ENCLOSURE 1

EXAMINATION REPORT - 50-62/OL-86-02

Facility Licensee: University of Virginia
Charlottesville, Virginia 22091

Facility Name: University of Virginia

Facility Docket No.: 50-62

A written examination was administered at University of Virginia near Charlottesville, Virginia.

Chief Examiner: K. E. Brockman — 12/23/86
Date Signed

Approved by: for John F. Munro, Section Chief — 12/23/86
Date Signed

Summary:

Examination on October 14, 1986

One candidate was administered a written examination, and passed.

REPORT DETAILS

1. Facility Employees Contacted:

   J. P. Farrer

2. Examiners:

   *K. E. Brockman, RII
   L. King, RII

   *Chief Examiner

3. Examination Review Meeting

   At the conclusion of the written examination, the examiner provided J. P. Farrer with a copy of the written examination and answer key for review. The following comments were made by the facility reviewers.

   a. SRO Exam

      (1) Question H.06(b).

          Facility Comment:

          The thermodynamics concepts concerning steam generation are not applicable at the UVAR; recommend deletion of question.

          NRC Resolution:

          Partially agree. Since only quality deals with steam generation, part (b) of the question was deleted from exam. Point values were adjusted appropriately.

U. S. NUCLEAR REGULATORY COMMISSION
SENIOR REACTOR OPERATOR LICENSE EXAMINATION

FACILITY: UNIVERSITY OF VIRGINIA

REACTOR TYPE: TEST

DATE ADMINISTERED: 86/10/07

EXAMINER: BROCKMAN, K.

CANDIDATE: - MASTER -

INSTRUCTIONS TO CANDIDATE:

Use separate paper for the answers. Write answers on one side only. Staple question sheet on top of the answer sheets. Points for each question are indicated in parentheses after the question. The passing grade requires at least 70% in each category. Examination papers will be picked up six (6) hours after the examination starts.

CATEGORY VALUE	% OF TOTAL	CANDIDATE'S SCORE	% OF CATEGORY VALUE	CATEGORY
~~20.00~~ 19.50	100.00			H. REACTOR THEORY
~~20.00~~ 19.50				Totals
		Final Grade		

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

Candidate's Signature

NRC RULES AND GUIDELINES FOR LICENSE EXAMINATIONS

During the administration of this examination the following rules apply:

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

2. 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.

3. Use black ink or dark pencil only to facilitate legible reproductions.

4. Print your name in the blank provided on the cover sheet of the examination.

5. Fill in the date on the cover sheet of the examination (if necessary).

6. Use only the paper provided for answers.

7. Print your name in the upper right-hand corner of the first page of each section of the answer sheet.

8. Consecutively number each answer sheet, write "End of Category __" as appropriate, start each category on a new page, write only on one side of the paper, and write "Last Page" on the last answer sheet.

9. Number each answer as to category and number, for example, 1.4, 6.3.

10. Skip at least three lines between each answer.

11. Separate answer sheets from pad and place finished answer sheets face down on your desk or table.

12. Use abbreviations only if they are commonly used in facility literature.

13. The point value for each question is indicated in parentheses after the question and can be used as a guide for the depth of answer required.

14. Show all calculations, methods, or assumptions used to obtain an answer to mathematical problems whether indicated in the question or not.

15. Partial credit may be given. Therefore, ANSWER ALL PARTS OF THE QUESTION AND DO NOT LEAVE ANY ANSWER BLANK.

16. If parts of the examination are not clear as to intent, ask questions of the examiner only.

17. You must sign the statement on the cover sheet that indicates that the work is your own and you have not received or been given assistance in completing the examination. This must be done after the examination has been completed.

18. When you complete your examination, you shall:

a. Assemble your examination as follows:

(1) Exam questions on top.

(2) Exam aids - figures, tables, etc.

(3) Answer pages including figures which are part of the answer.

b. Turn in your copy of the examination and all pages used to answer the examination questions.

c. Turn in all scrap paper and the balance of the paper that you did not use for answering the questions.

d. Leave the examination area, as defined by the examiner. If after leaving, you are found in this area while the examination is still in progress, your license may be denied or revoked.

QUESTION H.01 (3.00)

Using the attached integral rod worth curve for a three-rod reactor, answer the following:

a. Assuming that criticality is achieved with Rods A and B 80% withdrawn and Rod C 45% withdrawn, CALCULATE the NEGATIVE REACTIVITY which was present - AND - the PRE-STARTUP K-EFF. (1.0)

b. If Rod C is moved to 55% withdrawn, from the critical positions in (a) above, STATE what the STABLE PERIOD meter indication would be. (1.0)

c. An A - B - C rod withdrawal sequence is used.
Rods can only be WITHDRAWN TO 90%.
Shutdown K-eff is 0.88 with counts of 15 cps.

CALCULATE the Rod Position necessary to attain counts stable at 60 cps. (1.0)

QUESTION H.02 (1.00)

The reactor is being started up after shutdown for two weeks with the startup source installed. The rod withdrawal is stopped at the - 0.2 % ^k/k position and power level stablizes. Which of the following statements concerning how power level will respond in the next hour if no other actions are taken is correct?

a. Reactor power will remain essentially constant.

b. Reactor power will slowly decrease due to being subcritical.

c. Reactor power will rapidly decrease to initial prestartup level.

d. Reactor power will slowly increase due to long-lived delayed neutrons.

(***** CATEGORY H CONTINUED ON NEXT PAGE *****)

QUESTION H.03 (1.00)

With the reactor initially at a keff of 0.99, a certain reactivity change causes the count rate to double. If this same amount of reactivity is again added to the reactor, which of the following will be the status of the reactor?

a. Subcritical

b. Critical

c. Supercritical

d. Prompt Critical

QUESTION H.04 (2.00)

For the following definitions, STATE the term that is defined.

a. The factor by which neutron population changes between generations (from fission). (0.5)

b. The decay of an excited nucleus into a stable nucleus with the simultaneous ejection of electromagnetic energy. (0.5)

c. The amount of time required for the neutron population to increase by a factor of "e" (2.718). (0.5)

d. A gamma ray causes the ejection of an electron from a target atom; the gamma ray's energy is totally transmitted to the electron for ejection. (0.5)

QUESTION H.05 (1.00)

Which of the following describes the beta decay of a nuclide? (1.0)

a. Atomic Mass # decreases by 1, number of protons remains constant

b. Atomic Mass # remains the same, number of protons increases by 1

c. Atomic Mass # remains the same, number of protons remains constant

d. Atomic Mass # decreases by 1, number of protons decreases by 1

(***** CATEGORY H CONTINUED ON NEXT PAGE *****)

QUESTION H.06 ~~(1.50)~~ 1.00

MATCH the terms in Column A with the correct relationship in column B.

Column A	Column B
a) Specific Entropy	1) BTU/deg F
b) Quality	2) Ratio of local $\dot{Q}$ to Critical Heat Flux
c) ~~Enthalpy~~ deleted	3) Internal energy of a substance
	4) % steam mass to total steam & water mass
	5) BTU/lbm-deg R
	6) Ratio of Critical Heat Flux to local $\dot{Q}$
	7) Internal Energy plus Flow Energy of a substance
	8) % steam volume to total steam & water volume

QUESTION H.07 (2.00)

DESCRIBE how neutrons are produced by the:

a) Plutonium - Beryllium (Pu-Be) source. (1.0)

b) Antimony - Beryllium (Sb-Be) source. (1.0)

QUESTION H.08 (3.00)

For each of the conditions listed below, STATE the term in the K-eff expression which is affected the most. JUSTIFY your answer.

a. Withdrawal of a control rod several inches. (1.0)

b. A 10 deg F increase in the moderator temperature. (1.0)

c. Burnup of U-235. (1.0)

(***** CATEGORY H CONTINUED ON NEXT PAGE *****)

QUESTION H.09 (1.50)

Concerning Reactor Kinetics:

a. If power in a reactor was rapidly DECREASED from 100% to 20%, STATE whether -eff (decay constant) for the delayed neutron precursors INCREASE, DECREASE, or REMAIN THE SAME. (0.5)

b. EXPLAIN why there is a difference in the value of Beta and Beta-effective. (1.0)

QUESTION H.10 (1.00)

Which one of the following statements regarding the Limiting Criteria for Safety Limits fotr the UVAR is correct?

a. At low power levels and low flow rates the burnout ratio is the limiting criteria.

b. Hot channel flow instability at high power levels is the limiting criteria.

c. For high power and high flow, the burnout ratio is the limiting criteria.

d. Flow instability is the limiting crtieria for all flow rates with the reactor at low power levels.

QUESTION H.11 (1.00)

Which statement below describes centrifugal pump RUNOUT conditions?

a. High Pressure, Low Flow, High Power Demand

b. High Pressure, Low Flow, Low Power Demand

c. Low Pressure, High Flow, High Power Demand

d. Low Pressure, High Flow, Low Power Demand

e. Low Pressure, Low Flow, High Power Demand

(***** CATEGORY H CONTINUED ON NEXT PAGE *****)

QUESTION H.12 (1.00)

Which of the following statements concerning Samarium reactivity effects is correct?

a. The EQUILIBRIUM (at power) value of Samarium is DEPENDENT upon power level. The PEAK value of Samarium following a shutdown is DEPENDENT upon power level prior to shutdown.

b. The EQUILIBRIUM (at power) value of Samarium is DEPENDENT upon power level. The PEAK value of Samarium following a shutdown is INDEPENDENT of power level prior to shutdown.

c. The EQUILIBRIUM (at power) value of Samarium is INDEPENDENT of power level. The PEAK value of Samarium following a shutdown is DEPENDENT upon power level prior to shutdown.

d. The EQUILIBRIUM (at power) value of Samarium is INDEPENDENT of power level. The PEAK value of Samarium following a shutdown is INDEPENDENT of power level prior to shutdown.

QUESTION H.13 (1.00)

Attached Figure # 219 shows a POWER HISTORY and four possible XENON traces (Reactivity vs Time). SELECT the most accurate curve for displaying the expected XENON transient.

(***** END OF CATEGORY H *****)
(********** END OF EXAMINATION **********)

ANSWERS -- UNIVERSITY OF VIRGINIA -86/10/07-BROCKMAN, K.

ANSWER H.01 (3.00)

a. Rod A - 5 % ^k/k
Rod B - 3.9 % ^k/k
Rod C - 3.55% ^k/k

12.45% ^k/k = Shutdown Reactivity (0.5)

(K-eff - 1)/K-eff = -.1245 -> k - 1 = -.1245 * k -> k = 0.89 (0.5)

b. Rod C Inserts = 0.45 ^k/k

T = (Beta-eff - rho)/lambda * rho = (.007 - .0045)/.08 * .0045
= 6.94 seconds (1.0)

c. C2/C1 = (1-k1)/(1-k2)
60/15 = (1 - .89)/(1 - k2) -> k2 = .97 -> 10.5% ^k/k (0.5)

Rod A w/d @ 90% = -5.15 % ^k/k
Rod B w/d @ 90% = -4 % ^k/k

Rod C needs 1.35% ^k/k (10.5% - 9.15%) = 24% Withdrawn (0.5)

REFERENCE
NUS, Module 3, Unit 6

ANSWER H.02 (1.00)

a

REFERENCE
Basic Reactor Theory, Subcritical Multiplication

ANSWER H.03 (1.00)

c

REFERENCE
General Electric, Reactor Theory, Chapter 3

HBR, Reactor Theory, Session 42, pp. 3 & 4
DPC, Fundamentals of Nuclear Reactor Engineering

ANSWERS -- UNIVERSITY OF VIRGINIA -86/10/07-BROCKMAN, K.

004/000-K5.08 (2.6/3.2)

ANSWER H.04 (2.00)

a. K-effective

b. Gamma Decay

c. Period (Fermi Age)

d. Photoelectric Effect (0.5 each)

REFERENCE
General Electric, Reactor Theory, Chapters 1, 3

ANSWER H.05 (1.00)

b

REFERENCE
NUS, Vol 2, pp 7.3-2

ANSWER H.06 (~~1.50~~ 1.00)

a) 5

b) 4

~~c) 7~~ deleted (0.5 each)

REFERENCE
NUS, Vol 4, pp 1.4-2, 1.4-4, 3.5-4, 6.4-6

ANSWERS -- UNIVERSITY OF VIRGINIA -86/10/07-BROCKMAN, K.

ANSWER H.07 (2.00)

a) Pu-239 decay releases an alpha which then interacts with the Beryllium (0.5)

$$^{9}_{4}\mathrm{Be}\ (\alpha,n)\ ^{12}_{6}\mathrm{C}$$ (0.5)

b) Sb-124 decays to Te-124, releasing a gamma (0.5)

$$^{9}_{4}\mathrm{Be}\ (\gamma)\ ^{4}_{2}\mathrm{He} + ^{1}_{0}\mathrm{n}$$ (0.5)

REFERENCE
General Electric, Reactor Theory, Chapter 2

DPC, pp 113, 114

ANSWER H.08 (3.00)

a) Thermal Utilization Factor (0.5)

f = (# of neutrons absorbed in fuel) / (# of neutrons absorbed)
The Denominator decreases with rod withdrawal (0.5)

b) Non-Leakage Probability (0.5)

Decreases due to the decreases moderator density - neutrons travel further before thermalization/absorbtion (0.5)

c) Thermal Utilization Factor (0.5)

As in (a) above, the numerator will decrease, while the loss of fuel will be negated by Fission Product buildup in the denominator. (0.5)

REFERENCE
General Electric, Reactor Theory, Chapter 1

DPC, pp 68 - 72

ANSWERS -- UNIVERSITY OF VIRGINIA -86/10/07-BROCKMAN, K.

ANSWER H.09 (1.50)

a) DECREASE (0.5)

b) Beta represents the fraction of all fission neutrons born delayed.

Beta-eff takes into account that these delayed neutrons are born at LOWER ENERGIES, so that they are MORE PROBABLE TO REACH THERMAL ENERGY AND CAUSE FISSION than are the prompt neutrons. (The Beta becomes "weighted" to show the effects of this phenomenon) (1.0)

REFERENCE
General Electric, Reactor Theory, Chapter 4

DPC, Fundamentals of Nuclear Reactor Engineering, pp 37 - 42

ANSWER H.10 (1.00)

c

REFERENCE
UVA: UVAR SAR, p 133

ANSWER H.11 (1.00)

c

REFERENCE
NUS, Vol 4, pp G-8

ANSWER H.12 (1.00)

c

REFERENCE
General Electric, Reactor Theory, Chapter 6

MCG: DPC, Fundamentals of Nuclear Reactor Engineering, p 170

ANSWERS -- UNIVERSITY OF VIRGINIA -86/10/07-BROCKMAN, K.

ANSWER H.13 (1.00)

c

REFERENCE
General Electric, Reactor Theory, Chapter 6

EIH: GPNT,Vol VII, Chapter 10.1-83-86
BSEP: L/P 02-2/3-A, pp 172 - 176; 02-06-A, pp 57 - 60

QUESTION	VALUE	REFERENCE
H.01	3.00	KEB0000837
H.02	1.00	KEB0000838
H.03	1.00	KEB0000839
H.04	2.00	KEB0000840
H.05	1.00	KEB0000841
H.06	1.50	KEB0000842
H.07	2.00	KEB0000843
H.08	3.00	KEB0000844
H.09	1.50	KEB0000845
H.10	1.00	KEB0000846
H.11	1.00	KEB0000847
H.12	1.00	KEB0000848
H.13	1.00	KEB0000859
	20.00	
	20.00	

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