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

EXAMINATION REPORT NO. 50-193/85-01

FACILITY DOCKET NO. 50-193

FACILITY LICENSE NO. R-95

LICENSEE: Rhode Island Atomic Energy Commission
Narragansett, Rhode Island

FACILITY: Rhode Island Atomic Energy Commission

EXAMINATION DATES: April 24, 1985

CHIEF EXAMINER: Noel F Dudley 5-21-85
N. Dudley, Reactor Engineer (Examiner) Date

REVIEWED BY: RM Keller 5/21/85
R. M. Keller, Projects Section No. 1C Date

APPROVED BY: HB Kister 6/3/85
H. B. Kister, Chief, Projects Branch No. 1 Date

SUMMARY: One candidate was examined and one SRO license was issued.

REPORT DETAILS

TYPE OF EXAMS: Replacement X

EXAM RESULTS:

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

1. Chief Examiner at Site: N. Dudley, NRC

1. Personnel Present at Exit Interview:

   NRC Personnel

   N. Dudley, Lead Reactor Engineer (Examiner)

   Facility Personnel

   Dr. F. DiMeglio, Director
   M. Doyle, Assistant Director

2. Summary of NRC Comments made at exit interview:

   The candidate passed the oral portion of the examination due to his knowledge of the facility systems and operations. He displayed weaknesses in the areas of thermo hydraulics, subcritical multiplication, and use of the emergency plan. There were no emergency implementing procedures in the Horn Building, which is used as the control center during a reactor building evacuation. The candidate had difficulty making decisions using the information provided during oral scenarios.

   More than one set of prints is maintained in the control room which may lead to problems in control of the prints.

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

   The facility recognized the need to provide future SRO candidates with additional training in decision making. The facility noted that other NRC inspections had identified the need to decentralize or formalize the functions held by the director and assistant director.

4. Changes Made to Written Exam During Examination Review:

Answer No.	Change	Reason
I.05a Question	Change "scintillating" to "ion chamber".	Identifies correct type of gamma monitors installed at facility.
K.05 Question	Change to "If a leak developed by the primary cooling pump during refueling could the core be uncovered? Explain."	The primary coolant pump does not have a vent.
L.07c Question	Change "of 5 ppm" to "above T.S. Limit. Also provide the T.S. Limit."	Recently approved T.S. have removed chemistry limits on makeup water.

Answer No.	Change	Reason
J.04b	Delete	The neutron source is not removed during routine startups.
H.02	Add "(small effect at plant)".	Incorporates facility comment.
H.03b	Change to "No difference [0.4] because the reactor is below power level at which the power coefficient begins adding negative reactivity".	Power levels are below the point of adding heat.
H.07b	Change "Convective flow to atmosphere" to "Natural convective flow to pool which acts as heat sink".	The pool acts as heat sink and heat transferred to atmosphere is minimal.
I.01b	Change to "Post as radiation area (2½ mr/hr)".	Conforms to facility procedures.
I.04b	Correct for distant of 1 ft.	Incorrect distance for desired radiation level calculation was used in the answer.
J.01	Add "accept other calculations of SDM [1.0]".	Allows other SDM calculations to be accepted for partial credit.
J.04a	Change to "Prevent overload of detectors and loss of indication".	Corrects for facility equipment configuration.
J.07	Change "Reactor power will decrease; no scram" to "High temperature scram".	Corrects for proper plant response.
K.01b	Delete "at pool".	SRO not required to be at pool.
K.03d	Change "6" to "3".	Criticality is expected with 26 fuel elements and 20 are loaded. Allowed to load ½ the difference.

Answer No.	Change	Reason
K.06	Delete "Assure the". Add "Check for fuel damage".	Ventilation system does not automatically realign on stack monitor alarms.
K.08a	Add "or low power section".	Dry gamma room maybe used.
L.01	Add "Changes to reactivity".	Identifies additional required log entry.
L.06c	Change to "H.P.".	Conforms to facility procedure.
L.07a	Change to "Shutdown Rx".	Conforms to facility requirement.
L.08	Change to "a. Prevent reactivity excursions; b. Reactivity effects of loading fuel in vacancies; c. Shielding and N^{16} decay".	Provides original reasons for inclusion of each requirement in the Technical Specifications.

Attachment: Written Examination and Answer Key (SRO)

MASTER

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

FACILITY: RHODE ISLAND & PROV. P AEC

REACTOR TYPE: TEST

DATE ADMINISTERED: 85/04/24

EXAMINER: DUDLEY, N.

APPLICANT: ____________

INSTRUCTIONS TO APPLICANT:

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 and a final grade of at least 80%. Examination papers will be picked up six (6) hours after the examination starts.

CATEGORY VALUE	% OF TOTAL	APPLICANT'S SCORE	% OF CATEGORY VALUE	CATEGORY
20.00	20.00	________	________	H. REACTOR THEORY
19.50	19.50	________	________	I. RADIOACTIVE MATERIALS HANDLING DISPOSAL AND HAZARDS
~~20.50~~ 19.5	~~20.50~~ 1[illegible]	________	________	J. SPECIFIC OPERATING CHARACTERISTICS
19.00	19.00	________	________	K. FUEL HANDLING AND CORE PARAMETERS
21.00	21.00	________	________	L. ADMINISTRATIVE PROCEDURES, CONDITIONS AND LIMITATIONS
~~100.00~~ 98.5	100.00	________	________	TOTALS

FINAL GRADE ________________%

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

____
APPLICANT'S SIGNATURE

QUESTION H.01 (3.00)

Let us assume that we have a reactor just critical at 100 KW. By some means we remove all the delayed neutrons.

a. Explain how and why reactor power would respond to this change. (1.0)

b. Explain how and why reactor power would respond just prior to and just after removal of all the delayed neutrons if the reactor was prompt critical at 100 KW. (2.0)

QUESTION H.02 (3.00)

Explain why the neutron startup source appears as positive, negative and zero reactivity worth depending on the power level.

QUESTION H.03 (2.00)

a. Under steady-state operation, would there be any significant difference between the control rod positions at 100 watts and 1000 watts? Explain.

b. Under steady-state operation, would there be any significant difference between the control rod positions at 100 KW and 1000 KW? Explain.

QUESTION H.04 (3.00)

a. In a subcritical reactor enough reactivity is added to double the count rate. What would be the effect of adding the same amount of reactivity again? Explain your answer.

b. With an initial power level of 10 KW, reactivity is added to raise power to 20 KW. What would be the effect of adding the same amount of reactivity again? Explain your answer.

QUESTION H.05 (3.00)

Assume that a reactor has been at rated power for 72 hours and then is shutdown for one hour. Sketch a continous trace of xenon concentration and briefly explain any changes for the following schedule:

a. Show xenon concentration for one hour before shutdown. (1.0)

b. One hour after shutdown a reactor startup is made. Power is increased to 50% of rated and maintained for 12 hours. (1.0)

c. At 12 hours the reactor power is increased to rated conditions and maintained for 24 hours. (1.0)

QUESTION H.06 (3.00)

The reactor operator is conducting a routine reactor startup after it has been shutdown for several days. Prior to withdrawing a shim blade he reads a stable count of 50 cps on the startup channel. Immediately after withdrawing this blade he reads a count of 80 cps.

a. If he performed no blade motion for five minutes, would the count rate increase, decrease or remain the same? Explain, assuming the reactor is subcritical at 80 cps. (1.0)

b. After 5 minutes he withdraws another blade the same distance but the reactor is still subcritical. Would the change in count rate (time and magnitude) be different than he saw in part (a) above? Explain. (1.0)

c. What indications would the operator observe to determine when the reactor had gone critical? (1.0)

QUESTION H.07 (3.00)

a. Explain why the gate will open on loss of primary flow.

b. Explain how heat is removed from the core on loss of primary flow.

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

QUESTION I.01 (2.00)

A 23 year old individual has accumulated a lifetime occupational dose of 24 rem of whole body exposure documented in accordance with 10CFR20 and has received no exposure during the present calender quarter.

a. How long may he work in a 3 mrem/hr area if he works an 8 hour day Monday through Friday? Show your work. (1.5)

b. What sign posting, labeling, signal, or control requirements exist, if any, for the work area described in part a? (0.5)

QUESTION I.02 (1.50)

The following two questions concern the operation of the pneumatic tube system:

a. What is the maximum on-contact reading (in mrem/hr) allowed of a sample before special permission is required to remove it from the reactor room?

b. Who is authorized to give the special permission for removal of the sample?

QUESTION I.03 (1.00)

As a general guide, the maximum permissible level for beta-gamma contamination (after decon efforts have been made) as measured with a thin window GM detector at the surface of the contamination shall be ________ mr/hr for hazard groups 1 and 2 and _________mr/hr for hazard groups 3 and 4.

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

QUESTION I.04 (3.00)

A 10 ml vial of a mixed gamma and beta source in liquid form with a beta particle energy of 0.5 MeV has been spilled on the floor of the reactor room. Readings at 10 feet indicate 1.0 mr/hr on a beta-gamma survey meter. Give any thumb rules used in answering the following questions:

a. At what distance from the spill will the beta-gamma readings start to include the betas? (0.5)

b. If the reading at one foot is 100 mr/hr what is the beta to gamma ratio? Show your calculations. (1.5)

QUESTION I.05 (3.00)

a. List the locations of three ~~scintillating~~ ION CHAMBER type gamma monitors placed around or near the reactor. (1.5)

b. What type of monitor is employed at the pneumatic system receiver stations and beam port areas? (0.5)

c. What condition or conditions cause the stack exhaust gas monitor system to alarm and for what purpose? (1.0)

QUESTION I.06 (3.00)

During reactor operation, the dose rate from the delay tank may be in excess of 100 mrem/hr.

a. Why?

b. Who is required to have possession of the entrance key when the entrance is locked?

c. What facility requirements exist when entering the delay tank room?

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

QUESTION I.07 (3.00)

a. Does the biological effect of a 100 REM dose depend on whether it is a neutron or gamma dose? Explain.

b. Does the biological effect resulting from bodily intake of a given quantity (in terms of microcuries) of a radioactive material depend on which particular isotope is involved? Explain.

QUESTION I.08 (3.00)

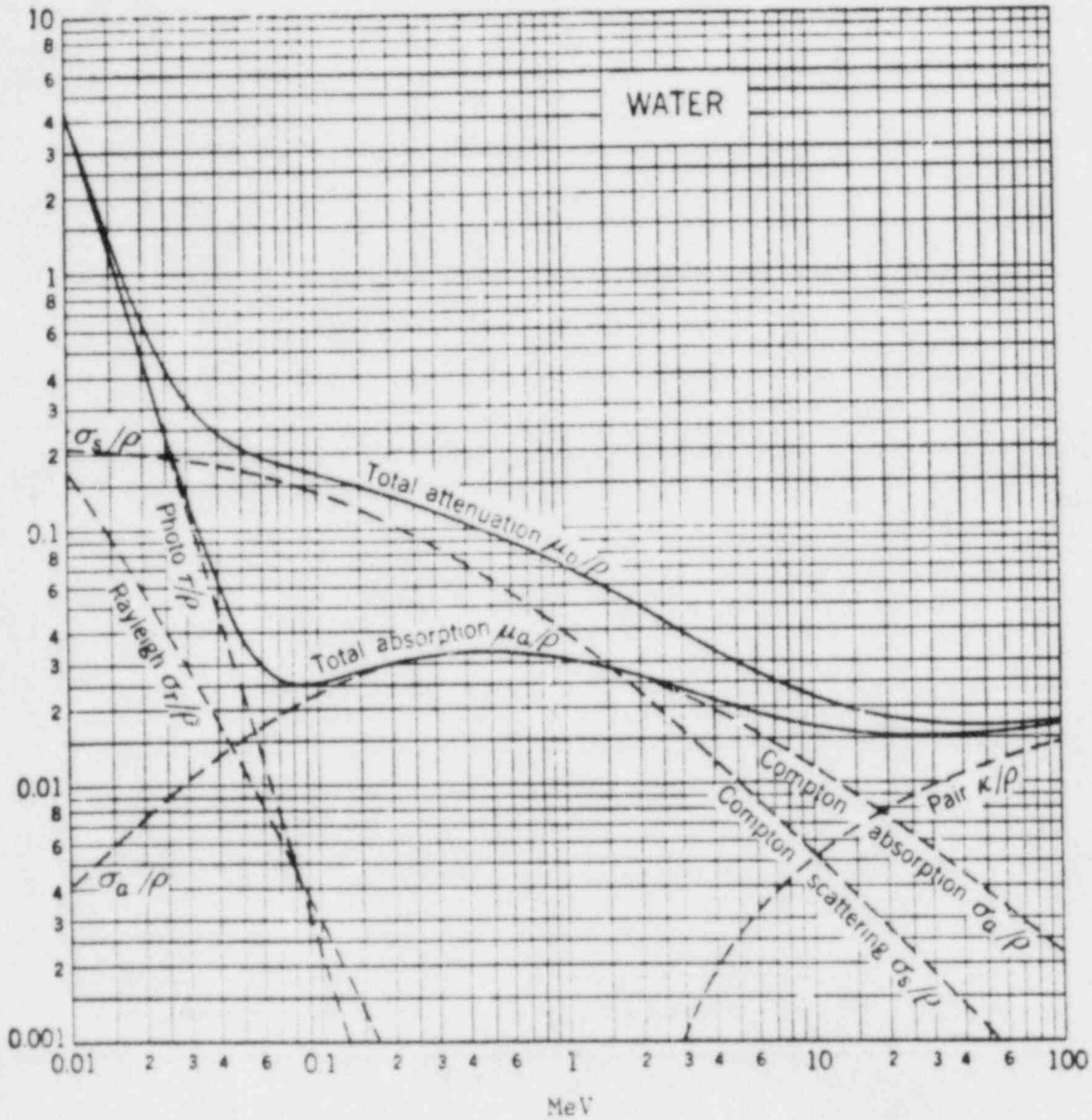
A fuel element is suspended in the Reactor Pool approximately 1 meter under water. A radiation survey meter held at the surface of the water reads 100 mrem/hr.

a. Ignoring buildup, what radiation level would you expect if the fuel element broke the water? Assume 1 cc of water weights 1 gm and that Figure 5.3 is applicable to your plant. (1.0)

b. If the fuel element was placed in a 1 inch lead shield cask, what would the radiation level be at the surface? Assume a tenth thickness of 2 inches for lead. (1.0)

c. If the radioactive isotopes in the fuel element had an average half life of 30 minutes, how long would it take for the radiation level at the surface of the cask to drop to 20 mrem/hr? (1.0)

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



MASS ATTENUATION COEFFICIENTS FOR GAMMA RAYS IN WATER

From The Atomic Nucleus, by R. D. Evans,
Copyright 1955

(Courtesy of McGraw-Hill, New York, N.Y.)

Figure 5.3.

QUESTION J.01 (2.50)

EXPLAIN and CALCULATE what the required shutdown margin is for reactor operations in accordance with the Technical Specifications.

QUESTION J.02 (1.50)

What actions should be taken if an irradiated vial explodes when the rabbit has returned to the receiving station?

QUESTION J.03 (2.50)

What actions should the Senior Operator take following a scram?

QUESTION J.04 (2.50)

a. During a reactor startup, what would be the effect on plant operations if the startup counter is not moved to its center position and then to its out position as the counts build up? (1.0)

b. DELETE ~~What must be done during a startup to allow removal of the plutonium-beryllium source? (1.5)~~

QUESTION J.05 (3.00)

a. What automatic actions will occur if normal electrical power is lost when the reactor is at 500 KW?

b. What loads, if any, should be energized following a loss of normal power?

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

QUESTION J.06 (3.00)

Assuming the reactor is operating at 95% power, indicate for each of the following situations whether the reactor should be SCRAMMED, SHUTDOWN, REDUCED IN POWER, or MAINTAINED AT POWER. Consider each situation seperately.

a. Reactor power drops unexpectedly to 92%.

b. Reactor power increases to 97% as the pool water temperature increases.

c. The alarm for the high neutron flux on one of the compensated ion chamber safety channels becomes inoperable due to a faulty relay.

d. The temperature of the coolant leaving the core during forced convection cooling reaches 120 F.

e. Primary flow indication begins to decrease due to a detector failure. (Assume pin hole leak in the dp cell diaphram.)

QUESTION J.07 (2.50)

What would be the effect on the plant of securing the secondary circulating pump? Assume plant was initially at 100% power, with all rods in manual control, and that systems operate normally and no operator action is taken. Include the safety channel, if any, which causes a scram.

QUESTION J.08 (3.00)

What four automatic functions should occur if the evacuation button is depressed?

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

QUESTION K.01 (3.00)

a. Who must authorize any movement of the core?
b. What operators must be present for any movement of the core and where should they be located?
c. What instrumentation must be available for any movement of the core?
d. What must be adequately shielded when the core is to be moved to the low power section of the pool?

QUESTION K.02 (2.00)

a. How is a fuel element constructed to prevent release of radioactive fission products? (0.8)
b. What THREE indications would be indicative of a release of fission products from the fuel elements? (1.2)

QUESTION K.03 (3.00)

For each one of the four attached 1/M plots indicate the maximum number of fuel elements which may be loaded, in accordance with procedure, before another count rate reading should be taken.

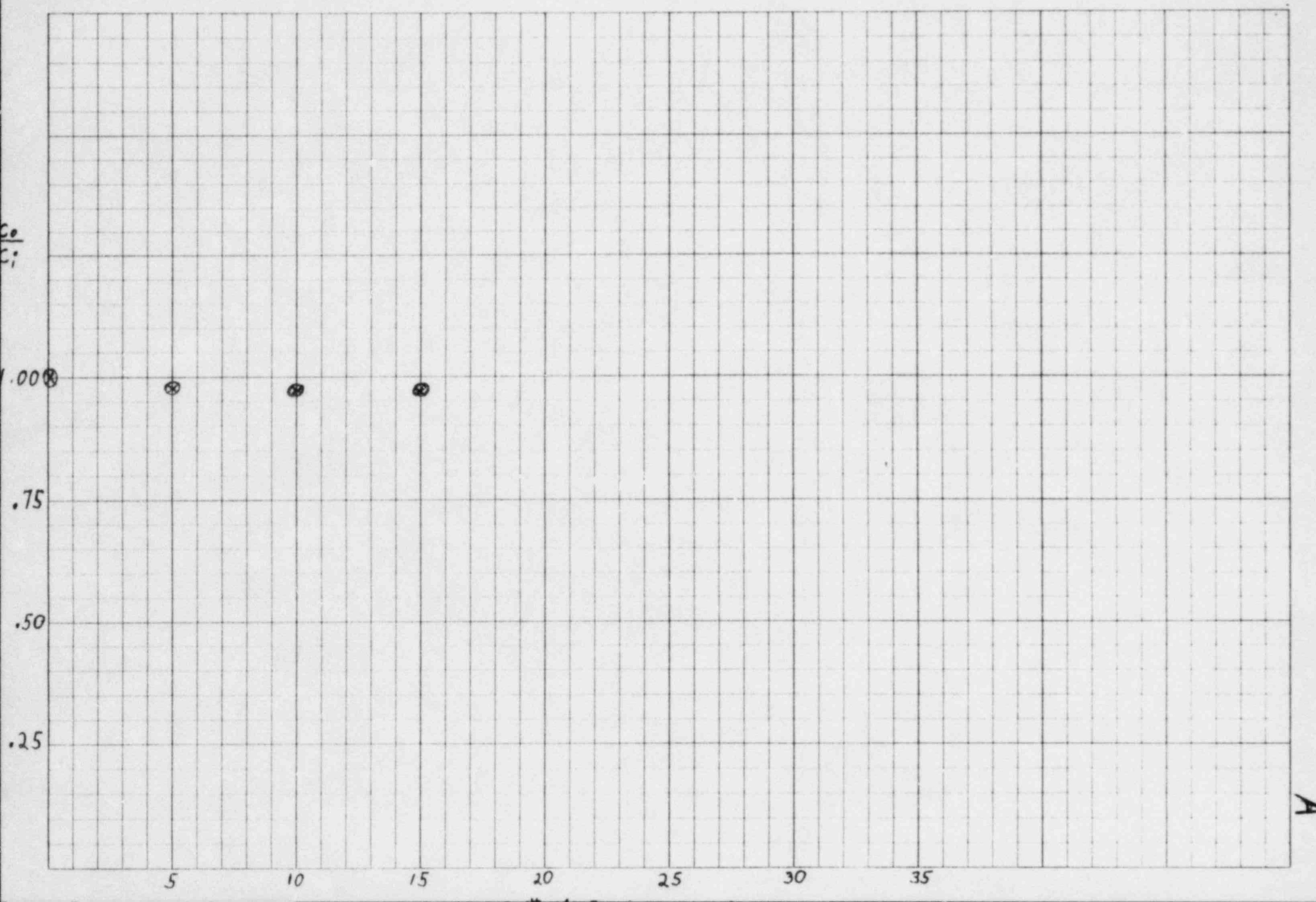
QUESTION K.04 (2.00)

a. Explain why the 1/M plot cannot be used during fuel loading once a critical mass has been established.
b. How would an excess reactivity measurement be conducted after a fuel element is added to a core which has been determined to be a critical mass?

QUESTION K.05 (1.50)

If A LEAK DEVELOPED BY ~~the vent on~~ the primary cooling pump ~~was left open~~ during refueling could the core be uncovered? Explain.

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


$\frac{C_o}{C_i}$
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.50
.25
5
10
15
20
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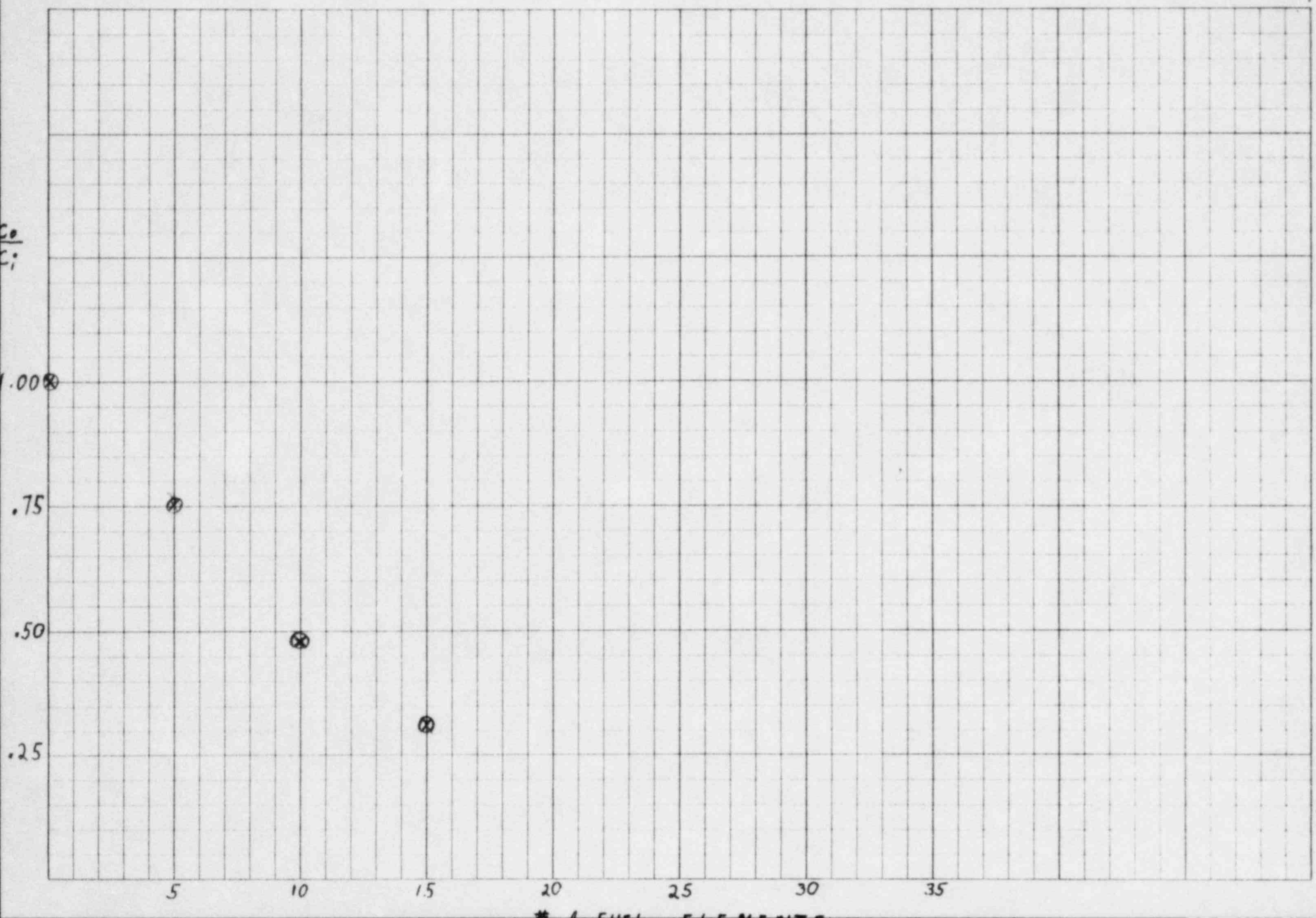
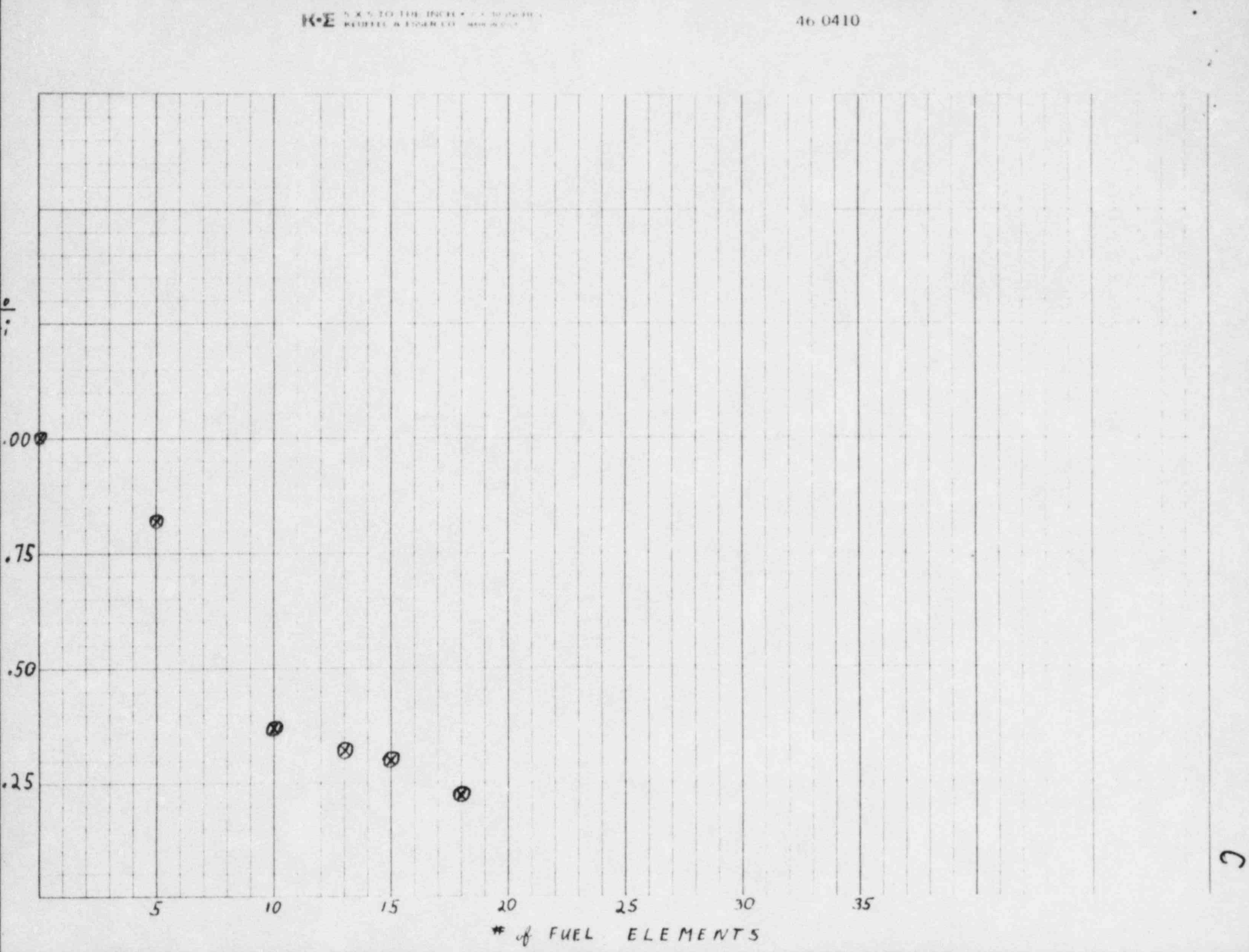
35
A

B

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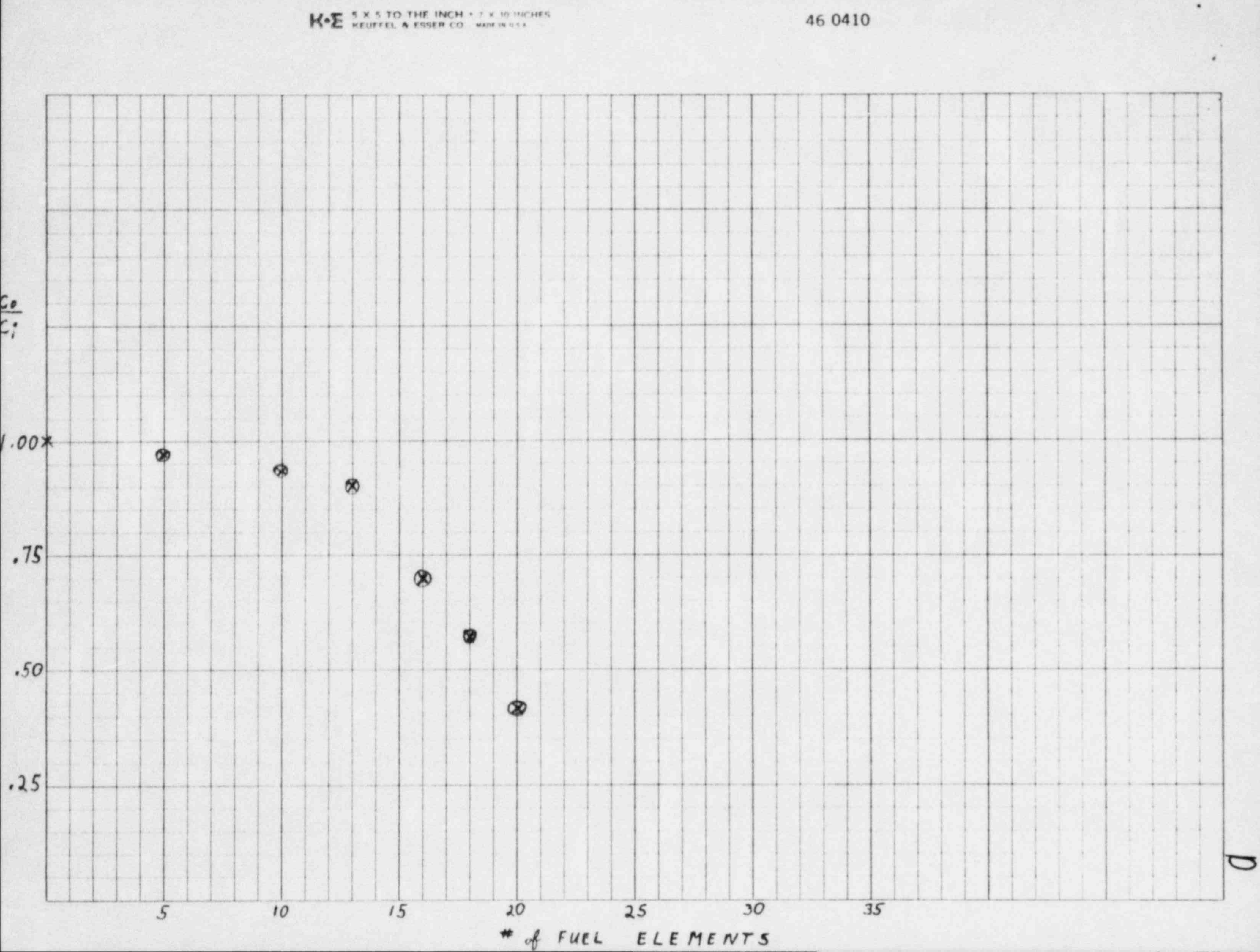
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# of FUEL ELEMENTS

QUESTION K.06 (1.50)

If during refueling operations an irradiated fuel element is dropped onto the top of the core, what actions, if any, should be taken. The stack monitor has alarmed and radiation levels around the pool are 10 mr/hr.

QUESTION K.07 (3.00)

a. How is new fuel stored? (0.75)

b. How is irradiated fuel stored? (0.75)

c. Explain why different storage arrangements are necessary for new and irradiated fuel? (1.5)

QUESTION K.08 (3.00)

In what area or areas of the pool will fuel be located to provide:

a. Gamma radiation
b. Neutron and gamma radiation
c. Radiation to the Beam Ports
d. Radiation to the Pneumatic Tubes
e. Radiation to the Dry Gamma Facility

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

QUESTION L.01 (2.00)

a. What are THREE items that should be recorded in the reactor log book? (1.2)

b. When should an entry be recorded in the reactor log book? (0.8)

QUESTION L.02 (2.00)

For each of the following procedural changes indicate whether or not the change can be approved by a licensed SRO. Justify your answer.

a. A temporary change to the startup procedure which allows pulling two rods at once.

b. A change to a maintenance procedure which changes the specifications for the container to collect water from a flush of secondary piping.

QUESTION L.03 (2.50)

a. At what THREE times is the Senior Reactor Operator required to be present at the facility? (1.5)

b. What is the Senior Reactor Operator's responsible for when he is assigned to a shift? (1.0)

QUESTION L.04 (1.50)

For each of the following situations determine what Emergency Classification, if any, should be made. Table 1.1 is provided.

a. A small private plane carrying radiactive isotopes for a hospital crashes across the road from the facility.

b. All water is lost from the pool area resulting in radiation levels of 500 mr/hr in the reactor building. All automatic equipment has functioned properly.

c. The gate valve remains shut after the primary coolant pump is secured during operations at 500 watts.

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

TABLE 1.1 EMERGENCY EVENT CLASSIFICATION MATRIX

CLASS	NOTIFICATION OF UNUSUAL EVENT	ALERT	SITE EMERGENCY
ACTION LEVEL	a ACTUAL OR PROJECTED RADIOLOGICAL EFFLUENT 10 X MPC AT SITE BOUNDARY (AVG. OVER 24 HRS, OR 15 mR WB ACCU. 24 HRS.). b SITUATION HAS POTENTIAL FOR CAUSING DAMAGE TO FACILITY OR EQUIPMENT. c SITUATION HAS POTENTIAL FOR CAUSING INJURY TO PERSONNEL WITHIN THE FACILITY.	a ACTUAL OR PROJECTED RADIOLOGICAL EFFLUENT 50 X MPC AT SITE BOUNDARY (AVG. OVER 24 HRS. OR 75mR WB ACCU. IN 24 HRS. OR 20mR/hr. FOR 1 HR. WB OR 100 mR THYROID DOSE). b SITUATION IS POTENTIALLY LIFE THREATENING TO PERSONNEL WITHIN THE REACTOR FACILITY.	a ACTUAL OR PROJECTED RADIOLOGICAL EFFLUENT 250 X MPC AT SITE BOUNDARY (AVG. OVER 24 HRS. OR 100mR/hr. FOR 1 HR. OR 500mR THYROID DOSE). b SITUATION IS POTENTIALLY HARMFUL TO PUBLIC WITHIN THE SITE BOUNDARIES. c SITUATION IS LIFE THREATENING TO PERSONNEL IN THE FACILITY.
INITIATING EVENTS	a STACK MONITOR READING 10 X NORMAL. (TO 30K CPM). b NOTIFICATION AFTER HOURS OF STACK MONITOR ALARM BY BEEP. c THREATS TO OR BREACH OF SECURITY. d FIRE. e UNCONTROLLED RELEASE OF RADIOACTIVITY TO BUILDING. f SEVERE NATURAL PHENOMENA. g UTILITIES FAILURES. h EXPLOSION.	a STACK MONITOR READING 50 X NORMAL. (TO 150K CPM). b ABNORMAL LOSS OF POOL WATER. c RADIATION DOSE RATES OR 100mR/hr. FOR 1 HR. IN REACTOR BUILDING. d AMBIENT EXPOSURE LEVELS INCREASED BY FACTOR OF 1000. e REACTOR SAFETY SYSTEM FIRE. f ATTACK FROM OUTSIDE FORCES. g UNCONTROLLED RELEASE OF TOXIC GASES. h UNCONTROLLED RELEASE OF FLAMMABLE GASES.	a STACK MONITOR READING 250 X NORMAL. (TO 750K CPM). b ABNORMAL CONTINUING LOSS OF POOL WATER. c EARTHQUAKE DAMAGE TO REACTOR SAFETY SYSTEM. d FLOODING. e TORNADO OR HURRICAN DAMAGE TO REACTOR STRUCTURE. f IMMINENT LOSS OF CONTROL OF THE REACTOR.
RESPONSE PROCEDURES	a SHUTDOWN/SECURE REACTOR b ORDER EVACUATION OF PUBLIC FROM ONSITE. c NOTIFY EMERGENCY COORDINATOR. d NOTIFY OPERATION STAFF, IN-HOUSE EMERGENCY TEAMS. e NOTIFY APPLICABLE OFFSITE EMERGENCY ORGANIZATION; ASSURE AVAILABLE TO RESPOND.	a SHUTDOWN/SECURE REACTOR b ORDER EVACUATION OF PUBLIC FROM ONSITE. c NOTIFY EMERGENCY COORDINATOR. d IDENTIFY/EVACUATE/ISOLATE TROUBLE AREAS WITHIN OPERATIONS/AND/OR SITE BOUNDARIES AS REQUIRED. e NOTIFY IN-HOUSE EMERGENCY TEAMS. f NOTIFY APPLICABLE OFFSITE EMERGENCY ORGANIZATION; ASSURE AVAILABLE TO RESPOND.	a SHUTDOWN/SECURE REACTOR b ORDER EVACUATION OF PUBLIC FROM ONSITE. c NOTIFY EMERGENCY COORDINATOR. d IDENTIFY/EVACUATE/ISOLATE TROUBLE AREAS WITHIN OPERATIONS/ AND/OR SITE BOUNDARIES AS REQUIRED. e ASSEMBLE IN-HOUSE EMERGENCY TEAMS. f ARRANGE FOR MONITORING AT SITE BOUNDARY TO ASSESS NEED FOR OFFSITE PROTECTIVE MEASURES. g NOTIFY APPLICABLE OFFSITE EMERGENCY ORGANIZATION; ASSURE AVAILABLE TO RESPOND. h NOTIFY THE NRC.

QUESTION L.05 (3.00)

The reactor is at 100% power with experiments in progress. An excited experimenter calls you, the on duty Senior Reactor Operator, and reports that the wall monitor near the receiver station is alarming.

a. What additional information do you need from the experimenter to analyze the situation?

b. What should be your major concerns?

QUESTION L.06 (3.00)

For each of the following, indicate who in the organizational chain is authorized to:

a. Allow an experimenter to insert and remove his own experiments.
b. Supervise short repetative irradiations which have been approved by a signed Irradiation Request Form.
c. Approve the removal of a sample following a long irradiation.
d. Give permission to startup the reactor.
e. Review and approve all experiments before they are initially performed.

QUESTION L.07 (3.00)

What actions, if any, are required in each of the following situations?

a. The reactor is operating at 500 KW when the truck door must be opened.

b. The reactor is operating at 100 watts when the building ventilation fan becomes inoperable.

c. The reactor is operating at 500 Kw when the effluent water in the makeup system is measured to have a particulate level ~~of 5 ppm~~ ABOVE T.S. LIMIT. ALSO PROVIDE T.S. LIMIT.

d. The reactor is at 100 watts when the effluent water of the cleanup system is measured to have a resistance of 9 X 10E5 ohm-cm.

REFERENCE
Operating Procedures p 7-3

ANSWER J.05 (3.00)

a. Reactor scrams [0.5]
   Propane gas generator unit starts [0.5]
   Automatic transfer switch operates [0.5]

b. CAF EMERGENCY LIGHTS
   SUMP PUMP
   POWER AVAILABLE TO SAFETY SYSTEMS

.

REFERENCE
Operating Procedures p 10-1

ANSWER J.06 (3.00)

a. Shutdown
b. Scram
c. Maintain power
d. Maintain power
e. Scram

REFERENCE
Operating Procedures p 8-2
T.S. p 12, 28, 29

ANSWER J.07 (2.50)

Pool temperature will increase adding negative reactivity. [0.75]
~~Reactor power will decrease. [0.75]~~
Pool high temperature alarm activated [0.5]
~~No scram. [0.5]~~
HIGH TEMP SCRAM

REFERENCE
054: TS p. 9
     DS-01-1 and DS 02-2
170: Operations Manual, Chap. 3 - Reactor Water Systems
     Reference Package, Reactor Parameters

QUESTION L.08 (4.00)

Explain the reason or basis for each of the following Technical Specification operating limits.

a. The absolute value of the reactivity worth of any single independent experiment shall not exceed 0.006.

b. There shall be no more than one vacant fuel element position within the periphery of the active section of the core.

c. The minimum depth of water above the top of the active core shall be 23 feet.

d. No experiment shall be installed in the reactor in such a manner that it could shadow the nuclear instrumentation system monitors.

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

$f = ma$

$v = s/t$

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

$w = mg$

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

$E = mc^2$

$KE = 1/2\ mv^2$

$a = (V_f - V_o)/t$

$A = \lambda N$

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

$PE = mgh$

$V_f = V_o + at$

$w = \theta/t$

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

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

$W = v\ \Delta P$

$\Delta E = 931\ \Delta m$

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

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

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

$Pwr = W_f \Delta h$

$I = I_o e^{-\mu x}$

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

$TVL = 1.3/\mu$

$HVL = -0.693/\mu$

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

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

$SUR = 26.06/T$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$\Sigma = \sigma N$

$I_1 d_1 = I_2 d_2$

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

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

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

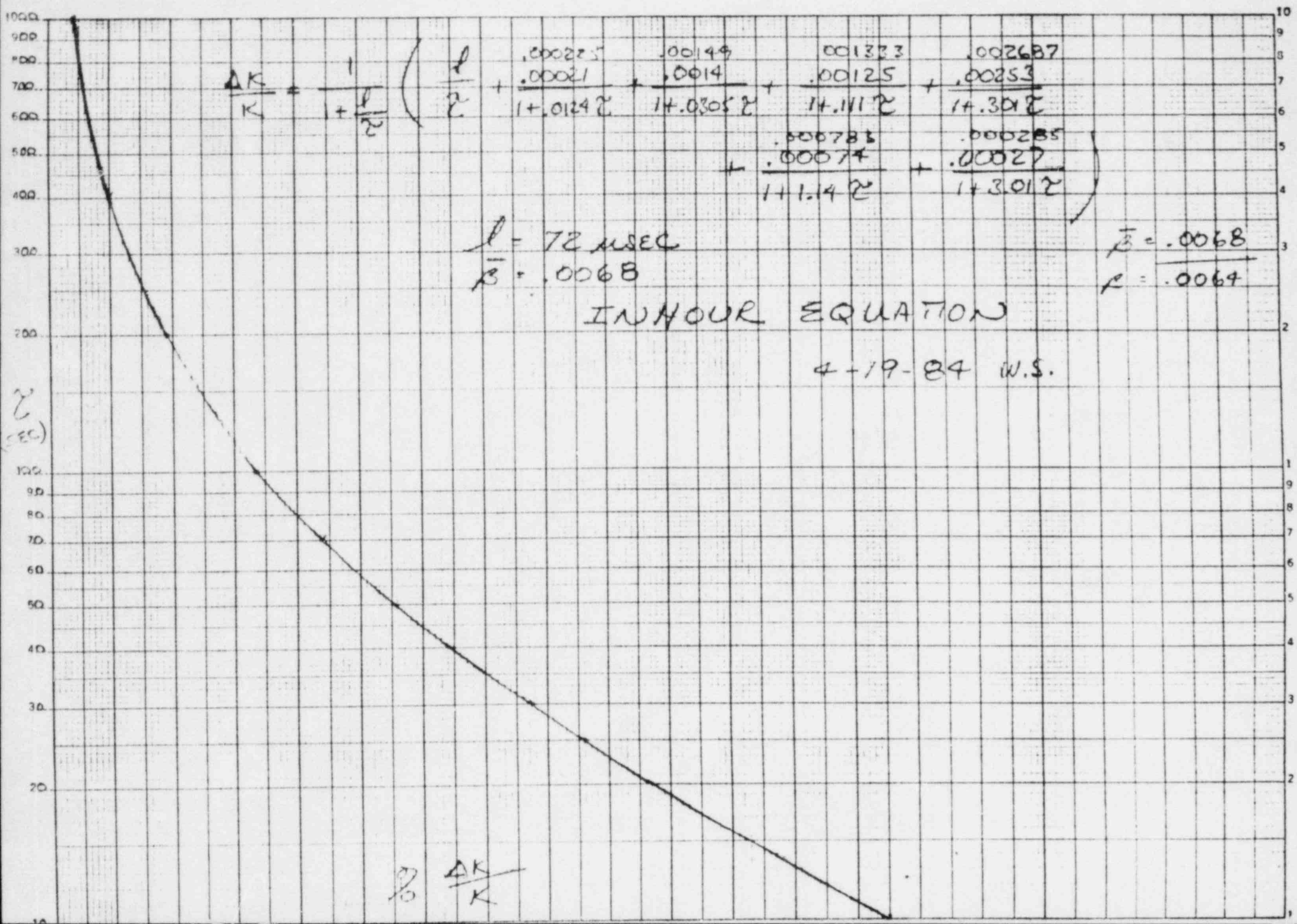
Water Parameters

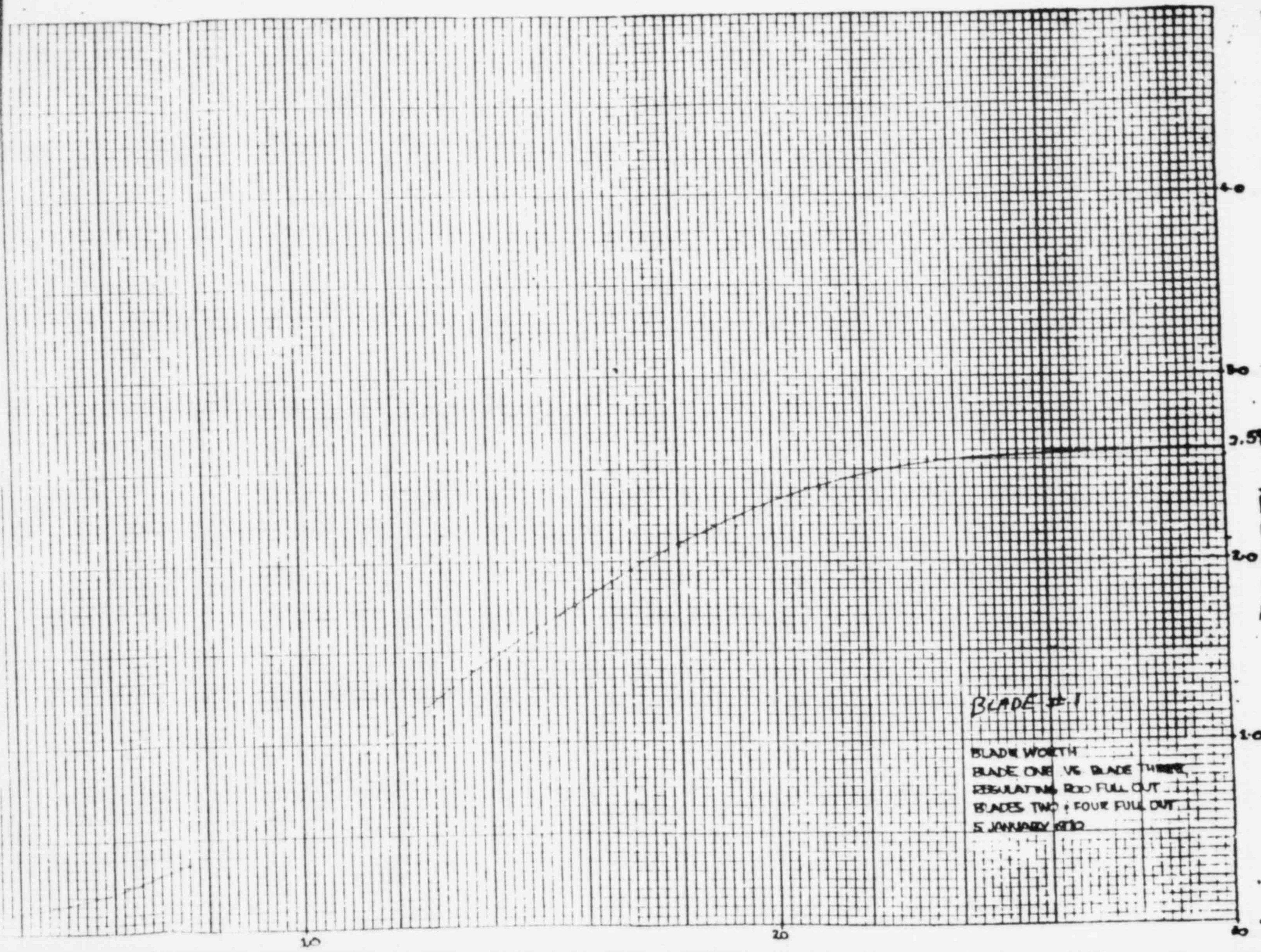
1 gal. = 8.345 lbm.
1 gal. = 3.78 liters
1 ft^3 = 7.48 gal.
Density = 62.4 lbm/ft^3
Density = 1 gm/cm^3
Heat of vaporization = 970 Btu/lbm
Heat of fusion = 144 Btu/lbm
1 Atm = 14.7 psi = 29.9 in. Hg.
1 ft. H_2O = 0.4335 lbf/in.^{2}

Miscellaneous Conversions

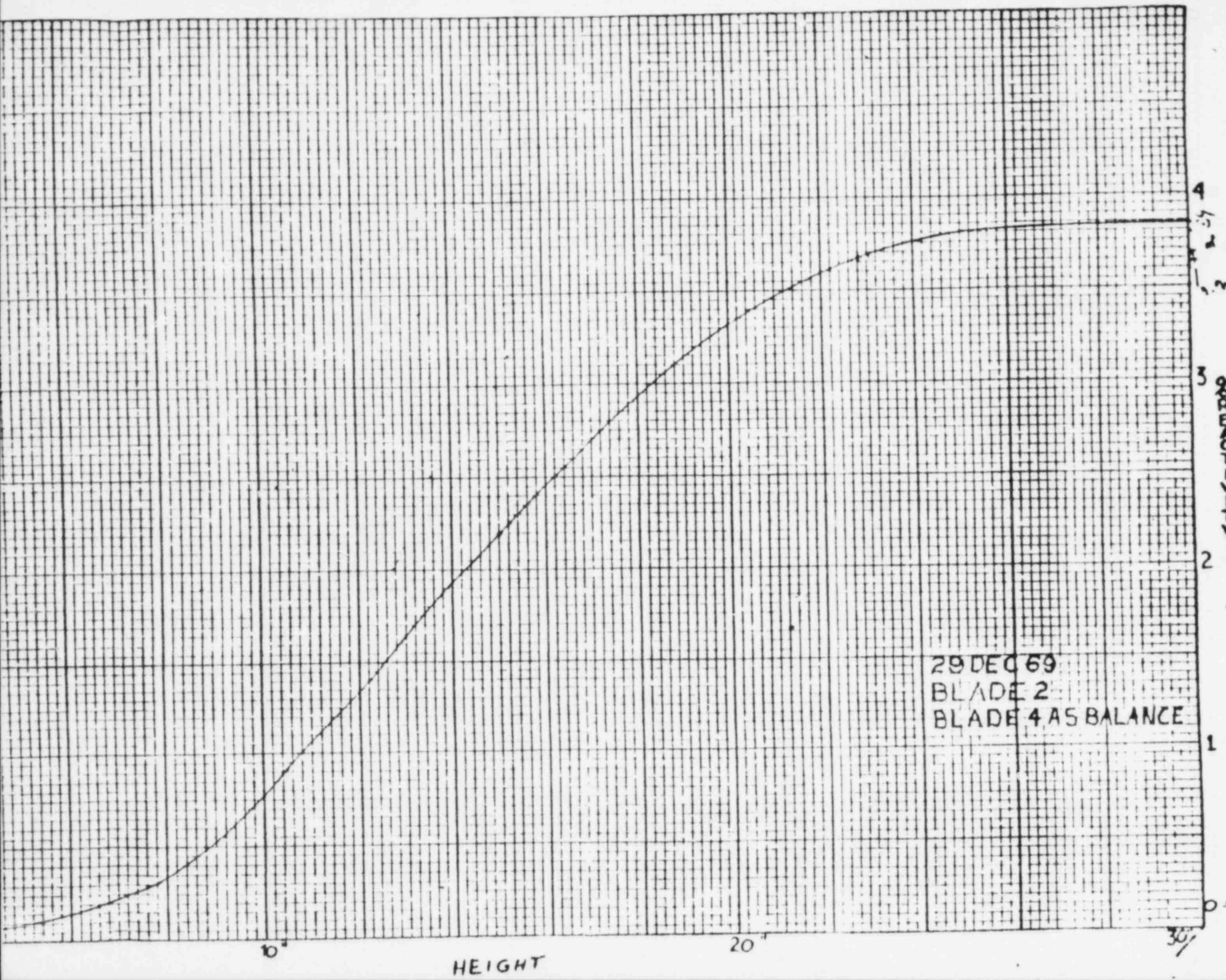
1 curie = 3.7 x 10^{10} dps
1 kg = 2.21 lbm
1 hp = 2.54 x 10^3 Btu/hr
1 mw = 3.41 x 10^6 Btu/hr
1 in = 2.54 cm
°F = 9/5°C + 32
°C = 5/9 (°F-32)
1 BTU = 778 ft-lbf

K+E SEMI LOGARITHMIC 358-64

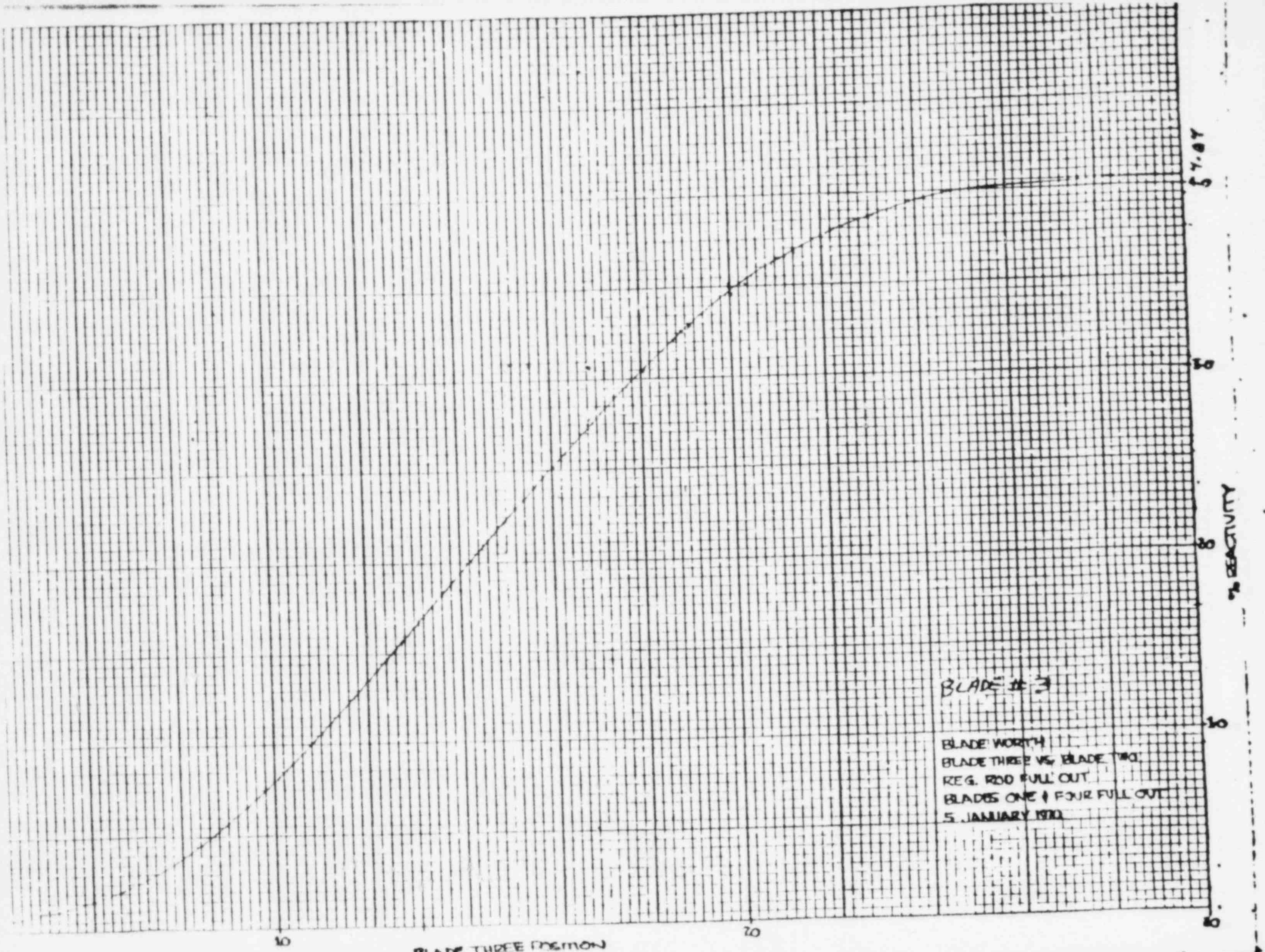




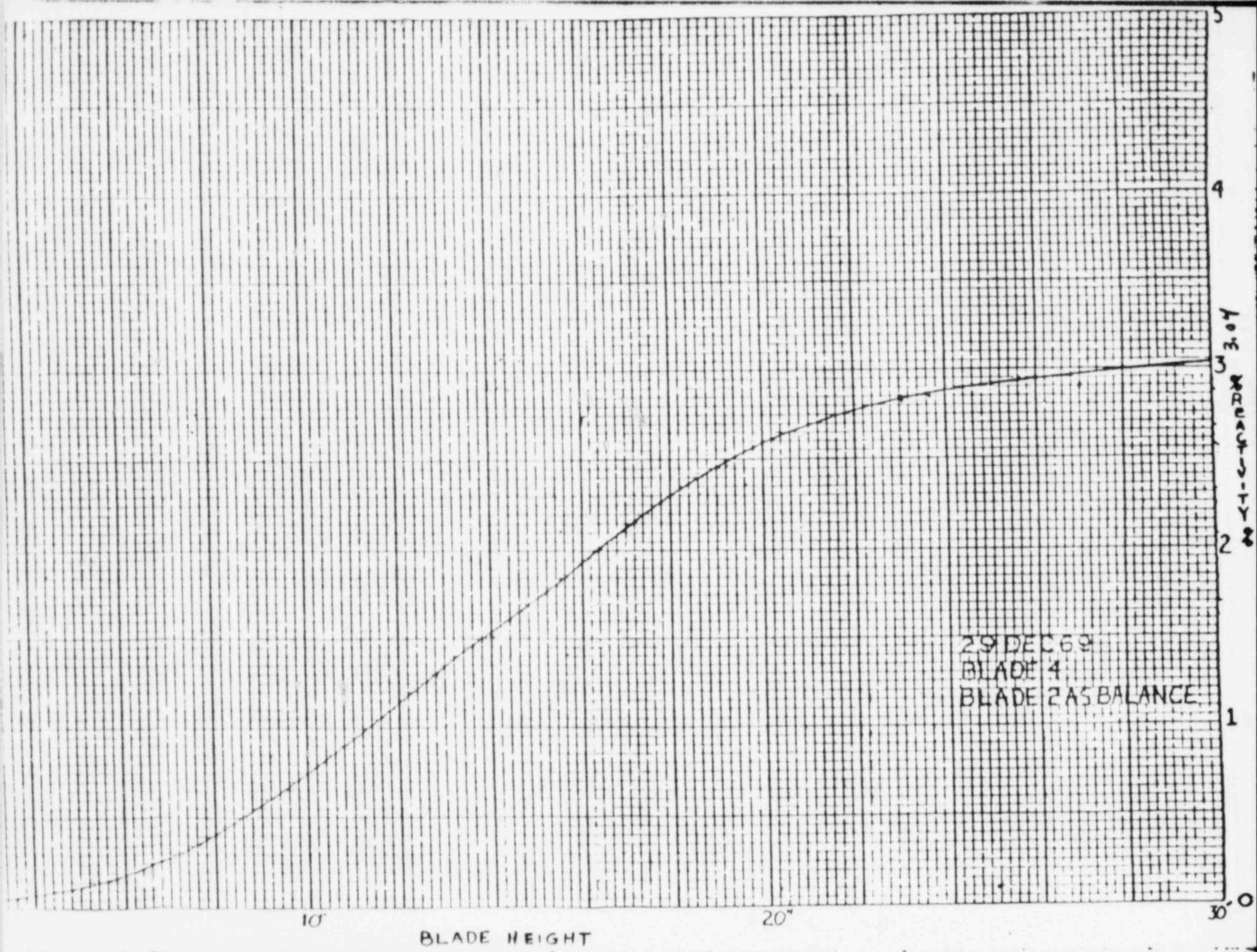
BLADE #1
BLADE WORTH
BLADE ONE VS BLADE THREE
REGULATING ROD FULL OUT
BLADES TWO & FOUR FULL OUT
5 JANUARY 1970
% REACTIVITY
4.0
3.0
2.59
2.0
1.0
0
10
20



29 DEC 69
BLADE 2
BLADE 4 AS BALANCE
REACTIVITY %
0
1
2
3
4
10"
20"
30"
HEIGHT



BLADE # 3
BLADE WORTH
BLADE THREE VS BLADE TWO
REG. ROD FULL OUT
BLADES ONE & FOUR FULL OUT
5 JANUARY 1970
10
20
30
REACTIVITY
10
20
BLADE THREE POSITION



29 DEC 69
BLADE 4
BLADE 2 AS BALANCE
3.07
% REACTIVITY
0
1
2
3
4
5
10"
20"
30"
BLADE HEIGHT

ANSWERS -- RHODE ISLAND & PROV. P AEC-85/04/24-DUDLEY, N.

ANSWER H.01 (3.00)

a. Reactor power would decrease since delayed neutrons were required to maintain the initial critical condition. (1.0)

b. Reactor power would be increasing prior to removing the delayed neutrons and steady immediately after due to the reactor sustaining criticality on prompt neutrons alone. (2.0)

ANSWER H.02 (3.00)

Below a given power level the source is adding more neutrons than it is absorbing and it has a positive worth. [1.0]
At a given power level the source is adding the same number of neutrons as it is absorbing and has a zero worth. [1.0]
Above a given power level the source absorbs more neutrons than it adds and has a negative worth. [1.0]
(SMALL EFFECT AT PLANT)

REFERENCE
Operating Procedures p 7-3
Safeguards Report p 10

ANSWER H.03 (2.00)

a. No difference [0.4] because the reactor is below heat range and the power coefficient does not add any negative reactivity. [0.6]

b. ~~Rods would be higher at 1000 KW [0.4] to compensate for the negative reactivity added by the power coefficient. [0.6]~~
NO DIFFERENCE [0.4] BECAUSE THE REACTOR IS BELOW POWER LEVEL AT WHICH THE POWER COEFFICIENT BEGINS ADDING NEGATIVE REACTIVITY.

REFERENCE
Safeguards Report (1962) p 44

ANSWERS -- RHODE ISLAND & PROV. P AEC-85/04/24-DUDLEY, N.

ANSWER H.04 (3.00)

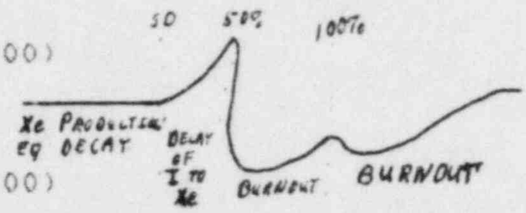
a. Reactor would be supercritical. [0.75] By doubling count rate 1-Keff is halved.
Assume Keff = 0.90 at 20 cps then Keff = 0.95 at 40cps
change in reactivity = 0.05/(0.9 X 0.95) = 5.85% delta K/K
reactivity need for criticality= 0.05/(0.9 X 1.0) = 5.26% delta K/K
.5% delta K/K excess reactivity would be added. [0.75]
(Calculations not required for full credit)

b. 30% power [0.75]
power coefficient of reactivity is linear [0.75]

REFERENCE
Nuclear Energy Training, Module 3 Rx Ops, Unit 12.1

ANSWER H.05 (3.00)

A.1 Std.



ANSWER H.06 (3.00)

a. Increase slightly then level out due to sub-critical mult. (1.0)
b. Larger increase and longer to level out-greater number of generations. (1.0)
c. Steadily increasing count rate or slight positive period with no rod withdrawal. (1.0)

ANSWER H.07 (3.00)

a. When flow is lost, the pressure drop across the core decreases. [0.5]
Pressure differential across the gate decreases. [0.5]
The counter weight opens the gate. [0.5]

b. Conductive heat flow across fuel into coolant. [0.5]
Natural convective flow to surface of the pool. [0.5]
~~Convective flow to atmosphere. [0.5]~~
NATURAL CONVECTIVE FLOW TO POOL WHICH ACTS AS HEAT SINK [0.5]

REFERENCE
Safeguard Report (1962) p 54

ANSWERS -- RHODE ISLAND & PROV. P AEC-85/04/24-DUDLEY, N.

ANSWER I.01 (2.00)

a. Max. Dose = Dose Rate X Time [0.5]
1.25 Rem = 0.003 Rem/hr X 8 hr/day X No. of Days [0.7]
No. of Days= 52 days or 10.4 weeks [0.3]

b. ~~Restricted area; controlled access~~ POST AS RADIATION AREA (2½ mr/hr) [0.5]

REFERENCE
Radiation Safety Guide p 20, 21, 30

ANSWER I.02 (1.50)

a. 200 mrem [0.75]
b. ~~CAF~~ SRO or HP STAFF [0.75]

REFERENCE
Operating Procedure p 12-4

ANSWER I.03 (1.00)

0.1 mr/hr
1.0 mr/hr [0.5 each]

REFERENCE

RINSC Radiation Safety Guide pg. 32

ANSWER I.04 (3.00)

a. 12 ft/Mev x 0.5 Mev= 6 ft [0.8]

b. d x (r)^2 = D x (R)^2 [0.6]
1 mr/hr x (10)^2 = D x (~~2~~ 1)^2 [0.3]
D = ~~25~~ 100 mr/hr [0.1]
Beta dose = 100mr/hr - ~~25~~ 100 mr/hr [0.5]
= ~~75~~ 0 mr/hr [0.1]
~~Beta to gamma ratio = 75/25 = 3~~ [0.6]
NO BETA'S PRESENT

ANSWER I.05 (3.00)

a. CAF [0.5 each] ANY 3 @ BRIDGE, THERMAL COLUMN, FUEL SAFE, STACK, DEMINERALIZER, HX

b. Geiger tubes [0.5]

c. Beta particulate monitor [0.5]
Gas monitor [0.5]

REFERENCE
T.S. p 14, 15

ANSWER I.06 (3.00)

a. Holdup tank allows N 16 to decay away. The N 16 produces high energy gammas and have a short half life. [1.0]

b. SRO [1.0] (CONTROLED IN KEY SAFE)

c. CAF Use portable radiac when entering room. [1.0]

ANSWER I.07 (3.00)

a. No [0.5] A Rem dose accounts for the type and energy of radiation. [1.0]

b. Yes [0.5] Internal dose depends on biological and physical T 1/2, referred organ, type of radiation. [1.0]

REFERENCE
Radiation Safety Guide p 25, 26

ANSWER I.08 (3.00)

a. I = Io e{-ux} [0.4]
100 mrem/hr = Io e{-0.035 cm(-1) 100 cm} [0.4]
Io = 3311 mrem [0.2]

b. I = Io 10 {-x/TVL} [0.4]
= 100 mrem/hr 10 {1 in/ 2 in} [0.4]
= 69 mrem/hr [0.2]

c. A = Ao e{-0.693/ half life X t} [0.4]
t = (ln A/Ao) x half life /-0.693 = ln 20/100 X 30 min./-0.693 [0.4]
t = 70 min [0.2]

ANSWER J.01 (2.50)

Reactor must be subcritical if any single control element and the regulating element were withdrawn. [1.~~0~~5]

minimum SDM = reactivity of most reactive contol element + reg rod
= 0.07 + 0.007
= 0.077

ACCEPT OTHER CALCULATION OF SDM [1.0]

REFERENCE
T.S. p. 27,28

ANSWER J.02 (1.50)

Use intercom to inform RO
Rinse contaminated skin
Wait for H.P.
[0.5 each]

REFERENCE
Operating Procedures p 12-4

ANSWER J.03 (2.50)

Assure actions required for the safety of personnel or protection of equipment have been taken. [0.7]
Determine cause [0.5]
Correct abnormal condition [0.5]
Complete applicable portions of the checkout procedure and authorize startup of reactor [0.5]
Assure actions are recorded in log [0.3]

REFERENCE
Operating Procedures p 9-2

ANSWER J.04 (2.50)

PREVENT OVERLOAD OF DETECTOR OR LOSS OF INDICATION, A

a. ~~Damage the proportional counter so that there would not be source range indication following a shutdown. [1.0]~~

DELETE

~~b. Must remove slowly [0.5] and compensate for reactivity changes by withdrawing a control blade. [1.0]~~

REFERENCE
Operating Procedures p 7-3

ANSWER J.05 (3.00)

a. Reactor scrams [0.5]
Propane gas generator unit starts [0.5]
Automatic transfer switch operates [0.5]

b. CAF EMERGENCY LIGHTS
SUMP PUMP
POWER AVAILABLE TO SAFETY SYSTEMS

REFERENCE
Operating Procedures p 10-1

ANSWER J.06 (3.00)

a. Shutdown
b. Scram
c. Maintain power
d. Maintain power
e. Scram

REFERENCE
Operating Procedures p 8-2
T.S. p 12, 28, 29

ANSWER J.07 (2.50)

Pool temperature will increase adding negative reactivity. [0.75]
~~Reactor power will decrease. [0.75]~~
Pool high temperature alarm activated [0.5]
~~No scram. [0.5]~~
HIGH TEMP SCRAM

REFERENCE
054: TS p. 9
DS-01-1 and DS 02-2
170: Operations Manual, Chap. 3 - Reactor Water Systems
Reference Package, Reactor Parameters

ANSWERS -- RHODE ISLAND & PROV. P AEC-85/04/24-DUDLEY, N.

ANSWER J.08 (3.00)

Evacuation horn blows.
Air conditioning and normal ventilation turns off.
Dampers on all ventilating ducts leading to the outside have closed.
Building cleanup system air scrubber comes on.
[4 at 0.75 each]

REFERENCE
T.S. p. 24

ANSWER K.01 (3.00)

a. Assistant Director [0.75]
b. RO in MCR [0.35]
   SRO ~~at pool~~ [0.4]
c. Control and safety system instrumentation [0.75]
d. Dry Irradiation Facility [0.75]

REFERENCE
Operating Procedures p. 5-1

ANSWER K.02 (2.00)

a. Fuel is contained i uminum cladding (15 mils thick) [0.8]

b. Increasing reading rea monitor
   Increasing reading r monitor
   Increasing reading ack exhaust gas or particulate monitor
   Increasing activi ol samples
   [any 3 @ 0.4 each]

REFERENCE
Safeguards Report
Emergency Plan p.

ANSWER K.03

a. 2
b. 3
c. 3 (ACCEPT OTHER NUM
d. ~~4~~ 3 [0.75 each

REFERENCE
Operating Procedures, 2-4

ANSWER K.04 (2.00)

a. If a critical mass exists a constant subcritical power level cannot be established with all blades out.

b. Use in-hour method elaborate.

ANSWERS -- RHODE ISLAND & PROV. P AEC-85/04/24-DUDLEY, N.

REFERENCE
Operating Procedure, p 2-4

ANSWER K.05 (1.50)

No. [0.5] There is an automatic anti-siphon loop connected to each of the primary lines. [1.0]

REFERENCE
Safeguards Report (1962) p 24

ANSWER K.06 (1.50)

~~Assure the~~ ventilation system realigns. [0.75]
recover dropped element. [0.75]
CHECK FOR FUEL DAMAGE

REFERENCE
Emergency Plan p 13

ANSWER K.07 (3.00)

a. Stored in egg crates which contain not more than 3 fuel elements. IN FUEL STORAGE SAFE. Maybe stored dry. [0.75]

b. Stored in racks in the fuel pool. (9 or 18 element racks.) [0.75]

c. Irradiated fuel contains decay heat, which must be removed, [0.75] and fission decay products, which require shielding. [0.75]

REFERENCE
T.S. p 17

ANSWER K.08 (3.00)

a. Fuel storage OR LOW POWER
b. High and Low Power sections
c. High Power section
d. High Power section
e. Low Power section

[0.6 each]

ANSWERS -- RHODE ISLAND & PROV. P AEC-85/04/24-DUDLEY, N.

REFERENCE
Safeguards Report (1962) p 23, 30, 33

ANSWER L.01 (2.00)

a. All control blades and regulating rod movements
All experiment insertions and removals
Changes in Operators and Senior Operators
Important instructions to the relief operator [any 3 @ 0.4 each]
CHANGES TO REACTIVITY

b. Record at the time and in the order in which they occur. [0.8]

REFERENCE
Operating Procedure p 8-1

ANSWER L.02 (2.00)

a. No [0.6] Procedure change effects safe operation of the plant. [0.4]

b. Yes [0.6] Does not change intent of procedure. [0.4]

ANSWER L.03 (2.50)

a. Initial startup and approach to power.
Recovery from unplanned shutdown or power reduction.
Refueling.
[0.5 each]

b. Responsible for all activities which may affect reactor operations or involve radiation hazards. [1.0]

REFERENCE
T.S. p 20

ANSWER L.04 (1.50)

a. No classification
b. Site Emergency
c. Unusual Event
[0.5]

REFERENCE
Emergency Plan Implementing Procedures, Table 1.1

ANSWER L.05 (3.00)

a. Has a sample been withdrawn from the core? [0.6]
   Is the sample still in the receiver? [0.6]
   What was the reading on the wall monitor? [0.3]

b. Minimize exposure of experimenter. [0.6]
   Minimize spread of contamination. [0.6]
   Reduce radiation levels at the reciever station. [0.3]

REFERENCE
Operating Procedures p 12-3

ANSWER L.06 (3.00)

a. Assistant Director
b. RO
c. ~~Assistant Director~~ H.P.
d. SRO
e. Reactor Utilization Committee

[0.6 each]

REFERENCE
Operating Procedures p 7-1, 12-1, 12-2
T.S. p 23

ANSWER L.07 (3.00)

a. SHUT DOWN Rx ~~Station a member of the station operations staff at the door.~~ [0.75]
b. Scram the reactor. [0.75]
c. Drain and refill the makeup system. [0.75]
d. No action required. [0.75]

REFERENCE
T.S p 24, 25

ANSWER L.08 (4.00)

PREVENT REACTIVITY EXCURSIONS

a. ~~Will not cause fuel melt; prevents reactor from going prompt critical.~~ [1.0]

b. ~~Prevents flux tilt due to water hole peaking which can lead to fuel damage.~~ [1.0] REACTIVITY EFFECTS OF LOADING FUEL IN ~~BPR~~ VACANCIES.

c. ~~Absorb Iodine released by possible fuel element failure.~~ [1.0] SHIELDING AND N16 DECAY

d. Prevent erroneous and unreliable information from being sent to the control system safety circuits. [1.0]

REFERENCE

T.S. p 23-25

Safeguards Report (1962) p 68

QUESTION	VALUE	REFERENCE
H.01	3.00	DUD0000774
H.02	3.00	DUD0000775
H.03	2.00	DUD0000776
H.04	3.00	DUD0000777
H.05	3.00	DUD0000778
H.06	3.00	DUD0000779
H.07	3.00	DUD0000824

	20.00	
I.01	2.00	DUD0000791
I.02	1.50	DUD0000797
I.03	1.00	DUD0000798
I.04	3.00	DUD0000799
I.05	3.00	DUD0000800
I.06	3.00	DUD0000801
I.07	3.00	DUD0000787
I.08	3.00	DUD0000792

	19.50	
J.01	2.50	DUD0000806
J.02	1.50	DUD0000811
J.03	2.50	DUD0000812
J.04	2.50	DUD0000813
J.05	3.00	DUD0000814
J.06	3.00	DUD0000815
J.07	2.50	DUD0000817
J.08	3.00	DUD0000805

	20.50	
K.01	3.00	DUD0000807
K.02	2.00	DUD0000808
K.03	3.00	DUD0000809
K.04	2.00	DUD0000810
K.05	1.50	DUD0000820
K.06	1.50	DUD0000825
K.07	3.00	DUD0000827
K.08	3.00	DUD0000828

	19.00	
L.01	2.00	DUD0000816
L.02	2.00	DUD0000818
L.03	2.50	DUD0000829
L.04	1.50	DUD0000831
L.05	3.00	DUD0000821
L.06	3.00	DUD0000822
L.07	3.00	DUD0000830

TEST CROSS REFERENCE

QUESTION	VALUE	REFERENCE
L.08	4.00	DUD0000823

	21.00	

	100.00	