U.S. NUCLEAR REGULATORY COMMISSION

REGION III

Report No. 50-087/OL-85-01

Docket No. 50-087 License No. R119

Licensee: Westinghouse Electric Corporation
505 Shiloh Boulevard
Zion, IL 60099

Facility Name: Westinghouse Nuclear Training Reactor

Examination Administered At: Westinghouse Nuclear Training Center

Examination Conducted: One (1) SRO

Examiner: Ralph R. Ferrell
R. Ferrell
7/29/85
Date

Approved By: R. Higgins for
J. McMillen
Operator Licensing Section
7/29/85
Date

Examination Summary

Examination administered on June 20-21, 1985 (Report No. 50-087/OL-85-01)
Results: One (1) SRO passed the written and operational exams.

REPORT DETAILS

1. Examiner

   R. Ferrell - Chief Examiner

2. Examination Review Meeting

   At the conclusion of the written examination, the examiner met with Karen Reuter and Roy Sackschewsky of the NTR staff to review the written examination. A list of the comments was generated and, along with the examiners responses, is included in a separate attachment.

3. Exit Meeting

   At the conclusion of the site visit the examiner met with members of the NTR staff to discuss results of the examination. They were informed that the one (1) NTR SRO candidate clearly passed the operational portion of the examination.

Westinghouse NTR SRO Exam Comments

Attachment

Comment H.01

No starting point was given for this question which may lead to a number of different solutions for the first section of the desired curve. The examinee could assume that the initial fission rate was that associated with the intrinsic neutron level in the core and thus would not decrease as those in the key.

Examiner response H.01

Agreed - The answer key was changed to reflect the above comment.

Comment H.06 and H.07

Both of these questions are valid reactor theory questions, but really do not apply to the NTR since the restrictions on Power levels and the minimum integrated power effectively eliminates any "Decay Heat" or "Xenon and Samarium" buildups.

Examiner response H.06 and H.07

The examiner agrees with the above comment but at the same time the terms "Decay Heat, Xenon, and Samarium" are basic nuclear theory concepts the candidate should be familiar with and therefore, the questions are valid. The candidate did well on the above questions.

Comment I.06A

Since the question did not specify if the foil was irradiated or not, the answer could include the foils stored in the NTR Office File Safe.

Examiner response I.06A

Agreed - The additional answer provided above was added to the key.

Comment I.06C

Samples that have decayed to insignificant levels may be returned to the NTR File Safe; however, often they are simply kept in the Radiation Safety Lap (HP Lab) safe until they are again irradiated for another experiment.

Examiner response I.06C

Agreed - The additional answer provided above was added to the key.

Comment I.07

The effected wall may be described as the "South wall of the Penthouse" or "North wall of the Reactor Room."

Examiner response I.07

Agreed - The additional answer provided above was added to the key.

Comment J.04

The answer may be derived from the Precautions and Limitations and Procedure for Experiment 20 in our Experiments Manual which includes reduction in trip setpoints for C1 and C2, lowering of Channel F neutron level trip, providing portable monitors, stable periods longer than 30 seconds, close monitoring of radiation levels in the control room and limiting reactor power to less than 2 watts. Reference Pp 20-6 to 20-10.

Examiner response J.04

Agreed - The additional answers provided above were added to the key.

Comment J.05

The answer key describes the supercritical reactor vice the critical reactor referred to in the question. At the NTR we can illustrate the response of a critical reactor in the source range with Channel A. A critical reactor in the source range will be noted by:

1. No rod motion
2. Linear increase in power in the source range with the source installed.
3. Vertical trace with the source withdrawn.
4. The period meter will tend toward infinity.

This is probably unique to the NTR since our source range power level is monitored by a linear recorder and the source may be remotely removed from the core. Period meter will tend to infinity.

Examiner response J.05

Agreed - The additional answers provided above were added to the key.

Comment J.06

Success is determined in Experiment 6 (page 6-3) by simply subtracting the shutdown reactivity from the total rod worth. In doing the initial core physics tests for this core the methods outlined in the FSAR were used.

Examiner response J.06

Agreed - The additional answer provided above was added to the key.

Comment K.04

The LCO for excess reactivity is given by two specifications (3.1.1 and 3.1.2) are shown to be equivalent in the basis. In 3.1.2 it states that the maximum excess reactivity that can be loaded into the core is 8.55$. This quantity assures that spec 3.1.1 will be satisfied which states that the core must be able to be shut down by at least 1$ with the most reactive rod stuck fully out of the core and failures of experiments. The pertinent basis section is on page 13 of the Technical Specifications.

Examiner response K.04

Agreed - The additional answer provided above was added to the key.

Comment K.05

Sections 3.5.3.1, 3.5.3.2 and 3.5.3.3 of the Ops Manual (P. 3-30 - 3-33) outline precautions, personnel protection and procedures for the movement of fuel. These points may also be given to answer this question.

Examiner response K.05

Agreed - The question was graded very loosely based on the above comment.

Comment L.01

The use of "Who" at the beginning of the question may lead the examinee to believe that only one person is desired as the answer.

Examiner response L.01

Agreed - Examiner will accept only one (1) of the two (2) for full credit.

Comment L.02

Additional points should be added to this list. A summary of requirements are given on the "Reactor Room Entry Checklist" which is attached. Also it is now the practice of the instruction staff in training situations to require all personnel to wear lab coats, safety glasses and rubber shoe cover when entering the reactor room.

Examiner response L.02

Agreed - The additional answers provided above were added to the key.

Comment L.04

Answers 1 and 2 are no longer valid with the Technical Specification revision included in the recent NTR Facility License renewal. Items 3 and 5 are performed as a single item and are identified by a single title on the current surveillance list. Thus the list of quarterly surveillances has been shortened.

Examiner response L.04

Agreed - items 1 and 2 were deleted from the answer key and 3 and 5 combined into one (1).

Comment L.05

The Ops Manual section 2.3.3, Pp 2-8, specifies that a SRO shall maintain the control board under direct surveillance when the reactor is not secured. Thus the Ops Manual is more restrictive than the Technical Specifications. Consequently according to the Ops Manual: L.05 A is False and L.05 B is True.

Examiner response L.05

Agreed - The answer key was corrected.

Comment L.08

There may have been a typographical error in the answer key. "approach procedure" should read "approved procedure" or "approved experiment" (Exp 13).

Examiner response L.08

Agreed - The typo was corrected.

EXAM MASTER

Exam Review
K. Reuter
Ron S.

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

FACILITY: WESTINGHOUSE ELECTRIC CORP

REACTOR TYPE: NTR

DATE ADMINISTERED: 85/06/20

EXAMINER: R.R.FERRELL

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
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
100.00	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 (2.25)

Figure H-1 shows positive reactivity being inserted into an initially sub-critical reactor. On the same figure, sketch the corresponding fission rate and assume no source-sketch only.

QUESTION H.02 (3.00)

A. If during a startup, the count rate is 40 cps and Keff=0.95, what will the count rate be when Keff = 0.98? [1.5]

B. If the control rods were moved an increment of 2 inches to achieve this increase in count rate, about how many more inches would you have to withdraw the rods to achieve criticality? Assume rod worth is linear over distance to be traveled. [1.5]

QUESTION H.03 (2.00)

Explain how a 1/M plot is used to predict criticality. In your answer discuss the variables that can affect the accuracy of the plot.

QUESTION H.04 (3.00)

Explain the following terms:

A. Reactivity, ρ [1.0]

B. Reactor Period [1.0]

C. Prompt Critical [1.0]

QUESTION H.05 (3.00)

A. State 2 purposes for the installed neutron source in the N-24-S core. [1.5]

B. Identify the source type and write the reaction that produces neutrons. [1.5]

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

QUESTION H.06 (2.00)

What is the source of decay heat in the reactor?

QUESTION H.07 (3.00)

Explain the production and removal mechanisms for Xe-135 and Sm-149.

QUESTION H.08 (1.75)

A. If Keff of the N-24-S core were made to be 1.0016, calculate the reactivity insertion in %Δk/k, $, and PCM. [1.0]

B. Calculate the resultant reactor period and SUR from this positive reactivity insertion. State all assumptions. [.75]

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

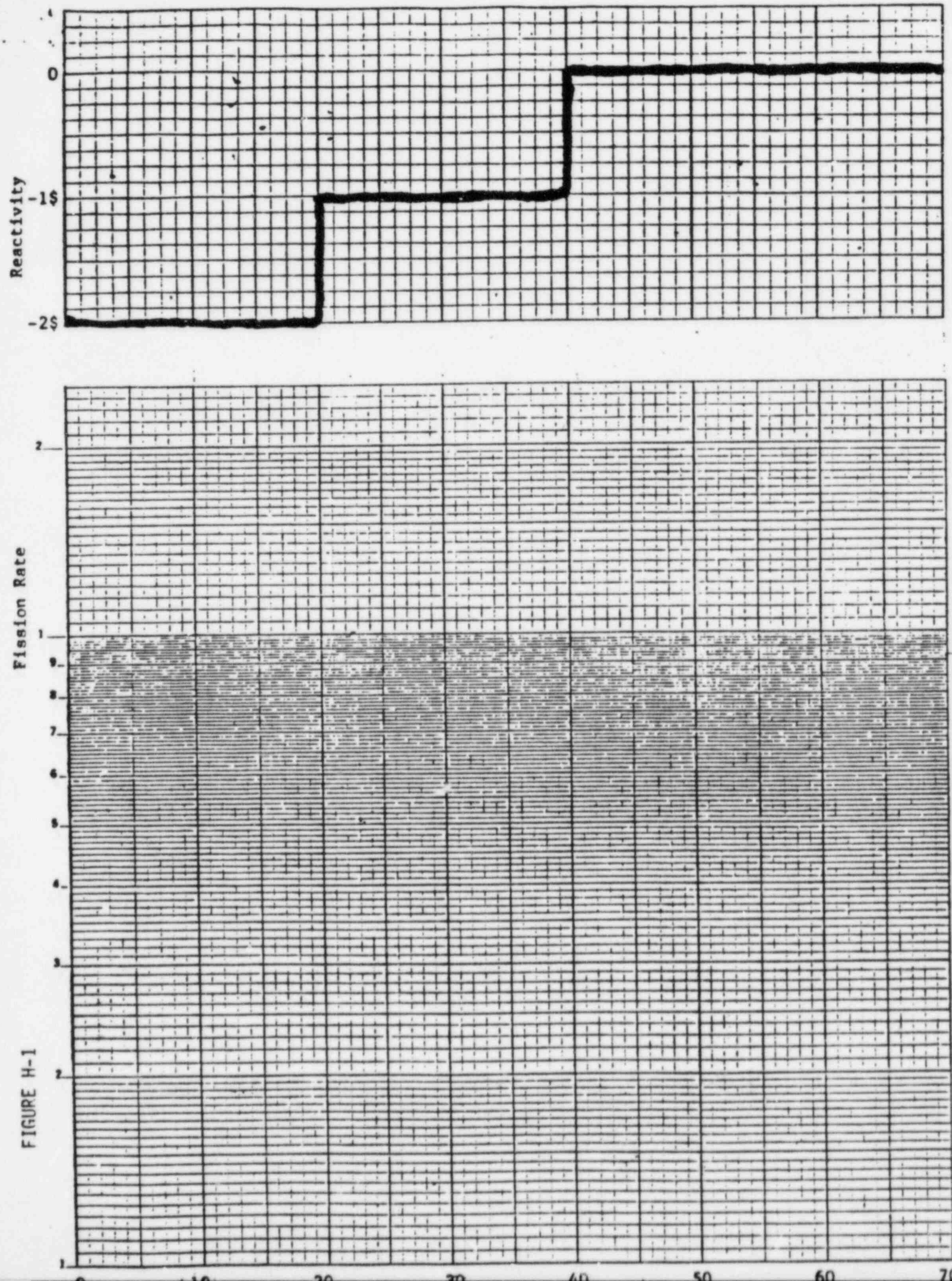

FIGURE H-1

QUESTION I.01 (2.25)

What are the weekly NTR Permissible Working limits for radiation exposure established at the facility for the following?

A.Head and Trunk
B.Feet and ankles
C.Skin of the whole body [.75 ea.]

QUESTION I.02 (2.75)

A.Where are the 3 area gamma monitors located in the NTR facility? [1.50]

B.What additional function is provided by one of these monitors that the other two do not have? [1.25]

QUESTION I.03 (2.00)

Describe how to check if a low range beta-gamma instrument is functioning properly.

QUESTION I.04 (1.00)

If I-131 has a biological half-life Of 138 days and a radiological half-life of 8 days, then half of the ingested radioactive atoms will remain in the body at: (select one-no calculation necessary)

A.138 days
B.73 days
C.8 days
D.7.56 days

QUESTION I.05 (2.00)

What indications must exist at the NTR to indicate a contamination problem is present?

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

QUESTION I.06 (4.50)

Gold and Indium foils are frequently uesd as irradiation samples.Answer the following concerning these samples.

A.Where are they stored? [1.25]

B.How are they marked/identified? [2.0]

C.What happens to these samples when the activity has decayed to insignificant levels? [1.25]

QUESTION I.07 (2.00)

Why is the 'CAUTION-RADIATION AREA' sign attached to the cover over the entrance to the ladder leading to the NTR 'penthouse'?

QUESTION I.08 (2.00)

What levels of radiation would you expect to find in an area marked as follows:

A.CAUTION-RADIATION AREA [1.0]

B.CAUTION-HIGH RADIATION AREA [1.0]

QUESTION I.09 (1.50)

Per 10CFR20 (Standards for Protection against Radiation), give 3 reasons that would require notification to the NRC in the following time frames:

A.Immediate Notification [.75]

B.24 hour notification [.75]

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

QUESTION J.01 (2.50)

Answer the following questions TRUE or FALSE.

A.Power is limited to 100 watts when an experiment is installed in the reactor tank.
B.An unplanned or inadvertant reactor trip,in itself constitutes an ABNORMAL occurrence.
C.The higher differential worth of the shim rods makes them inappropriate for making fine reactivity adjustments.
D.During controlled critical operations at power levels in excess of about 5,000 watt,it is permissable to silence the Control Room audible alarm for the criticality monitor.
E.Power is limited to 100 watts when the reactor is in the N-24-S configuration.

[.5 ea]

QUESTION J.02 (3.00)

Explain the basis for:

A.Rod speed at 3.76 in/min. [1.5]

B.24 cps at count-rate - cutout 'low' setpoint. [1.5]

QUESTION J.03 (2.00)

Why is it preferable to operate at as low a power level as possible when extended steady state operation is to take place.

QUESTION J.04 (2.00)

When approaching criticality,under what condition/s may the reactor be controlled by moderator level? Why are these condition/s necessary?

QUESTION J.05 (2.50)

Describe how an operator can determine when the reactor is critical during startup. Be specific in your answer and list at least 3 indications.

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

QUESTION J.06 (2.00)

How was K excess of the core experimentally determined?

QUESTION J.07 (2.00)

Why are graphite rods a better reflector than water?

QUESTION J.08 (2.00)

What are 4 purposes of the interlock system?

QUESTION J.09 (2.00)

Refer to figure J-1. Identify those regions indicated by arrows A through F.

A.
B.
C.
D.
E.

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

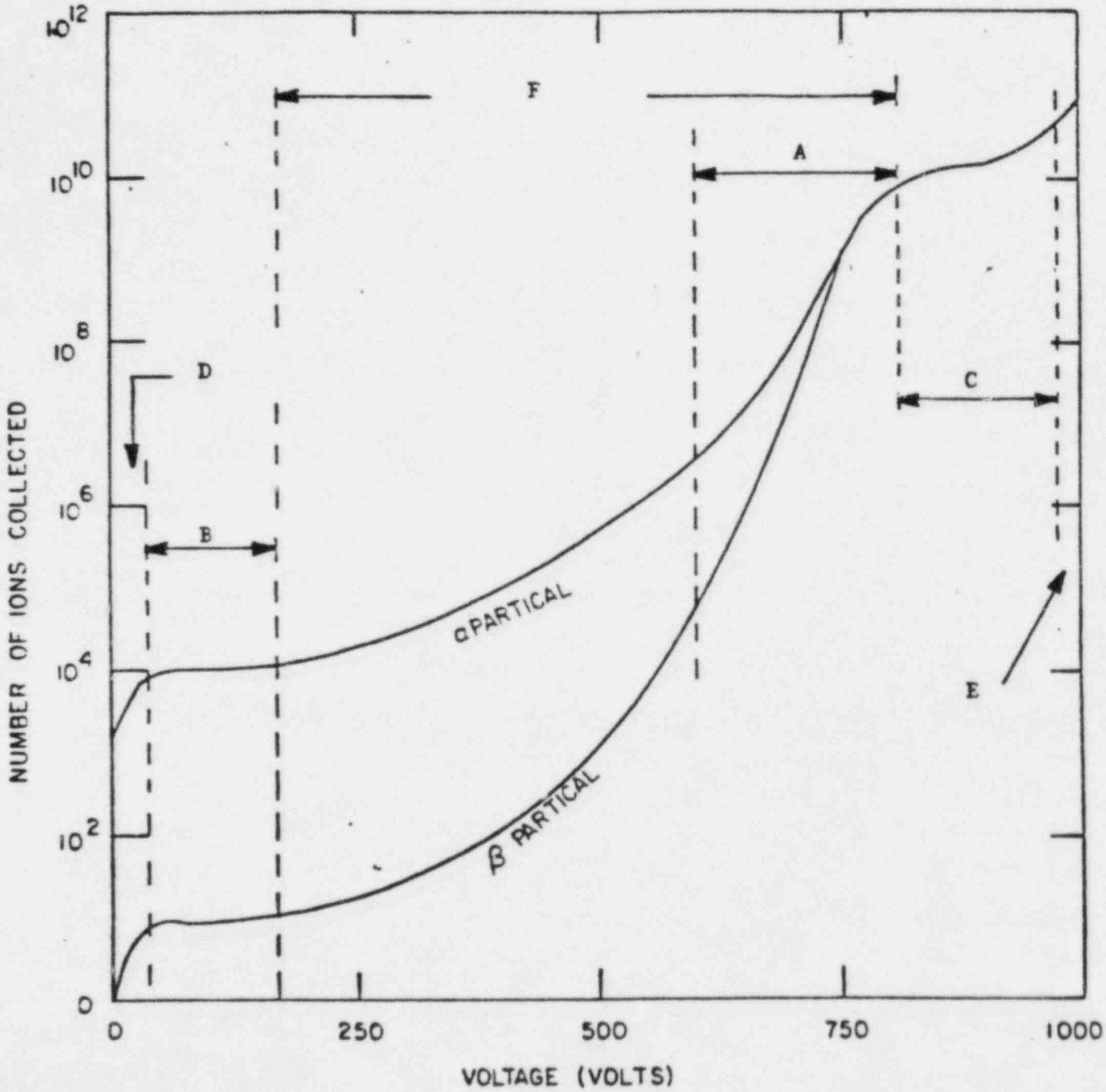

FIGURE J-1 Characteristic Curve of a Gas-Filled Detector

QUESTION K.01 (1.00)

Who must approve all fuel handling procedures?

QUESTION K.02 (1.50)

What 3 individuals can direct radioactive material handling operations (other than fuel)?

QUESTION K.03 (2.75)

1. What are the approved storage areas for reactor fuel in the Reactor Room? [.75]
2. How many fuel elements can be out of approved storage areas at any time? [.50]
3. Where can the control rods be stored? [.50]
4. Who can authorize the removal of Special Nuclear Material from the Reactor room? [.50]
5. How much Special Nuclear Material can be removed from the Reactor Room at any one time? [.50]

QUESTION K.04 (3.00)

State the Tech Spec limits for each of the following:

A. Maximum control rod and moderator-shield water reactivity insertion rate. [.75]

B. Excess reactivity [.75]

C. Control rod drop time [.75]

D. Required moderator water level [.75]

QUESTION K.05 (3.50)

Briefly discuss 7 fuel handling precautions that you would outline to a class of trainees who were going to unload the NTR core for their first time.

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

QUESTION K.06 (2.75)

Describe the NTR Biological Shield.

QUESTION K.07 (4.50)

For each of the following NTR components, give a brief description as appropriate.

A.Fuel enrichment.
B.Upper Grid Plate.
C.Lower Grid Plate.
D.Absorber material.
E.Normal Core Configuration.
F.Reflector. [75 ea.]

QUESTION K.08 (1.00)

What personal dosimeters must be worn by the work staff during fuel handling operations?

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

QUESTION L.01 (1.00)

A.Who can authorize radiation exposure in excess of the 1.25 REM whole body limits?

QUESTION L.02 (2.00)

List 4 conditions that must be satisfied in order to allow personnel to occupy the Reactor Room?

QUESTION L.03 (2.00)

A.When is the reactor considered 'secured'? [1.0]

B.When is the reactor considered 'operational'? [1.0]

QUESTION L.04 (2.50)

List 5 items that have to be verified quarterly per the surveillance/maintenance schedule.

QUESTION L.05 (2.25)

For the following questions concerning licensed operators,answer TRUE or FALSE

A.A licensed SENIOR operator is not required to be present when recovering from an unplanned shutdown when the cause has been identified. [.75]

B.A licensed SENIOR operator has to be present on any approach to criticality. [.75]

C.A licensed SENIOR operator must be present during any change in the core configuration. [.75]

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

QUESTION L.06 (3.00)

A. Who has to review and approve changes in the operating procedures? [1.0]

B. Under what conditions can temporary changes be made to the operating procedures? [1.0]

C. What action is required after the temporary change is made? [1.0]

QUESTION L.07 (2.00)

What are the minimum safety system system channels required to make a startup on the NTR?

QUESTION L.08 (2.25)

List 3 situations during which an interlock can be bypassed.

QUESTION L.09 (3.00)

Concerning the NTR EMERGENCY PLAN, answer the following questions:

A. Where is the PRIMARY EMERGENCY SUPPORT CENTER? [.6]

B. Where can the EMERGENCY ALARM be actuated from? [.6]

C. Who assumes responsibility for all appropriate actions? [.6]

D. Under what conditions can normal activities resume at the NTR following termination of the incident that caused the Emergency Plan to be implemented? [.6]

E. When are Emergency Plan drills conducted at the NTR? [.6]

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

$f = ma$

$v = s/t$

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

$w = mg$

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

$E = mc^2$

$KE = 1/2\ mv^2$

$a = (V_f - V_o)/t$

$PE = mgh$

$V_f = V_o + at$

$w = \theta/t$

$W = v\ \Delta P$

$\Delta E = 931\ \Delta m$

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

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

$Pwr = W_f \Delta h$

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

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

$SUR = 26.06/T$

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

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

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

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

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

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

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

$\Sigma = \sigma N$

$A = \lambda N$

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

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

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

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

$I = I_o e^{-ux}$

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

$TVL = 1.3/u$

$HVL = -0.693/u$

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

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

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

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

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

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

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

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

$I_1 d_1 = I_2 d_2$

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

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

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

__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.
1 ft. H_2O = 0.4335 $lbf/in.^2$

__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

EQUATION SHEET

$\dot{Q} = \dot{m}\Delta h$

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

$\dot{Q} = \dot{m}c_p\Delta T$

$h_L = k\dot{m}V^2$

$DNBR = \frac{Q_c}{Q_x}$

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

$P = P_o e^{t/\tau}$

$SUR = \frac{26.06}{\tau}$

$\tau = \frac{\beta - \rho}{\lambda\rho}$

$\tau = \frac{1^*}{\rho} + \frac{\beta - \rho}{\lambda\rho}$

$\rho = \frac{k_{eff} - 1}{k_{eff}}$

$\Delta\rho = \frac{k_2 - k_1}{k_2 k_1}$

$\frac{CR_1}{CR_2} = \frac{1 - k_{eff_2}}{1 - k_{eff_1}}$

$RR = \Sigma_f \phi_{th}$

$SCR = \frac{S}{1 - k_{eff}}$

$M = \frac{CR_1}{CR_o}$

$\overline{\lambda} = 0.1\ sec^{-1}$

$1^* = 10^{-5}\ sec$

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

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

$\rho = \Delta k/k$

$W_{total} = (h_{in} - h_{out})\eta_T$

$A = \lambda N$

$N = N_o e^{-\lambda t}$

17.58 watts = 1 BTU/min

1 psi = 6.895 P_a

1 psi = 2.036 inches Hg @ 0°C

1 psi = 27.68 inches H_2O @ 4°C

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ANSWERS -- WESTINGHOUSE ELECTRIC CORP-85/06/20-R.R.FERRELL

ANSWER H.01 (2.25)

See Figure H-1

Note: The ~~3~~ 2 distinctive curve traces are worth ~~.75~~ 1.125 ea. (NO STARTING POINT SPECIFIED)
1 or 1/3 OF GRAPH WILL BE MIN

REF: Chapter 7, p.7-69

ANSWER H.02 (3.00)

A. $\frac{C1}{C2} = \frac{1-K2}{1-K1}$

C1=40, K1=0.95, K2=0.98

$C2 = \frac{C1(1-K1)}{1-K2} = \frac{40(1-0.95)}{(1-0.98)}$

C2=100

B. $\rho = \frac{\Delta k}{k} = \frac{0.03}{0.95} = 0.0315\ \Delta k/k$

For 2 in. of travel this gives a total of $\frac{0.0315\ \Delta k/k}{2\ \text{in.}} = \frac{0.0157\ \Delta k/k}{\text{in.}}$

Assuming that the control rod worth remains constant over the region of interest, the required reactivity addition to reach criticality is

$\rho = \frac{1.0-0.98}{0.98} = 0.0204\ \Delta k/k$; Travel =0.0204/0.0157=1.29 in.

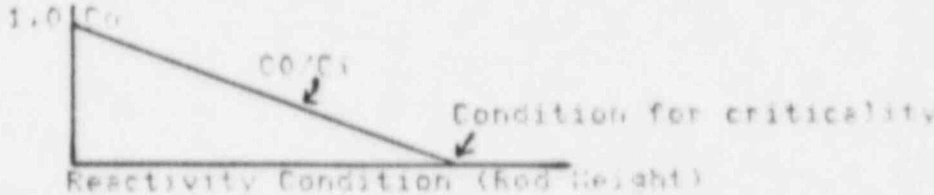
REF. OP Chapter 8, p.8-27

ANSWERS -- WESTINGHOUSE ELECTRIC CORP-85/06/20-R.R.FERRELL

ANSWER H.03 (2.00)

1/M=Co/Ci where:Ci=count rate of the NIS channel with a reactivity change
Co=base count rate

When at the conditions for the base count rate,the 1/M value is 1. As reactivity is added,the count rate increases. The new resulting count rate =Ci. Therefore this 1/M value is less than 1. By extending the line through these points, to the horizontal axis a prediction for critical conditions can be obtained.



1/M used during fuel loading or rod pulls on NTR.
REF.NTR Requal Training Manual

ANSWER H.04 (3.00)

A. $\rho = \frac{K_{eff}-1}{K_{eff}}$ The fractional change of the effective multiplication factor from 1 [1.0]

B.Time required to change reactor power by a factor of e [1.0]

C.Reactor is critical on prompt neutrons only (ρ=B) [1.0]

REF.Fundamentals of Reactor Physics

ANSWERS -- WESTINGHOUSE ELECTRIC CORP-85/06/20-R.R.FERRELL

ANSWER H.05 (3.00)

A.1.Verify NI's are operable
2.Make a controlled approach to criticality or supply an adequate neutron population such that subcritical multiplication can be observed as the reactor approaches criticality [.75 ea]

B.Source:Pu-Be,2 Ci [.50]

$${}^{239}_{94}Pu \rightarrow {}^{4}_{2}\alpha + {}^{235}_{92}U \qquad {}^{4}_{2}\alpha \rightarrow [{}^{13}_{6}C]^{*} \rightarrow {}^{12}_{6}C + 1\ \text{neutron}$$ [1.0]

REF.NTR Requalification Training Manual

ANSWER H.06 (2.00)

Attenuation of the beta and gamma from fission products in reactor materials

REF.Fundamentals of Reactor Physics

ANSWER H.07 (3.00)

Xe is a daughter of I which is a daughter of Te (a fission product). Xe also is a direct fission product. It can be removed by decay to Cesium or 'burnup' by absorption of a thermal neutron. [1.5]

Sm is a daughter of Promethium (formed by fission and also a daughter of Neudymium). It can be removed by 'burnup',but Sm is stable. [1.5]

Xe PRODUCTION:Direct Fission
Decay (Sb135 [B-]>Te135 [B-]>I135 [B-]>Xe135)
REMOVAL:Decay (Xe135 [B-]>Cs135)
Burnup (neutron absorption)

Sm PRODUCTION:Direct Fission
Decay (Ce149 [B-]>Pr149 [B-]>Nd149 [B-]>Pm149 [B-]>Sm149
REMOVAL:Burnup (neutron absorption)

REF.Fundamentals of Reactor Physics

ANSWERS -- WESTINGHOUSE ELECTRIC CORP-85/06/20-R.R.FERRELL

ANSWER H.08 (1.75)

A. Keff = 1.0016

$\frac{.0016}{1.0016} = .0016 \frac{\Delta K}{K}$

160 PCM = .2¢
800 PCM/$

160 PCM

B. Rx Period

$\rho = \frac{\bar{\beta}_{eff}}{1 + \bar{\lambda} T}$

$\rho + \rho \bar{\lambda} T = \bar{\beta}_{eff}$

$T = \frac{\bar{\beta} - \rho}{\bar{\lambda}\rho} = \frac{.008 - .0016}{(.1)(.0016)} = 40$ sec

Assume $\bar{\beta} = .00800$

$\bar{\lambda} = .1\ sec^{-1}$

$\rho = .0016$

SUR = 26.06/T = 26.06/40 = .65 DPM

REF. NTR Requal Training Manual

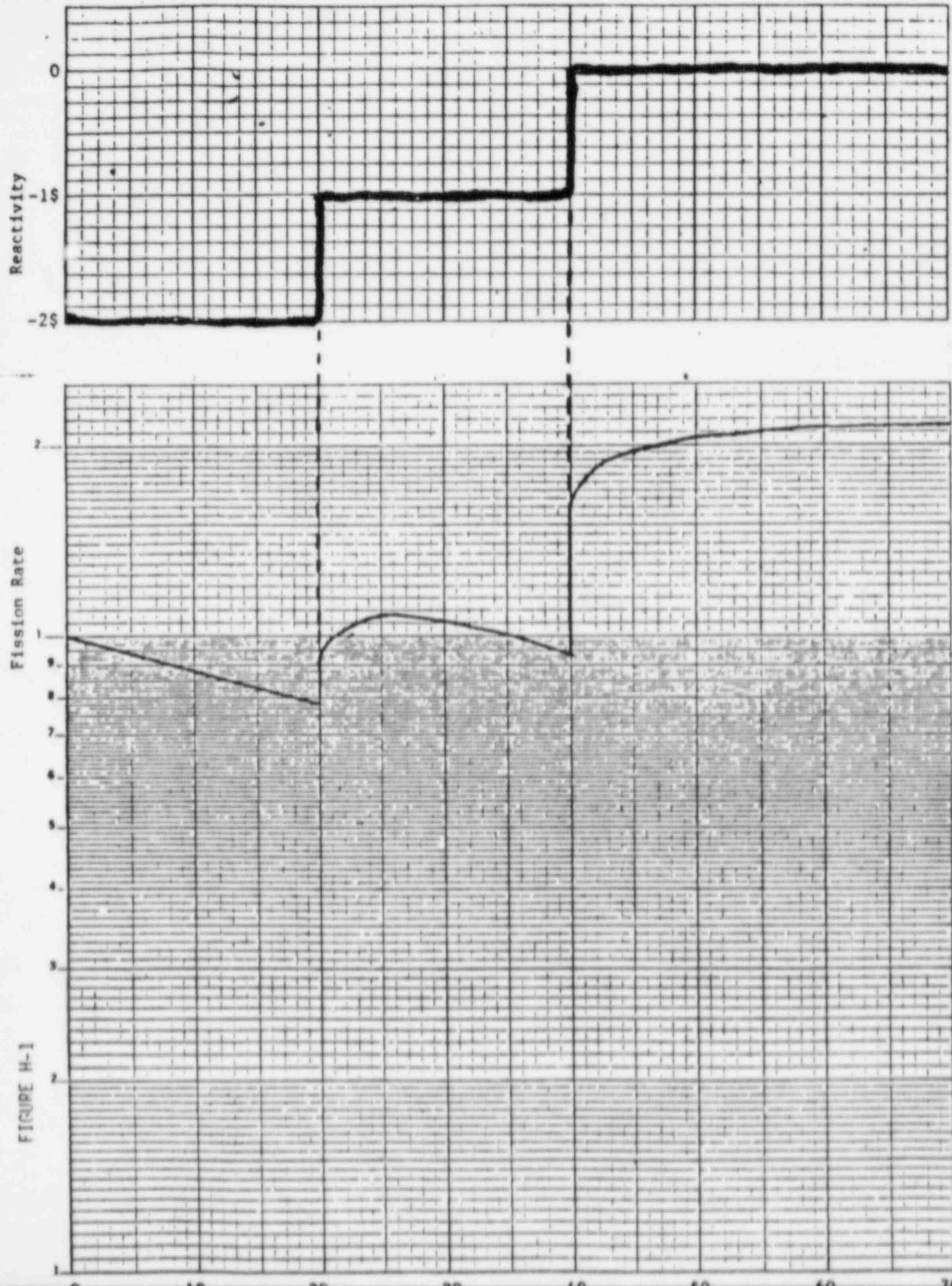


FIGURE H-1

ANSWERS -- WESTINGHOUSE ELECTRIC CORP-85/06/20-R.R.FERRELL

ANSWER I.01 (2.25)

A.300 mRem
B.1875 mRem
C.750 mRem [.75 ea.]

REF.Operating Manual,p.3-21

ANSWER I.02 (2.75)

A.Control Room
Entryway
Reactor Room [0.5 ea.]

B.Reactor Room-area monitor and criticality monitor for fuel storage area
Level meter and audible alarm on the reactor control board
[1.25]

REF.Ops Manual,p.3-22,23

ANSWER I.03 (2.00)

1.Check the battery
2.Use a gamma source to ensure response
3.Check the calibration sticker [.66 ea.]

REF.Operations Manual,p.4-5

ANSWER I.04 (1.00)

D.7.56 days

Effective half-life=TB x TR/TR + TB

REF.Chapter 4,p.4-58

ANSWERS -- WESTINGHOUSE ELECTRIC CORP-85/06/20-R.R.FERRELL

ANSWER I.05 (2.00)

Smear samples-200 dpm beta-gamma or 10 dpm alpha activity per 100 square cm of smear area

REF.Ops Manual,p.3-25

ANSWER I.06 (4.50)

A.Radiation Safety Lab [1.25]
or NTR Office File Safe

B.Stored in envelopes [.5] marked with a radiation warning symbol [.5] and labeled [.25]to show the time of irradiation [.25],type of material [.25] and degree of hazard involved (activity and/or dose rate) [.25] [2.0]

C.NTR Facility file safe [1.25]
or Radiation Safety Lab

REF.Ops Manual,p.3-29

ANSWER I.07 (2.00)

During full power operations the radiation levels at the south wall will be in the order of 30 to 40 mREM/hour due to 'shine' and scattering from the reactor. Accept: North wall of Rx Room

REF.NTR Requalification Training Program.

ANSWER I.08 (2.00)

A.5-100 mREM/hr [1.0]

B.> 100 mREM/hr or 100 mREM in any 5 consecutive days [1.0]

REF.10CFR20.202

ANSWERS -- WESTINGHOUSE ELECTRIC CORP-85/06/20-R.R.FERRELL

ANSWER I.09 (1.50)

A.Whole body exposure > 25 REM;skin > 150 REM;extremities > 375 REM
Releases > 10CFR20 limits (5000 times over 24 hours)
Loss of 1 working week of operations
Damage to property of > $200,000 [3/4 at .75 ea]

B.Exposure to whole body > 5 REM;skin > 30 REM;extremities > 75 REM
Releases > 10CFR20 limits (500 times over 24 hours)
Loss of 1 day of operation
Damage to property of > $2,000 [3/4 at .75 ea]

REF.10CFR20.403

ANSWERS -- WESTINGHOUSE ELECTRIC CORP-85/06/20-R.R.FERRELL

ANSWER J.01 (2.50)

A.TRUE
B.FALSE
C.FALSE
D.TRUE
E.FALSE [.5 ea.]

REF.OPERATING PROCEDURES,pp.4-43,44,59

ANSWER J.02 (3.00)

A.Rod 1 peak diff.worth is app.18 PCM/.01T

Tech Spec. limit $ .035/sec=28 PCM/sec
(Keff>.99)

Therefore max rod speed allowable

$$\frac{28\ PCM}{sec} \times \frac{.01T}{18\ PCM} \times \frac{60\ sec}{min.} \times \frac{4.7\ in}{Turn.} = \frac{4.39\ in}{min.}$$

Therefore:at 3.76 in/min the reactivity addition rate is < .035$/sec [1.5]

B.Sensitivity of detector 8.33 cps/nv

Tech Spec.2.5 nv

(2.5 nv)(8.33 cps/nv)=20.85 cps

24 cps is conservative [1.5]
REF.B4-Requalification Training Program

ANSWER J.03 (2.00)

To minimize the total integrated power

REF.Ops Manual,p.4-44

ANSWERS -- WESTINGHOUSE ELECTRIC CORP-85/06/20-R.R.FERRELL

ANSWER J.04 (2.00)

Only when the reactor is first made critical by control rod movements. This assures that the control rod is the primary mode of reactivity control in a critical reactor.

ACCEPT: REDUCTION IN TRIP SETPOINT PERC. 5%, LOWERING CHANNEL FOR LEVEL TRIP, PROVIDING PORTABLE MONITORS, STABLE PERIOD LONGER THAN 30 SECONDS, CLOSE MONITORING OF RADIATION LEVELS IN THE CONTROL ROOM AND LIMITING RX POWER TO ≤ 2 WATTS

REF.TS,3.1,p.7

ANSWER J.05 (2.50)

With period meters and flux instruments[1.0]where with no rod movement flux instruments indicate a steady increase in power[.75]and a constant positive period is indicated on the period meters[.75] [2.5]

REF.Ops Manual,p.4-4,5

OR NO ROD MOTION
LINEAR T IN POWER IN THE SR WITH SOURCE INSTALLED
VERTICAL TRACE WITH THE SOURCE WITHDRAWN
PERIOD METER WILL TREND TOWARD INFINITY

ANSWER J.06 (2.00)

By poisioning the core with std.stainless steel rods,aluminum inserts and by measuring the reactivity worth of the poision rods and the portions of the control rods still in the core or by meas. the differential rod worths in the normal core. OR EXPERIMENTS SUBTRACTING THE SHUTDOWN REACTIVITY FROM THE TOTAL ROD WORTH

REF.FSAR III-104

ANSWER J.07 (2.00)

$$\text{Mod ratio} = \frac{\Sigma_s \xi}{\Sigma_a}$$

Σ_a (graphite) << Σ_a (water)

Therefore M.R. (graphite) > M.R. (water)

σ_a (H_2O) = .66 barns

σ_a (C_{12}) = .9 x 10^{-3} barns

REF.NTR Requal Training Manual

ANSWERS -- WESTINGHOUSE ELECTRIC CORP-85/06/20-R.R.FERRELL

ANSWER J.08 (2.00)

1.Correct sequence of operations performed
2.Positive reactivity added by only one means at a time
3.Insures proper and safe reactor conditions exist
4.Permits entry of reactor room under specified conditions with reactor'on' but prevents addition of positive reactivity during this entry
5.Assures reactivity addition rates not exceeded

[4/5 at .5 ea]

REF.FSAR III-61 thru 65

ANSWER J.09 (2.00)

Refer to figure J-1

A.Limited Proportionality
B.Ionization Chamber region
C.Geiger Meuller Region
D.Recombination Region
E.Continious Discharge Region
F.Proportional Region

REF.4.Chapter 2,p.2-4

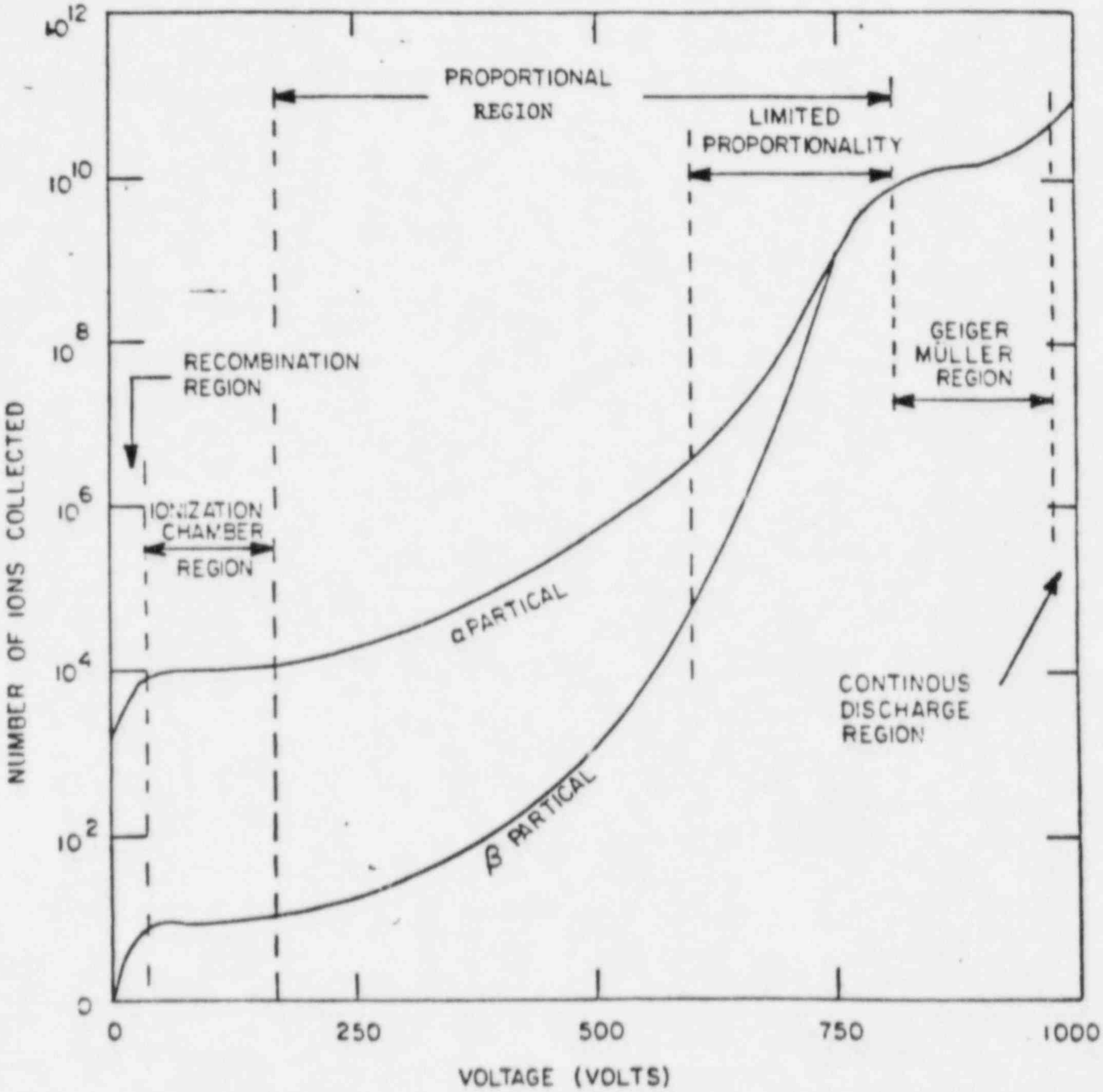


FIGURE J-1 Characteristic Curve of a Gas-Filled Detector

ANSWERS -- WESTINGHOUSE ELECTRIC CORP-85/06/20-R.R.FERRELL

ANSWER K.01 (1.00)

Facility Manager

REF.Ops Manual,p.2-3

ANSWER K.02 (1.50)

1.SRO
2.Radiation Safety Coordinator
3.WTC staff member deemed capable by the NTR Facility Manager [.5 ea.]

REF.Ops Manual,p.2-8

ANSWER K.03 (2.75)

A.Reactor core
Fuel storage area
6 fuel storage thimbles in the Reactor Tank [.25 ea.]
B.6 [.50]
C.Approved Storage Rack (9 locations) [.50]
D.NTR Facility Manager [.50]
E.500 grams [.50]

REF.Ops Manual,p.3-28

ANSWER K.04 (3.00)

A.0.10$/sec when Keff is <0.99 MAX PERTS @.55$
0.035$/sec when Keff >0.99 [.75]

B.1$ [.75]

C.Full out to full in at < 1.2 sec which includes a max carriage release time of 0.125 sec. [.75]

D.5 ft. above the top of the core [.75]

REF.TS,p.5,6,13,14

ANSWERS -- WESTINGHOUSE ELECTRIC CORP-85/06/20-R.R.FERRELL

ANSWER K.05 (3.50)

1.SRO in charge-follow his direction
2.Adequate SDM (at least 3 $)
3.Required instrumentation-1 SR w/audible count rate and intercom working
4.Use of handling tools and equipment
5.Record movement of fuel
6.Personnel dosimetry,portable survey instruments and protective clothing
7.Initial radiation surveys and estimates of exposure
8.Plan job rotation
9.Job responsibilities and tasks
10.do not rush,handle fuel carefully to avoid mechanical damage[7/10 at .5]

REF.Ops Manual,3.5.2,p.3-16

ANSWER K.06 (2.75)

Core is surrounded by about 3 feet of water at the sides,about 6 feet of water at the top. Core is located about 11 feet below ground level. Therefore the earth and cement dump tank structure afford shielding in sideward directions. A cone of radiation is emitted upward in the annulus between the dump and reactor tanks,limiting power levels to 10 kw

REF.7:Appendix A,p.A-4

ANSWER K.07 (4.50)

A.93.5% U-235

B.Aluminum,1 inch thick,elongated hexagonal,shape,with 93 position holes

C.Al,~51 in.in dia.,4 in.thick at edges,6 in.thick in center,with properly positioned holes. Located 44 in.below the upper grid plate. This plate is directly coupled to reactor tank flange.

D.Cadmium

E.19 fuel elements and 5 control rods and followers configured with detectors and source as in NTR-RX-1. Called N-24-S if all 19 elements are standard.

F.Light water,~ 2 feet thick,and graphite cylinders

REF.Ops.Manual A-2,3 [.75 ea]

ANSWERS -- WESTINGHOUSE ELECTRIC CORP-85/06/20-R.R.FERRELL

ANSWER K.08 (1.00)

1.Neutron and Beta-Gamma sensitive TLD

2.Direct readout pocket ion chambers [.5 ea]

REF.Ops Manual,p.4-3

ANSWERS -- WESTINGHOUSE ELECTRIC CORP-85/06/20-R.R.FERRELL

ANSWER L.01 (1.00)

Site Radiation Officier and the NTR Manager {WILL ACCEPT EITHER FOR FULL CREDIT}

REF.Ops Manual,p.3-20

ANSWER L.02 (2.00)

1.2 people in visual contact (1 must be an authorized individual)
2.Rx subcritical by at least 3$ (2400 PCM)-no remote changes which could produce + reactivity effects
3.Audible signal of Rx source multiplication
4.Personnel dosimetry must be worn
5.Personnel exiting must be monitored for external contamination
6.Eating,drinking,or smoking is prohibited
7.Secure small personal items that could fall into the tank [4/7 at.5 ea.]
(ADDITIONAL REQUIREMENTS ATTACHED)

REF.Operations Manual,p.3-40

ANSWER L.03 (2.00)

A.Control rods fully inserted and the master power switch key is removed from the switch OR no fuel in the core [1.0]

B.When it is not secured [1.0]

REF.Ops Manual,p.3-41

ANSWER L.04 (2.50)

Any 5 of the following at .5 each

1.~~Area rad monitor/portable survey instrument recalibration~~
2.~~Smearable contamination measurements on 2 fuel elements~~ } REMOVED ON LAST TECHSPEC REVISION
3.Leak-test of sealed radiation sources
4.Emergency cabinet inventory and eqpt.inspection
5.Inventory of radiation sources
6.Reading of environmental monitoring badges
7.Sample of ion exchanger beds for low level contamination
8.Security key inventory
9.Security system tests and inspections

REF.Ops Manual,p.5-6

ANSWERS -- WESTINGHOUSE ELECTRIC CORP-85/06/20-R.R.FERRELL

ANSWER L.05 (2.25)

A.TRUE
B.FALSE
C.TRUE [.75 ea]

REF.TS,p.38

ANSWER L.06 (3.00)

A.Review of RSC
Approval by facility manager [.5 ea.]
B.Do not change the intent of the original procedure/approved by facility manager [.5 ea.]
C.Recorded in the operating records
Reported to RSC [.5 ea.]

REF.TS.p.44

ANSWER L.07 (2.00)

A.Keff <.99
1 Linear-Log N level with high N level trip
1 Linear-Log N level

B.Keff > .99
2 Linear-Log N level with high N level trip
1 Period with trip
1 Linear or Log Gamma Level with trip

REF.TS,p.51

ANSWER L.08 (2.25)

key-on room entry
management authorization in writing
~~approach~~ APPROVED procedure(EXPERIMENT) [.75 ea]

REF.Ops Manual,p.4.3.4.F

...URES, CONDITIONS AND LIMITATIONS

...E ELECTRIC CORP-85/06/20-R.R.FERRELL

[.6]

[.30 ea]
[.6]

[.30 ea]

[.30 ea]

...(3.00)

...om

...ity staff member present
... levels are < 10CFR20 limits
...R Manager
...years
...uring each each intervening year
...ncy Plan,p.12,21,39