most of this air prevented from saturating the reactor primary water? (1.0)

b. Why is this important? (1.0)

ANSWER B.4

a. The overflow drains into the hold-up tank, which is vented releasing the air. **(+1.0)**

b. Excessive quantities of Ar^{41} from air-saturated primary cooling water are eliminated reducing the requirements for exhaust ventilation. **(+1.0)**

Reference(s)

1. Training Manual (TM), Features of Facility Design, B-3.

- Section B continued on next page -

Points Available

QUESTION B.5

Select the best answer (a., b., or c.). (0.5)

When the ~~by-pass~~ purification system of (a.) filter, (b.) ion-exchanger filter, and (c.) ion-exchanger are all arranged in series, the maximum recommended flow through this alignment is:

a. 50 gpm
b. 200 gpm
c. 100 gpm

ANSWER B.5

c. 100 gpm **(+0.5)**

Reference(s)

1. Training Manual (TM), Features of Facility Design, p. B-9.

QUESTION B.6

The total worth of the five shim safety rods is closest to (0.5)

a. 9.35% $\Delta k/k$
b. 7.85% $\Delta k/k$
c. 10.9% $\Delta k/k$

ANSWER B.6

a. **(+0.5)**

Reference(s)

1. Training Manual (TM), Features of Facility Design, p. B-10.

- Section B continued on next page -

Points Available

QUESTION B.7

a. What is the purpose of the hinged, flapper plate (valve) attached to the side of the plenum? (1.0)

b. How is it designed to operate? (1.5)

ANSWER B.7

a. The valve, when open, provides a path for thermal connection cooling of the core. **(+1.0)**

b. It is closed initially with a push rod from the bridge **(+0.5)**, and drops open by gravity provided by counter-weights when pressure from forced primary flow is lost (loss of primary pump) **(+1.0)**.

Reference(s)

1. Training Manual (TM), Features of Facility Design, Section B, p. B-7.

- End of Section B -

C. GENERAL OPERATING CHARACTERISTICS (15.0)

Points Available

QUESTION C.1

Identify three (3) contributors to the power coefficient in order of significance, with the most significant (greatest in magnitude) first. (1.5)

ANSWER C.1

First	Fuel Temperature (Doppler)
Second	Moderator Temperature
Third	Void Coefficient or Pressure Coefficient

(+0.5 each)

Reference(s)

1. Training Manual (TM), General Operating Characteristics, Section C, p. C-3.

- Section C continued on next page -

Points Available

QUESTION C.2

Answer TRUE or FALSE and briefly justify (explain) your choice.

1. At Cintichem the CIC on the log N is generally kept in a slightly over compensated condition. (1.0)

2. The two strongest rods at Cintichem are 1 and 4. (1.0)

ANSWER C.2

1. FALSE **(+0.5)**. Slightly under-compensated condition to bring the instrument on scale at startup and to avoid spurious periods **(+0.5)**.

2. FALSE **(+0.5)**. Rods 2 and 5 are the strongest **(+0.5)**.

Reference(s)

1. Training Manual, Section C, p. C-5.
2. Training Manual, Section C, p. C-4.

- Section C continued on next page -

Points Available

QUESTION C.3

If the reactor is shutdown after extended operation with an estimated 2% $\Delta k/k$ remaining in the gang at time of shutdown,

a. how much time is available for a reactor restart? Assume 0.02% $\Delta k/k/min$ Xenon buildup. (1.0)

b. what are the options available for a restart if the reactor is not restarted within the time as determined in a.? (2.0)

ANSWER C.3

a. 100 minutes; 2% $\Delta k/k \div 0.02\% \Delta k/k/min$ = 100 minutes. **(+1.0)**

b. Must wait for some fraction of the reactor dead time to elapse **(+1.0)** OR must perform an Xenon reload. **(+1.0)**

Reference(s)

1. Training Manual (TM), Specific Operating Characteristics, Section J, p. J-9.

- Section C continued on next page -

Points Available

QUESTION C.4

Complete the following.

a. At Cintichem, the reactivity worth of any single experiment shall not exceed ________________. (0.5)

b. The combined worth of all experiments that can add positive reactivity to the core upon withdrawal or malfunction shall not exceed ________________. (0.5)

c. During critical operation, no samples removed or loaded shall exceed ________________. (0.5)

ANSWER C.4

a. 0.5% Δk
b. 2.0% Δk
c. ±0.25% Δk

(+0.5 each)

Reference(s)

1. Training Manual (TM), General Operating Characteristics, Section C, p. C-4.

- Section C continued on next page -

Points Available

QUESTION C.5

Complete the following table for the selected safety channels below. For example, the table is completed for the power level channel. (2.0)

Channel	Function	Operating Mode
1. Power Level (normal)	Scram at 7.5 MW	Start-up
2. Pool Temperature	________	________
3. Coolant Flow	________	________
4. Flapper Valve	________	________
5. Bridge Excursion Monitor	________	________

ANSWER C.5

1. Power Level (normal)	given	given
2. Pool Temperature	Alarm @ 115°F	all
3. Coolant Flow	Scram <2000 gpm	at forced circulation above 250 kw
4. Flapper Valve	Scram above 250 kw with valve open *	"
5. Bridge Excursion	Detect high radiation alarm and isolate at 5 R/hr	Start-up

(+0.25 each)

Reference(s)

1. Regulation Manual, RM-03-2

- Section C continued on next page -

* - Tech Spec Limit -

OK Op Limit - 100 Kw

Points Available

QUESTION C.6

Explain why that during a long shutdown, there is a constant decrease in the CR trace on the log count rate (LCR) channel. (1.0)

ANSWER C.6

This is due to fission product decay - fewer gamas with fewer photo-neutrons produced. **(+1.0)**

Reference(s)

1. Training Manual, Section C, p. C.5.

- Section C continued on next page -

Points Available

QUESTION C.7

Given these two expressions,

$$T = \frac{T_2}{\ln_2}$$

$$T = \frac{T_{10}}{\ln_{10}}$$

where T is reactor period.

a. Define T_2 and T_{10}. (1.0)

b. Identify which channel is used to measure each. (1.0)

ANSWER C.7

a. T_2 is the time required for reactor power to double **(+0.5)** as measured on the linear N channel **(+0.5)**.

b. T_{10} is the time required for the reactor power to increase by a factor of 10 **(+0.5)** as measured on the Log N channel **(+0.5)**.

Reference(s)

1. Training Manual, Section J, p. 2.

- Section C continued on next page -

Points
Available

QUESTION C.8

How is the Integral Worth of a rod expressed, and what does Integral Worth of a rod mean? (2.0)

ANSWER C.8

Integral Worth is expressed in % $\Delta k/k$ **(+1.0)** and is the total value of the reactivity change the rod is capable of effecting for its full-length of travel **(+1.0)**.

Reference(s)

1. Training Manual, Section J, p.1.

- End of Section C -

D. INSTRUMENTS AND CONTROLS (15.0)

Points Available

QUESTION D.1

Briefly describe what the bucking current on the Log N amplifier accomplishes. (1.0)

ANSWER D.1

The bucking in the Log-N amplifier eliminates false scrams where compensated ion chamber (CIC) over-compensation is suspected, i.e., bucking brings Log-N recorder just on scale during start-up preventing the input capacitor from being charged in the wrong direction, thus overcoming the gamma current from the CIC. **(+1.0)**

compensating current that is in excess of

Reference(s)

1. Training Manual (TM), Instruments and Control, Section D, p. D.20
2. " " " " " p. D 14.

QUESTION D.2

Give two (2) distinct advantages of a Log-N amplifier over a linear amplifier. (2.0)

ANSWER D.2

a. Can cover a wider range of flux changes. without switching. OK

b. Its percentage reading accuracy is the same at all points on the chart.

c. Exponential flux changes appear as straight lines on the recorder.

(+1.0 each, +2.0 maximum)

Reference(s)

1. Training Manual (TM), Instrument and Control, Section D, pp. D-23. D-27

- Section D continued on next page -

Points
Available

QUESTION D.3

Give two (2) reasons why a malfunction of the autocontrol system cannot increase reactivity sufficiently to take the reactor to prompt critical. (2.0)

ANSWER D.3

a. The total worth of the regulatory rod is much less than the amount necessary (0.81% $\Delta k/k$) to make the reactor prompt critical. **(+1.0)**

b. The regulatory rod is driven by a constant speed motor that limits its rate of travel to 24 in. per minute, making it impossible to make sudden changes (short periods) in reactivity. **(+1.0)**

Reference(s)

1. Training Manual (TM), Instruments and Control, Section D, p. D-43.

- Section D continued on next page -

Points Available

QUESTION D.4

Give any two (2) of the the four (4) control actions (inhibits) performed by the Log-N channel. (2.0)

ANSWER D.4

Any two of the following.

a. Prohibits shim and regulating rod withdrawal for periods less than 30 sec.

b. Bypassing count rate (start-up) channel inhibits above 0.001 N_L (0.001 of 50 kw).

c. Reverses shim-rods at periods less than 10 sec or neutron fluxes greater than 125%, OR when neutron flux is greater than 2 N_L (~100 kw) with any shim rod less than 50% withdrawn.

d. Bypasses process system scrams (primary pump, flapper, and flow) below 2 S/L (~100 kw)

(+1.0 each, +2.0 maximum)

Reference(s)

1. Training Manual (TM), Instruments and Control, Section D, p. D-35.

- Section D continued on next page -

Points Available

QUESTION D.5

What are the consequences, if any, if reactor operation is in auto when the neutron flux at the ion chamber location of the linear-N channel is reduced by some purely local means (some absorber being placed in front of the chamber), or by a change in flux distributions over the reactor (shim rods repositioned)? (2.0)

ANSWER D.5

The change will be interpreted by the auto system as a power change **(+1.0)**. The system will try to restore power, raise it unnecessarily **(+1.0)**.

Reference(s)

1. Training Manual (TM), Instruments and Control, Section D, p. D-43.

Points Available

QUESTION D.6

Explain why the flux monitoring instruments at Cintichem are only roughly proportional to power. (1.0)

ANSWER D.6

The neutron flux monitors "see" only leakage neutron flux because of their locations outside the reactor core and are incapable of monitoring the internal neutron flux within the core, measurement of which would correctly determine power. **(+1.0)**

Reference(s)

1. Training Manual (TM), Instruments and Control, Section D, p. D-27.

- Section D continued on next page -

Points Available

QUESTION D.7

Answer TRUE or FALSE.

a. In an ionization chamber, operating in the ionization region, the saturation current is in strict proportion to the radiation field. (0.5)

b. Operating an ionization chamber in its plateau region means that its output is sensitive to small changes in collector voltage. (0.5)

c. The length of a plateau in an ionization chamber is not affected by the strength of the radiation field. (0.5)

d. If the CIC is under compensated, the Log N will remain on scale even though the power level in the core is nil. (0.5)

ANSWER D.7

a. TRUE
b. FALSE
c. FALSE
d. TRUE

(+0.5 each)

Reference(s)

1. Training Manual (TM), Instruments and Controls, Section D, pp. D-13, D-14.
2. Training Manual (TM), General Operating Characteristics, pp. C-4, C-5.

- Section D continued on next page -

Points Available

QUESTION D.8

Give the three (3) control actions performed by the count rate (CR) channel. (3.0)

ANSWER D.8

Prevention of shim and regulatory rod withdrawal when

a. the CR recorder is turned off **(+1.0)** OR
b. the counting rate is not in the 2 - 9800 cps range **(+1.0)** OR
c. the period is less than 30 seconds **(+1.0)**.

Reference(s)

1. Training Manual (TM), Instruments and Controls, Section D, p. D-33.

- End of Section D -

E. SAFETY AND EMERGENCY SYSTEMS (16.0)

Points Available

QUESTION E.1

Answer TRUE or FALSE.

a. The automatic transfer switch will transfer power to emergency bus upon failure of utility power, but not back to normal power when utility power is firmly restored. (0.5)

b. Stringer tubes may be removed from the reactor while it is critical. (0.5)

c. Unexplained alarm of 2 area monitors requires an immediate reactor shutdown. (0.5)

ANSWER E.1

a. FALSE **(+0.5)**
b. FALSE **(+0.5)**
c. TRUE **(+0.5)**

Reference(s)

1. a. Regulations Manual, RM-08-3.
2. b. Regulations Manual, RM-09-7.
3. c. Emergency Procedures, EP-03-03.

- Section E continued on next page -

Points Available

QUESTION E.2

Give the primary reason why the primary pump shall not be operated unless the secondary pump is operating. (1.0)

ANSWER E.2

To prevent leakage of primary water into the secondary side in case of a heat exchanger tube leak. **(+1.0)**

Reference(s)

1. Regulations Manual, RM-06-01, RM-06-03.

QUESTION E.3

Give the reason why mercury bearing instruments and equipment shall not be allowed in areas where accidental spillage could introduce mercury into the primary. (1.0)

ANSWER E.3

Because of the use of aluminum in the primary system, which the mercury will chemically attack. **(+1.0)**

Reference(s)

1. Regulations Manual, RM-06-2.
2. CAF.

- Section E continued on next page -

Points
Available

QUESTION E.4

Why should the hold-up tank contain a water depth of at least 3 feet but no more than 7 feet? (2.0)

ANSWER E.4

~~To assure a minimum amount of primary coolant to cover the core during core cooling by natural connection (+1.0) but not so much water as to over-flow the basin at these times. (+1.0)~~

(1.0)

3' - To provide NPSH for primary pump (cavitation)

7' To permit continued gravity flow through core after loss of primary pump by assuring sufficient available volume in hold up tank (1.0)

Reference(s)

1. Regulations Manual, RM-06-01.
2. CAF. To

QUESTION E.5

Give the limits of the control rod drive mechanisms for

a. the length of travel (0.5)
b. drive speed (0.5)
c. simultaneous withdrawal (ganging) (0.5)

ANSWER E.5

a. 24 inches
b. 5 inches/min
c. 2 drives (rods)

(+0.5 each)

Reference(s)

1. Regulations Manual, RM-09.

- Section E continued on next page -

Points Available

QUESTION E.6

a. How is the "evacuation sequence" in the emergency ventilation system initiated? (1.0)

b. Below are most of the events in the "evacuation sequence." Supply the three (3) key events that are missing in the sequence and indicate when in the sequence they would occur. (3.0)

Sequences

- All supply dampers close.
- Pool sweep dampers close.
- Hold-up tank vent line and air purge valves close.
- Beam tube exhaust fan shuts down.

After seven (7) seconds or when reactor building pressure reaches 1-inch negative pressure.

- Emergency exhaust fan starts.
- Emergency exhaust fan's damper opens.

ANSWER E.6

a. Initiated by Excursion Monitor (Bridge Monitor) **(+0.5)**, or manually by console operator **(+0.5)**.

b. 1. Immediately **(+0.5)**, reactor building supply fan shuts down **(+0.5)**.

2. After 7 seconds **(+0.5)**, main exhaust damper closes **(+0.5)**, and

3. After 7 seconds **(+0.5)**, exhaust fan shuts down **(+0.5)**.

Reference(s)

1. Regulations Manual, RM-07, pp. 3 and 4.

- Section E continued on next page -

Points Available

QUESTION E.7

When the yellow bulb at the entrance to the transformer room lights and starts flashing, it indicates that the overload protectors on the emergency generator have tripped.

a. What is the significance of this? (1.0)
b. What two (2) actions must the reactor operator do? (1.0)

ANSWER E.7

a. The emergency generator may not start. **(+1.0)**
b. The reactor operator must shutdown the reactor **(+0.5)** and the reactor operator notify a senior operator **(+0.5)**.

Reference(s)

1. Regulations Manual, RM-08, p. 3.

QUESTION E.8

What is the condition that requires the emergency core spray to be turned on? (1.0)

ANSWER E.8

When the condition results in the core being uncovered. **(+1.0)**

Reference(s)

1. Regulations Manual, RM-06-3.

- Section E continued on next page -

Points Available

QUESTION E.9

Answer TRUE or FALSE.

a. The worth of the regulating rod shall not exceed 0.6% Δk. (0.5)

b. The emergency generator should NOT start when the power outage lasts less than 15 seconds. (0.5)

c. High-level radiation incidents are those requiring evacuation according to the Regulations Manual. (0.5)

d. Hourly CAM rate meter readings, entered into the reactor log book, may be substituted for a failed CAM recorder. (0.5)

ANSWER E.9

a. TRUE
b. FALSE
c. TRUE
d. TRUE

(+0.5 each)

Reference(s)

1. a. Regulations Manual, RM-09-5.
2. b. Regulations Manual, RM-08-2.
3. c. Emergency Procedures, EP-02-01.
4. d. Emergency Procedures, EP-03-05.

- End of Section E -

F. STANDARD AND EMERGENCY OPERATING PROCEDURES (11.5)

Points Available

QUESTION F.1

Answer TRUE or FALSE.

The following conditions warrant immediate shutdown of the reactor. (2.0)

a. The reactor critical with the control rods more than 50% withdrawn from the core.

b. Loss of the water seal in the canal.

c. Failure of the auto transfer switch.

d. Inadvertent initiation of the evacuation sequence.

ANSWER F.1

a. FALSE
b. TRUE
c. TRUE
d. FALSE

(+0.5 each)

Reference(s)

1. Regulations Manual, RM-04.

- Section F continued on next page -

Points Available

QUESTION F.2

Give two (2) reasons why the reactor operator is instructed to keep the control rods within ±10% of their mean position during all rod manipulations when reactor power is above 500 kw. (1.0)

ANSWER F.2

To assure that hot spots in the core (fuel degradation or excessive burnup) are avoided **(+0.5)** and that experiments receive their expected radiation **(+0.5)**, etc

Reference(s)

1. Regulations Manual, RM-04-7
2. CAF

- Section F continued on next page -

Points Available

QUESTION F.3

Complete the following with the required words so that Cintichem Regulation is properly stated. (2.5)

a. When radiation alarms occur, ____________________ without waiting for approval of emergency director may initiate the evacuation sequence or shutdown the reactor.

b. The core should be loaded with a minimum of ______________ fuel elements with each control element in place being considered as a ______________ element.

c. The unexpected absence of a second reactor operator at a facility for ____________ hours is acceptable provided immediate action is taken.

d. The Console Checklist (RS-01), Process Equipment Checklist, (RS-02), and the Electronic Equipment Checklist (RS-03) need not be completed where a restart is intended within ________ hours after any shutdown.

ANSWER F.3

a. Reactor operation personnel **(+0.5)**
b. 30 **(+0.5)**, half **(+0.5)**
c. 2 **(+0.5)**
d. 8 **(+0.5)**

Reference(s)

1. a. Emergency Procedures EP-03-02.
2. b. Regulations Manual, RM-10-6.
3. c. Regulations Manual, RM-03-4.
4. d. Regulations Manual, RM-03-7.

- Section F continued on next page -

Points Available

QUESTION F.4

Immediate shutdown of the reactor and initiation of the evacuation sequence with evacuation of building personnel is required for one combination of the following alarm conditions. Select the one (1) correct combination. (0.5)

a. 1. All three stack recorders going off scale.
   2. Unexplained alarm of both reactor building CAMs in any combination (recorder or rate meter, alert or high level).
   3. Unexplained alarm of one or more building or canal radiation alarms simultaneously, or consecutively with a stack alarm.

b. 1. Unexplained alarm of two or more area monitors.
   2. Unexplained alarm of both reactor building CAMs in any combination (recorder or rate meter, alert or high level).
   3. Unexplained alarm of one or more building or canal radiation alarms simultaneously or consecutively with a stack alarm.

c. 1. Unexplained alarm of one or more area monitors.
   2. All three stack recorders going off scale.
   3. Unexplained alarm of one or more building or canal radiation alarms simultaneously, or consecutively with a stack alarm.

ANSWER F.4

The answer is b. (The only answer above that does not include the incorrect statement "all three stack recorders going off scale.") **(+0.5)**

Reference(s)

1. Emergency Procedures, EP-03-03.

- Section F continued on next page -

Points Available

QUESTION F.5

a. Give the only reason for a reactor operator to activate the stress alarm. (1.0)

b. How may a reactor operator cancel a stress alarm? (1.0)

ANSWER F.5

a. If law enforcement personnel are required in the reactor building. **(+1.0)**

b. By making two (2) calls to the boiler house requesting that the alert be canceled. **(+1.0)**

Reference(s)

1. Emergency Procedures, EP-09.

QUESTION F.6

Briefly describe the procedures the roving operator is to complete following an intrusion alarm. (1.5)

ANSWER F.6

1. Interrogate the four (4) intrusion alarm buttons
2. Investigate the areas
3. Report to control room every ten (10) minutes

(+0.5 each)

Reference(s)

1. Emergency Procedures, EP-10.

- Section F continued on next page -

Points
Available

QUESTION F.7

Complete the following statements with the proper terms.

a. During reactor operation, the safety of the facility is the direct responsibility of __________________. (1.0)

b. Loading or removal of samples from the core shall be done only by or under the direction of __________. (1.0)

ANSWER F.7

a. the licensed operator at the console. **(+1.0)**
b. a licensed operator. **(+1.0)**

Reference(s)

1. Regulations Manual, RM-04.

- End of Section F -

G. RADIATION CONTROL AND SAFETY (13.0)

Points Available

QUESTION G.1

What three (3) principles (parameters, factors) are used to control radiation exposure? (0.9)

ANSWER G.1

time
distance
sheilding

(+0.3 each)

Reference(s)

1. Training Manual (TM), Radiation Control and Safety, Section G, p. G-23.

QUESTION G.2

Assume that eight (8) centimeters of a particular lead glass will reduce the gamma radiation from 150 mr/hr to 75 mr/hr.

a. How many centimeters of this lead glass will be required to reduce similar gamma radiation from 400 mr/hr to 200 mr/hr? (0.4)

b. How many centimeters of this glass will be required to reduce a gamma radiation level from 80 mr/hr to 10 mr/hr? (0.7)

ANSWER G.2

a. 8 cm (by inspection) **(+0.4)**

b. 24 cm $80/10 = 8 = (1/2)^3 \propto 3$ half-value layers (HVL)
1 HVL = 8 cm, 3 HVL = 24 cm. **(+0.7)**

Reference(s)

1. Training Manual (TM), Radiation Control and Safety, Section G, p. G-14.

- Section G continued on next page -

Points
Available

QUESTION G.3

Briefly explain the permissible whole-body dose for persons employed at Cintichem facility, giving (1) the permissible whole-body limits and (2) the allowable whole-body limits (10 CFR limits). (2.0)

ANSWER G.3

The permissible whole-body dose is 1-1/4 rem per calendar quarter at Cintichem facility **(+1.0)**.

The 10 CFR limits is 3 rem per quarter for an individual whose radiation history is complete and their lifetime dose does not exceed 5 (N-18) **(+1.0)**.

Reference(s)

1. Training Manual (TM), Radiation Control and Safety, Section G, p. G-12.

QUESTION G.4

State how a real iodine release would be characterized in the stack monitoring system. (1.0)

ANSWER G.4

A real iodine release would be characterized by a high iodine level on the chart AND that it persists after the gas monitor has dropped to a low level. (+1.0)

Reference(s)

1. Training Manual (TM), Radiation Control and Safety, Section G, p. G-10.

- Section G continued on next page -

Points
Available

QUESTION G.5

A recently recovered irradiated sample, as a radioactive source, may require two roped-off areas around it with different postings for each. Briefly explain how this may happen. (2.0)

ANSWER G.5

One roped-off area will be at the boundary where the radiation level (dose rate) is 5 millirem/hr and posted as a "Radiation Area" **(+1.0)** and an inner roped-off area will be required at the boundary where the dose rate is 100 millirem/hr and posted as a "High Radiation Area" **(+1.0)**.

Reference(s)

1. Training Manual (TM), Radiation Control and Safety, Section G, p. G-12.

QUESTION G.6

Assume a radiation field from gamma radiation is expected to be at least 4 R/hr. What kind of portable radiation instrument is required, and what portable gamma sensitive instrument is not acceptable here, Briefly telling why - for 2nd part of Question (1.0)

ANSWER G.6

A portable ionization chamber **(+0.5)** A Geiger Counter (GM) 0.25 would saturate in moderate to high radiation fields giving an unacceptable reading (0.25) and is not an acceptable alternative **(+0.5)**.

Reference(s)

1. Radiation Control and Safety, Section G, p. G-7.

- Section G continued on next page -

Points
Available

QUESTION G.7

Answer TRUE or FALSE. (2.0)

a. The maximum range in air of a beta particle ranges from 28 inches to 6 feet.

b. The only units of dose that can be added to give total dose from different types of radiation (i.e., alpha, beta, gamma) are units expressed in rad.

c. The only radiation that the CAM units do NOT respond to is that due to alpha.

d. The reading of a pocket dosimeter is a dose rate.

ANSWER G.7

a. FALSE (6 inches to 28 feet)
b. FALSE (rem)
c. TRUE
d. FALSE (dose)

(+0.5 each)

Reference(s)

1. Training Manual (TM), Radiation Control and Safety, Section G, p. G-19, 15, 11, 8, and 6, respectively.

- Section G continued on next page -

Points Available

QUESTION G.8

Give ~~the~~ two limitations of the Cutie Pie as a survey instrument. (1.0)

ANSWER G.8

1. Does not detect low energy radiation.
2. Does not detect neutrons.
3. Has an upper limit of 5 rads/hr.

(+0.5 each, +1.0 maximum)

Reference(s)

1. Training Manual (TM), Radiation Control and Safety, Section G.

- Section G continued on next page -

Points Available

QUESTION G.9

Select the best answer and show all calculations. (2.0)

An encapsulated Co-60 source hanging on the wall in the pool is to be removed and placed in a cask for transfer. Assume the average gamma energy is 1.25 Mev and that HP has approved the transfer, having measured the dose rate at 3 feet from the source at 100 mr/hr. The amount of Co-60 activity in the capsule could be no more than about

a. 1 Ci
b. 1/8 Ci
c. 1/2 Ci
d. 2 Ci

Hint: Dose rate in R/Hr at 1 ft. = 6 CiE R/Hr
Ci = curies
E = gamma energy

ANSWER G.9

The answer is value b. (1/8 Ci). **(+1.0)**

Calculation Method.

Dose rate at 1 ft. = 900 mr/Hr = 0.9 R/Hr
Dose rate at 3 ft. = 100 mr/Hr
Dose rate at 1 ft. = $(3^2/1^2) \cdot 100$ mr/Hr
= $9 \cdot 100$ mr/Hr
= 900 mr/Hr
0.9 = 6 CiE = Ci (1.25)(6)
Ci = 0.12 ≈1/8 Ci **(+1.0)**

Reference(s)

1. Training Manual (TM), Radiation Control and Safety, Section G, p. G-15.

- Section G continued on next page -

- END OF EXAM -