U. S. NUCLEAR REGULATORY COMMISSION

REGION V

Examination Report No. 50-243/OL-86-01

Facility Name: Oregon State TRIGA Reactor

Docket No. 50-243

Examinations Administered at: Corvallis, Oregon, January 6, 1986

Chief Examiner: G. W. Johnston, Operator License Examiner — 1/15/86 Date Signed

Approved By: John O. Elin, Chief, Operations Section — 1/15/86 Date Signed

Summary:

Examinations on December 17-19, 1985

A written examination was administered to one Reactor Operator candidate. The candidate passed the written examination. No Operating examination was administered. A waiver was granted for the Operating examination.

1. Persons Examined

One Reactor Operator candidate.

2. Examiner

*G. Johnston, RV

*Lead Examiner

3. Persons Attending Exit Meeting

Licensee Representatives:

B. Dodd, Assistant Reactor Administrator
T. Anderson, Reactor Supervisor

NRC:

G. Johnston, RV

4. Written Examination and Facility Review

The written exam was administered as follows:

One Reactor Operator - January 6, 1986.

Immediately after the administration of the examination the facility staff reviewed the examination and the key, and provided the examiner with all their comments. No comments were to be forwarded.

5. Exit Meeting

The exit meeting was conducted immediately after the review of the examination. No Operating examination was administered. The examiner discussed future exam scheduling and other concerns raised by the staff about licensing actions.

Resolution of Facility Comments

1.0 Facility Comment: Question C.3

The facility reviewers indicated to the examiner that the pool temperature constant had just been measured and was found to be 4.93 deg. C per 100 kW-hr.

Resolution:

The examiner will take into account the possible use of a different temperature constant as long as the candidate indicates the use of one in the calculation.

2.0 Facility Comment: Question C.4

The reviewers indicated that an insertion of $2.30 of prompt reactivity would place the reactor outside the Technical Specification limits.

Resolution:

The examiner agrees with the comment and will take that into account when grading. If the candidate indicates that it is outside the TS requirements full credit will be allotted.

3.0 Facility Comment: Question C.6

The reviewers expressed a concern that the question may be misleading. This concern was based on reading the answer in the key, it appeared to them that the key focused on delayed neutrons and not the prompt neutrons.

Resolution:

The examiner feels the relationship expressed in the key is important and would expect the candidate to cover it in the response.

U.S. NUCLEAR REGULATORY COMMISSION

REACTOR OPERATOR LICENSE EXAMINATION

Exam Key

graded to

Facility: Oregon State

Reactor Type: TRIGA

Date Administered: January 6, 1986

Examiner: Gary Johnston

Applicant: ____________

INSTRUCTIONS TO APPLICANT:

Use separate paper for the answers. Staple question sheet on top of the answer sheets. Points for each question are indicated in parenthesis 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	Applicant's Score	% of Cat. Value	Category
14	~ 100	______	______	C. General Operating Characteristics
		Final Grade	______	

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

____
Applicant's Signature

C

EQUATION SHEET

$f = ma$

$w = mg$

$E = mC^2$

$KE = \frac{1}{2}mv^2$

$PE = mgh$

$W = v\Delta P$

$\Delta E = 931\Delta m$

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

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

$Pwr = W_f\,\dot{m}$

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

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

$SUR = 26.06/T$

$T = 1.44\ DT$

$SUR = 26\left(\frac{\lambda_{eff}\rho}{\bar{\beta} - \rho}\right)$

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

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

$T = (\bar{\beta} - \rho)/\lambda_{eff}\rho$

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

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

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

$\Sigma = N\sigma$

$T = \frac{t_2 - t_1}{\ln(CR_2/CR_1)}$

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

$v = s/t$

$s = v_o t + \frac{1}{2}at^2$

$a = (v_f - v_o)/t$

$v_f = v_o + at$

$\omega = \theta/t$

$$\text{Cycle efficiency} = \frac{\text{Net Work (out)}}{\text{Energy (in)}}$$

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

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

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

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

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

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

$TVL = 1.3/\mu$

$HVL = 0.693/\mu$

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

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

$CR_1(1 - K_{eff})_1 = CR_2(1 - K_{eff})_2$

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

$M = (1 - K_{eff})_0/(1 - K_{eff})_1$

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

$\ell^* = 1 \times 10^{-5}$ seconds

$\lambda_{eff} = 0.1\ \text{seconds}^{-1}$

$I_1 d_1 = I_2 d_2$

$I_1 d_1^2 = I_2 d_2^2$

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

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

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 Btu = 778 ft-lbf

1 inch = 2.54 cm

$^oF = 9/5\,^oC + 32$

$^oC = 5/9\,(^oF - 32)$

REACTOR OPERATORS EXAMINATION

SECTION C

General Operating Charachteristics

C.1 (4.0)

Refer to the Figure C-1 which shows an instantaneous, negative reactivity insertion into an already critical reactor core (at time t=0), followed by a removal of this negative reactivity after a stable reactor period is reached (at time t=1), thus rendering the reactor critical once again. ASSUMING NO SOURCE NEUTRONS:

a. Show the resulting reactor period as a function of time for this reactivity change. (1.0)

b. Show the reactor power level as a function of time for this reactivity change. (1.0)

c. Explain the shape of the reactor power response at a time IMMEDIATELY AFTER t=0. (1.0)

d. Explain the shape of the reactor power response at a time IMMEDIATELY PRIOR TO t=1. (1.0)

C.1 Answer:

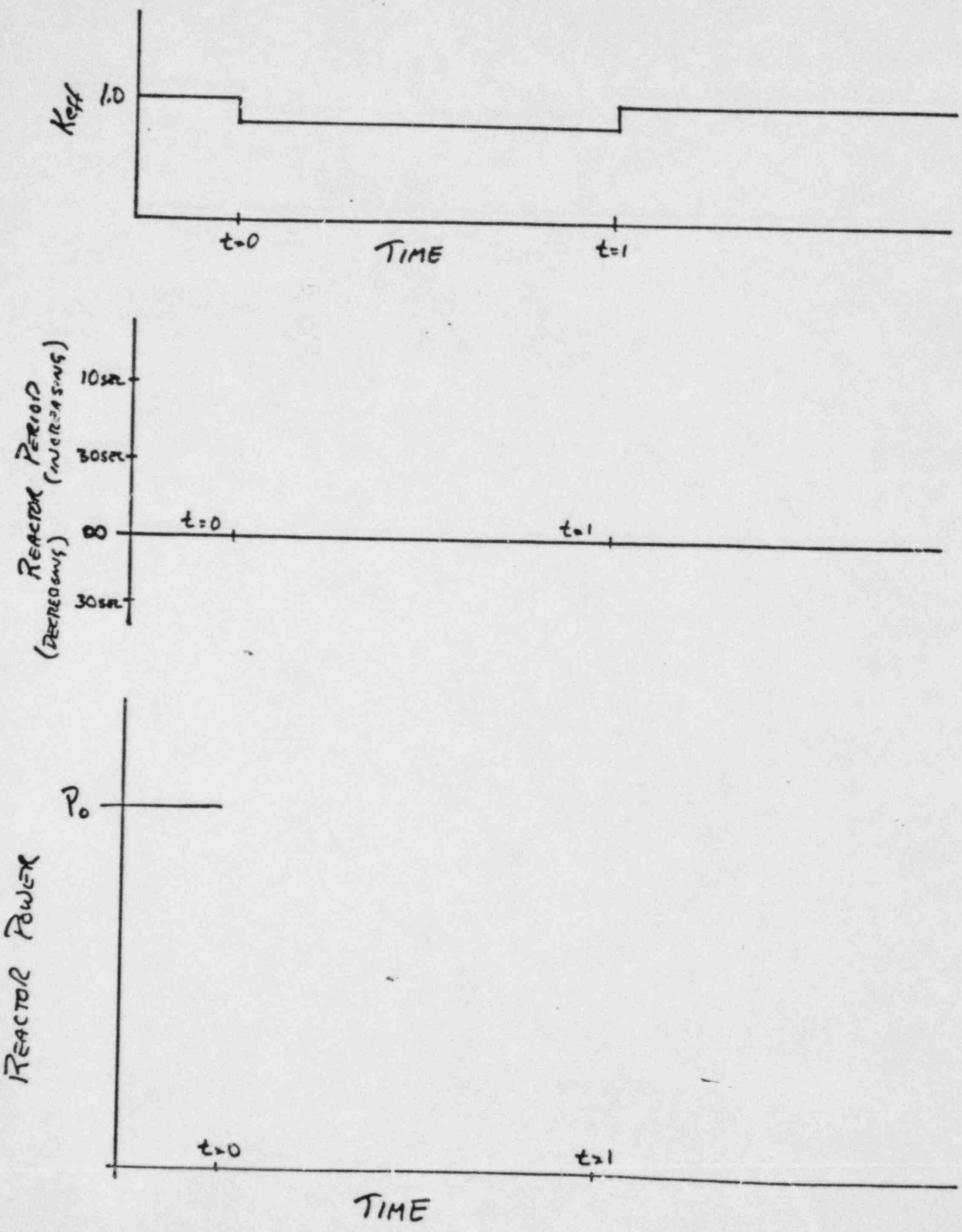
a. and b. ATTACHED (2.0)

c. "Prompt Drop" in total neutron flux due to a reduction in prompt neutron production. (1.0)

d. "Negative Stable Period" due to the decay of delayed neutron precursors. The delayed neutron population is relatively large due to the over abundance of delayed neutron precursors. (1.0)

Reference: "Nuclear Reactor Engineering" (Glasstone and Sesonske)

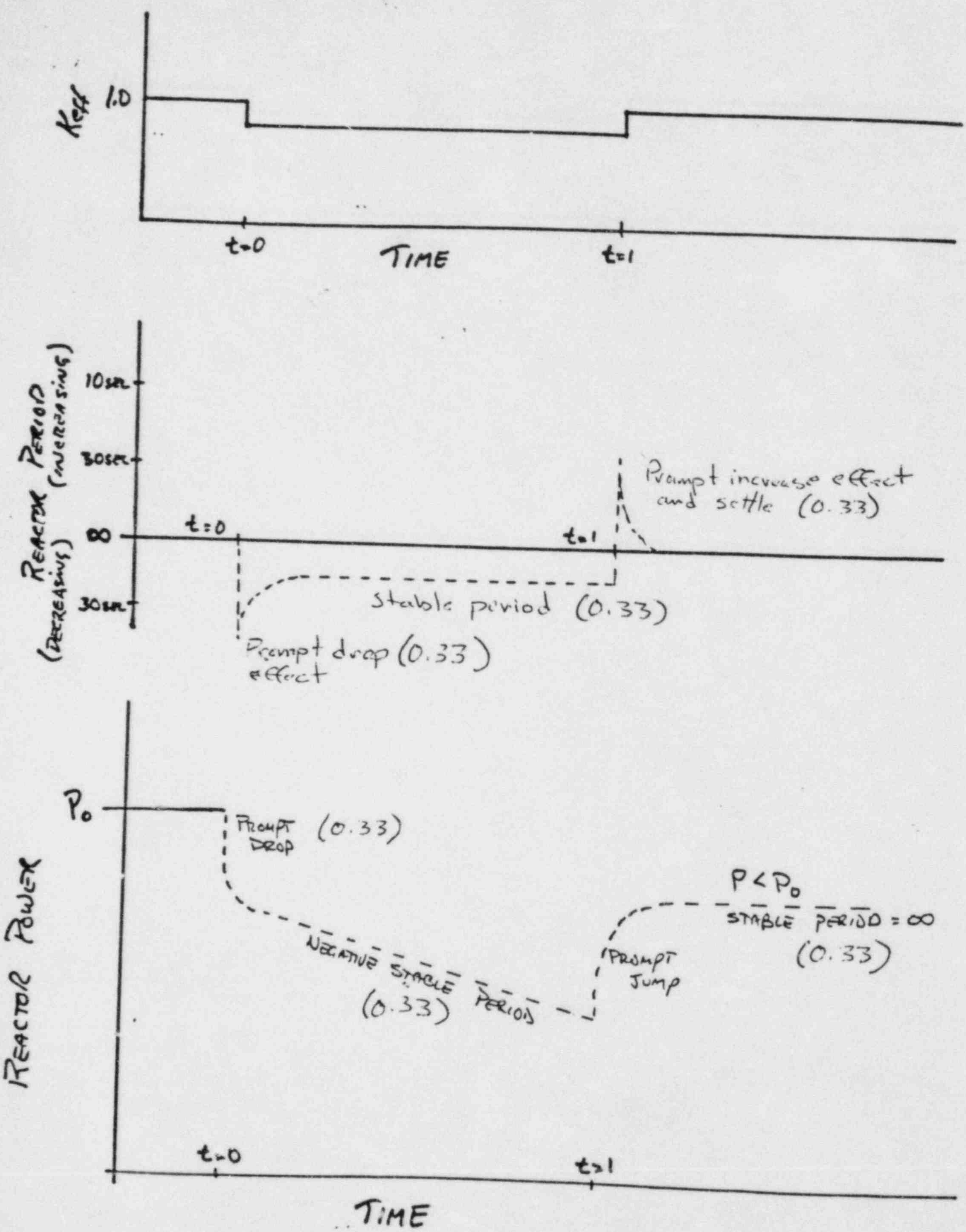
FIGURE C-1



Keff
1.0
t=0
TIME
t=1
REACTOR PERIOD
(INCREASING)
(DECREASING)
10sec
30sec
∞
30sec
t=0
t=1
REACTOR POWER
P0
t=0
t=1
TIME

FIGURE C-1

KEY



C.2 (1.5)

The following data were taken during a transient for a reactor. Calculate the "reactor period".

TIME (SECONDS)	COUNT RATE
0	200
30	330
60	550
90	895
120	1480
150	2440

C.2 Answer:

$$T = \frac{t2 - t1}{\ln (CR2/CR1)}$$

$$= \frac{150 - 30}{\ln (2440/330)}$$

= 60 sec.

Reference: "Academic Program for Nuclear Power Plant Personnel", Volume II, pp. 5-37, General Physics Corporation.

C.3 (2.5)

During operation the secondary cooling system fails, the OSTR pool temperature is 71 deg. F and the reactor is operating at 150 kilowatts.

a. If the reactor continued to operate at 150 kilowatts, what would be the pool temperature after 4 hours? Show any assumptions. (1.5)

b. What would the estimated reactivity effect of this change in pool temperature be? (Indicate magnitude and direction.) (1.0)

C.3 Answer:

a. At approximately 5.25 deg. C per 100 kW-hr the change in temperature would be:

150 (4) = 600 kW-hr (0.5)

5.25 (600)/ 100 = 31.5 deg C. (0.5)

31.5 (9/5) = 56.7 deg. F

71 + 56.7 = 127.7 (+ or - 1 deg.) deg. F (0.5)

Will accept deg. C.

b. With 0.005 $ per 10 deg. C :

- Rho = 31.5 (0.005)/ 10 = 0.0158 $ (1.0)

Reference: "Oregon State TRIGA Training Manual", Volumes V and VI pages V-17 and VI-75.

Candidate may use new pool constant of 4.93 °C per 100kw-hr.

C.4 (2.0)

An experimenter has determined that an experiment needs a pulse of approximately 1500 megawatts peak power. The previously logged pulse had a peak power of 2100 megawatts with a prompt reactivity of $2.30.

a. What prompt reactivity must be inserted to provide an approximate peak of 1500 megawatts? (2.0)

C.4 Answer:

a. P1 = last known pulse = 2100 MW
P2 = Projected pulse = 1500 MW
delta K1 = Prompt reactivity last pulse = $2.30
delta K2 = Prompt reactivity of projected pulse.

$$\frac{P1}{(\text{delta } K1)^{2}} = \frac{P2}{(\text{delta } K2)^{2}} \qquad (1.0)$$

$$(\text{delta } K2)^{2} = \frac{P2\ (\text{delta } K1)^{2}}{P1}$$

$$\text{delta } K2 = \left(\frac{(1500)}{2100}(2.30)^{2}\right)^{0.5}$$

delta K2 = $1.94 (1.0)

Reference: "Oregon State TRIGA Reactor Training Manual", Volume VI, pages VI-101 and VI-102.

$2.30 of prompt reactivity would place reactor outside of Tech. Specs., candidate may not determine answer as Key shows. Full credit for a discussion of Tech. Spec. limitation will be allowed.

C.5 (1.5)

Regarding critical rod position:

a. Give <u>three</u> factors that may cause a change in critical rod position? (1.5)

C.5 Answer:

a.

1. Power history (Xenon, fuel burnup). (0.5)

2. Temperature. (0.5)

3. Experiments. (0.5)

Reference: "Oregon State TRIGA Reactor Training Manual", Volume VI, pages VI-22 to VI-29.

C.6 (1.0)

Regarding reactor control:

a. Why is it important that at their generation (emission), prompt neutrons have a higher average energy level than delayed neutrons? (1.0)

C.6 Answer:

a. The prompt neutrons will experience a greater loss due to leakage and absorbtion from the higher energy level (0.5). This effectively gives the delayed neutrons more influence by giving more weight to their effect on the kinetic behavior of the reactor (0.5).

Reference: "Oregon State TRIGA Reactor Training Manual", Volume VI, pages VI-32 and VI-33.

C.7 (1.5)

Consider two cases, both begin with the same flux level.

Case A: The rods are withdrawn immediately to the point at which criticality occurs.

Case B: The rods are withdrawn slowly to the point of criticality.

a. Will the flux at which the reactor becomes critical be the same for both cases? Explain. (1.5)

C.7 Answer:

a. No (0.5). In Case A the flux will barely have time to change during withdrawal, so that the reactor will become critical at a low flux level (0.5). In Case B, the flux builds in from sub-critical multiplication, therefore it has a considerably larger level than Case A (0.5).

Reference: "Oregon State TRIGA Reactor Training Manual", Volume VI, page VI-50.

END OF SECTION C

END OF EXAMINATION