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

EXAMINATION REPORT NO. 84-02

FACILITY DOCKET NO. 50-223

FACILITY LICENSE NO. R-125

LICENSEE: University of Lowell
1 University Avenue
Lowell, Massachusetts 01854

FACILITY: University of Lowell

DATE: May 7, 1984

CHIEF EXAMINER: L. Whitaker, Reactor Engineer — Date: 5/30/84

APPROVED BY: Robert M. Keller, Chief, Project Section 1D — Date: 5/30/84

SUMMARY: One candidate was administered Section H of an SRO examination. All sections of SRO exam were waived except Section H - Reactor Theory. Candidate passed the examination.

REPORT DETAILS

TYPE OF EXAMS: Initial ____ Replacement X Requalification ____

EXAM RESULTS:

	RO Pass/Fail	SRO Pass/Fail	Inst. Cert Pass/Fail	Fuel Handler Pass/Fail
Written Exam	/	1 / 0	/	/
Oral Exam	/	/	/	/
Simulator Exam	/	/	/	/
Overall	/	1 / 0	/	/

1. CHIEF EXAMINER AT SITE: L. Whitaker

2. PERSON EXAMINED

   SRO (Section H)
   Neault, Robert M.

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

None

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

None

3. Comments on availability and candidate familiarization with plant reference material:

None

4. Comments on availability and candidate familiarization with plant design, procedure, T. S. changes and LERs:

None

5. Comments on interface effectiveness with plant training staff and plant operations staff during exam period.

None

6. Improvements noted in training programs as a result of prior operator licensing examinations/suggestions, etc:

None

7. Personnel Present at Exit Meeting:

NRC Personnel

L. Whitaker, NRC Examiner

NRC Contractor Personnel

None

Facility Personnel

T. Wallace, Reactor Supervisor

8. Summary of NRC Comments made at exit interview:

Proposed security changes were briefly discussed. Mr. Whitaker directed Mr. Wallace to describe the changes in a letter to Region I.

9. Summary of facility comments and commitments made at exit interview:

None

10. CHANGES MADE TO WRITTEN EXAM

Question No.	Change	Reason
H-3	Answer changed	Made to correspond to question numbers.

Attachment:

Written Examination and Answer Key (SRO Section H)

U. S. NUCLEAR REGULATORY COMMISSION
SENIOR REACTOR OPERATOR [redacted] EXAMINATION

FACILITY: Lowell University

REACTOR TYPE: GE Flatplate

DATE ADMINISTERED: May 8, 1984

EXAMINER: L. W. Whitaker

CANDIDATE: [redacted]

INSTRUCTIONS TO CANDIDATE:

Use separate paper for the answers. Staple question sheet on top of answer sheets. Points for each question are indicated in parentheses after the question. A score of 70% or greater in each category, and 70% overall is passing.

CATEGORY VALUE	% OF TOTAL	APPLICANT'S SCORE	% OF CATEGORY VALUE	CATEGORY
25	25			H. REACTOR THEORY
15	15			I. RADIOACTIVE MATERIALS HANDLING DISPOSAL AND HAZARDS
21	21			J. SPECIFIC OPERATING CHARACTERISTICS
22	22			K. FUEL HANDLING AND CORE PARAMETERS
17	17			L. ADMINISTRATIVE PROCEDURES, CONDITIONS AND LIMITATIONS
100	100.0			TOTALS:

FINAL GRADE ________________ %

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

____
Candidate's Signature

H. REACTOR THEORY (25 pts)

H.1. Define or Explain: (5 pts) (.5 each)

a. Effective Multiplication Factor
b. Precursor
c. Flux
d. Subcritical Multiplication
e. Doppler Broadening
f. Binding Energy
g. Beta
h. Beta Effective
i. Macroscopic Cross Section
j. Reactivity

H.2. Write the expression for Keff, describe each term. (4 pts) (1 each)

H.3. The reactor is rising on a stable period of 35 sec. What is the Keff? Show all work and assumptions. (2 pts - formula)
(2 pts - answer)

H.4. Explain the significance of delayed neutrons as they relate to operation of the Lowell University Reactor. (3 pts)

H.5. Concerning neutron lifetime:

a. define this term (2 pts)
b. what effect do the materials inside the reactor have on neutron lifetime? (2 pts)

H.6. Show by sketch approximate Xenon values as the following occur:
(5 pts) (1 each)

a. power rise to equilibrium (0 power history)
b. shutdown for 18 hours
c. return to equilibrium power
d. decreased power level to 50%
e. scram

Refs?

ANSWERS

LOWELL UNIVERSITY SRO EXAM

May 8, 1984

L. Whitaker, Examiner

H. REACTOR THEORY

H.1. Define or explain.

a. Effective multiplication factor .5

The effective multiplication factor includes the leakage of both fast and thermal neutrons.

$$K_{eff} = \frac{\text{\# fission neutrons in one generation}}{\text{\# fission neutrons in previous generation}} = nepfL_sL_f$$

($nepfL_sL_f$)

b. Precursor .5

A fission fragment which emits a delayed neutron

c. Flux .5

$\phi = nv = n/cm^2 s$

The number of neutrons that pass through a square cm of area per second .5

d. Fluence .5

$\Phi = nvt = \phi t\ n/cm^2$

The total number of neutrons which have passed through a given area over a period of time .5

e. Subcritical mulitiplication .5

The number of neutrons from source and fuel divided by the number of source without fuel (K < 1) .5

f. Doppler broadening .5

Broadening of U-238 reasonable peaks due to oscillation of U238 atoms in fuel lattice. More neutrons are captured in resonance as they appear as resonance energies for a longer time (since resonances are broader)

H. REACTOR THEORY (cont)

g. Binding energey .5

The energy that binds a particle to the nucleus, or the energy required to form a nucleus from its individual constituents. Also the energy equivalent of the mass defect.

h. Beta .5

Fraction of all neutrons which were born delayed

i. Beta effective .5

The effective fraction of thermal neutrons. The fraction of neutrons reaching thermal energy born as delayed neutrons

j. Macroscopic cross section .5

The probability of an interaction per unit depth in a material

k. Reactivity .5

A measure of how far away from a prompt critical condition a reactor core is

H.2. Write the expression for K_{eff}. Define each term. (4 pts) (1 each)

n-reproduction factor

$$n = \frac{\text{\# of neutrons produced by fission from thermal neutrons}}{\text{\# of thermal neutrons absorbed in the fuel}}$$

e-fast fission factor

$$\varepsilon = \frac{\text{Net \# of neutrons produced by all fissions}}{\text{\# of neutrons produced by thermal fissions}}$$

p-resonance escape probability (p)

$$p = \frac{\text{\# of neutrons that escape resonance capture while slowing down}}{\text{Net \# of neutrons produced by all fissions (total fast neutrons-leakage)}}$$

H.3. The reactor power is rising on a stable period of 35 sec. What is the K_{eff} of the reactor? State any assumptions.

(2 pts-formula)
(2 pts-answer)

T=35 sec → P19¢ = .00133
(From in-hour curve)

$$P = \frac{k-1}{k}$$

$$Pk = k-1$$

$$Pk-k = k-1$$

$$k(P-1) = -1$$

$$k = \frac{-1}{P-1} = \frac{1}{1-P} = \frac{1}{1-.00133} = \frac{1}{0.99867} = 1.0013 = \text{Keff}$$

H.4. Explain the significance of delayed neutrons as they relate to the operations of the Lowell University reactor. (3 pts)

Delayed neutrons are necessary since they allow control of the reactor by adjustment of control rods. This is done by keeping the reactor critical requiring the full delayed fraction of neutrons. This then allows the time necessary to make physical changes by adjusting control rods thereby controlling the reactor.

H-5 a. What is meant by neutron lifetime? (2 pts)

The time from when a neutron is born from a fissioning atom until it is absorbed.

b. What effect do the materials used in a reactor have on neutron lifetime? (2 pts)

The higher the content of materials in a core that will absorb fast or above thermal neutrons the shorter the "average" lifetime of the neutrons

H.5. Show (by simple sketch) a xenon buildup curve as the reactor undergoes the following: in sequence. Numerical values for reactivity are not required

a. Rise to equilibrium (1)

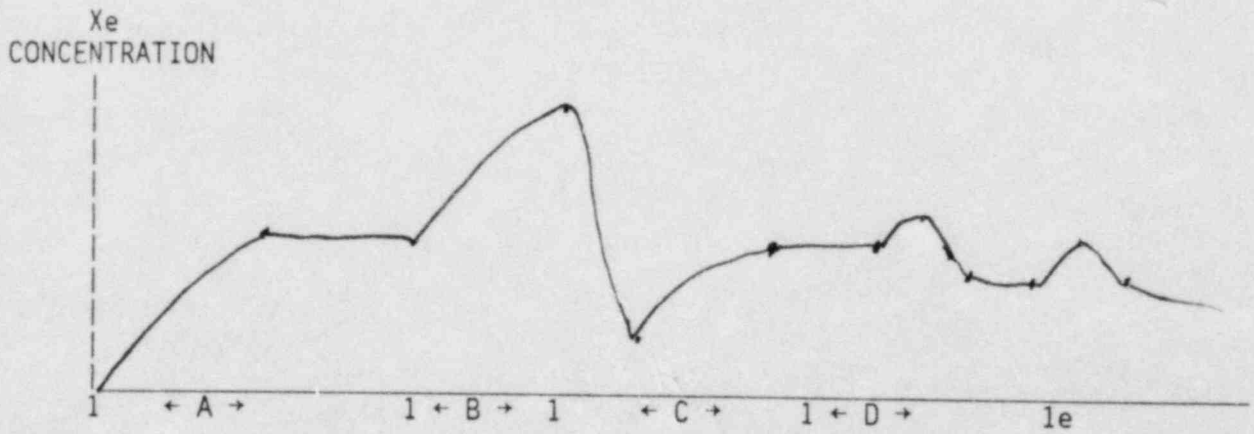
b. Shutdown for 18 hours (1)

c. Brought to power and equilibrium (1)

d. Power decreased and leveled off (1)

e. Reactor scrammed. (1)

1. Reactor brought up to power
2-3. Xenon concentration at equilibrium
4. Peak value for xenon
5. Reactor started up again
6-7. Xenon concentration at equilibrium
7. Reactor power reduced
8. Xenon concentration at equilibrium



FIGURE

XENON POISONING
DURING A PERIOD OF OPERATION,
SHUTDOWN TIME, AND SECOND
PERIOD OF OPERATION