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

EXAMINATION REPORT NO. 50-225/88-01(OL)

FACILITY DOCKET NO. 50-225

FACILITY LICENSE NO. CX-22

LICENSEE: Rensselaer Polytechnical Institute
Troy, New York 12181

FACILITY: RPI Critical Facility

EXAMINATION DATES: May 24-25, 1988

CHIEF EXAMINER: Noel F. Dudley 6-12-88
N. Dudley, Senior Operations Specialist, DRS — Date

APPROVED BY: P W Eselgroth 6-21-88
Peter W. Eselgroth, Chief PWR Section Operations Branch, DRS — Date

SUMMARY: One Senior Reactor Operator (SRO) applicant was administered a written and an operating examination. The applicant failed to pass both portions of the examination and a proposed license denial was issued.

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REPORT DETAILS

TYPE OF EXAMINATION: Replacement

EXAMINATION RESULTS: One (1) SRO applicant failed both the written and operating portions of the examination.

CHIEF EXAMINER AT SITE: N. Dudley, NRC

Personnel Present at the Exit Meeting

NRC Personnel

N. Dudley, Senior Operations Specialist

Facility Personnel

F. Rodriquez, Operations Supervisor

Exit Meeting

The facility provided review comments on the written examination. The examiner discussed the training and experience requirements for issuance of an NRC operating license and provide the licensee copies of 10 CFR 55 Operators' Licensee and NUREG 1021, Operator Licensing Examiner Standards Chapters ES-110 ES-111, ES-204, ES-303, and ES-404 which pertain specifically to non-power reactors.

Attachment: SRO Written Examination and Answer Key

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

FACILITY: RENSSELAER

REACTOR TYPE: TEST

DATE ADMINSTERED: 88/05/23

EXAMINER: JERRELL, D.

CANDIDATE ______________________

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

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

____
Candidate's Signature

NRC RULES AND GUIDELINES FOR LICENSE EXAMINATIONS

During the administration of this examination the following rules apply:

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

2. 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 (2.00)

With the reactor critical, a small amount of positive reactivity is rapidly inserted. EXPLAIN the "prompt jump" and subsequent linear power increase which would be observed on the nuclear instrumentation. (2.0)

QUESTION H.02 (2.00)

The reactor is maintaining a constant power level indication on the nuclear indication at an intermediate power level with the source fully inserted. Assume that the source is then instantaneously withdrawn. DRAW on a graph of neutron population versus time the behavior which would result and EXPLAIN the shape of this resulting curve. (2.0)

QUESTION H.03 (2.00)

a. WHY is the plutonium source surrounded by beryllium? (1.0)

b. Following an extended shutdown (6 months), WOULD you expect the effective source strength to INCREASE, DECREASE, or REMAIN THE SAME? JUSTIFY your answer. (1.0)

QUESTION H.04 (1.50)

With the reactor operating at 100% power, an experimental apparatus in the central area of a B core configuration suddenly fails, filling the previously voided volume with water. STATE WHAT automatic actions, if any, would occur if no operator actions are taken. JUSTIFY your answer and STATE any assumptions. (1.5)

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

QUESTION H.05 (2.00)

DRAW a diagram of FUEL/MODERATOR ratio versus REACTIVITY (units not required), SHOW the approximate full (water covered) operating point and INDICATE how this operating point is effected by draining water to the water storage tank. (2.0)

QUESTION H.06 (2.50)

a. HOW (direction) and WHY (reason) does reactivity change with an increase in the temperature of the reactor fuel? (2.0)

b. WHAT is this phenomena commonly called? (0.5)

QUESTION H.07 (2.50)

The "in-hour" equation, as given below, relates reactivity to reactor period.

$$rho = \frac{l^*}{T} + \sum_{L=1}^{6} \frac{\beta i}{1 + \lambda i\ T}$$

a. DEFINE the symbols 1*, beta-i, and lamdba-i. (1.5)

b. WHY does the sum go from 1 to 6? (1.0)

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

QUESTION H.08 (3.50)

Assume the reactor is operating at 270 W and a boron strip worth 60 cents falls out of the core. The reactor power takes a prompt jump to 675 W followed by a subsequent power rise on a stable 6.5 second period.

a. IF a scram were not initiated for 7 seconds into the transient and 60 msec were required to turn the power rise after the initiation of scram, WHAT is the maximum power level the reactor would reach? (1.75)

b. Assuming an adiabatic fuel temperature increase (i.e., no heat transfer from the fuel) during the transient, with the specific heat of the fuel 0.10 Btu/lbm deg F, and the fuel mass of 10 lbm, WHAT would be the rise in fuel temperature? (1.75)

QUESTION H.09 (2.00)

SKETCH a control rod differential worth curve and EXPLAIN the reason for its shape. LABEL the axes on your graph. (2.0)

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

QUESTION I.01 (3.00)

a. Briefly EXPLAIN HOW reactor tank water is verified safe for off-site discharge (3 steps). (2.25)

b. WHAT administrative control would prevent a new RO from inadvertently pumping reactor water to the river? (0.75)

QUESTION I.02 (3.50)

A three curie gamma source falls out of its shield cask midway between two students who are separated by 4 meters. One student ducks behind a shield wall consisting of 4" of lead located next to him, while the other student runs back to the far wall located 9 feet further away from the source.

WHAT dose rate is each student receiving a) prior to and b) following their actions?

STATE ALL assumptions and SHOW ALL work. (3.5)

QUESTION I.03 (2.50)

A person is standing in a radiation field for 15 minutes consisting of

1. 10 rad of thermal neutrons
2. 20 rad of 1 Mev beta radiation
3. 30 rad of 1 Mev gamma radiation

DETERMINE WHAT the total dose is in REM. SHOW all calculations and formulas. (2.5)

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

QUESTION I.04 (3.00)

a. Fill in the table below with federal exposure limit values for radiation workers. (2.0)

REM per calendar quarter

	Quarterly Average	Quarterly Maximum
Whole body	____	____
Skin	____	X
Extremities	____	X

b. HOW much total whole body exposure could an 18-year-old freshman student receive if an NRC Form 4 were on file? (1.0)

QUESTION I.05 (3.00)

A job must be performed in a 2 REM radiation field. Two alternative methods are to be considered:

1. Two men working together can complete the job in 30 min.
2. Placing (20 min one-man job) and removing (20 min one-man job) shielding will reduce the radiation field in which the two men must work to 200 mRem/hr.

WHICH procedure is better and WHY? SHOW all work (3.0)

QUESTION I.06 (2.00)

If a radioactive sample produces 22 rem/hr at 1 meter and has a half life of 17 seconds, HOW LONG must one wait to manipulate it if a maximum allowable radiation of 1 rem/hr at 1 meter is required? (2.0)

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

QUESTION I 07 (3.00)

During full power operation the criticality detector system in the fuel storage area is found to be totally inoperative. Using the provided Technical Specifications pages, ANSWER the following:

a. HAVE Technical Specifications been violated? SUPPORT your answer. (1.5)

b. IS it acceptable to temporarily place a portable area radiation monitor in the fuel storage area and continue operations? SUPPORT your answer. (1.5)

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

QUESTION J.01 (1.00)

ANSWER TRUE or FALSE.

a. The instrument scrams at the RPI facility are based upon a fail-safe philosophy. (0.5)

b. Multiple channel scram triggers cause the probability for failure to scram to be acceptably small. (0.5)

QUESTION J.02 (3.00)

INDICATE whether a safety trip would be expected for each of the following instrument failures. Consider each failure separately and include WHAT safety trip would be expected for those failures which would cause a trip.

a. a Log N meter fails high (0.5)

b. a linear NI channel fails low (0.5)

c. a linear NI channel fails high (0.5)

d. a BF 3 detector fails high (0.5)

e. a UCI chamber loss of high voltage occurs (0.5)

f. tank temperature instrument fails high (0.5)

QUESTION J.03 (2.00)

Given the attached curves of integral bank control rod worth and period versus reactivity, WHAT is the minimum steady state period that would result from a bank rod withdrawal of one inch? (2.0)

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

QUESTION J.04 (3.00)

Certain valves in the water piping system at the Rensselaer Critical Facility are designed to fail to a preset position on loss of power. WHAT is the failed position, and give the basis for this failed configuration for the following:

1. pump discharge valve (1.5)

2. pump suction valve (1.5)

QUESTION J.05 (1.50)

WHAT is the function of the 1000 ohm resistor in the AC supply line to the scram relays? (1.5)

QUESTION J.06 (3.00)

The front panel of the solenoid interrupt circuit module has TWO voltmeters.

a. WHAT voltages do they indicate? (TWO items) (1.0)

b. WHAT are the normal indicated voltages? (TWO items) (1.0)

c. WHY are these indications important? (TWO items) (1.0)

QUESTION J.07 (2.50)

LIST the five (5) interlocks required to be met to allow rod withdrawal. (2.5)

QUESTION J.08 (1.00)

WHAT is the LENGTH and approximate WORTH of each control rod in the LEU core? (1.0)

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

QUESTION J.09 (1.00)

Assume the facility is operating at 100% power when the instrument air compressor fails and the instrument air system pressure drops to atmospheric. HOW will the facility respond with no operator action? Include cause and effect relationship for each component effected. (1.0)

QUESTION J.10 (2.00)

Assume the facility is operating at 100% power when the 400 cycle MG set fails. HOW will the facility respond with no operator action? Include cause and effect statements for each component effected. (2.0)

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

QUESTION K.01 (2.00)

STATE if the following are TRUE or FALSE.

a. Fuel pins may be stored in the vault or in a fully dispersed array inside the reactor tank. (0.5)

b. The fuel in the vault is stored in B10 lined steel tubes. (0.5)

c. The k-infinity of fully loaded storage tubes shall remain subcritical by at least $142.00 when flooded with water. (0.5)

d. A licensed senior operator and the critical facility supervisor shall be present for all fuel transfers. (0.5)

QUESTION K.02 (1.50)

Fill-in-the-blanks.

In the positive period method of control rod calibration, the _________ position of the rods is related to a measured period caused by _________ of a rod by a _________ amount. (1.5)

QUESTION K.03 (1.50)

SPECIFY the following core parameters for a SPERT fuel pin.

1. fuel pellet chemical form (name or formula) (0.5)

2. fuel pellet U-235 enrichment (w/o) (0.5)

3. cladding material (0.5)

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

QUESTION K.04 (3.00)

DRAW a plot of 1/M versus fuel mass and SKETCH in characteristic curves for the case of:

1. neutron detector too close to startup source (1.0)
2. neutron detector proper distance from startup source (1.0)
3. neutron detector too far from startup source (1.0)

LABEL all axes and curves.

QUESTION K.05 (4.00)

STATE the four (4) reactor parameters that must be determined per Technical Specifications during the initial testing of an unknown or previously untested core configuration. BRIEFLY tell WHY this is required prior to operation (one reason why all four must be measured.) (4.0)

QUESTION K.06 (3.00)

With regard to safe core loading guidelines:

a. WHAT position must control rods be in prior to loading any fuel? (1.0)

b. You load ten fuel pins during the first step and observe no change in count rate. WHAT is the maximum number of fuel pins which can be loaded during the second step prior to observing the count rate? WHY? (1.0)

c. WHAT must be done if the source is relocated during fuel loading? (1.0)

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

QUESTION K.07 (2.00)

For a known core configuration, it is desired to replace a single stationary fuel pin. Five requirements must be met per Technical Specifications to perform this task. LIST four (4). (2.0)

QUESTION K.08 (3.00)

In regard to the reactor power calibration, ANSWER the following:

a. WHY is it necessary to determine absolute thermal flux rather than a value for simply total flux at a point in the core? (1.0)

b. GIVE two (2) reasons WHY Au-197 is usually used to measure thermal flux? (1.0)

c. WHY is a cadmium cover used on some of the gold foils? (1.0)

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

QUESTION L.01 (3.00)

GIVE the Technical Specifications bases for each of the following specifications:

a. minimum flux level of 2 cps (1.0)

b. maximum thermal power level of 135 watts (1.0)

c. minimum period of 5 seconds (1.0)

QUESTION L.02 (2.00)

WHEN (2 occasions) and under WHAT two (2) PROVISIONS may the reactor door scram be bypassed? (2.0)

QUESTION L.03 (2.00)

a. WHAT is the minimum tank temperature allowed per Technical Specifications for reactor operation? (0.5)

b. WHAT is the basis for this value? (1.0)

c. HOW is tank temperature measured? (0.5)

QUESTION L.04 (4.00)

A feasibility study for producing a new detector liner is to be conducted in the reactor. A very small quantity of a coarse powder which is doubly encapsulated consisting of ferric chloride and uranium dioxide is to be inserted into the reactor for activation. STATE two (2) Technical Specifications that would be applicable, AND the reason (basis) for each. STATE any assumptions. (4.0)

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

QUESTION L.05 (1.50)

While reading the Technical Specifications Section 4.1.2, water dump time surveillance requirements, you find that it references Specification 3.1, Item 4 (rod drop time), rather than the proper Section 3.1, Item 5 (water dump reactivity time) WHAT, if anything, must be done? (1.5)

QUESTION L.06 (1.00)

DEFINE the term OPERABLE per Technical Specifications. (1.0)

QUESTION L.07 (1.50)

From the following steps GIVE the order of their priorities when immediate actions must be taken if emergency conditions develop at the reactor facility, i.e., which is first consideration, second, etc.

1. Steps to prevent the spread of hazards associated with accident conditions. (0.5)

2. Steps to minimize the extent of damage to the critical facility and its equipment. (0.5)

3. Steps for human safety. (0.5)

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

QUESTION L.08 (3.00)

You are in the office when an explosion with thick smoke and intense heat occurs in the counting room where the facility and operations supervisors are conducting an experiment. As SRO, ANSWER the following:

a. WHAT is your first action? (0.5)

b. WHO is in charge? (0.5)

c. WILL respirator protection be necessary prior to fighting the fire? (0.5)

d. WILL the emergency alarm be automatically initiated? (0.5)

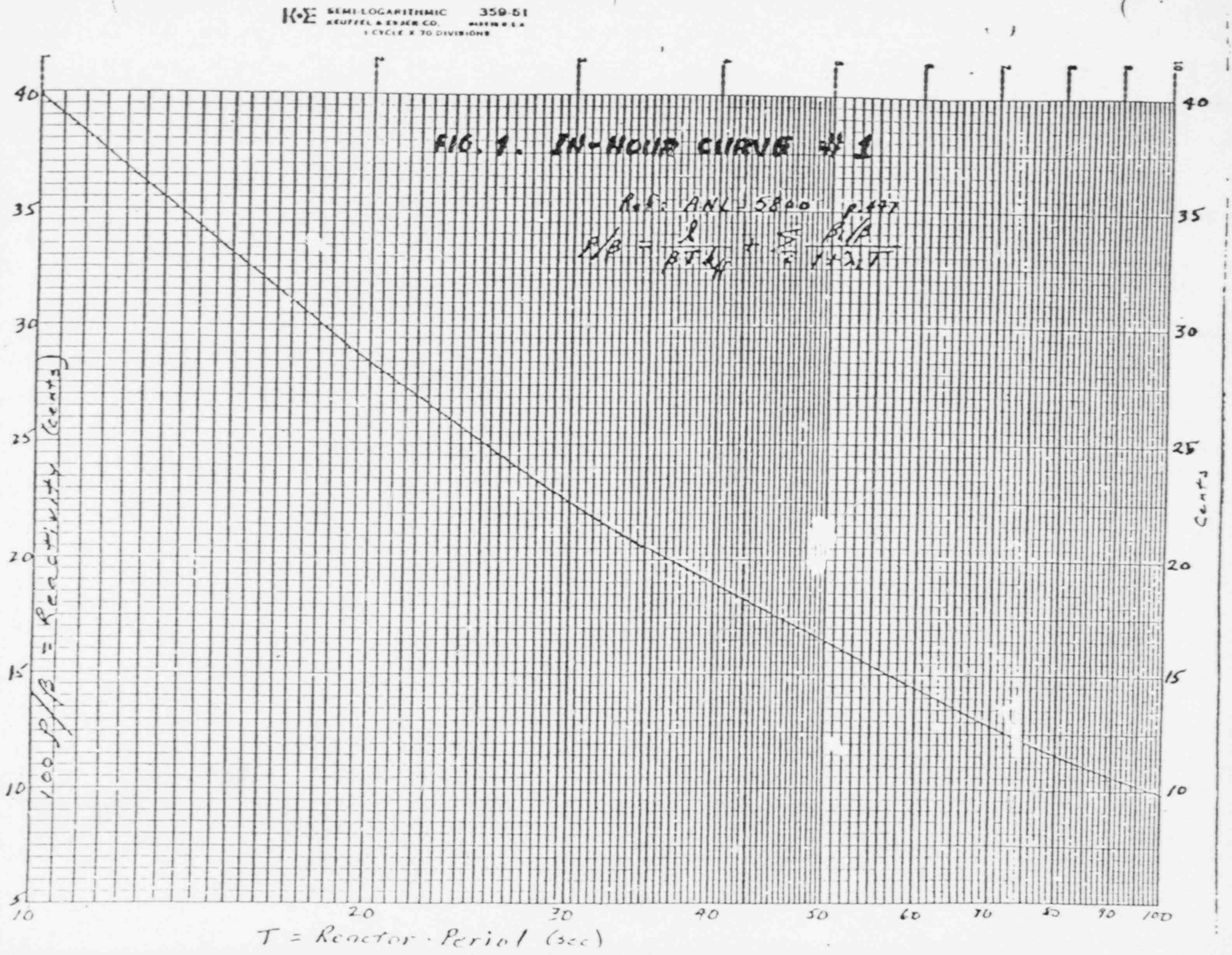
e. Assuming that you could rescue one of the men from the counting room, WHERE should he be taken for treatment? (0.5)

f. WHO should be called first? (0.5)

QUESTION L.09 (2.00)

STATE the two (2) conditions that must be met to allow a restart following a scram. (2.0)

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



K·E SEMI-LOGARITHMIC 359-51
KEUFFEL & ESSER CO.
1 CYCLE X 70 DIVISIONS
FIG. 1. IN-HOUR CURVE # 1
Ref: ANL-5800 p.477
$\rho/\beta = \frac{l}{\beta T k_{eff}} + \sum_i \frac{\beta_i/\beta}{1+\lambda_i T}$
$100\ \rho/\beta$ = Reactivity (cents)
Cents
T = Reactor Period (sec)

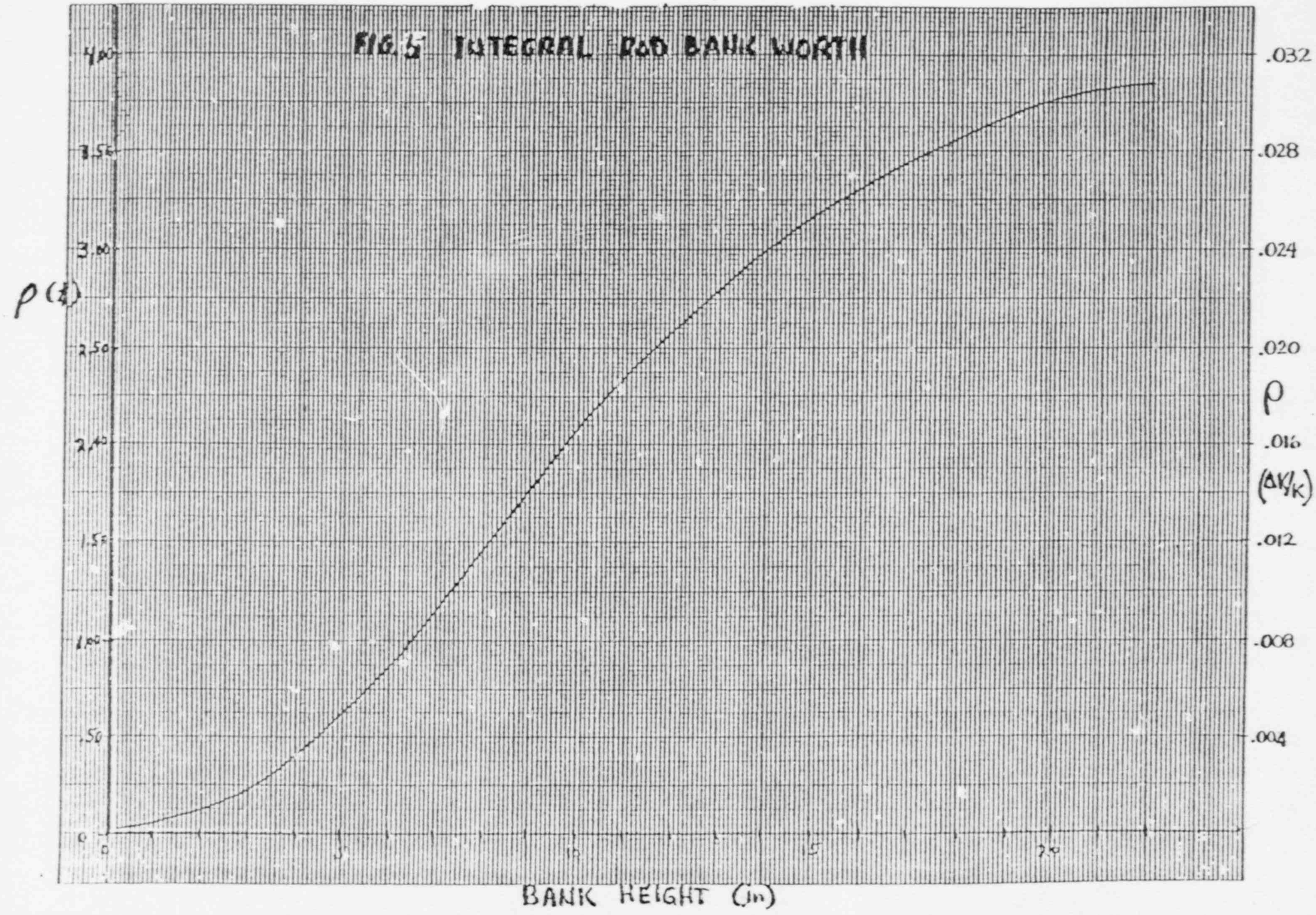


FIG. 5 INTEGRAL ROD BANK WORTH
ρ ($)
4.00
3.50
3.00
2.50
2.00
1.50
1.00
.50
0
ρ
(Δk/k)
.032
.028
.024
.020
.016
.012
.008
.004
0
5
10
15
20
BANK HEIGHT (in)

the SAR. During the initial test period of the reactor, measurements and calculations of core parameters will be for standard assemblies which are to be utilized in the reactor's operational program.

4.3 Radiation Monitoring

Applicability

These specifications apply to the surveillance of the area and air radiation monitoring equipment.

Objective

The purpose of these specifications is to assure the continued validity of radiation protection standards in the facility.

Specification

The criticality detector system, area gamma monitors, and the mobile particulate air monitor shall be checked daily if the reactor is operated, tested monthly, and calibrated semiannually.

Bases

Experience has demonstrated that calibration of the criticality detectors, air gamma monitors, and the mobile air monitoring instrument semiannually is adequate to assure that significant deterioration in accuracy does not occur. Furthermore, the operability of these radiation monitors is included in the daily pre-startup check list.

3.3 Radiation Monitoring

Applicability

These specifications apply to the minimum radiation monitoring requirements for reactor operations.

Objective

The purpose of these specifications is to assure that adequate monitoring is available to preclude undetected radiation hazards or uncontrolled releases of radioactive material.

Specifications

1. The minimum complement of radiation monitoring equipment required to be operating for reactor operation shall include:

a. A criticality detector system which monitors the main fuel storage area and also functions as an area monitor. This system shall have a visible and an audible alarm in the control room.

b. An area gamma monitoring system which shall have detectors at least in the following locations: (1) Control room; (2) Reactor room near the fuel vault; (3) Reactor room (high level monitor), and; (4) Outside the reactor room window.

c. Instruments to continuously sample and measure the particulate activity in the reactor room atmosphere shall be operating whenever the reactor is to be operated.

d. The radiation monitors required by 3.3.1 a, b, and c, may be temporarily removed from service if replaced by an equivalent portable unit.

2. Portable detection and survey instruments shall be provided.

Bases

The continuous monitoring of radiation levels in the reactor room and other stations assures the warning of the existence of any abnormally high radiation levels. The availability of instruments to measure the amount of particulate activity in the reactor room air assures continued compliance with the requirements of 10 CFR Part 20. The availability of required portable monitors provide assurance that personnel will be able to monitor potential radiation fields before an area is entered.

In all cases, the low power levels encountered in operation of the critical assembly minimizes the probable existence of high radiation levels.

3.4 Experiments

Applicability

These specifications apply to all experiments placed in the reactor tank.

Objective

The objective of these specifications is to define a set of criteria for experiments to assure the safety of the reactor and personnel.

EQUATION SHEET

Where $\dot{m}_1 = \dot{m}_2$

$(density)_1(velocity)_1(area)_1 = (density)_2(velocity)_2(area)_2$

$KE = \frac{mv^2}{2}$ $PE = mgh$ $PE_1 + KE_1 + P_1V_1 = PE_2 + KE_2 + P_2V_2$ where V = specific volume
P = Pressure

$Q = \dot{m}c_p(T_{out} - T_{in})$ $Q = UA\,(T_{ave} - T_{stm})$ $Q = \dot{m}(h_1 - h_2)$

$P = P_o 10^{(SUR)(t)}$ $P = P_o e^{t/T}$ $SUR = \frac{26.06}{T}$ $T = \frac{(B-p)t}{p}$

$\text{delta } K = (K_{eff} - 1)$ $CR_1(1-K_{eff1}) = CR_2(1-K_{eff2})$ $CR = S/(1-K_{eff})$

$M = \frac{(1-K_{eff1})}{(1-K_{eff2})}$ $SDM = \frac{(1-K_{eff}) \times 100\%}{K_{eff}}$

$\text{decay constant} = \frac{\ln(2)}{t_{1/2}} = \frac{0.693}{t_{1/2}}$ $A_1 = A_o e^{-(\text{decay constant}) \times (t)}$

Water Parameters

1 gallon = 8.345 lbs
1 gallon = 3.78 liters

1 ft^3 = 7.48 gallons

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 psia = 29.9 in Hg

Miscellaneous Conversions

1 Curie = 3.7×10^{10} dps
1 kg = 2.21 lbs

1 hp = 2.54×10^3 Btu/hr

1 MW = 3.41×10^6 Btu/hr
1 Btu = 778 ft-lbf
1 Btu = 1055 w·sec

Degrees F = (1.8 x Degrees C) + 32
1 inch = 2.54 centimeters
g = 32.174 ft-lbm/lbf-sec^2

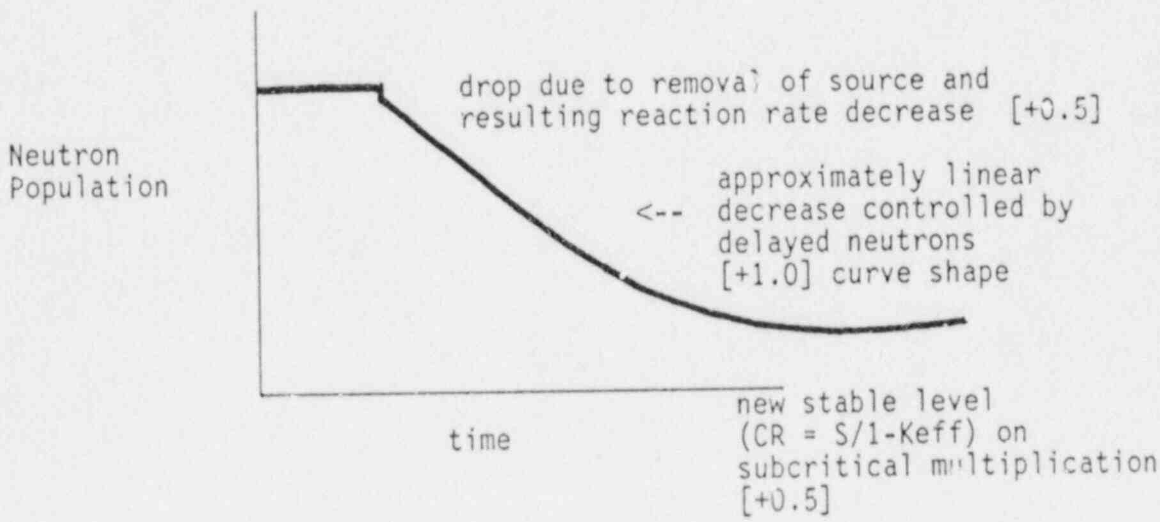
ANSWER H.01 (2.00)

The fission rate increases generating additional fast neutrons [0.5]
Reaction rate begins to diverge on prompt neutrons alone [+0.5]
Since reactor is not prompt critical additional power raise is dependent on delayed neutrons [1.0]

REFERENCE

1. RPI: SER, p. 14-3.
2. Generic: Lamarsh, J. R. "Introduction to Nuclear Reactor Theory," p. 427.

ANSWER H.02 (2.00)



REFERENCE

1. RPI: SER, p. 7-1.

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

ANSWER H.03 (2.00)

a. The plutonium causes a (n,2n) reaction in the beryllium thus acting as a source strength multiplier. [+1.0]

b. Remains the same [+0.5] - the half life of plutonium (24K years) is very long compared to the shutdown period (so no appreciable decay would take place) [+0.5].

REFERENCE

1. RPI: SER, p. 7-1.

ANSWER H.04 (1.50)

Assumption: small worth experiment [+0.5]

Positive reactivity would be inserted [+0.5] causing power to increase to the high flux trip setpoint and a scram would result [+0.5].

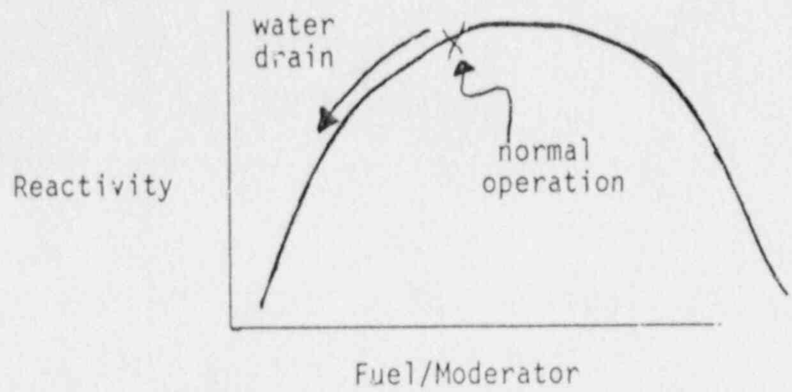
REFERENCE

1. RPI: SAR modification, p. 15.

2. RPI: SER, p. 7-2.

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

ANSWER H.05 (2.00)



Grading: graph shape [+1.0]
operating point (under-moderated) [+0.5]
water drain indication [+0.5]

REFERENCE

1. RPI: Answers to SAR Questions, October 1986, Table 5.2.

ANSWER H.06 (2.50)

a. An increase in fuel temp decreases resonance escape probability (increases resonance capture) (value of P decreases). [+0.5]

   This effect is seen because:

   1. the microscopic cross section peak is lowered, but its effect is felt over a broader energy band [+0.5]

   2. the overall probability for resonance capture during neutron slowing down through resonance energies is increased [+0.5]

   3. since resonance escape (P) is 1 - neutrons captured by resonance absorption then reactivity decreases [+0.5]

b. this effect is called Doppler or temperature broadening [+0.5]

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

REFERENCE

1. Generic: Lamarsh, J. R. "Introduction to Nuclear Reactor Theory."

ANSWER H.07 (2.50)

a. l* = prompt neutron generation time

beta-i = average fraction of neutrons per fission due to the i-th group of delayed neutrons

lambda-i = decay constant for the i-th group of delayed neutrons

[+0.5] each

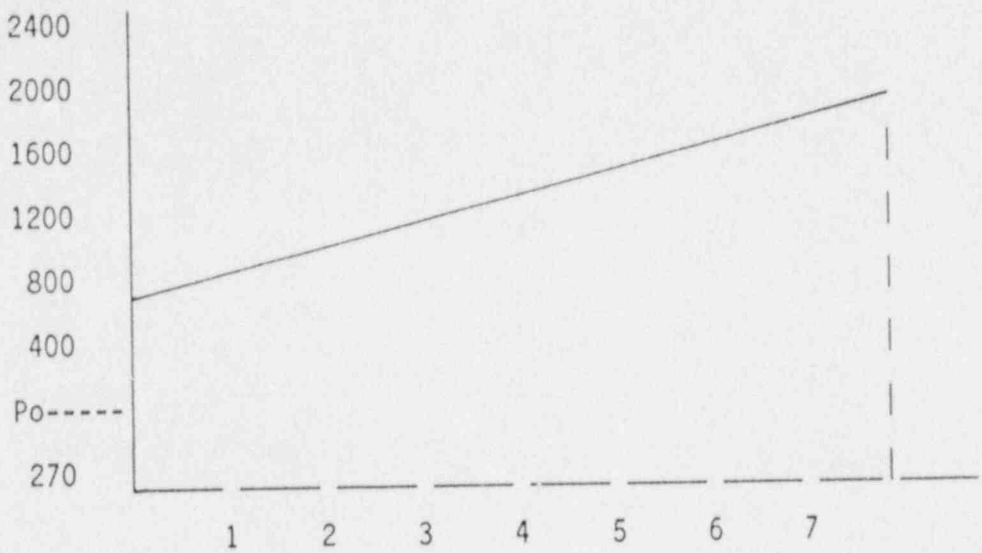
b. There are six predominant groups of delayed neutrons, i.e., the fission process can be adequately described by assuming six radioactive decay chains that generate all of the delayed neutrons. [+1.0]

REFERENCE

1. RPI: "A Manual of Experiments for the Rensselaer Reactor Facility," Richard M. Kacich, May, 1975, pp. 37 and 38.

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

ANSWER H.08 (3.50)



GRAPH NOT REQUIRED IN SOLUTION

a. P = Poe**t/tau [+0.5] tau = 6.5 sec
t = 7 sec + 60 ms = 7.06 sec (50 - 100 ms for neg insertion)

P = (675) e (7.06/6.5) = 2000 w [+1.0]

b. Q = mCp delta T [+0.5]

from a) Q = (675 + 2000/2) 7.05 = (1337.5) 7.05 = 9429.4 watts
x 1 Btu/1055 w x s = 8.94 Btu [+1.0]

$$\text{delta T} = Q/mCp = \frac{8.94 \text{ Btu}}{10 \text{ lbm} \times 0.1 \text{ Btu/lbm deg F}} = 9 \text{ deg F} \quad [+0.5]$$

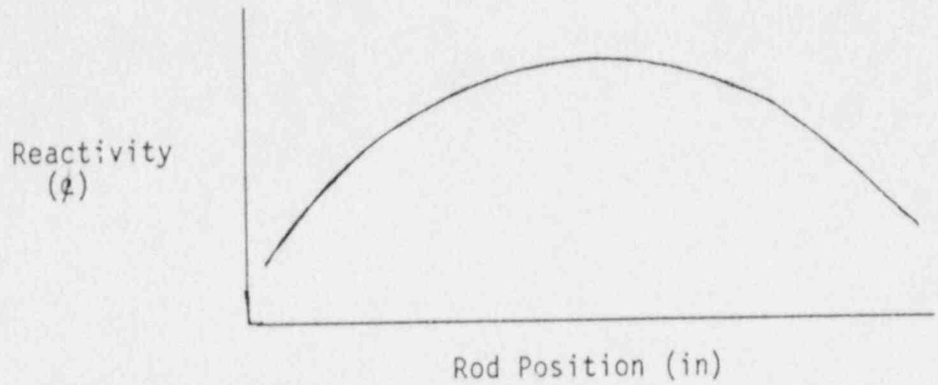
(accept 8 to 10 de

REFERENCE

1. RPI: Harris and Wicks (RPI) letter to Thomas (NRC), September 21, 1983.

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

ANSWER H.09 (2.00)



[+0.5] for shape and [+0.5] for axis labels

The incremental rod worth is due to the shape of the neutron flux (essentially a chopped sine wave) [+0.5] and the effectiveness (worth/in) of the rod being (linearly) dependent on flux density (by R = flux x macroscopic cross-section) [+0.5].

REFERENCE

1. RPI: Manual of Experiments, pp. 41 through 43.

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

ANSWER I.01 (3.00)

a. 1. mix the reactor tank and storage tank using fill and dump [+0.75]

2. evaporate a (1 l) sample to dryness [+0.75]

3. measure activity of residue [+0.75]

(if below allowable limit, pump to the river)

b. The shutoff valve to the river discharge line (valve 8) is locked shut with the key in control of the SRO. [+0.75]

REFERENCE

1. RPI: Operating Procedure, May 1987, pp. 5 and 6.

2. RPI: Piping Flow Diagram.

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

ANSWER I.02 (3.50)

Assumption

1. A 3 curie gamma source will produce approximately 3 R at a distance of one meter [+0.5].

2. Two inches of lead will provide one half value thickness, i.e., 2" Pb --> I/2 [+0.5].

a) Prior to moving each is receiving

$I_1 d_1^2 = I_2 d_2^2$ $I_1 = 3$ R $d_2 = 2$ M $d_1 = 1$ M

$$I_2 = \frac{I_1 d_1^2}{d_2^2} = \frac{3(1)^2}{2^2} = \frac{3}{4} \text{ R/hr} \quad [+0.5]$$

b) Following their actions they receive

Shielding case

4" PB = 2 HVL

I = Io x(1/2)**2 [+0.5] = (0.75)(1/4) = 0.19 R/hr [+0.5]

Distance case

$$I_2 = \frac{I_1 d_1^2}{d_2^2} \quad [+0.5]$$

$I_1 = 3$ R $d_2 = 2$ m + 3 m = 5 m

$d_1 = 1$ M

= (3R)(1)**2/(5)**2 = 3/25 = 0.12 R/hr [+0.5]

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

REFERENCE

1. RPI: Equation Sheet.

2. RPI: Manual of Experiments, Appendix A, p. 146.

ANSWER I.03 (2.50)

rem = rad x rbe [+0.5]

1. rem (neutron) = 10 x 3 = 30 [+0.5]
2. rem (beta) = 20 x 1 = 20 [+0.5]
3. rem (gamma) = 30 x 1 = 30 [+0.5]

Total dose = 80 rem/hr x 15 min = 20 rem [+0.5]

REFERENCE

1. RPI: Personel Safety and Radiation Monitoring, p. 5.

ANSWER I.04 (3.00)

a. REM per calendar quarter

	Quarterly Average	Quarterly Maximum	
Whole body	1.25	3	
Skin	7.5	X	[+0.5] each
Extremities	18.75	X	

b. no occupational exposure is allowed until a person's 19th year (5(N-18)=0) [+1.0]

REFERENCE

1. Generic: 10CFR50.

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

ANSWER I.05 (3.00)

Case 1

2 men x 2 rem/hr x 1/2 hr = 2 rem (1 rem each man) [+0.5]

Case 2

sheild manipulation

1 man x 2 rem/hr x 2/3 hr = 1.33 rem [+0.5]

perform the job

2 men x 0.2 rem/hr x 1/2 hr = 0.2 rem [+0.5]

Total = 1.53 [+0.5]

Alternative 2 because of ALARA considerations [+1.0]
(lower total radiation exposure)

REFERENCE

1. RPI: Personnel Safety and Radiation Monitoring, pp. 1 and 2.

ANSWER I.06 (2.00)

$A = A_o e^{-\text{lambda } t}$ lambda $= \frac{0.693}{T_{1/2}} = \frac{0.693}{17 \text{ s}} = 0.041 \text{ s}^{-1}$

ln (A/Ao) = - lambda t

t = 1/lambda ln (Ao/A) = 1/0.041 ln (22) = 75.83 s
= 1.26 min

REFERENCE

1. RPI: Equation Sheet.

2. Generic: Murry, R. L. "Introduction to Nuclear Engineering," p. 27.

ANSWER I.07 (3.00)

a. Yes [+0.5], the Technical Specifications require the criticality detector to be operating for reactor operation [+1.0].

b. Yes [+0.5], Section 3.3.1.d allows an equivalent unit replacement [+1.0].

Grading Note: There appears to be a conflict between Tech Spec 3.3.1.a and 3.3.1.d centering on alarms in the control room. Also how long may this condition exist? Section 4.3 is not definative.

REFERENCE

1. RPI: Technical Specifications, Section 3.3 (attached).

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

ANSWER J.C1 (1.00)

a. False [+0.5] (Loss of power to instrument scrams will not cause a trip)

b. True [+0.5]

REFERENCE

1. RPI: Instrumentation and Interlock Diagrams, Figure 2.

2. RPI: SAR, p. 27.

ANSWER J.02 (3.00)

a. yes high power
b. no
c. yes high power
d. no
e. no
f. no

[+0.5] each

REFERENCE

1. RPI: Instrumentation and Interlock Diagrams; Control Instrumentation Block Diagram.

ANSWER J.03 (2.00)

A bank withdrawal of one inch would produce a maximum reactivity change of approximately 21.5¢ (from Figure 5) [+1.0]. This would induce a positive reactor period of about 32 seconds (from Figure 1) [+1.0].

(accept 30 to 34 seconds)

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

REFERENCE

1. RPI: Technical Plant Data, Figures 1 and 5.

2. Equation Sheet.

ANSWER J.04 (3.00)

1. Pump discharge (reactor tank fill valve) fails CLOSE. [+0.5] To prevent inadvertent filling of the reactor tank during abnormal conditions. [+1.0]

2. Pump suction (return valve) fails OPEN. [+0.5] To provide a drain line from the reactor tank to the storage tank during times of abnormal conditions. [+1.0]

Any two (2), +3.0 maximum.

REFERENCE

1. RPI: Section 11, Instrumentation and Interlock Diagrams.

ANSWER J.05 (1.50)

This resistor limits the current surge (prevents fuses 1A and 1B from blowing resulting from shorting of the scram relays which is necessary) during an instrument scram [+1.5].

REFERENCE

1. RPI: Instrumentation and Interlock Diagrams, p. 4, Figure 2.

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

ANSWER J.06 (3.00)

a. rectifier AC input voltage [+0.5]
rectifier DC output voltage [+0.5]

b. input 110 VAC [+0.5] (accept 120)
output 110 VDC [+0.5]

c. positive indication of power interruption to scram solenoids [+0.5]

positive indication of power interruption to the scram relays [+0.5]

REFERENCE

1. RPI: Instrumentation and Interlock Diagram, pp. 4 and 5, Figure 2.

ANSWER J.07 (2.50)

1. 400 Hz power on
2. fill pump off
3. chart recorder on
4. reactor period <15 sec.
5. startup channel on and counts > 5

[+0.5] each

REFERENCE

1. RPI: Startup Procedure.

ANSWER J.08 (1.00)

length = 36" [+0.5]
worth = approx. 0.007 delta K/K [+0.5]

REFERENCE

1. RPI: Responses to Questions (March 3, 1987), p. 7.

ANSWER J.09 (1.00)

dump valve fails open draining moderator tank [+0.6]
reactor will shut down [+0.4]

REFERENCE

1. RPI: Startup Procedures, Section 9.1.

ANSWER J.10 (2.00)

~~rods drop due to loss of power (plant shut down) [+1.0]~~
control rods cannot be moved due to 400 Hz interlock ~~[+1.0]~~ [+1.5]
CONTROL ROD POSITION IS LOST [0.5]

REFERENCE

1. RPI: Startup Procedure, Sections 14 and 15.

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

ANSWER K.01 (2.00)

a. false (vault only) [+0.5]
b. false (Cd lined) [+0.5]
c. true (subcritical by rho = 0.10; $1.00 = 0.007) [+0.5]
d. false ~~(senior operator only)~~ [+0.5]
(SUPERVISOR ONLY) 6-12-88

REFERENCE

1. RPI: Proposed Mods to Technical Specifications, Section 5.6.

ANSWER K.02 (1.50)

critical [+0.5]
withdrawal [+0.5]
known (measured) [+0.5]

REFERENCE

1. RPI: Manual of Experiments, p. 41.

ANSWER K.03 (1.50)

1. UO-2 or uranium dioxide [+0.5]

2. 4.8 w/o [+0.5] for 4.6 to 5.0 w/o

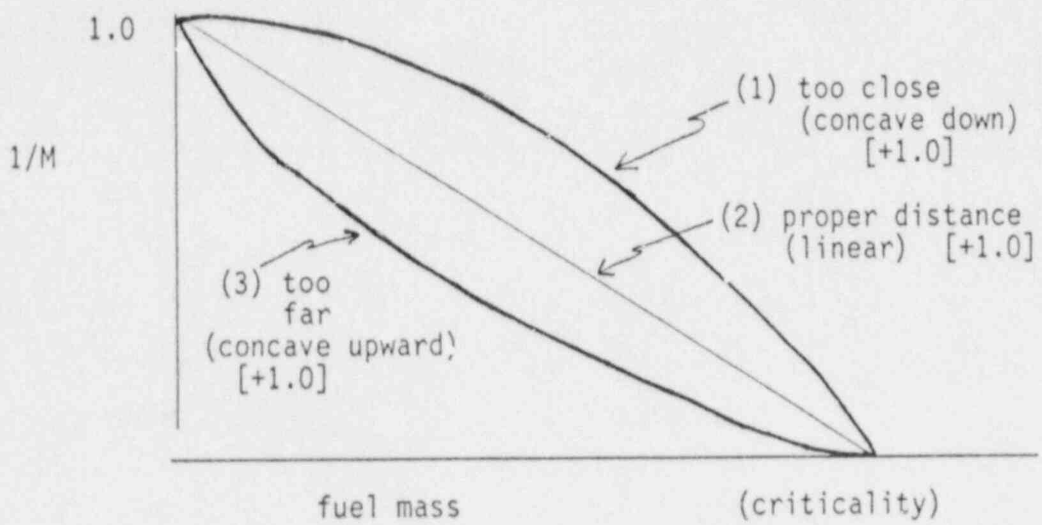
3. stainless steel [+0.5]

REFERENCE

1. RPI: SAR, June 1986.

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

ANSWER K.04 (3.00)



REFERENCE

1. RPI: Manual of Experiments, pp. 24 through 28.

ANSWER K.05 (4.00)

1. control rod bank reactivity worth [+0.75]
2. temperature and void coefficient of reactivity [+0.75]
3. reactor power measurements [+0.75]
4. shutdown margin [+0.75]

These parameters must be measured to assure that they are within the limiting values analyzed in the Safety Analysis Report (SAR). [+1.0]

REFERENCE

1. RPI: Technical Specifications, Section 4.2.

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

ANSWER K.06 (3.00)

a. fully inserted [+1.0]

b. TEN ~~Three~~ [+0.5]. The number of elements added at any step can never exceed that of the previous step (procedure). (Alternate - explain linear extrapolation error in 1/M method) [+0.5].

c. Two count rates must be taken at the same fuel loading [+0.5] to ensure (subsequent readings of neutron flux are) referenced to a common base [+0.5].

REFERENCE

1. RPI: Manual of Experiments, pp. 29 and 30.

ANSWER K.07 (2.00)

1. net change in reactivity must be < $0.72

2. reactor subcritical by at least $1.00

3. initially only one vacant position within active fuel lattice

4. NIs on scale and dump valve not bypassed

5. critical rod bank position checked following completion

Any four (4) [+0.5] each, maximum +2.0

REFERENCE

1. RPI: Proposed Technical Specifications Modifications, p. 5-4.

ANSWER K.08 (3.00)

a. Power (fission rate) is directly proportional to thermal flux only (and to use total flux would introduce large errors). [+1.0]

b. 1. strong absorption cross-section [+0.5]

2. half-life that produces a workable activity for counting [+0.5]

c. Cadmium absorbes thermal neutrons preferentially allowing a total flux to epithermal flux subtraction. [+0.5]

REFERENCE

1. RPI: Manual of Experiments, pp. 8-8 through 8-12.

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

ANSWER L.01 (3.00)

a. prevent ~~a non-visible~~ start-up WITHOUT INSERTING SOURCE (instrument operability and low level rate visibility) [+1.0]

b. damage to fuel clad (exceeding a safety limit) will not occur due to (any analyzed) design transient(s) [+1.0]

c. allows time for safety channels to insert negative reactivity prior to significant energy deposition in the core [+1.0]

REFERENCE

1. RPI: Technical Specifications, Section 2.2.

ANSWER L.02 (2.00)

WHEN - during maintenance checks [+0.5] and radiation surveys [+0.5]

PROVISIONS - Operations Supervisor permission [+0.5]
no other scram bypassed [+0.5]

REFERENCE

1. RPI: Technical Specifications, Section 3.0, Table 1.

ANSWER L.03 (2.00)

a. Tmin = 50 degrees F [+0.5]

b. Maintain operation within the temperature range for which the net positive reactivity limit is applicable. (limit potential positive reactivity) [+1.0]

c. thermocouple (readout) [+0.5]

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

REFERENCE

1. RPI: Technical Specifications, Section 3.2.3.

ANSWER L.04 (4.00)

Assume: not flammable, explosive or chemically reactive [+1.0]

1. written procedure approved by NSRB [+0.5]

   basis: ensure experiment is well planned and evaluated for safety [+1.0]

2. the maximum reactivity worth of the sample must not exceed $0.60 [+0.5]

   basis: ensure that reactor controls are capable of overcoming the positive reactivity of the sample [+1.0]

REFERENCE

1. RPI: Technical Specifications, Section 3.4.

ANSWER L.05 (1.50)

Since this error appears to be typographical, (no substantive change) [+0.5] the SRO should get the approval of the Operations Supervisor to make a temporary change to the Technical Specifications [+0.5]. It should be documented and subsequently reviewed by the NSRB (for incorporation in future Technical Specifications change submittal) [+0.5].

REFERENCE

1. RPI: Technical Specifications, Sections 3.1, 4.1.2, and 6.2.

ANSWER L.06 (1.00)

A system or component is capable of performing its intended function in its required manner. [+1.0]

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

REFERENCE

1. RPI: Technical Specifications, p. 1-2.

ANSWER L.07 (1.50)

1. second [+0.5]
2. third [+0.5]
3. first [+0.5]

REFERENCE

1. RPI: Emergency Procedures, p. 3.

ANSWER L.08 (3.00)

a. ensure that a reactor scram was initiated [+0.5]

b. the SRO [+0.5]

c. Yes (respirators are mandatory since radioactive materials would be involved) [+0.5]

d. No (manual only) [+0.5]

e. Ellis hospital [+0.5]

f. Schenectady Fire Department [+0.5]

REFERENCE

1. RPI: Emergency Procedures, Section 6.2 and 6.6.

ANSWER L.09 (2.00)

1. the cause of the scram has been determined [+1.0]
2. all conditions for operation are normal [+1.0]

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

REFERENCE

1. RPI: Operating Procedure, p. 3.

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

REFERENCE

1. RPI: Operating Procedure, p. 3.

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