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

EXAMINATION REPORT NO. 50-020/88-02 (OL)

FACILITY DOCKET NO. 50-020

FACILITY LICENSE NO. R-37

LICENSEE: Massachusetts Institute of Technology
138 Albany Street
Cambridge, Massachusetts 02139

FACILITY: Massachusetts Institute of Technology Reactor (MITR-II)

EXAMINATION DATES: September 12 & 13, 1988

CHIEF EXAMINER: Edward Yachimiak 10/19/88
Edward Yachimiak, Operations Engineer — Date

APPROVED BY: for Larry E Briggs 10/19/88
Peter W. Eselgroth, Chief, PWR Section — Date

SUMMARY: Written and operating examinations were administered to One (1) Senior Reactor Operator (SRO) candidate and One (1) Reactor Operator (RO) candidate. Both candidates succesfully completed their respective examinations and were granted licenses.

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REPORT DETAILS

TYPE OF EXAMINATION: Replacement

EXAMINATION RESULTS:

	SRO Pass/Fail	RO Pass/Fail
Written	1 / 0	1 / 0
Operating	1 / 0	1 / 0
Overall	/ 0	1 / 0

CHIEF EXAMINER AT SITE: E. Yachimiak, USNRC

OTHER EXAMINERS: D. Silk, USNRC

1.0 Generic Strengths

The following generic strength was noted during the administration of the operating examinations. This information is being provided to the licensee in recognition of the efforts of the Nuclear Reactor Laboratory (NRL) staff to adequately train and qualify their NRC license candidates.

Both candidates displayed a thorough knowledge of the security plan which has been implemented at the MITR-II. Each candidate briefed the examiners on the confidentiality of the security plan and explained the limited "need to know" nature of the security system. Each candidate was familiar with the immediate and follow-up actions for security violations, as specified in the procedures, and was able to discuss each action in detail.

2.0 Personnel Present at the Exit Meeting

J. Bernard, Director of Operations, MITR-II
O. Harling, Director of Nuclear Reactor Laboratory
K. Kwok, Superintendent, MITR-II

Attachments:
1. RO Written Examination and Answer Key
2. SRO Written Examination and Answer Key
3. Facili'~ Comments on the Written Examination
4. NRC Response to the Facility Comments

U.S. NUCLEAR REGULATORY COMMISSION
REACTOR OPERATOR LICENSE EXAMINATION

Facility: MITR-II

Reactor Type: Research

Date Administered: 88/09/12

Examiner: Gordon Robinson

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 Cat. Value		
14.5	14.5	____	____	A.	Principles of Reactor Operation
14.0	14.0	____	____	B.	Features of Facility Design
14.5	14.5	____	____	C.	General Operating Characteristics
14.5	14.5	____	____	D.	Instruments and Controls
14.0	14.0	____	____	E.	Safety and Emergency Systems
14.5	14.5	____	____	F.	Standard and Emergency Operating Procedures
14.0	14.0	____	____	G.	Radiation Control and Safety
100.0		____			

Final Grade ______%

All work done on this exam 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.

A. PRINCIPLES OF REACTOR OPERATION

QUESTION A.01 (2.5)

(a.) Your reactor is subcritical by 4 percent delta K/K. Your startup channel reads 30 cps. When the count rate has increased to 300 cps., WHAT is the new K-effective. SHOW ALL WORK. Useful equations are appended to the end of the exam. (2.0)

(b.) TRUE or FALSE? For a given amount of positive reactivity insertion while the reactor is sub-critical, the closer the reactor is to critical the larger the change in countrate. (0.5)

QUESTION A.02 (2.0)

Two minutes after a scram of your reactor from full power, a significant number of neutrons are still present in the core. List the major sources of these neutrons and state the origin of each source. (2.0)

QUESTION A.03 (2.0)

Indicate whether the following statements concerning fission product poisoning are TRUE or FALSE for the MITR-II.

a. The amount of positive reactivity needed to overcome the equilibrium value of xenon-135 poisoning at 100 percent of full power is twice that needed to overcome equilibrium xenon-135 at 50 percent power. (0.5)

b. Upon shutting down the reactor after an extended run at full power, the xenon concentration peaks approximately eleven (11) hours after shutdown. (0.5)

c. When increasing power from 50 percent power (after extended operation) to 100 percent power, the xenon-135 concentration initially decreases and then increases. (0.5)

d. Shutting down the reactor from full power causes the samarium-149 concentration to change. (0.5)

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

A. PRINCIPLES OF REACTOR OPERATION

QUESTION A.04 (2.0)

During a normal startup to full power after several weeks of maintenance, the reactor is placed on a 60 second period. The initial power is 100 watts. With no rod movement, would this reactor period be sustained for 8 minutes? Show your calculations and JUSTIFY your answer. (2.0)

QUESTION A.05 (2.0)

In a subcritical reactor, if a reactivity of 0.003 delta K/K is added to the reactor, will it take longer to reach equilibrium if the initial K-effective is 0.95 or if K-effective is 0.995? Briefly justify your choice. (2.0)

QUESTION A.06 (2.0)

A critical reactor is placed on a stable reactor period at low power. When measured with a stop watch, the doubling time was 35 seconds. WHAT is the approximate reactivity which has been inserted? SHOW ALL WORK. Useful equations are appended to the end of the exam. (2.0)

QUESTION A.07 (2.0)

Indicate whether the following statements are TRUE or FALSE.

In general as shim blades are raised:

a. The axial spatial location of the point of maximum flux will be higher. (0.5)

b. The magnitude of the flux (in Part a.) will be increased. (0.5)

c. The magnitude of the thermal neutron flux available at the beam port reentrant thimble tips increases. (0.5)

d. Power density decreases in the A and B rings. (0.5)

(***** END OF CATEGORY A *****)

B. FEATURES OF FACILITY DESIGN

QUESTION B.01 (2.5)

Draw a simple schematic of the Heavy Water Reflector Clean-up System. Include the following:

a. All major components. Indicate direction of flow between components. (1.5)

b. Location of outlet from the reflector tank and location of return to the main flow system. (0.5)

c. Location of all flow, temperature, and conductivity measuring devices. (0.5)

QUESTION B.02 (2.0)

Consider the Heavy Water Helium Gas System.

a. Give TWO (2) reasons WHY helium is used instead of air in this system. (1.0)

b. WHAT TWO (2) operating conditions of the recombiner, if met, assure that the deuterium concentration in the cover gas will not exceed 6 percent by volume. (1.0)

QUESTION B.03 (2.0)

Briefly describe HOW normal shutdown cooling is obtained and WHAT operator actions must be taken to obtain maximum flow. (2.0)

QUESTION B.04 (2.0)

Consider the Reactor Building Ventilation System.

a. WHY is it important to place the switch that provides local control of the main intake damper in the "Weekend-open" position whenever the building is left unattended? (1.0)

b. Briefly describe HOW the reactor building differential pressure is maintained. (1.0)

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

B. FEATURES OF FACILITY DESIGN

QUESTION B.05 (1.5)

Briefly describe the THREE (3) step process used to seal a primary beam port. (1.5)

QUESTION B.06 (2.0)

Consider the reactor core configuration.

a. Briefly explain the method used to number the fuel element positions in the three rings of the reactor core. (1.0)

b. WHY are the fuel elements designed to be axially symmetric? (1.0)

QUESTION B.07 (2.0)

In accordance with your technical specifications, indicate the following:

a. Minimum primary coolant system flow rate at full power operation. (0.5)

b. Maximum power level with no primary coolant pumps in operation. (0.5)

c. Maximum allowable bulk pool temperature during full power operation. (0.5)

d. Minimum water level above core (you may use the overflow pipe as a reference point if you wish). (0.5)

(***** END OF CATEGORY B *****)

C. GENERAL OPERATING CHARACTERISTICS

QUESTION C.01 (2.0)

WHAT influences the magnitude of the negative reactivity inserted when the heavy water reflector is dumped during a major scram? Briefly explain WHY this change in magnitude occurs. (2.0)

QUESTION C.02 (2.0)

The temperature coefficient of reactivity for the MITR-II encompasses TWO (2) distinct phenomena. Both insert negative reactivity with an increase in temperature. Briefly describe the reason for this reactivity change for EACH phenomenon. (2.0)

QUESTION C.03 (1.5)

Indicate whether the following statements concerning primary system water chemistry are TRUE or FALSE. Consider each statement separately.

a. It is permissible to operate the reactor if the pH value is in excess of 7.0 if the cause of the high pH is known. (0.5)

b. It is permissible to operate the reactor if the conductivity exceeds 2.0 micromhos when the cause of the excess is known and is not related to the fuel or to the primary system's integrity. (0.5)

c. It is NOT permissible to operate the reactor if the chloride reading is in excess of 6 ppm. (0.5)

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

QUESTION C.04 (2.0)

During full power operation of your reactor WHAT change in position of the regulating rod, if any, will be required to maintain a conrtant power level if reactivity changes occur by the following means: (Assume each change occurs independently.)

a. Light water leaks into the heavy water reflector. (0.5)

b. A large polyethelene sample is injected into the reflector tank reentrant thimble using the pneumatic tube assembly 2PH1. (0.5)

c. The heavy water blister tank suddenly floods while operating with the medical therapy room in use with all shutters open. (0.5)

d. A large piece of cadmium is injected into the graphite reflection region using the pneumatic tube assembly 1PH2. (0.5)

QUESTION C.05 (2.0)

Give TWO (2) reasons WHY the regulating rod reactivity worth per inch withdrawn is greatest at the beginning of rod withdrawal (first inch withdrawn). (2.0)

QUESTION C.06 (2.5)

During the previous week the reactor was operated at full power for six hours a day from Monday until Wednesday afternoon. The following Monday an additional sample was loaded in an orificed sample assembly. Briefly describe WHAT information is required to obtain an estimated critical position. Assume no new fuel is added. (2.5)

QUESTION C.07 (1.5)

The fuel management pattern at the MITR-II usually calls for refueling when the critical shim bank position reaches 16 inches.

a. Approximately WHAT is the core excess reactivity at this time? (0.5)

b. WHY is this excess reactivity necessary? (1.0)

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

QUESTION C.08 (1.0)

Indicate whether the following are TRUE or FALSE:

a. If in the process of refueling, fresh fuel is placed in the B-ring and partially-spent fuel is placed in the A and C-rings, the net result is to concentrate power in the center of the core. (0.5)

b. Replacement of an orificed sample assembly with a fuel element increases the power density in the neighboring elements. (0.5)

(***** END OF CATEGORY C *****)

D. INSTRUMENTS AND CONTROLS

QUESTION D.01 (2.5)

a. Briefly describe HOW a fission chamber detects neutrons. (1.5)

b. Briefly describe HOW unwanted signals from gammas and alphas are removed from the output signal of fission chamber. (1.0)

QUESTION D.02 (2.5)

During automatic operation, the regulating rod is driven to the near-in position by a slowly increasing reactivity transient (i.e. xenon burnout). Explain the reactor control system's response if no operator action is taken. (2.5)

QUESTION D.03 (2.5)

Indicate which of the following are interlocks which must be satisfied in order to obtain initial blade motion (withdraw - permit interlocks):

a. Hold-down grid latched (0.5)

b. Two out of three of the Power Level Channels (Channels 4, 5, and 6) on scale (0.5)

c. Main tank at overflow (0.5)

d. Inner and/or outer main lock gaskets pressure switches closed (0.5)

e. Primary coolant flow greater than 1800 gpm (0.5)

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

QUESTION D.04 (2.0)

The "SUB-CRITICAL POSITION" interlock circuit provides a convenient reference point at which the operator can pause to make a complete instrument check before bringing the reactor to criticality. List TWO (2) other reasons this interlock is incorporated into the shim blade control circuit. (2.0)

QUESTION D.05 (1.0)

WHAT operator action will cause the "WITHDRAW PERMIT CIRCUIT OPEN" scram alarm to activate without causing the reactor to scram? (1.0)

QUESTION D.06 (2.5)

a. Briefly explain WHY the reactor must be held at constant power twenty- four hours for thermal equilibrium to be reached. (0.7)

b. Once thermal equilibrium is reached, WHAT information is needed to calculate thermal power? (1.8)

QUESTION D.07 (1.5)

Briefly describe HOW the conductivity cell in the primary coolant measures the conductivity of the water. (1.5)

(***** END OF CATEGORY D *****)

E. SAFETY AND EMERGENCY SYSTEMS

QUESTION E.01 (2.5)

Indicate if the electrical loads listed below WILL or WILL NOT automatically be supplied by the Emergency Power Distribution System if normal power fails.

a. Startup channel No. 1 (0.5)

b. Rod control (0.5)

c. Core purge blower (0.5)

d. Magnet power (0.5)

e. Primary coolant auxiliary pump (MM2) (0.5)

QUESTION E.02 (1.5)

Indicate whether the following questions concerning the Containment Pressure Relief System are TRUE or FALSE.

a. This system is intended to be used to relieve all types of pressure buildup in the building containment. (0.5)

b. This system will automatically be actuated if the containment pressure reaches 2.0 psig. (0.5)

c. This system's charcoal filter is designed to absorb most (approximately 99 percent) of the iodine that may be present in the exhaust air. (0.5)

QUESTION E.03 (2.5)

Consider Emergency Cooling.

Mode 2 of Emergency Cooling assumes the level in the core tank cannot be maintained at the overflow level, but it has been determined that it is not dropping below the reactor inlet penetration.

a. Briefly describe the flow path through the core. (1.0)

b. Indicate the THREE (3) means by which heat is removed from the primary system. (1.5)

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

E. SAFETY AND EMERGENCY SYSTEMS

QUESTION E.04 (2.5)

Consider the Main Core Tank Level Indicators (ML-3A and ML-3B).

a. Briefly describe the principle of operation and arrangement used to produce the main core tank level indications. (1.5)

b. Indicate the differences in operation of these level indicators. (1.0)

QUESTION E.05 (2.0)

WHAT are the differences in circuitry, if any, between a scram caused by a short period and a scram caused by low primary coolant flow. (2.0)

QUESTION E.06 (1.5)

In addition to dropping the shim blades, list THREE (3) other automatic actions a MAJOR SCRAM initiates. (1.5)

QUESTION E.07 (1.5)

Indicate the SCRAM setpoints for the following:

a. Reactor period (0.5)

b. Primary coolant low flow (0.5)

c. Low heavy water flow (0.5)

(***** END OF CATEGORY E *****)

F. STANDARD AND EMERGENCY OPERATING PROCEDURES

QUESTION F.01 (2.5)

Consider the temporary bypassing of a safety function NOT required by Technical Specifications.

a. If not part of an approved procedure, list the THREE (3) people (by job title) who should approve the bypass. (1.0)

b. WHAT THREE (3) actions must be taken after the physical installation of a jumper? (1.5)

QUESTION F.02 (2.0)

Other than radiation monitors and their alarms, indicate TWO (2) likely indications of a fuel element cladding failure as given in AOP 5.8.2 "Fission Product Detection in the Primary Coolant". (2.0)

QUESTION F.03 (2.5)

For the below listed malfunctions indicate whether the immediate actions require a MAJOR SCRAM, MINOR SCRAM, SHUTDOWN BY ARI, or NO SHUTDOWN is required. Assume the reactor is operating at full power and has not scrammed automatically and that no other abnormal conditions have been noted.

a. A Period Channel Level Signal Off-Scale Alarm occurs. (0.5)

b. The Low Flow Transfer Pump Alarm occurs. (0.5)

c. The Low Flow Shield Coolant Alarm occurs. (0.5)

d. A Low Flow Auxiliary Pump MM2 Alarm occurs. (0.5)

e. A Low Pressure Compressed Air Alarm occurs. (0.5)

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

F. STANDARD AND EMERGENCY OPERATING PROCEDURES

QUESTION F.04 (2.0)

A "High Pressure Reactor Inlet" alarm occurs (AOP 5.2.11) while your reactor is at full power. In addition to an increase in the heat exchanger outlet pressure, indicate FOUR (4) other conditions that, if any one of them exist, require the operator to scram the reactor. (2.0)

QUESTION F.05 (2.0)

In accordance with your Technical Specification definition, list the FOUR (4) types of reactivity changes that constitute variabl^ reactivity. (2.0)

QUESTION F.06 (2.0)

A serious fire occurs in the control room while the reactor is at full power. In accordance with AOP 5.7.8, "Smoke Detector System", WHAT actions should the reactor operator perform (if possible) prior to evacuating the control room? (Assume all required personnel have been notified.) (2.0)

QUESTION F.07 (1.5)

Indicate whether the following statements concerning a normal hot weather reactor startup to full power (SOP 2.3.1) are TRUE or FALSE.

a. If the reactor is not critical when the shim bank exceeds the estimated critical position by 0.5 inches, the shim bank must be lowered to 1.0 inches or more below the estimated critical position. (0.5)

b. When 1 MW of reactor power is reached, a five minute soak period is maintained to allow the reactor core and primary coolant to approach thermal equilibrium. (0.5)

c. Between 50 KW and 300 KW a 30 to 40 second period is recommended (0.5)

(***** END OF CATEGORY F *****)

G. RADIATION CONTROL AND SAFETY

QUESTION G.01 (1.5)

Does the biological effect of 10 Rem depend on whether it is a neutron or gamma dose?
Briefly explain your answer. (1.5)

QUESTION G.02 (2.0)

A radiation survey meter is located one foot from a small single radioiostope sample and reads 100 mRem/hr. Fifteen minutes earlier the reading was 200 mRem/hr with the meter in the same position. HOW long must you wait until the radiation level drops to 10 mRem/hr? SHOW ALL WORK. (2.0)

QUESTION G.03 (1.5)

In accordance with the Required Procedures for Radiation Protection indicate whether the following are TRUE or FALSE.

a. Liquids are NOT allowed to be placed into a collection container designated for solid waste. (0.5)

b. It IS permissible to place a small bottle containing low level radioactive water into a "Liquid Radioactive Waste" collection container. (0.5)

c. It IS permissible to dispose of a 3 pound slightly radioactive piece of metal in a collection container designated for solid waste. (0.5)

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

QUESTION G.04 (2.0)

A portable radiation monitor indicates a reading of 60 mr/hr at a distance of 10 feet from what could be considered a radioactive point source (gamma emmitter). You are required to work on a valve located 5 feet from the source. You estimate the job will take 10 minutes. WHAT dose would you expect [illegible]ceive if you worked on the valve for 10 minutes? [illegible]W ALL WORK. (2.0)

QUESTION G.05 (2.0)

Consider the Core Purge Monitor.

a. WHAT type of detector is used in this monitor? (0.5)

b. Describe the automatic actions which occur if the "High Radiation Core Purge" alarm is actuated. (1.5)

QUESTION G.06 (1.0)

An operator enters an area that is posted as a "radiation area" (as defined in 10 CFR 20). He performs a job that takes him 40 minutes to complete. WHAT is the MAXIMUM dose he could expect to receive? (1.0)

QUESTION G.07 (2.0)

According to 10CFR 20, an individual in a restricted area may be allowed to receive a whole body dose of radiation greater than 1.25 Rems per calendar quarter under certain conditions. Name the conditions. (2.0)

QUESTION G.08 (2.0)

Give the following information concerning N-16:

a. HOW is N-16 produced? (0.5)

b. WHAT is the primary hazard associated with the production of N-16? (0.5)

c. Is N-16 a radiation problem when the reactor is shutdown? Briefly explain. (1.0)

(***** END OF EXAM *****)

$f = ma$

$v = s/t$

Cycle efficiency = (Network out)/(Energy in)

$w = mg$

$s = V_0 t + 1/2\ at^2$

$E = mc^2$

$KE = 1/2\ mv^2$

$a = (V_f - V_0)/t$

$A = \lambda N$

$A = A_0 e^{-\lambda t}$

$PE = mgh$

$V_f = V_0 + at$

$w = \theta/t$

$\lambda = \ln 2/t_{1/2} = 0.693/t_{1/2}$

$W = v\ \Delta P$

$t_{1/2}eff = \frac{[(t_{1/2})(t_b)]}{[(t_{1/2}) + (t_b)]}$

$\Delta E = 931\ \Delta m$

$I = I_0 e^{-\Sigma x}$

$\dot{Q} = \dot{m} Cp \Delta t$

$\dot{Q} = UA\Delta t$

$I = I_0 e^{-ux}$

$Pwr = W_f \Delta h$

$I = I_0\ 10^{-x/TVL}$

$TVL = 1.3/u$

$P = P_0 10^{sur(t)}$

$HVL = -0.693/u$

$P = P_0 e^{t/T}$

$SUR = 26.06/T$

$SCR = S/(1 - K_{eff})$

$CR_x = S/(1 - K_{effx})$

$SUR = 26\rho/\ell^* + (\beta - \rho)T$

$CR_1(1 - K_{eff1}) = CR_2(1 - K_{eff2})$

$T = (\ell^*/\rho) + [(\bar{\beta} - \rho)/\lambda\rho]$

$M = 1/(1 - K_{eff}) = CR_1/CR_0$

$T = \ell/(\rho - \beta)$

$M = (1 - K_{effo})/(1 - K_{eff1})$

$T = (\beta - \rho)/(\lambda\rho)$

$SDM = (1 - K_{eff})/K_{eff}$

$\rho = (K_{eff} - 1)/K_{eff} = \Delta K_{eff}/K_{eff}$

$\ell^* = 10^{-5}$ seconds

$\bar{\lambda} = 0.1\ \text{seconds}^{-1}$

$\rho = [(\ell^*/(T\ K_{eff})] + [\bar{\beta}_{eff}/(1 + \bar{\lambda}T)]$

$I_1 d_1 = I_2 d_2$

$P = (\Sigma\phi V)/(3 \times 10^{10})$

$I_1 d_1{}^2 = I_2 d_2{}^2$

$\Sigma = \sigma N$

$R/hr = (0.5\ CE)/d^2(\text{meters})$

$R/hr = 6\ CE/d^2\ (\text{feet})$

Water Parameters

1 gal. = 8.345 lbm.
1 gal. = 3.78 liters
1 ft^3 = 7.48 gal.
Density = 62.4 lbm/ft^3
Density = 1 gm/cm^3
Heat of vaporization = 970 Btu/lbm
Heat of fusion = 144 Btu/lbm
1 Atm = 14.7 psi = 29.9 in. Hg.

Miscellaneous Conversions

1 curie = 3.7×10^{10} dps
1 kg = 2.21 lbm
1 hp = 2.54×10^3 Btu/hr
1 mw = 3.41×10^6 Btu/hr
1 in = 2.54 cm
°F = 9/5°C + 32
°C = 5/9 (°F-32)
1 BTU = 778 ft-lbf

Corrected answer sheet

A. PRINCIPLES OF REACTOR OPERATION
ANSWERS -- MITRII - 88/9/12 - ROBINSON, G.

ANSWER A.01 (2.5)

a. $\frac{CR2}{CR1} = \frac{1-(Keff1)}{1-(Keff2)} = 10$ (0.75)

delta $K/K = \frac{1-(Keff1)}{(Keff1)}$ .04; (Keff1) = 0.962 (0.5)

$\frac{1-.962}{1-(Keff2)}$ = 10; Keff2 = .9962 (0.75)

b. TRUE (0.5)

REFERENCE
Reactor Physics Notes: Reactor Startup and Reactor Subcritical Multiplication p. 8.

ANSWER A.02 (2.0)

Delayed neutrons from fission fragment decay (i.e. Br-87 with a 55 second half-life). (1.0) ~~(0.75)~~

Photoneutrons from gammas (from fission fragment decay) which interact with deuterium (in the heavy water reflector). (1.0) ~~(0.75)~~

~~Neutrons from installed source, polonium, and beryllium.~~ ~~(0.5)~~ (CAF ~~this source may have been removed or is insignificant.~~ If so, adjust point value to 1.0 each for above answers.)

NOTE: Information in parenthesis NOT required to receive full credit for answer.

REFERENCE
Reactor Physics Notes: Reactor Startup and Reactor Subcritical Multiplication p. 7 and Reactor Kinetics p. 11.

ANSWER A.03 (2.0)

a. FALSE (0.5)
b. FALSE (0.5)
c. TRUE (0.5)
d. TRUE (0.5)

REFERENCE
Reactor Systems Manual 10.7
Reactor Physics Notes: Reactivity Feedback and Measurement of a Xenon Transient p. 24, 30, 32.

ANSWER A.04 (2.0)

P(t) = P(o) exp (t/tau) = 100 watts exp (480/60) (0.5)

P(t) = 298 kw (0.5)

yes
~~No,~~ increase in moderator temperature ~~would add negative reactivity and lengthen period~~ does not become noticeable until about 1 MW with cooling towers in operation. (1.0)

(Note: The temperature reactivity feedback effect becomes apparent at approximately 100 kw, SOP PM 2.3 p. 3.) note: This is in error

REFERENCE
Reactor Physics Notes: Reactor Kinetics p. 4
Reactor Systems Manual 10.8

ANSWER A.05 (2.0)

The case when K-effective is 0.995 will take longer to reach equilibrium. (0.5)

The nearer K-effect is to one, the longer it takes to reach a new steady state, because of the increased number of generations which exist with the increased population. (1.5)

REFERENCE
Reactor Physics Notes: Reactor Startup and Reactor Subcritical Multiplication p. 8, 9, 10.

ANSWER A.06 (2.0)

$$\text{Period} = \frac{D.T}{.693} = \frac{35\ sec}{.693} = 50.5\ sec$$ (0.5)

Reactivity = beta /(1 + lambda x tau) (0.5)
= .00786/(1 + .08 x 50.5) (0.5)
= .00156 delta K/K (0.5)
or 0.198 beta

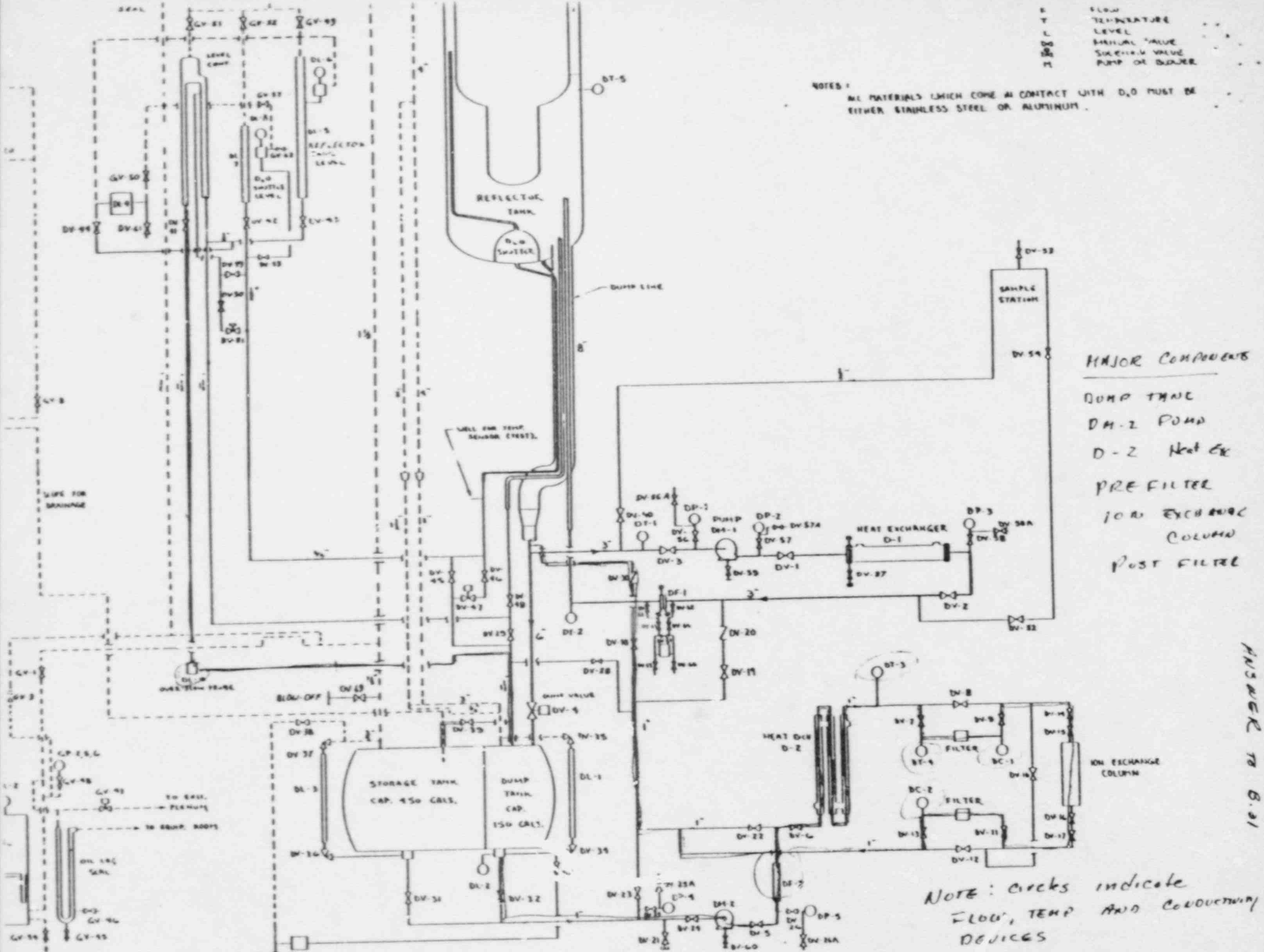
REFERENCE
Reactor Physics Notes: Reactor Kinetics and Control Rod Calibration by Reactor Period Measurement p. 3, 4, 14, 18.

ANSWER A.07 (2.0)

a. TRUE (0.5)
b. FALSE (0.5)
c. FALSE (0.5)
d. TRUE (0.5)

RERFERENCE
Reactor System Manual 10.2

ANSWER TO B.01



MAJOR COMPONENTS

DUMP TANK
DM-2 PUMP
D-2 Heat Ex
PREFILTER
ION EXCHANGE COLUMN
POST FILTER

NOTE: Circles indicate FLOW, TEMP AND CONDUCTIVITY DEVICES

ANSWER B.01 (2.5)

See enclosed figure (3.3-1)

REFERENCE
Reactor Systems Manual 3.7 and Fig. 3.3-1

Answer B.02 (2.0)

a. Moisture entrained with the air would degrade the heavy water (D20 dilution). (0.5)
Nitrous oxide formation from the presence of air in high radiation fields would cause corrosion. (0.5)

b. The temperature of the middle of the recombiner must exceed a minimum required value (50 degrees C.). (0.5)
The flow rate through the recombiner must be between certain flow rates (1.5 and 8.0 cfm.). (0.5)
Also, avoid activation of argon and provide inert medium for transport of disassociated D_2/O_2 to recombiner

REFERENCE
Reactor Systems Manual 3.16

ANSWER B.03 (2.0)

Normal shutdown cooling is provided by air auxiliary pump (MM-2) and the cleanup loop heat exchanger (HE-2). (1.0)

Maximum flow can be obtained by bypassing the ion column and the inlet and outlet filters. (1.0).

REFERENCE
Reactor Systems Manual 3.4

ANSWER B.04 (2.0)

a. If the ventilation should be lost, the intake damper will close, thereby, forcing all air within the building to flow past the plenium monitor prior to being discharged. (1.0)

b. A manually operated exhaust control damper (located in the stack base) is used to throttle the overall flow of air through the ventilation system. (0.5)
The opening of the damper is adjusted to maintain the building differential pressure between the intake and the exhaust. (0.5)

REFERENCE
Reactor Systems Manual 8.12, 8.16

ANSWER B.05 (1.5)

1. A plug is placed in the port. (0.5)
2. Gas seals are made by bolting a ring against the aluminum flange of the liner. (0.5)
3. A gasket cover is bolted over the beam port's opening. (0.5)

REFERENCE
Reactor Systems Manual 2.4

ANSWER B.06 (2.0)

a. Fuel element positions in each ring are numbered sequentially in the clockwise direction from the regulating rod position. (1.0)
b. The elements are axially symmetric so that they can be inverted in order to equalize any peaking in axial burnup. (1.0)

REFERENCE
Reactor Systems Manual 1.4, 1.5

ANSWER B.07 (2.0)

a. 1800 gpm (0.5)
b. 100 kw (0.5)
c. 60 degrees C (0.5)
d. 4 inches below the overflow pipe (0.5)
(CAF for actural height above core)

REFERENCE
Technical Specifications p. 2-5

ANSWERS - MITRII - 88/9/12 - ROBINSON, G.

ANSWER C.01 (2.0)

The amount of negative reactivity added is dependent on the position of the shim blade bank. (1.0)

This effect can be considered as being due to the shadowing influence that the blade bank inserts on the reflector. (1.0)

REFERENCE
Reactor Systems Manual p. 10.6

ANSWER C.02 (2.0)

a. An increase in the light water temperature will insert negative reactivity by causing the hardening in the neutron spectrum. (1.0)

b. An increase in the heavy water reflector temperature will insert negative reactivity by allowing more neutron leakage. (1.0)

REFERENCE
Reactor Systems Manual p. 10.8

ANSWER C.03 (1.5)

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

REFERENCE
Operating Procedure Checklist PM 3.1.1.1 p. 13

ANSWER C.04 (2.0)

a. OUT (0.5)
b. IN (0.5)
c. ~~OUT~~ IN (0.5)
d. NO EFFECT (0.5)

REFERENCE
Reactor Systems Manual p. 10.10

ANSWER C.05 (2.0)

a. The full-in position for the regulatory rod is six inches above the bottom of the fuel elements. (1.0)

b. Once the regulating rod is withdrawn any appreciable amount, it is heavily shadowed by the adjacent shim blades. (1.0)

REFERENCE
Reactor Systems Manual p. 10.6

ANSWER C.06 (2.5)

a. The delta K due to temperature change or the change in average temperature and temperature coefficient. (0.5)

b. The delta K due to the additional sample. (0.5)

c. The delta K due to burnup or MWH and delta K per MWH. (0.5)

d. The previous critical rod positions. (0.5)

e. Rod worth curves. (0.5)

REFERENCES
Operating Procedure Checklist PM 3.1.1.2 p. 13

ANSWER C.07 (1.5)

a. Approximately 2 beta of excess reactivity. (0.5)

b. In order to be able to override the xenon shutdown transient. (1.0)

REFERENCE
Reactor Systems Manual p. 10.8

ANSWER C.08 (1.0)

a. TRUE (0.5)
b. TRUE (0.5)

REFERENCE
Reactor Systems Manual p. 10.5

D. INSTRUMENTS AND CONTROLS

ANSWER D.01 (2.5)

a. A neutron entering the chamber causes a uranium atom (in the uranium oxide coating) to fission. (0.75)
The resulting fission products create a large negative ionization pulse in the counting gas. (0.75)

b. A pulse height selector is used to distinguish the large negative pulses created by neutron-induced fissions from the smaller pulse produced by the gamma rays and alpha particles. (1.0)

REFERENCES
Reactor Systems Manual p. 5.3

ANSWER D.02 (2.5)

The automatic control circuit can no longer keep reactor power at the set power level and power would start to increase. (0.5)
The automatic run-down circuit causes a visual alarm. (0.5)
After 30 seconds delay, the circuit transfers reactor control to manual mode. (0.75)
The circuit then drives in the selected shim rod. (0.75)

REFERENCE
Reactor Systems Manual p. 4.5

ANSWER D.03 (2.5)

a. must be satisfied (0.5)

b. need not be satisfied (0.5)

c. must be satisfied (0.5)

d. must be satisfied (0.5)

e. need not be satisfied for 100 KW operation (0.5)
must be satisfied for full power operation

(Acceptable answer therefore is a, c, and d.)
and e

REFERENCE
Reactor Systems Manual p. 4.1 and 4.2

ANSWERS - MITRII - 88/9/12 - ROBINSON, G.

ANSWER D.04 (2.0)

1. To maintain the shim blade bank pro ammed at a uniform height during the final approach to criticality. (1.0)

2. To establish a level, below the critical position, to which the shim blades may be individually withdrawn in one step. (1.0)

REFERENCE
Reactor Systems Manual p. 4.3

ANSWER D.05 (1.0)

Depressing the "all-absorbers- in" pushbutton will give the scram alarm but will not scram the reactor. (1.0)

REFERENCE
Reactor Systems Manual p. 4.5

ANSWER D.06 (2.5)

a. The graphite reflector has a large heat capacity and is slow to attain an equilibrium temperature distribution. (0.7)

b. Primary flow rate, core temp. rise, and heat capacity. (0.6)
Heavy water reflector flow rate, temp. rise, and heat capacity. (0.6)
Shield coolant flow rate, temp. rise, and heat capacity (0.6)

REFERENCE
Reactor Systems Manual p. 6.4

ANSWER D.07 (1.5)

Two concentric cylindrical electrodes, measures the resistivity of the water. (0.5)

A potential voltage applied across the cell produces a current that is inversely proportional to resistivity. (0.5)

Resistivity varies inversely with conductivity. (0.5)

(Also acceptable is - conductivity is directly proportional to current flowing through the cells.)

REFERENCES
Reactor Systems Manual p. 6.1

ANSWER E.01 (2.5)

a. WILL NOT BE SUPPLIED (0.5)

b. WILL BE SUPPLIED (0.5)

c. WILL NOT BE SUPPLIED (0.5)

d. WILL BE SUPPLIED (0.5)

e. WILL BE SUPPLIED (0.5)

REFERENCE
Reactor Systems Manual p. 8.34

ANSWER E.02 (1.5)

a. FALSE (0.5)

b. FALSE (0.5)

c. TRUE (0.5)

REFERENCE
Reactor Systems Manual p. 8.23

ANSWER E.03 (2.5)

a. The flow goes up through the core and down through the flow ~~shroud~~ guide check valves (by natural circulation). (1.0)

b. i. Heat lost to ambient (0.5)

ii. Heat lost to the reflector ~~b~~Tank (0.5)

iii. Heat lost to the off-gas system (0.5)

REFERENCE
Reactor Systems Manual p. 3.5

ANSWERS - MITRII - 88/9/12 - ROBINSON, G.

ANSWER E.04 (2.5)

a. Both employ differential pressure transducers that measure the difference between static pressure in the air gap area (above the outlet plenum) and the pressure developed by a reference leg that extends into the core tank to a point immediately above the top of the fuel. (1.5)

b. ML-3A is electrically-driven (piezo- electric differential pressure transducer) and is supplied by emergency power. (0.5)

ML-3B is pneumatically-driven (transmitter) and is supplied by instrument air. (0.5)

REFERENCE
Reactor Systems Manual p. 6.8

ANSWER E.05 (2.0)

A period scram is fast acting, that is it is coupled directly to the magnet-current amplifiers and upon a preset scram signal interrupts the current to the magnets of the six shim blades. (1.0)

A low primary coolant flow caused scram is initiated by a relay which opens the withdraw circuit, thereby, causing the current to the magnets to be cut off. (1.0)

REFERENCE
Reactor Systems Manual p. 9.8

E. SAFETY AND EMERGENCY SYSTEMS

ANSWERS - MITRII - 88/9/12 - ROBINSON, G.

ANSWER E.06 (1.5)

1. Secures the ventilation system (0.5)
2. Seals the containment shell (0.5)
3. Dumps the top part of the heavy water reflector (0.5)

REFERENCE
Reactor Systems Manual p. 9.8

ANSWER E.07 (1.5)

a. 10 second period (0.5)
b. 1975 gpm (0.5)
c. ~~90~~ 95 gpm (0.5)

REFERENCE
Reactor Systems Manual p. 9.9

F. STANDARD AND EMERGENCY OPERATING PROCEDURES

ANSWERS - MITRII - 88/9/12 - ROBINSON, G.

ANSWER F.01 (2.5)

a.	Reactor Superintendent	(0.34)
	Duty Shift Supervisor	(0.33)
	The Electronics Supervisor	(0.33)
	(or designated alternates)	
b.	Two responsible people must check the jumper after installation.	(0.5)
	The jumper must be tagged for identification.	(0.5)
	A record of the authorizer's initials must be recorded on the bypass log sheet.	(0.5)

REFERENCE
Administrative Procedure PM 1.9 p. 1

ANSWER F.02 (2.0)

High Primary Coolant Conductivity (alarm) (1.0)

Increase in results of the weekly analysis of the primary coolant. (1.0)

REFERENCE
Abnormal Operating Procedure PM 5.8.2

ANSWER 5.03 (2.5)

a.	MINOR SCRAM	(0.5)
b.	NO SHUTDOWN REQUIRED	(0.5)
c.	MINOR SCRAM	(0.5)
d.	~~SHUTDOWN BY ARM~~ NO SHUTDOWN REQUIRED	(0.5)
e.	NO SHUTDOWN REQUIRED	(0.5)

REFERENCE
Abnormal Operating Procedures PM 5.1.4, PM 5.2.1, Pm 5.3.2, PM 5.4.3, PM 5.5.4

ANSWER F.04 (2.0)

Any four (4) of the following:

1. Any change in reactivity
2. Any decrease in primary coolant flow
3. Any increase in the core purge
4. Any increase in primary conductivity readings
5. Any increase in the core outlet temperature
6. Any increase in the core delta temperature

(Note: Each response is worth 0.5 points.)

REFERENCE
Abnormal Operating Procedure PM 5.2.11

ANSWER F.05 (2.0)

Xenon (0.5)
Fuel Burnup (0.5)
Sample changes made in operation (0.5)
Changes in experiments during operation (0.5)

REFERENCE
Technical Specifications p. 3-33

ANSWER F.06 (2.0)

Scram the reactor. (0.5)
Turn on the "DO NOT ENTER" sign for the back personnel lock. (0.5)
Remove the reactor KEYS and (0.5)
Console log (0.5)

REFERENCE
Abnormal Operating Procedure PM 5.7.8

ANSWER F.07 (1.5)

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

REFERENCE
Standard Operating Procedure PM 2.3 p. 2 and 3

G. RADIATION CONTROL AND SAFETY

ANSWERS - MITRII - 88/9/12 - ROBINSON, G.

ANSWER G.01 (1.5)

NO (0.5)
The unit Rem considers the different effects. Rem is a biological unit, thus different radiation causing the same dose in Rem should have the same effect. (1.0)

REFERENCE
10 CFR 20
RPO Notes and Memos p. 13

ANSWER G.02 (2.0)

A(t) = A(o) e ** - lambda t (0.5)

t = 15 minutes

A(t) / A(o) = 100 / 200 = 0.5 (0.5)

lambda = -(ln 0.5) / 15 min = .046 / min (0.5)

t = -(ln 10/100) / (0.046/min) = 50 minutes (0.5)

REFERENCE
Nuclear Reactor Engineering, Glasstone and Sesonske p. 31

ANSWER G.03 (1.5)

a. TRUE (0.5)

b. FALSE (0.5)

c. TRUE (0.5)

REFERENCE
MIT Required Procedures for Radiation Protection p. 20 and 21

G. RADIATION CONTROL AND SAFETY

ANSWERS - MITRII - 88/9/21 - ROBINSON, G.

ANSWER G.04 (2.0)

D1 X R1 X R1 = D2 X R2 X R2 (0.5)

$$D2 = \frac{(60\ mr/hr) \times 10\ ft \times 10\ ft}{5\ ft \times 5\ ft} = 240\ mr/hr \quad (1.0)$$

$$Dose = \frac{(240\ mr/hr) \times 10\ min}{(60\ min/hr)} = 40\ mr \quad (0.5)$$

REFERENCE
Nuclear Reactor Engineering, Glasstone and Sesonske p. 524

ANSWER G.05 (2.0)

a. G-M "Pancake" detector (0.5)

solenoid valve (isolation)
b. ~~MV-83~~ automatically closes (0.5)
~~MU-64~~ automatically closes solenoid isolation valve) (0.5)
Core purge blower is turned off (0.5)

REFERENCE
Reactor Systems Manual p. 7.12

ANSWER G.06 (1.0)

Maximum dose rate is 100 mr/hr (0.5)
(40 min/60 min) x 100 mr = 66.7 mr (0.5)

REFERENCE
IV CFR 20.203

ANSWER G.07 (2.0)

a. He/she does not exceed 3 Rem per quarter. (0.5)

b. His/her radiation histroy is known and recorded on the proper form (Form 4). (0.5)

c. The dose received when added to his/her radiation history does not exceed 5(N-18) Rems where N = the person's age at his/her birthday. (1.0)

REFERENCE
10 CFR 20.101

ANSWER G.08 (2.0)

a. N-16 comes from O-16 via a(n,p) reaction. (0.5)

b. Its primary hazard is the high energy gamma ray given off (0.5)

c. NO, (0.25)
because of its short half life (7 sec) (0.75)

REFERENCE
Nuclear Reactor Engineering, Glasstone and Sesonske p. 402

ATTACHMENT 2

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

FACILITY: MIT

REACTOR TYPE: RESEARCH

DATE ADMINSTERED: 88/09/12

EXAMINER: YACHIMIAK, E.

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
19.50 ~~20.00~~	20.00			H.	REACTOR THEORY
19.50 ~~20.00~~	20.00			I.	RADIOACTIVE MATERIALS HANDLING DISPOSAL AND HAZARDS
* 20.00	20.00			J.	SPECIFIC OPERATING CHARACTERISTICS
18.50 ~~20.00~~	20.00			K.	FUEL HANDLING AND CORE PARAMETERS
19.00 ~~20.00~~	20.00			L.	ADMINISTRATIVE PROCEDURES, CONDITIONS AND LIMITATIONS
96.5 ~~100.0~~		Final Grade	%		Totals

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

Candidate's Signature

* Changes made to exam due to resolution of Facility comments.

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 (1.50) ~~(2.00)~~

a. WHY is the value of Beta-effective greater than the value of Beta? (1.00)

deleted
~~b. WHY does the value of Beta-effective decrease during core life? (0.50)~~

c. WHAT is the source of the neutrons that cause the characteristic -80 second period on a reactor scram? (0.50)

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

QUESTION H.02 (2.50)

Given that the reactor is subcritical with a Keff of 0.9875 and a Start-Up channel reading 2000 CPS:

a. WHAT would Keff be after a reactivity addition causes the count rate to increase to 4000 CPS? SHOW ALL WORK.

b. Would the reactor be Subcritical, Critical, or Supercritical if 1.59 Beta was added to the 0.9875 Keff core? SHOW ALL WORK.

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

QUESTION H.03 (2.75)

Assume the reactor is on a stable 40-second period.

a. HOW long (in minutes) will it take to change power level TWO (2) decades? SHOW ALL WORK. (1.75)

b. HOW much reactivity (in Millibeta) has been inserted into the reactor in order to place it on this stable period? Assume the reactor was just critical prior to this reactivity insertion. SHOW ALL WORK. (1.00)

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

QUESTION H.04 (1.50)

a. HOW (Increase, Decrease, No Change) does a DECREASE in reactor power affect the Capture Cross Section of U-238 at its resonance energies? (0.50)

b. WHAT are TWO (2) reasons WHY a neutron whose energy is slightly above the upper limit of a U-238 resonance capture energy will still have a high probability for capture by a U-238 atom? (1.00)

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

QUESTION H.05 (4.00)

a. Briefly state the Production AND Removal mechanisms for Xe-135 AND Sm-149. Include applicable elements and isotopes. (3.00)

b. HOW (Increase, Decrease, No Change) would Xe-135 affect the the reactor's Actual Shutdown Margin TWO (2) hours after a reactor trip from continuous power operation at > 100 kW? (0.50)

c. HOW long does it take Xe-135 to build into a core that has been shutdown for refueling? Assume the reactor is run at rated power. (0.50)

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

QUESTION H.06 (2.00)

a. WHY does the moderator temperature coefficient become MORE negative as the moderator heats up?

b. WHAT are the TWO (2) reasons for the negative reactivity effect associated with an INCREASE in moderator temperature?

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

QUESTION H.07 (2.00)

a. WHY is D2O (heavy water) used in the MITR-II as a reflector instead of H2O?

b. HOW does the D2O reflector produce source neutrons when the reactor is subcritical?

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

QUESTION H.08 (1.25)

Calculate reactor power (in MW) given the following operating conditions:

Reactor Inlet Temperature	-	110 F.
Reactor Outlet Temperature	-	130 F.
Reactor Primary Coolant Flow Rate	-	1800 gpm

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

QUESTION H.08 (1.25)

Calculate reactor power (in MW) given the following operating conditions:

Reactor Inlet Temperature	-	110 F.
Reactor Outlet Temperature	-	130 F.
Reactor Primary Coolant Flow Rate	-	1800 gpm

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

QUESTION H.09 (2.00)

Answer the following questions regarding the design of the MITR-II fuel elements:

a. WHY must the fuel have a minimum cladding thickness of 0.008 inches?

b. HOW would a thicker clad affect the ability of a fuel element to transfer heat during power operations?

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

QUESTION I.01 (2.50)

a. WHAT THREE (3) conditions would individually activate the "Waste Tanks" alarm on the control room scram panel? (1.50)

b. WHERE would water from the Waste Tanks vent to if both tanks were overfilled? (0.50)

c. WHAT administrative action prevents an inadvertant discharge from the Waste Tanks to the sewer system? (0.50)

QUESTION I.02 ~~(2.00)~~ (1.50)

WHAT are the ~~THREE (3)~~ TWO (2) actions AND the ONE (1) control room indication which are automatically initiated on a steadily increasing sump level in the equipment room?

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

QUESTION I.03 (1.50)

In accordance with operating procedure 3.12.2, "Procedure for Cell Entry,"

a. WHAT preventative action must be taken to protect persons from exposure to high radiation levels whenever the LEFT cell is not on use? (1.00)

b. WHOSE approval is required prior to entry into the RIGHT cell? (0.50)

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

QUESTION I.04 (2.50)

Given a gamma source which has a measured dose rate of 100 mR/Hr at 10 feet from the source:

a. Calculate how much time must pass (in minutes) until the dose rate at 1 foot will be 100 mR/Hr. Assume a source half-life of 15 minutes. (1.50)

b. Instead of waiting for the source to decay further, calculate HOW MUCH lead shielding (in centimeters) would have to be used in order to lower the dose rate from 100 mR/Hr to 1 mR/Hr at 1 foot. Assume a mass attenuation coefficient of 0.189 ~~(gm/cm2)~~ and a density of 11.34 (gm/cm3). (1.00)

(cm2/gm)

(***** CATEGORY 1 CONTINUED ON NEXT PAGE *****)

QUESTION I.05 (3.00)

An irradiated component is surveyed with a portable instrument. The open window indication is 2.00 R/Hr while the closed window reading is 1.50 R/Hr both at a distance of 18 inches.

a. WHAT is the Beta dose rate at 18 inches from the component?

b. WHAT would be the maximum time that you could remain at the survey distance without exceeding your 10CFR20 quarterly WHOLE BODY limit? Assume you are without a Form NRC-4 and have no current exposure this quarter. Also, assume that you are wearing the appropriate protective clothing/articles.

c. WHAT would your 10 CFR 20 limit for quarterly AND lifetime dose be with a completed Form NRC-4?

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

QUESTION I.06 (1.50)

WHAT are THREE (3) gases that are removed by the Core Purge (Off-Gas) System?

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

QUESTION I.07 (2.00)

a. HOW do the gamma-sensitive scintillation detectors detect Tritium leakage into the Secondary Water System from the D2O reflector heat exchanger?

b. WHY must blowdown of the cooling tower basins be secured whenever the reactor is not operating?

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

QUESTION I.08 (3.00)

a. In order to receive radioactive material ordered for delivery to the NRL, a member of the operations staff must possess WHAT TWO (2) qualifications? (1.00)

b. WHAT FOUR (4) actions need to be taken by the individual receiving a radioactive material package? (2.00)

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

QUESTION I.09 (2.00)

a. WHAT are the TWO (2) reasons for which an individual may be authorized to incur radiation exposures in excess of the 10 CFR 20 limits?

b. If time permits, WHAT TWO (2) people should make the above authorizations?

(***** END OF CATEGORY I *****)

QUESTION J.01 (2.25)

Describe the operation of the pneumatic tube system including both the rabbit insertion and ejection processes. Identify ALL major components in your description.

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

QUESTION J.02 (1.50)

a. WHAT are TWO (2) reasons for having a CO_2 purge maintained to the water-cooled, vertical sample thimbles? (1.00)

b. WHY is it necessary to water-cool the vertical thimbles which are used for sample irradiation? (0.50)

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

QUESTION J.03 (2.50)

a. Explain the operation of the Anti-Syphon valves (both open and closed positions), specifically addressing HOW tne valve would prevent the complete drainage of the core tank on a coolant pipe break.

b. Explain the operation of the convection valves during both normal and loss of coolant flow conditions. Include in your explanation a decription of the coolant flowpaths involved.

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

QUESTION J.04 (2.50)

Describe the operation of a compensated ion chamber AND explain WHY compensation is necessary. Include in your explanation the power levels at which this detector is used to detect neutrons.

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

QUESTION J.05 (2.75)

a. WHY is 125 volt D.C. storage battery power needed to prevent simultaneous closure of the two (2) main 13.8 KV circuit breakers? (0.75)

b. Describe the operation of the emergency electrical power distribution system, including the 5 KVA motor-generator (M/G) set, during both the loss and susequent restoration of normal power. (2.00)

QUESTION J.06 (2.00)

WHAT FOUR (4) actions occur when a major scram pushbutton is depressed?

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

QUESTION J.07 (1.50)

a. When operating at full power, WHAT could result if secondary system temperature dropped to less than 6 degrees C.? (0.50)

B. WHAT are TWO (2) actions that could be taken to reduce the rate of secondary system heat removal WITHOUT decreasing reactor power? (1.00)

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

QUESTION J.08 (1.00)

During a reactor startup, WHY is reactor power held constant for FIVE (5) minutes after each 1 MW increase in power level?

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

QUESTION J.09 (2.00)

WHAT are the FOUR (4) requirements imposed by the "automatic-control-permissive" circuit which must be met before the reactor can be shifted to automatic control?

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

QUESTION J.10 (2.00)

WHAT are ~~the~~ FOUR (4) functi -s of the Cleanup System?

(***** END OF CATEGORY J *****)

QUESTION K.01 (2.00)

During performance of a spent fuel transfer:

a. WHY is the inner door of the main personnel lock left open? (0.50)

b. WHAT are TWO (2) locations in the core tank from which fuel elements may be transferred to the transfer cask? (1.00)

c. WHY is the reflector dumped prior to fuel movement? (0.50)

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

QUESTION K.02 (3.50)

a. Describe the construction of the storage racks currently installed in the spent fuel storage pool. Include in your description the rack's material composition AND the reason for the material's use. (2.50)

b. WHAT are TWO (2) reasons for using high purity deionized water in the spent fuel storage pool? (1.00)

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

QUESTION K.03 (1.50)

a. HOW much time must elapse between a reactor shutdown and the removal of fuel from the core if the reactor had previously operated at power levels in excess of 100 KW? (0.50)

b. WHAT is the Technical Specification basis for the above time constraint? (1.00)

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

QUESTION K.04 (1.00)

Bolt Cutters are required for the removal of WHAT TWO (2) reactor reactivity control components?

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

QUESTION K.05 (2.00)

In accordance with PM-3.3.2, "Spent Fuel Removal,"

a. WHAT precaution must be taken by individuals whenever they are performing physical work activities on the reactor top with the reactor top shield lid removed?

b. WHAT action must be performed on Nuclear Instrumentation Safety Channels 5 and 6 before a full power startup may be initiated?

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

QUESTION K.06 (3.00)

Give the basis for each of the following Technical Specifications:

a. The reactivity worth of the regulating rod connected to the automatic control system is less than 1.8 % delta k/k.

b. The maximum controlled reactivity addition rate is no more than: 5×10^{-4} delta k/k/second.

c. The reactivity worth of the D20 reflector dump is greater than the reactivity worth of the most reactive shim blade.

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

QUESTION K.07 (2.00)

WHAT are FOUR (4) conditions that could actuate a Spent Fuel Storage Pool (SFSP) alarm?

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

QUESTION K.08 (1.50)

In accordance with PM-1.15, "Refueling,"

a. WHAT TWO (2) individuals must sign the Fuel Loading Verification record and Fuel Loading Permission Form? (1.00)

b. Prior to exceeding WHAT power level must the Fuel Loading Verification record be signed by the two above individuals? (0.50)

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

QUESTION K.09 (2.00) ~~(3.50)~~

a. WHAT Fuel Element Assembly design characteristic enables the fuel to achieve a more complete burnup? (0.50)

b. ~~For a Fuel Element Assembly which has been loaded with an increased amount of U-235, explain HOW the addition of a Burnable Poison limits the initial increase in the reactivity worth associated with the element, but still allows for an increase in the element's overall burnup.~~ (1.50) deleted

c. HOW does the loading of Hafnium, fixed, neutron-absorber plates on the absorber spider assembly affect the core's nuclear flux/power? List TWO (2) effects. (1.50)

(***** END OF CATEGORY K *****)

QUESTION L.01 (2.50)

a. WHAT are THREE (3) reasons why all positions in the core tank must be filled and secured with either a fuel element or another approved unit before operating at full power is allowed per Technical Specifications? (1.50)

b. In accordance with Technical Specifications , WHY are at least FIVE (5) operable shim blades required to be within 2.0 inches of a banked (average shim blade height) position when the reactor is at power levels of greater than 100 kW? (1.00)

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

QUESTION L.02 (2.50)

a. WHAT THREE (3) reactor parameters have indication which is required to be supplied by emergency power whenever the reactor is operating? (1.50)

b. WHAT are the TWO (2) reasons that the use of emergency power is probably not necessary for the MITR-II? (1.00)

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

QUESTION L.03 (1.50)

a. WHAT reactor building pressure relief system interlock must be satisfied before a reactor startup can be conducted? (0.50)

b. The reactor building overpressure scram is installed to scram the reactor at less than 3.0 inches of H2O. WHAT is the basis for the value of this setpoint? (1.00)

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

QUESTION L.04 (3.50)

a. WHOSE permission is required before a warning tag can be posted AND WHO may post a warning tag? (1.00)

b. WHAT are FIVE (5) requirements which must be observed when "locking out" facility equipment AFTER permission is granted? (2.50)

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

QUESTION L.05 (1.50)

In accordance with 10 CFR Part 50.54(x), under WHAT conditions can an operator take reasonable action that departs from a license condition or a Technical Specification?

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

QUESTION L.06 (1.00)

WHOSE approval is required before Temporary Changes to Class B or C procedures may be made?

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

QUESTION L.07 (2.00)

a. Whenever jumpers are used to bypass safety functions, WHERE must a warning tag be placed so that the reactor is not started until the bypass is removed?

b. In WHAT condition can the reactor be in when Safety Functions, which are required by Technical Specifications as a Limiting Condition for Operation, are to be bypassed for testing purposes?

c. HOW many individuals are required to check the physical installation of a jumper after it has been installed?

d. TRUE or FALSE:

Safety Functions which are bypassed during a normal startup by key switches on the scram panel are logged onto the Bypass Log Sheet?

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

QUESTION L.08 ~~(2.50)~~ (1.50)

a. Using Attachment 2, classify, if applicable, each of the events listed below in accordance with PM-4.4, "Emergency Classification System." ~~(2.00)~~ (1.00)

deleted

1. ~~An experiment using bottled hydrogen gas becomes damaged resulting in the uncontrolled release of the gas from its container.~~

2. ~~A train derailment results in the complete rupture of both liquid waste storage tanks which were full at the time of the accident.~~

3. The MIT Campus Police inform you that an anonymous caller has just threatened to damage the reactor building.

4. An automatic reactor scram from full power occurs due to the tripping of a primary coolant pump.

b. Within HOW many hours after an Alert is declared must the NRC be notified? (0.50)

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

QUESTION

WHAT
the
safe

H.01 (1.50) ~~(2.00)~~

ause of the greater relative ability of delayed neutrons to cause
rmal ~~fission [0.50]~~ due to their lower birth energies [0.50]
gh probability for fission)
~~onium buildup [0.50]~~
mine-87 (longest lived neutron precursor) [0.50]

a. because delayed neutrons have lower birth energies [0.50] which ~~results~~ results in fewer delayed neutrons from being lost from the neutron cycle during the thermalization process [0.50]

Reactor Physics Notes

H.02 (2.50)

/CR1 = 1-Keff1/1-Keff2 [0.25]
)/2000 = 1-0.9875/1-Keff2 [0.50]
f2 = 0.99375 [0.50]
= 1.59 (Beta) * 0.00786 [0.50]
= 0.0124974
f = 0.9875 + Rho
f = 0.9999974 [0.25]
roximately critical [0.50]

Reactor Physics Notes

H.03 (2.75)

Po * 10 ^ (SUR*time) [0.25]
= 26.06/T [0.25]
= 26.06/40 = 0.6515 [0.50]
= 100 [0 25]
= 10 ^ (0 .515*t)
= 2/0.6515
= 3.07 minutes [0.50]
= (Beta - Rho)/(Rho*lambda) [0.25]
= (1.0 - Rho)/(Rho*0.1) [0.25]
= 200.0 Millibeta [0.50]

Reactor Physics Notes

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

ANSWER H.04 (1.50)

a. Increase (due to less broadening) [0.50]
b. - the neutron will loose very little energy in its collision which will place it right at the resonance capture energy [0.50]
   - the neutron is in the fuel where most of the material is U-238 atoms which makes them more likely targets for collisions [0.50]

REFERENCE

MITR-II Reactor Physics Notes

ANSWER H.05 (4.00)

a. Xe production:	directly from fission [0.50]
	(Beta) decay from I-135 [0.50]
Xe removal:	(Beta) decay to Cs-135 [0.50]
	neutron absorption (burnout) to Xe-136 [0.50]
Sm production:	(Beta) decay from Pm-149 [0.50]
Sm removal:	neutron absorption (burnout) to Sm-150 [0.50]

b. Increases [0.50]
c. 40 hours [0.50]

REFERENCE

MITR-II Reactor Physics Notes

ANSWER H.06 (2.00)

a. because the rate at which water expands [0.50] increases with temperature [0.50]
b. increased leakage [0.50]
   neutron spectral shift [0.50]

REFERENCE

MITR-II Reactor Physics Notes

ANSWER H.07 (2.00)

a. because of its lower thermal neutron absorption cross-section [1.00]
b. photo-neutron production [0.50] by gamma rays [0.25]
   from fission product decay [0.25]

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

REFERENCE

MITR-II Reactor Physics Notes

ANSWER H.08 (1.25)

```
Q = M*Cp*(T2 - T1) [0.25]
  = 1800 * 8.345 * 60 * 1.0 * 20 [0.50]
  = 1.8025 E+7 (BTU/Hr) / 3.42 E+6
Q = 5.286 MW [0.50]
```

REFERENCE

MITR-II Technical Specifications

ANSWER H.09 (2.00)

a. to prevent the release of radioactive fission gas into the reactor coolant [1.00]
b. it would increase the delay time for heat removal [0.50] on rapid power increases [0.50]

REFERENCE

MITR-II Technical Specifications 5-4

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

ANSWER I.01 (2.50)

a. ~~flow~~ level > 900 ~~gpm~~ gallons
a leak from the tank [3 X 0.50]
ambient temperature <= 32 F.
b. the stack [0.50]
c. the final valve in the discharge path is kept locked closed [0.50]

REFERENCE

RSM-8.19,8.20

ANSWER I.02 ~~(2.00)~~ (1.50)

pump one starts [0.50]
~~pump two starts [0.50]~~
inlet city water isolates [0.50]
"Leak Primary D2O System" annunciator alarms [0.50]

REFERENCE

RSM-8.19

ANSWER I.03 (1.50)

a. door must be closed [0.50] and locked [0.50]
b. MITR Radiation Protection Officer [0.50]

REFERENCE

PM-3.12.2 pages 1,2

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

ANSWER I.04 (2.50)

a. D1 * (R1)^2 = D2 * (R2)^2 [0.25]
   100 (mR/Hr) * 10^2 (ft2) = D2 * 1^2 (ft2)
   D2 = 10,000 mR/Hr [0.25]
   A = Ao * e (-lambda * time) [0.25]
   lambda = ln2 / half-life [0.25]
   lambda = 0.04621 (1/minutes) [0.25]
   100 (mR/Hr) = 10,000 (mR/Hr) * e (-0.04621 * time)
   time = 100 minutes [0.25]
b. I = Io * e (-mu * X) [0.25]
   mu = ~~1/~~mass attenuation coeficient * 11.34 (gm/cm3) [0.25]
   mu = ~~60 (1/cm) [0.25]~~ 2.14326 (1/cm) [0.25]
   1 = 100 * e (~~-60~~ * X)
   X = ~~0.0768 (cm) [0.25]~~
   2.15 (cm) [0.25]

REFERENCE

MITR-II Reactor Physics Notes

ANSWER I.05 (3.00)

a. open window - closed window [0.50]
   2.00 - 1.50 = 0.50 R/Hr [0.50]
b. 1.25 R/Qtr [0.50]
   1.25 / 1.50 = 50 minutes [0.50]
c. 3 R/Qtr [0.50]
   5(N-18) R [0.50]

REFERENCE

10 CFR 20.104

ANSWER I.06 (1.50)

N-16
Ar-41 [3 X 0.50]
Hydrogen

REFERENCE

RSM-3.2.5

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

ANSWER I.07 (2.00)

a. by detecting the presence of N-16 [0.50] and F-18 [0.50]
b. because of the short lived half lives of the detector sensitive isotopes which are used for tritium detection [1.00]

REFERENCE

RSM-7.4.1

ANSWER I.08 (3.00)

a. NRC SRO license [0.50]
   shift supervisor qualifications [0.50]
b. - notify the Radiaction Protection Officer
   - check package for DOT compliance [4 X 0.50]
   - perform a survey
   - check shipping papers against purchase order

REFERENCE

PM-1.10 page 18

ANSWER I.09 (2.00)

a. to save a human life [0.50]
   to ensure nuclear safety [0.50]
b. Director of Reactor Operations [0.50]
   MITR Radiation Protection Officer [0.50]

REFERENCE

PM-4.3 page 14

(***** END OF CATEGORY I *****)

ANSWER J.01 (2.25)

When a rabbit is inserted, solenoids [0.25] operate in such a manner that a vacuum [0.25] is channeled between the inner and outer tubes [0.25] Because there are perforations in the end of the inner tube, [0.25] the opening of a solenoid which applies atmospheric pressure to the outer tube [0.25] causes a differential pressure to exist across the rabbit, [0.25] propelling it to the in-pile limit [0.25]

The operation is reversed by another set of solenoid valves in order to eject the rabbit [0.50]

REFERENCE

RSM-2.10

ANSWER J.02 (1.50)

a. reduce Argon-41 production [0.50]
   prevent nitric acid formation [0.50]
b. gamma heating [0.50]

REFERENCE

RSM-2.9

ANSWER J.03 (2.50)

a. During normal conditions, the valves are closed by hydraulic pressure lifting the balls upward [0.25] On a pipe break, the balls drop by gravity opening the valve [0.25] Water then flows out of the core tank and out the break [0.25] This continues until the water level drops to the top of the valves, [0.25] when the flow of water is stopped by air intrusion into the valves [0.25]
b. During normal conditions, the valves are closed by hydraulic pressure lifting the balls upward [0.25] When core flow stops, the balls drop by gravity [0.25] allowing cold water [0.25] to flow downward through the valves [0.25] and up through the core [0.25]

REFERENCE

RSM Figures 1.15,1.16,1.17

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

ANSWER J.04 (2.50)

B10 (n , alpha) Li7 [0.75]
the charged products create ion pairs [0.25]
in the counting gas (N2) [0.25] which are seen as pulses
by the detector [0.25] the detector also detects gamma rays [0.25]
so these must be compensated for by another ion chamber without
the B10 lining [0.25] this signal is then subtracted from the
B10 lined ion chamber's signal [0.25]
the detector is good for intermediate [0.25] and full power levels [0.25]

REFERENCE

RSM-5.3

ANSWER J.05 (2.75)

a. because it supplies power to operate a motor-driven interlock [0.75]
b. the emergency lighting panel transfer switch immediately connects to battery power [0.50]
   the M/G set starts immediately [0.25] but is delayed from loading through a transfer [0.25] for 12 seconds [0.25]
   on restoration of power all transfer switches return to their normal positions [0.50] and the M/G set is stopped [0.25]

REFERENCE

RSM-8.31,8.32

ANSWER J.06 (2.00)

- the ventilation is secured
- the containment shell is sealed
- the top part of the D2O reflector is dumped [4 X 0.50]
- the withdrawal permit circuit is interrupted causing the shim blades to drop

REFERENCE

RSM-9.8

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

ANSWER J.07 (1.50)

a. D2O freezing could occur [0.50]
b. - shift cooling tower fans to low speed
   - adjust cooling tower slats [2 X 0.50]
   - bypass flow to basins

REFERENCE

PM-5.4.6

ANSWER J.08 (1.00)

to allow the reactor core and primary coolant to approach thermal equilibrium [0.50] thereby reducing stress on the fuel element and cladding [0.50]

REFERENCE

PM-2.3.1

ANSWER J.09 (2.00)

- all shim blades must be above the subcritical interlock position
- the deviation between power-set and actual power must not exceed 1.5%
- the regulating rod control switch must be in the neutral position
- the regulating rod must be withdrawn beyond its near-in position

[4 X 0.50]

REFERENCE

RSM-4.4

ANSWER J.10 (2.00)

- maintain the purity of the primary H2O
- maintains core level by means of a continuous overflow [4 X 0.50]
- provides for a surge volume
- provides cooling flow through the H2O medical shutter tank
- provides for decay heat removal

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

REFERENCE

RSM-3.2.3

RSM-3.2.6

(***** END OF CATEGORY J *****)

ANSWER K.01 (2.00)

a. to prevent personnel entry into the reactor building [0.50]
b. fuel storage ring [0.50]
   transfer basket (core flow guide) [0.50]
c. ensure adequate shutdown margin [0.50]

REFERENCE

PM-3.3.1 page 2
PM-3.3.2 pages 3,4

ANSWER K.02 (3.50)

a. five by five (seven by seven) matrix of open-ended boxes [0.50]
   in an aluminum frame [0.50] OR Cadmium frame
   made of aluminum-cadmium-aluminum sandwich [0.50] OR cadmium lined
   used for corrosion resistance (aluminum) [0.50]
   neutron absorption characteristics (cadmium) [0.50]
b. decay heat removal [0.50]
   shield personnel from gamma radiation [0.50]

REFERENCE

RSM-8.38

ANSWER K.03 (1.50)

a. four (4) days [0.50]
b. prevent melting from afterheat [1.00]

REFERENCE

MITR-II Technical Specifications 3-39

ANSWER K.04 (1.00)

regulating rod absorber [0.50]
control (shim) blade [0.50]

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

REFERENCE

PM-3.4 1.3.4.2

ANSWER K.05 (2.00)

a. check that there are no loose or unattached items in their clothing (affix loose items with tape) [1.00]
b. low power safety amplifiers must be replaced by full power safety amplifiers [1.00]

REFERENCE

PM-3.3.2

ANSWER K.06 (3.00)

a. the total worth of the rod is to be limited such that the complete withdrawal of the rod will not ~~(make the reactor prompt critical)~~ cause fuel damage [1.00]
b. in the event of an accidental continuous insertion of reactivity at the above maximum rate, the response of the reactor safety system period and level trips will adequately protect the reactor [1.00]
c. the additional independent capability for reactivity control provided by the D2O reflector dump gives added assurance that the reactor can be made subcritical under an adverse condition of fuel loading or control blade malfunction [1.00]

REFERENCE

MITR-II Technical Specification 3-32 thru 3-35

ANSWER K.07 (2.00)

- loss of power to the SPSP control and alarm panel
- a leak from the pool
- low SFSP water level [4 X 0.50]
- low flow thru the SFSP ion exchanger

REFERENCE

PM-5.7.12, "Spent Fuel Storage Pool," page 1

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

ANSWER K.03 (1.50)

a. senior reactor operator [0.50]
   superintendent [0.50]
b. 1.0 KW [0.50]

REFERENCE

PM-1.15

ANSWER K.09 ~~(3.50)~~ (2.00)

a. it is axially symmetric [0.50]
b. ~~The burnable poison has a high absorption cross-section for thermal neutrons [0.50] so its negative reactivity worth initially compensates for the reactivity worth of the added U-235 [0.25] After the poison absorbs a neutron, it is permanently removed from the competition process [0.50] This mechanism delays the decrease in reactivity worth of the fuel element, thus increasing its life (burnup) [0.25]~~ Deleted
c. maximizes [0.25] flux and power (densities) [0.25] in the lower half of the core [0.25]
   minimizes [0.25] power (peaking) [0.25]
   in the top half of the core [0.25]

REFERENCE

RSM-1.3,1.4
PM-3.3.1

(***** END OF CATEGORY K *****)

ANSWER L.01 (2.50)

a. prevent mechanical damage to the components [0.50]
   prevent core reactivity changes due to movement [0.50]
   assure proper flow distribution and cooling [0.50]
   (ensure validity of safety limits)
b. so as not to appreciably affect core power distribution [1.00]
   (hot channel factor or peaking factor)

REFERENCE

MITR-II Technical Specifications 3-41

ANSWER L.02 (2.50)

a. neutron flux
   main tank coolant level [3 X 0.50]
   primary coolant outlet temperature
b. loss of power automatically scrams the reactor [0.50]
   coolant will still cover the core (melting will not occur) [0.50]

REFERENCE

MITR-II Technical Specifications 3-23

ANSWER L.03 (1.50)

a. minimum negative differential pressure [0.50]
b. prevent reactor scram on momemtary low positive pressure [0.50] which may occur after a ventilation shutdown [0.50]

REFERENCE

MITR-II Technical Specification 3-18

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

ANSWER L.04 (3.50)

a. on duty console operator [0.50]
   any member of the NRL/RPO staff [0.50]

b. - SRO will witness lockout
   - SRO will verify safe system condition [any 5 @ 0.50 each]
   - person performing work will perform lockout
   - person performing work will retain the key on his person
   - a notation as to the system being locked out shall be made on the status board
   - the system must be tagged out

REFERENCE

PM-1.14.3

ANSWER L.05 (1.50)

in an emergency [0.50]
when the action is needed to protect the public health and safety, [0.50]
and no other action is immediately apparent [0.50]

REFERENCE

10 CFR Part 50.54(x)

ANSWER L.06 (1.00)

two (2) reactor staff members [0.50] one (1) of whom shall hold an SRO license [0.50]

REFERENCE

PM-1.5

ANSWER L.07 (2.00)

a. on the shim blade control handle [0.50]
b. shutdown [0.50]
c. two (2) [0.50]
d. FALSE [0.50]

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

REFERENCE

PM-1.9

ANSWER L.08 ~~(2.50)~~ (1.50)

a. ~~1. Alert~~ deleted
~~2. Site Area~~
3. Unusual Event [2 X 0.50]
4. No Classification

b. 1 hour [0.50]

REFERENCE

PM-4.7.1
PM-4.4

ANSWER L.09 (3.00)

- if the probability of occurrence or the consequence of an accident or malfunction of equipment important to safety previously evaluated in the SAR may be increased [1.00]
- if a possibility for an accident or malfunction of a different type than any evaluated previously in the SAR may be created [1.00]
- if the margin of safety as defined in the basis for any Technical Specification is reduced [1.00]

REFERENCE

PM-1.4

(***** END OF CATEGORY L *****)
(********** END OF EXAMINATION **********)

Facility Comments on RO Exam, 12 Sept. 88

A.02 Source is not installed.

A.04 At 298 kW, the temperature change is still insignificant. The period would still be 60 seconds. (Note: PM 2.3 p.3 does give 100 kW as the point of adding heat. We shift to cooling towers at 250 kW and begin seeing temperature effects on the approach to 1 MW. PM 2.3 p.3 is in error.)

B.02(a) Also, avoid activation of argon, and

Provide inert medium for transport of disassociated D_2/O_2 to recombiner.

C.04(c) Answer should be 'In'. On flooding, which would be with D_2O, a positive reactivity addition is made. (If light water flooded it, the answer is correct, but the blister tank is surrounded by heavy water.)

D.03(c) Must have 1800 gpm for full power operation. For 100 KW operation, not required.

E.03(a) Should be flow 'guide' not 'shroud'.

E.03(b) Typo - 'bank' should be 'tank'.

E.07(c) Current setpoint is 95 gpm. It varies, but is always above minimum required of 75 gpm.

F.03(d)
F.03(e) Refer to PM 5.2.1 and PM 5.5.4. Neither requires an immediate shutdown. Both allow time to investigate and both require shutdown by ARI if certain conditions exist. Not sure how these should be answered.

G.05(b) MV-83 and MV-64 are referred to as the 'solenoid valves'. Memorization of valve numbers is not required.

Facility Comments on SRO Exam, 12 Sept. 1988

H.01a Concur that $\bar{\beta} > \beta$ because of their lower birth energies. As a result they have a lower probability of undergoing fast neutron leakage and to a lesser extent resonance capture. So, we agree with giving credit for "lower birth energies". We disagree with giving credit for 'cause thermal fission' because once thermalized both prompt and delayed have same probability of causing fission.

H.02b The MIT Reactor uses fully enriched fuel. There is very little U-238 and hence little plutonium buildup. Beta-effective does decrease on the MITR-II with core life because the blades are withdrawn further making the effective core volume larger. Hence, there is less leakage of prompt neutrons. Recall that from #H.01a, the principal difference between prompt and delayed neutrons is the leakage probability. Anything that decreases leakage decreases that difference.

H.03a It is not necessary to use startup rate. Problem could be solved directly (and more easily) using period.

H.04a Reason given in answer (less broadening) is correct but the effect is to decrease (not increase as indicated in the answer) the capture cross-section. Also, MITR fuel temperature varies only over a range of 30°C from zero to full power. So, the effect is quite small.

H.05b By definition, the shutdown margin is calculated by subtracting out xenon. So, the answer should be 'No Change'. If the question meant "by how much would the reactor be shutdown", then the answer is 'Increase'. (Note: Believe this point of confusion was discussed by the examiner during the test.)

H.08 Question should provide value for specific heat of water.

I.01a Typo in answer. It should be 'level' not 'flow' greater than 900 gallons (not gpm).

I.02 The sump system was recently modified. There is now only one pump.

I.04b Typo on units. Should be 0.189 cm^2/gram. Hence, in solution, multiply by density instead of dividing. Answer is about 2 cm.

I.09b Note: Director of Operations and Emergency Director may be the same person.

J.05a The 13.8 KV breakers are the property of the Cambridge Electric Company. The Reactor Staff is not allowed to operate them. Hence, question is not relevant.

J.10 Also provides shutdown cooling (decay heat removal) when reactor is shutdown. This is a fifth function of the cleanup system. RSM 3.2.6.

K.01b Answer is correct but note that fuel must go from the storage ring to the basket. It can not go direct from the storage ring.

K.02 Currently two types of boxes. One is aluminum-cadmium-aluminum, the other is cadmium-lined.

K.06a A 1.8% delta K/K insertion will make the reactor prompt critical. The answer should be that such an insertion will not cause a transient that is beyond the capability of the safety system to shut down the reactor before fuel damage occurs.

K.08 The answer is correct but the question's wording is confusing. The safety and operating limits must be verified before going above 1 KW. The SRO and Superintendent sign for doing that evaluation.

K.09a Also, radially symmetric.

K.09b The MIT Reactor does not use burnable poisons.

K.09c Answer is correct but inserts are currently made of boron stainless steel.

L.02b Also, minimum required equipment is provided by self-contained power supplies.

L.03 Answer given is correct. However, please see also PM 5.5.7, "Building Overpressure", which gives other factors involved in selecting the set point.

L.06 Must be two licensed reactor staff members, one of whom holds an SRO license for Class B. For Class C, could be two staff members, one of whom has an SRO.

L.08 Attachment Two was PM 4.4 page 1-5. These pages provide general advice and they are not the EALs given in the procedures. Hence, this question is difficult to grade. Comments are as follows:

(1) An H_2 release would be an event. The probability of problem has been increased, but no radiation release has occurred.

(2) A waste tank rupture would be an alert. A radiation release has occurred, it is limited in extent by the finite tank volume, and it is well below levels for site emergency. Waste tank activity is never more than a few millicuries, if that.

(3) This is an event as per written MITR procedures (The EALs).

(4) Not classified. Falls within scope of AOPs.

ATTACHMENT 4

NRC Response to the Facility Comments

A.02 Comment is valid and point count will be distributed as indicated in the answer sheet. The answer sheet anticipated this comment.

A.05 Comment is accepted. Answer key will be changed.

B.02a Comments are accepted. Answer key will be changed to include these answers.

C.04c Comment valid. Answer key will be changed.

D.03e Comment valid. Answer key will be changed.

E.03a Comment accepted. Answer key will be changed. Suggest change be made to Reactor Systems Manual p. 3.5.

E.03b Comment valid. Answer key will be changed.

E.07c Comment accepted. Answer key will be changed.

F.03d The question states that no other abnormal condition occurred, therefore F.03 (d) answer is NO SHUTDOWN REQUIRED (error in answer key).

F.03e The question states that no other abnormal condition occurred, therefore F.03 (e) answer is NO SHUTDOWN REQUIRED (answer key is correct).

G.05b Comment is accepted. Answer key will be changed.

H.01a The answer key was changed to: "because delayed neutrons have lower birth energies [0.50] which results in fewer delayed neutrons from being lost from the neutron cycle during the thermalization process [0.50]"

H.01b The question was deleted due to the lack of a reference. The value of the question was reduced by 0.50 points.

H.03 Either method is acceptable and since the answer does not change, no change was made to the answer key.

H.04a No changes were made to the answer key. The answer is correct, (Increase), since at the resonance energies the capture cross section Increases at lower temperatures. refer to Figure 4-2b.

H.05b The answer key was not changed because the candidate was informed during the examination that Actual Shutdown Margin was "the amount by which the reactor would be shutdown."

I.01a The answer key was changed to: "level _ 900 gallons." Please revise RSM-8.20 to correct this error.

I.02 The answer key was changed and the value of the question was reduced by 0.50 points. Please revise RSM-8.19 and any applicable drawings.

I.04b The answer key was changed to reflect the typo in this question. The correct answer is 2.15 cm.

I.09b The answer key was not changed because the reference material indicates only two (2) individuals: the Director of Reactor Operations (DRO) and the Radiation Protection Officer (RPO). However, if the full emergency organization is activated, then the DRO is the Emergency Director.

J.05a The answer key was not changed because the 13.8 KV circuit breaker motor-driven interlock is one of the loads which is directly supplied off the 125 VDC battery supply.

J.10 The answer key was changed to include a fifth correct answer: "provides for decay heat removal."

K.02 The answer key was changed to accept both answers for full credit.

K.06a The answer key was changed by deleting the non-required, bracketed portion of the answer. The answer is still correct since the SAR shows that a 1.8% delta K/K is the limit for a step reactivity insertion without fuel damage occuring.

K.09a The answer key was not changed because axially symmetric is the only answer which could be referenced.

K.09b The question was deleted thereby reducing the value of the question by 1.5 points. Please revise RSM-1.4 to reflect this non-use of burnable poisons.

K.09c The question, if used in the future, will be revised accordingly.

L.02b The answer key was not changed because a reference for the alternate answer was unavailable.

L.03 The comment was reviewed but all other alternate answers did not have adequate justification to qualify them as a basis for the scram setpoint. The answer key was not changed.

L.06 The answer key was not changed since the Class B criteria are more stringent.

L.08 The question should have included PM-4.5, "Emergency Action Levels." L.08a and L.08b will be deleted because of inadeqaute information. The value of the question was reduced by 1.00 points.