EXAMINATION REPORT NO. 50-224/OL-84-01

Facility Licensee: University of California, Berkeley
Dept. of Nuclear Engineering
Berkeley, CA 94720

Facility Docket No.: 50-224

Examinations administered at UC Berkeley TRIGA MK III Reactor in Berkeley, California.

Chief Examiner: [signature] for Walter J. Apley, PNL — 9-28-84 Date Signed

Approved by: for [signature] Robert J. Pate, Chief, Reactor Safety Branch — 10-1-84 Date Signed

Summary

Examinations on September 6, 1984.

Written and oral examination administered to one SRO-Instant. The SRO candidate passed both examinations.

REPORT DETAILS

1. Person Examined

   SRO Candidate

2. Examiner

   Walter J. Apley

3. Examination Review Meeting

   At the conclusion of the written examination, W. J. Apley met with T. H. Lim of the UC-Berkeley TRIGA MK III Reactor Staff to review the written examination and answer key. Dr. Lim expressed initial concern that some of the material provided had been out-of-date, but did not find a problem with any of the questions on the written exam.

4. Exit Meeting

   At the conclusion of the site visit, W. J. Apley again met with T. H. Lim to discuss the results of the examinations. The candidate was noted as a "Clear Pass" on the oral portion of the exam. No generic training or facility weaknesses were noted. The facility did not have any information relative to when the next licensing candidate might be put up.

U. S. NUCLEAR REGULATORY COMMISSION

SENIOR REACTOR OPERATOR LICENSE EXAMINATION

Facility: UC Berkeley

Reactor Type: TRIGA MK III

Date Administered: September 6, 1984

Examiner: Walter J. Apley

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
25	25			H. Reactor Theory
15	15			I. Radioactive Materials Handling, Disposal, and Hazards
20	20			J. Specific Operating Characteristics
25	25			K. Fuel Handling and Core Parameters
15	15			L. Administrative Procedures, Conditions, and Limitations
100				TOTALS

Final Grade ______

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

REVIEWED

Walter J. Apley

M. Dean D

[signature]

____
Applicant's Signature

H. REACTOR THEORY (25)

H.1 a. Numerically estimate the reactivity change in % delta K/K which would occur in the TRIGA reactor core, if the water temperature is maintained constant and the fuel temperature is raised 50°C.

1. + .4% delta K/K
2. + .1% delta K/K
3. 0% delta K/K
4. - .1% delta K/K
5. - .4% delta K/K (1.0)

b. Explain the physical phenomena responsible for why changes in fuel temperature affect reactivity. (2.0)

c. If the fuel temperature were held constant and the water temperature raised 50°C, would the reactivity change be the same or different than that of part "a" ? Explain your answer, including the physical phenomena responsible for the reactivity change due to the change in water temperature. Consider the difference in the magnitude of the reactivity changes and in the time responsiveness. (2.0)

H.2 The TRIGA reactor is critical and then the reactivity is increased by $1.00. What is the value of K-eff after the $1.00 addition ? (1.5)

H.3 The fraction of neutrons (produced by thermal neutron fissioning of U-235) that are delayed neutrons is a constant (Beta); however, the value of Beta-eff varies depending on the design of the reactor core. Explain the above statement. (2.0)

H.4 If the nuclear reactor is on a stable 35 sec period with the power level increasing, how long will it take to increase the power level 2 decades ? Show your calculation. (2.0)

-Category H Continued On Next Page-

H.5 The TRIGA reactor is operating at a steady power level of 1 MW when the pool liner is ruptured and the pool is emptied of water in 5 minutes. Assuming that the reactor does not trip (scram), explain what would happen to the reactivity of the core and to the radiation levels adjacent to the pool. (2.0)

H.6 The value of K-eff is 0.5 for the TRIGA reactor core and there is a continuous neutron source which emits 100 neutrons/neutron generation. What is the equilibrium neutron population ? Show any work or assumptions. (1.0)

H.7 The TRIGA reactor is shut down by 5 % delta K/K with a countrate of 10.

a. How much positive reactivity would have to be added to double the countrate ? Show your work. (1.0)

b. How much negative reactivity would have to be inserted to reduce the countrate by 1/2 ? Show your work. (1.0)

c. Why is there a difference in the values obtained for parts "a." and "b." ? (2.0)

H.8 During a power calibration, the connections to the water cooling system are closed. The reactor is operating at 500 kW. If the specific heat of the water/core system is 0.8 Btu/lbm-°F, how much of a temperature rise would be obtained in one hour ? Show your work and any assumptions. (3.0)

-Category H Continued On Next Page-

H.9 The TRIGA reactor has been shut down for 4 weeks. It is then brought immediately to a 1 MW power level and operated continuously and steadily at that level for 50 hours. After 50 hours at 1 MW the reactor is tripped.

a. Sketch the reactivity effect due to Xenon for a time period of 100 hours (from the time the reactor was taken up to 1 MW). (1.5)

b. On the same graph, sketch the reactivity effect due to Xenon if instead of 1 MW the reactor had been taken up to 500 kW. (1.5)

H.10 Choose the most correct statement from those given below. (1.5)

a. The unit of the "barn" is a measure for the macroscopic neutron cross section.

b. The most probable energy for each fission neutron is about 10 MeV.

c. The microscopic cross section for neutron interaction is a function of the isotope of the material and the energy of the neutron.

d. The reaction rate between neutrons and a given material follows a 1/neutron flux variation.

- End of Section H -

I. RADIOACTIVE MATERIALS HANDLING, DISPOSAL AND HAZARDS (15)

I.1 Fill in the table below; i.e., locations "a.", "b." and "c." Choose from values given below the table. (1.5)

External Dose Limits (rem per calendar quarter) (based on 17CAC 30265 (a) and 10 CFR 20.101).

	18 years of age & over
Whole body; head and trunk; active blood-forming organs; lens of eyes; or gonads	a.
Hands and forearms	b.
Skin of whole body	c.

18.75
1.25
7.5
0.75
0.0

I.2 Each proposed Radiation Use Authorization is assigned a Hazard Guide Value (HGV). Explain how the HGV is calculated and explain all quantities used in the calculation. (1.5)

I.3 H-3 is a beta emitter that is of importance in water reactors. It has a half-life of 12.3 yr, a maximum beta energy of 0.0186 MeV and a range in a unit density material of 0.00052 cm.

a. How much (what fraction) of a H-3 beta source has decayed in 24.6 years ? (1.0)

b. If C-14 has a half-life of 5730 yr and a maximum beta energy of .156 MeV, will the range of betas from C-14 in a unit density material be greater than, less than, or equal to the range of betas from H-3 ? (1.0)

-Category I Continued On Next Page-

I.4 A container holds some H-3 such that the contained activity is 0.9 mCi. TRUE or FALSE: If this container holds a cryogenic material and the H-3 is present as an impurity, then any person who uses the cryogenic material is exempt from the regulations of the "Radiation Safety Manual, University of California, Berkeley." (1.0)

I.5 List all the statements from those below that are correct: (2.0)

(a.) The most prominent naturally occurring source of radiation is the sun.

(b.) The earth itself is a source of radiation because of radioactive materials deposited in its crust.

(c.) The average exposure per year per person to radiation from natural sources is in the range of .1 to 1 mrem.

(d.) The most widespread source (in the U.S.) of man-made radiation is the use of X-rays for medical diagnosis and therapy.

(e.) The average exposure per chest X-ray is in the range of 5 to 50 mrem.

I.6 For the Berkeley TRIGA Reactor facility, define the following two terms, including all numerical specifications:

a. Radiation Area (1.0)

b. High Radiation Area. (1.0)

-Category I Continued On Next Page-

I.7 If 1 cm of lead will reduce the gamma-radiation level from 100 mrad/hr to 50 mrad/hr, how many centimeters will be required to reduce a gamma-radiation level from

a. 400 mrad/hr to 50 mrad/hr ? (1.0)

b. 50 mrad/hr to 25 mrad/hr ? (1.0)

I.8 a. Which decay mode listed below is closest to that of Ar-41 ?

1. $t_{1/2}$ = 3.81 hr / beta minus decay / no gamma

2. $t_{1/2}$ = 1.83 hr / beta minus decay / 1-2 Mev gamma

3. $t_{1/2}$ = 7.35 sec / beta plus decay / 6-8 Mev gamma (0.5)

b. Which decay mode listed below is closest to that of N-16 ?

1. $t_{1/2}$ = 1.83 hrs / alpha decay / no gamma

2. $t_{1/2}$ = 35.7 sec / beta minus decay / 1-2 Mev gamma

3. $t_{1/2}$ = 7.35 sec / beta minus decay / 6-8 Mev gamma (0.5)

I.9 Match the quality factor (letter) with the various radiation types (number.

a. Gamma rays
b. Beta particles
c. Alpha particles
d. Neutrons

1. 1
2. 10
3. 20 (2.0)

- End of Section I -

J.0 SPECIFIC OPERATING CHARACTERISTICS (20 POINTS)

J.1 a. What will actuate the emergency power supply ? (1.0)

b. What will happen on an emergency power supply actuation if the natural gas engine does not start within 90 seconds. Include any required operator action. (1.5)

J.2 Describe how, when there is an emergency closure of the valves in the room ventilation system, the neutronics laboratory will be maintained at a pressure slightly below atmospheric and that any air exhausted from the room will be scrubbed and filtered. (2.5)

J.3 Where does water from the personnel decontamination area (NE-10) drain to ? (0.5)

J.4 The pool volume is approximately how many cubic feet ? (0.5)

a. 500 ft3
b. 1000 ft3
c. 5000 ft3
d. 50,000 ft^3.

J.5 TRUE or FALSE: The Vertical Thermal Column is located below the Horizontal Thermal Column. (1.0)

J.6 TRUE or FALSE: The high speed pneumatic transfer system can be used when the reactor is in the center of the pool or at either end. (1.0)

J.7 Describe the design feature which minimizes the dose rate at the pool surface resulting from the nitrogen-16 formed in the coolant water as it passes through the core. (1.0)

J.8 During square wave operation, what:

a. Prevents a Period SCRAM ? (0.5)

b. Ensures that the linear power SCRAM is set at 1.1 MW ? (1.0)

-Category J Continued On Next Page-

J.9 What prevents movement of the reactor by the bridge drive while the reactor is operating ? (1.0)

J.10 What automatic action will occur if the pool water level drops below the top grid ? (1.5)

J.11 List the four (4) functions of the pool water cooling and purification system. (2.0)

J.12 TRUE or FALSE: Water flowing through the demineralizer must first pass through the shield cooling system. (1.0)

J.13 The following six (6) components are all located in which one of the listed regions (letter) ? (1) the watertight rotary specimen rack assembly, which surrounds the core / (2) the specimen removal tube / (3) the tube and shaft assembly / (4) the drive and indicator assembly on the reactor bridge / (5) the buoyancy chambers for vertical movement of the rotary specimen rack / (6) the specimen lifting assembly.

----

a. Horizontal thermal column
b. Vertical thermal column
c. Isotope production facility
d. Beam port facility (1.0)

J.14 Plot power and fuel temperature versus time for a $3.00 pulse. Assume that the pulse peaks at 2000 MW, peak fuel temperature is 450 degrees C, and the pulse width (as defined in the UC Berkeley SAR) is 20 milli-seconds. (2.0)

J.15 The maximum fuel temperature experienced by the TRIGA fuel following a Loss of Coolant accident has been conservatively estimated in the SAR as:

a. 200 to 300 degrees C
b. 550 to 700 degrees C
c. 900 to 1050 degrees C
d. 1250 to 1400 degrees C (1.0)

-End of Category J-

K.0 FUEL HANDLING AND CORE PARAMETERS (25 POINTS)

K.1 What design feature prevents a rod from dropping out of the bottom of the core ? (1.0)

K.2 Describe the location of the fuel element thermocouples, including why they are sited where they are. (1.5)

K.3 TRUE or FALSE: All control rods have a stroke of 15 inches. (0.5)

K.4 Match the control rod worth (letter) with the appropriate value (Number) listed below. (1.5)

a. Net change in reactivity caused by the withdrawal of a safety rod.

b. Net worth of each of the shim and regulating rods.

c. Net change in reactivity that can be caused by the operational withdrawal of the transient rod.

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1. 1.8% delta K/K
2. 2.1% delta K/K
3. 2.7% delta K/K

K.5 TRUE or FALSE: In the Transient Rod Drive System, the piston that strikes the anvil at the upper limit stop is the same one that strikes the bottom limit. (1.0)

K.6 TRUE or FALSE: During pulsing mode operation only the transient rod can be moved. (1.0)

-Category K Continued On Next Page-

K.7 Draw a top view of the reactor core grid array showing location of the:

a. Source
b. Core orientation relative to the exposure room
c. Three control rods
d. Transient rod
e. Pneumatic transfer system (rabbit) in-core terminus (2.5)

K.8 How does the fuel element worth (compared to water) change as you move from core ring G to F to E to D to C to B ? (1.0)

K.9 In the event of a fuel element failure, which of the isotopes listed below will escape to the control room ? Note: More than one answer may be correct.

a. Bromine
b. Iodine
c. Xenon
d. Krypton (1.0)

K.10 During fuel handling, by what amount must the reactor be subcritical ?

a. 0.50% delta K/K
b. 0.70% delta K/K
c. 1.00% delta K/K
d. 3.46% delta K/K (1.0)

K.11 TRUE or FALSE: Pool water level can be lowered to 10 to 20 inches from maximum to facilitate fuel and control rod handling. (1.0)

K.12 When moving a fuel element, what is the minimum water level that should be maintained over the element to provide adequate shielding ?

a. 1 to 2 feet
b. 3 to 4 feet
c. 5 to 6 feet
d. 8 to 9 feet (1.0)

-Category K Continued On Next Page-

K.13 Which of the following are not precautions listed in the Reactor Handling Equipment section of the Operations Manual ?

a. Never force the handle into or out of a locking position. If it does not rotate easily, push or pull the handle slightly, then try again.
b. When inserting or removing elements, be certain the handle is locked.
c. When an element is engaged in the grapple mechanism, the handle end of the tool should never be laid on the floor or on the tank covers.
d. When an element is engaged in the grapple mechanism, never coil the control cable in a circle of a diameter greater than about two (2) feet. (1.0)

K.14 Fuel elements which have bowing in excess of ? inch and longitudinal growth in excess of ? inch should be removed from the core prior to conducting any further pulsing operations.

a. .620, .010
b. .100, .062
c. .062, .100
d. .010, .620 (1.0)

K.15 When inspecting a fuel element, which is done first; the "bow test" or the "length measurement ?" (0.5)

K.16 Describe how a control rod calibration is performed. (2.5)

K.17 According to the TRIGA Mk III Technical Specifications, fuel elements being stored shall always be arranged in a geometrical array where the K-effective is less than ? for all conditions of moderation.

a. .98
b. .93
c. .88
d. .80 (1.0)

-Category K Continued On Next Page-

K.18 Which of the following rods may incorporate a fueled follower ? More than one response may be correct. If so, list all that are.

a. Shim Rod
b. Safety Control Rod
c. Regulating Control Rod
d. Transient Control Rod (1.0)

K.19 TRUE or FALSE: Fuel element bowing that results in touching will directly lead to a rapid fuel element failure. (1.0)

K.20 According to Technical Specifications, the reactivity worth of any single experiment shall be less than __?__ dollars. Fill in the blank. (1.0)

K.21 a. According to Technical Specifications, what is the fuel element thermocouple temperature limiting safety system setting ?

1. 500 degrees F
2. 900 degrees F
3. 930 degrees F
4. 1000 degrees F (1.0)

b. In which ring(s) should the thermocouple be placed ?

1. A
2. B or C
3. D or E
4. F or G
5. Any (1.0)

-End of Category K-

L. ADMINISTRATIVE PROCEDURES, CONDITIONS AND LIMITATIONS (15)

L.1 List all those statements below which are correct for the Berkeley TRIGA Reactor facility. (2.0)

(a.) NRC and State regulations require that all persons working in or frequenting a radiation area shall be informed of the presence of radioactivity.

(b.) Authorized Users working under the jurisdiction of a NRC license shall inform all female workers and/or students of the contents of NRC Regulatory Guide 8.13, Instructions Concerning Prenatal Radiation Exposure.

(c.) High Radiation Areas shall be properly and conspicuously posted; Radiation Areas and areas with even less potential dose levels need not be posted.

(d.) Current Radiation Use Authorizations shall be posted in the laboratories covered by the Authorization.

L.2 List those statements which are correct for the Berkeley TRIGA Reactor facility. (2.0)

(a.) All shipments of radioactive materials must have the prior approval of the Office of EH&S.

(b.) Packaging, monitoring and labeling of radioactive materials for shipment is the sole and direct responsibility of the Authorized User.

(c.) No radioactive material may be transferred from one person, department or project to another within the campus jurisdiction without the approval of the Radiation Safety Officer.

(d.) Approval must be obtained in advance from the Office of EH&S for special handling of shipments containing perishable or short half-life materials.

-Category L Continued On Next Page-

L.3 You are the reactor operator when a spill of radioactive material occurs. The accident could be classified as a major radiation incident or as a minor radiation incident. This accident could occur during normal working hours or during off-normal working hours.

a. Explain major radiation incidents and minor radiation incidents. (1.0)

b. What notification actions should you take ? (1.0)

L.4 From the following statements, choose the one statement that is the most correct. (1.0)

(a.) All experiments that are to be conducted with the use of the reactor are classified into five experimental classes (A,B,C,D and E).

(b.) If an experimenter plans to take any part of his experiment which has been activated as part of or incidental to the experiment out of the Reactor Facility, he need only have the approval of the reactor operator..

(c.) Experiments in Class A shall be subject to the restriction of no reactivity change larger than 0.7 % delta K/K.

(d.) All experiments that require the use of the exposure room must be classified as Class C or a more severe class.

L.5 Explain the difference between the A-List of personnel and the B-List with respect to entry to the reactor. (1.0)

L.6 List the two (2) personnel required to be present at the beginning of a Class B experiment (1.0)

L.7 List the three (3) personnel required to be present at the beginning of a Class C experiment. (1.0)

-Category L Continued On Next Page-

L.8 When the TRIGA reactor is operating, explain the responsibilities of the

a. Senior-Operator-in-Charge (0.5)

b. Reactor Operator. (0.5)

L.9 List the letter designations of all those statements given below that are correct statements. (2.0)

(a.) A copy of GA6600 - TRIGA Mk III Instrumentation Manual is kept at the reactor console.

(b.) All unexplained reactor trips (scrams) must be reported to the Reactor Supervisor and his approval obtained before the reactor may be restarted.

(c.) The excess reactivity of the reactor will be measured and recorded in the Reactor-Operations Log Book after any change that is calculated to affect the reactivity of the core by more than 7 % delta K/K.

(d.) At least two persons will be present whenever any maintenance work is being performed on the reactor.

L.10 In the event of a fire in the reactor room which is detected while you are at the control console, list your required actions. Consider the possibility that the fire cannot be controlled by the operating staff. (2.0)

- End of Section L -

-End of Exam-

EQUATION SHEET

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

$(\text{density})_1(\text{velocity})_1(\text{area})_1 = (\text{density})_2(\text{velocity})_2(\text{area})_2$

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

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

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

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

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

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

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 inch = 2.54 centimeters
Degrees F = (1.8) x (Degrees C) + 32
1 Btu = 778 ft-lbf
$g = 32.174$ ft-lbm/lbf-sec^2

U. S. NUCLEAR REGULATORY COMMISSION

SENIOR REACTOR OPERATOR LICENSE EXAMINATION

Facility: UC Berkeley

Reactor Type: TRIGA MK III

Date Administered: September 6, 1984

Examiner: Walter J. Apley

Applicant: ______________________

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15	15			L. Administrative Procedures, Conditions, and Limitations
100				TOTALS

ANSWER KEY

Final Grade ________

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

REVIEWED

Walter J. Apley

____
Applicant's Signature

H. REACTOR THEORY (25)

H.1 a. Numerically estimate the reactivity change in % delta K/K which would occur in the TRIGA reactor core, if the water temperature is maintained constant and the fuel temperature is raised 50°C.

1. + .4% delta K/K
2. + .1% delta K/K
3. 0% delta K/K
4. - .1% delta K/K
5. - .4% delta K/K (1.0)

b. Explain the physical phenomena responsible for why changes in fuel temperature affect reactivity. (2.0)

c. If the fuel temperature were held constant and the water temperature raised 50°C, would the reactivity change be the same or different than that of part "a" ? Explain your answer, including the physical phenomena responsible for the reactivity change due to the change in water temperature. Consider the difference in the magnitude of the reactivity changes and in the time responsiveness. (2.0)

a. *5

b. There is a large prompt negative temperature coefficient associated with the loss in moderating properties of the uranium - zirconium hydride fuel - moderator material at higher temperatures (underlined for full credit)

c. Different - (1.0)
Bath coefficient is actually slightly positive (0.5) going from 20-60°C and much slower (0.5) It is positive due to changing resonance capture pt. for neutrons.

Ref: SAR, p. 5-4, i, ii

H.2 The TRIGA reactor is critical and then the reactivity is increased by $1.00. What is the value of K-eff after the $1.00 addition ? (1.5)

$1.00 ≙ .7% ΔK/K

From formula sheet

$$\text{delta } k = \frac{(K_{eff} - 1)}{K_{eff}}$$

$$.7\%\ \Delta K/K = \frac{(K_{eff} - 1)}{K_{eff}}$$

$$K_{eff}(.7 \times 10^{-2}) = K_{eff} - 1$$

$$K_{eff}(.7 \times 10^{-2} - 1) = -1$$

$$K_{eff} = \frac{1}{(1 - .7 \times 10^{-2})} = \frac{1}{.993}$$

$$\boxed{K_{eff} = 1.00705}$$

Ref: SAR, p. 5-3

H.3 The fraction of neutrons (produced by thermal neutron fissioning of U-235) that are delayed neutrons is a constant (Beta); however, the value of Beta-eff varies depending on the design of the reactor core. Explain the above statement. (2.0)

Delayed neutrons are born at lower energies and therefore dependent on the design of the core a higher fraction (proportionally than fast neutrons) reach thermal energies where they can cause new fissions. It is at this lower energy that beta-eff is measured.

Ref: Lamarsh, Intro to Nucl. Engr., p. 73.

H.4 If the nuclear reactor is on a stable 35 sec period with the power level increasing, how long will it take to increase the power level 2 decades ? Show your calculation. (2.0)

T = 35 second period

∴ from formula sheet

$$SUR = \frac{26.06}{35} = .745$$

A SUR of .745 means that to go 2 decades

$$\frac{2}{.745} = \underline{\underline{2.68 \text{ minutes}}}$$

Another way to calculate

2 decades ≙ 100

From Formula sheet

$$P = P_0 e^{t/\tau}$$

$$\frac{P}{P_0} = 100 = e^{t/\tau} = e^{t/35\,sec}$$

$$\ln 100 = t/35 \text{ sec}$$

$$t = (35 \text{ sec})(\ln 100) = 35 \times 4.61$$

$$= \underline{2.68 \text{ minutes or } 161 \text{ seconds}}$$

Either way OK

Ref: Lamarsh, Intro to Nucl Engr, p.22

H.5 The TRIGA reactor is operating at a steady power level of 1 MW when the pool liner is ruptured and the pool is emptied of water in 5 minutes. Assuming that the reactor does not trip (scram), explain what would happen to the reactivity of the core and to the radiation levels adjacent to the pool. (2.0)

The reactor will go subcritical due to the loss of cooling water (1.0). The radiation levels would go up, but only to about 2-5 rem/hr on the patio.

Ref: SAR, p. 7-47 and 50

H.6 The value of K-eff is 0.5 for the TRIGA reactor core and there is a continuous neutron source which emits 100 neutrons/ neutron generation. What is the equilibrium neutron population ? Show any work or assumptions. (1.0)

From Formula Sheet:

$$CR = \frac{S}{1 - K_{eff}}$$

$$= \frac{100}{1 - .5}$$

CR = 200 neutrons

Ref: Lamarsh, Intro to Nuclear Engineering, p.254

H.7 The TRIGA reactor is shut down by 5 % delta K/K with a countrate of 10.

a. How much positive reactivity would have to be added to double the countrate ? Show your work. (1.0)

b. How much negative reactivity would have to be inserted to reduce the countrate by 1/2 ? Show your work. (1.0)

c. Why is there a difference in the values obtained for parts "a." and "b." ? (2.0)

From formula sheet

a. $K_{eff} = .95$ when $\delta K = 5\%\ \Delta K/K$

$\therefore CR_1(1-K_{eff_1}) = CR_2(1-K_{eff_2})$

$10(1-.95) = 20(1-K_{eff_2})$

$\frac{1}{2}(1-.95) - 1 = -K_{eff_2}$

$1 - .025 = K_{eff_2}$

$\boxed{K_{eff_2} = .975}$

b. $CR_1(1-K_{eff_1}) = CR_2(1-K_{eff_2})$

$10(1-.95) = 5(1-K_{eff_2})$

$\boxed{K_{eff_2} = .9}$

c. Margin to criticality is not a linear effect on count rate because it is extending the time it takes for n's to achieve equilibrium by multiplication. Therefore it is a log effect.

Ref: Lamarsh, Intro to Nucl. Engineering, p. 254

H.8 During a power calibration, the connections to the water cooling system are closed. The reactor is operating at 500 kW. If the specific heat of the water/core system is 0.8 Btu/lbm-°F, how much of a temperature rise would be obtained in one hour ? Show your work and any assumptions. (3.0)

Assume volume of pool 5000 ft³ or about 40,000 gallons (not needed for full credit).

V = 40,000 gal

From formula sheet 1 MW = 3.41×10^6 Btu/hr

∴ 500 Kw = 1.71×10^6 Btu/hr

$$\text{Heat up Rate} = \frac{\text{Heat in}}{(\text{Vol})(\text{spec ht})} = \frac{1.71 \times 10^6 \text{ Btu/hr}}{(40{,}000\text{ gal})(8 \text{ lb/gal})(.8 \text{ Btu/lb-°F})}$$

HUR = 6.67 °F/hr

Method important - 3/4 full credit
1/4 if value calculated correctly and assumptions not so off that temp/hr < 3°F/hr or over 15 °F/hr.

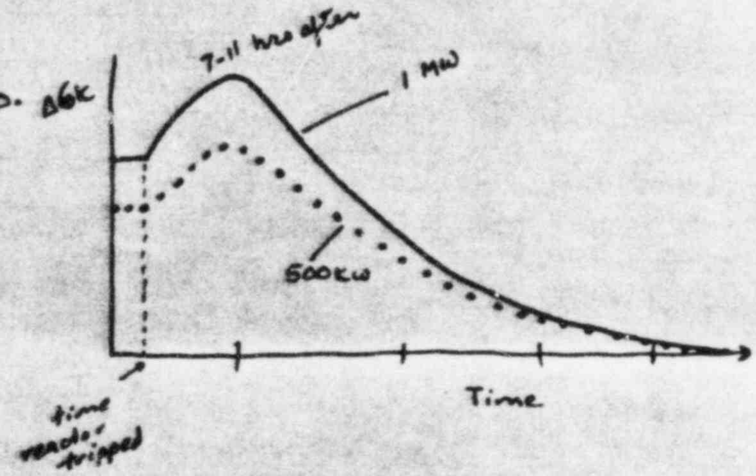
Ref: Reynolds, Thermodynamics, p. 85

H.9 The TRIGA reactor has been shut down for 4 weeks. It is then brought immediately to a 1 MW power level and operated continuously and steadily at that level for 50 hours. After 50 hours at 1 MW the reactor is tripped.

a. Sketch the reactivity effect due to Xenon for a time period of 100 hours (from the time the reactor was taken up to 1 MW). (1.5)

b. On the same graph, sketch the reactivity effect due to Xenon if instead of 1 MW the reactor had been taken up to 500 kW. (1.5)

a,b.



For "a" full credit

1.0 - shape of curve

.5 - pk in 7-11 hrs

For "b"

.5 - shape of curve

.35 - pk in 7-11 hrs

.65 - less but more than 1/2 of 1 MW case

Ref: Lamarsh, Intro to Nucl. Engr., p. 286

H.10 Choose the most correct statement from those given below. (1.5)

a. The unit of the "barn" is a measure for the macroscopic neutron cross section.

b. The most probable energy for each fission neutron is about 10 MeV.

c. The microscopic cross section for neutron interaction is a function of the isotope of the material and the energy of the neutron.

d. The reaction rate between neutrons and a given material follows a 1/neutron flux variation.

a. False - microscopic

b. False - ave energy ~ 1.98 MeV
with most probable ~ .73 MeV

c. True

d. False - maybe 1/energy but not ϕ

Ref: Lamarsh, Intro to Nucl. Engr, p.76

I. RADIOACTIVE MATERIALS HANDLING, DISPOSAL AND HAZARDS (15)

I.1 Fill in the table below; i.e., locations "a.", "b." and "c." Choose from values given below the table. (1.5)

External Dose Limits (rem per calendar quarter) (based on 17CAC 30265 (a) and 10 CFR 20.101).

	18 years of age & over
Whole body; head and trunk; active blood-forming organs; lens of eyes; or gonads	a.
Hands and forearms	b.
Skin of whole body	c.

18.75
1.25
7.5
0.75
0.0

a. 1.25
b. 18.75
c. 7.5

Ref: Rad Safety Manual, p. 47

I.2 Each proposed Radiation Use Authorization is assigned a Hazard Guide Value (HGV). Explain how the HGV is calculated and explain all quantities used in the calculation. (1.5)

Hazard Guide Value: A method used by the Office of EH&S to determine the relative hazard of a given experiment. The Hazard Guide Value is calculated by the formula, HGV = QTU where Q is the quantity in uCi, T is the toxicity factor of the radioisotope and U is the experimental use factor.

Ref: Rad Safety Manual, p.53-54

½ credit for definition - relative hazard
½ credit (.75) for three parameters

Toxicity - MPC in air of radionuclides
Use Factor - additive penalty factor based on potential for release of isotope to environment, contamination of personnel, and contamination of equipment and facilities.

I.3 H-3 is a beta emitter that is of importance in water reactors. It has a half-life of 12.3 yr, a maximum beta energy of 0.0186 MeV and a range in a unit density material of 0.00052 cm.

a. How much (what fraction) of a H-3 beta source has decayed in 24.6 years ? (1.0)

b. If C-14 has a half-life of 5730 yr and a maximum beta energy of .156 MeV, will the range of betas from C-14 in a unit density material be greater than, less than, or equal to the range of betas from H-3 ? (1.0)

a. ½ life of 12.3 yrs means it will decrease.

12.3 yrs to $1/2$

24.6 yrs to $1/2 \times 1/2 = \underline{1/4}$

b. Important thing here is the energy of the beta, not the half-life or source. Therefore the high energy beta from the C-14 will have a greater range.

Ref: Radiological health handbook, p. 124

1.4 A container holds some H-3 such that the contained activity is 0.9 mCi. TRUE or FALSE: If this container holds a cryogenic material and the H-3 is present as an impurity, then any person who uses the cryogenic material is exempt from the regulations of the "Radiation Safety Manual, University of California, Berkeley." (1.0)

True

Ref: Rad Safety Manual, p. 13

1.5 List all the statements from those below that are correct: (2.0)

(a.) The most prominent naturally occurring source of radiation is the sun.

(b.) The earth itself is a source of radiation because of radioactive materials deposited in its crust.

(c.) The average exposure per year per person to radiation from natural sources is in the range of .1 to 1 mrem.

(d.) The most widespread source (in the U.S.) of man-made radiation is the use of X-rays for medical diagnosis and therapy.

(e.) The average exposure per chest X-ray is in the range of 5 to 50 mrem.

a. True
b. True
c. False - closer to 170 mrem (range 100-200 mrem)
d. True
e. True

Ref: Rad Safety Manual, Blue Appendix, p. 17

I.6 For the Berkeley TRIGA Reactor facility, define the following two terms, including all numerical specifications:

a. Radiation Area (1.0)

b. High Radiation Area. (1.0)

Radiation area: Any area, accessible to individuals, in which there exists radiation at such levels that an individual could receive in any one hour a dose to the whole body in excess of 5 millirem, or in any 5 consecutive days a dose in excess of 100 millirem.

High radiation area: Any area, accessible to individuals, in which there exists radiation at such levels that an individual could receive in any one hour a dose to the whole body in excess of 100 millirem.

Ref: Rad Safety Manual, p. 7+8

I.7 If 1 cm of lead will reduce the gamma-radiation level from 100 mrad/hr to 50 mrad/hr, how many centimeters will be required to reduce a gamma-radiation level from

a. 400 mrad/hr to 50 mrad/hr ? (1.0)

b. 50 mrad/hr to 25 mrad/hr ? (1.0)

a. 1 cm D_γ goes from 100 to 50
∴ 1 cm is a half-thickness
to reduce the dose from 400→50, a factor of 8 will take

$$\underbrace{\tfrac{1}{2} \times \tfrac{1}{2} \times \tfrac{1}{2}} = \tfrac{1}{8}$$

3 half-thicknesses or **3 cm**

b. It take the same thickness to reduce the level from 50 to 25 as it did from 100 to 50. ∴ answer **1 cm**

Ref: LaMarsh, Radn. Shielding, p. 420

1.8 a. Which decay mode listed below is closest to that of Ar-41 ?

1. $t_{1/2}$ = 3.81 hr / beta minus decay / no gamma

2. $t_{1/2}$ = 1.83 hr / beta minus decay / 1-2 Mev gamma

3. $t_{1/2}$ = 7.35 sec / beta plus decay / 6-8 Mev gamma (0.5)

b. Which decay mode listed below is closest to that of N-16 ?

1. $t_{1/2}$ = 1.83 hrs / alpha decay / no gamma

2. $t_{1/2}$ = 35.7 sec / beta minus decay / 1-2 Mev gamma

3. $t_{1/2}$ = 7.35 sec / beta minus decay / 6-8 Mev gamma (0.5)

a. #2

b. #3

Ref: Ops Man, p. 59
Radiological Health Handbook, p. 384 + 234
SAR, p. 7-5

I.9 Match the quality factor (letter) with the various radiation types (number.

a. Gamma rays
b. Beta particles
c. Alpha particles
d. Neutrons

1. 1
2. 10
3. 20

(2.0)

a. 1
b. 10
c. 20
d. 10

Ref: Radiological Health Handbook, p.432

J.0 SPECIFIC OPERATING CHARACTERISTICS (20 POINTS)

J.1 a. What will actuate the emergency power supply ? (1.0)

b. What will happen on an emergency power supply actuation if the natural gas engine does not start within 90 seconds. Include any required operator action. (1.5)

a. Loss of line voltage

b. The battery will be disconnected (0.5)
The starter motor will have to be actuated manually (1.0)

Ref: SAR, p. 2-8

J.2 Describe how, when there is an emergency closure of the valves in the room ventilation system, the neutronics laboratory will be maintained at a pressure slightly below atmospheric and that any air exhausted from the room will be scrubbed and filtered. (2.5)

Upon emergency closure of the butterfly valves in the room ventilation system, the valves in the scrubber by-pass system are positioned so that room air is drawn through a separate absolute filter and thence through an activated charcoal scrubber for absorption of radio-active iodine and other absorbable species. The charcoal scrubber operates at room temperature, and is located at the south-west corner of the neutronics laboratory. In this way, the glove box ventilation system automatically becomes an emergency purge system which insures that the neutronics laboratory is maintained at a pressure slightly below atmospheric and that all air exhausted from the room is scrubbed and filtered.

Ref: SAR, p. 2-6 + 2-7

2.0 pts - what system lineup does it
.5 pts - flow path

J.3 Where does water from the personnel decontamination area (NE-10) drain to ? (0.5)

500 gal sump tk in room NE 1-11

Ref: SAR, p. 2-5

J.4 The pool volume is approximately how many cubic feet ? (0.5)

a. 500 ft^3
b. 1000 ft^3
c. 5000 ft^3
d. 50,000 ft^3.

c.

Ref: SAR, p.3-2

J.5 <u>TRUE</u> or <u>FALSE</u>: The Vertical Thermal Column is located <u>below</u> the Horizontal Thermal Column. (1.0)

False

Ref: SAR, Fig. 3-1, between pp. 3-2 and 3-3

J.6 <u>TRUE</u> or <u>FALSE</u>: The high speed pneumatic transfer system can be used when the reactor is in the center of the pool <u>or</u> at either end. (1.0)

True

Ref: SAR, p.4-14

J.7 Describe the design feature which minimizes the dose rate at the pool surface resulting from the nitrogen-16 formed in the coolant water as it passes through the core. (1.0)

Although the trapsport time for the N^{16} through the column of water above the core provides a large attenuation factor for N^{16} decay, a water jet diffuser has been added to provide additional decay time. The diffuser system pump is mounted on the reactor bridge above the pool. An aluminum suction pipe picks up pool water and discharges it in a stream angled downward just above the top of the core shroud. The turbulence thus imparted to the water convection currents leaving the core shroud breaks up gas bubbles and increases the distance that the N^{16} must travel to reach the surface of the pool water. This action significantly reduces the radiation intensity at the top of the reactor pool.

.5 credit for jet diffuser
.35 credit for increasing time
.15 credit for breaking up gas bubbles.

Ref: SAR, p. 3-31

J.8 During square wave operation, what:

a. Prevents a Period SCRAM ? (0.5)

b. Ensures that the linear power SCRAM is set at 1.1 MW ? (1.0)

(a)

In this mode the period meter and scram are disconnected, and the range switch on the linear power channel is set at the 1-Mw level. The linear power scram is thus retained at 1.1 Mw. An interlock prevents initiation of the square wave unless the range switch is on the 1-Mw setting.

(b)

Ref: SAR, p. 3-21

J.9 What prevents movement of the reactor by the bridge drive while the reactor is operating ? (1.0)

There is no power to the bridge drive unless the console key switch is off

Ref: SAR, p.3-25

J.10 What automatic action will occur if the pool water level drops below the top grid ? (1.5)

An emergency core spray system is provided so that if the pool water level were to drop below the top grid, a valve in the sanitary water line would open and water would be dumped into the shroud area above the top grid to cool the core.

Ref: SAR, p. 3-28

J.11 List the four (4) functions of the pool water cooling and purification system. (2.0)

1. Maintains low conductivity of the water to minimize corrosion of reactor components, particularly the fuel elements.
2. Reduces radicactivity in the water by removing nearly all particulate and soluble impurities.
3. Maintains optical clarity of the water.
4. Provides a means of dissipating the heat generated in the reactor.

Ref: SAR, p. 3-30

.5 credit for each item

J.12 TRUE or FALSE: Water flowing through the demineralizer must first pass through the shield cooling system. (1.0)

False - in that way it would bypass the demin.

Ref: SAR, Fig. 3.13, after p. 3-31

J.13 The following six (6) components are all located in which one of the listed regions (letter) ? (1) the watertight rotary specimen rack assembly, which surrounds the core / (2) the specimen removal tube / (3) the tube and shaft assembly / (4) the drive and indicator assembly on the reactor bridge / (5) the buoyancy chambers for vertical movement of the rotary specimen rack / (6) the specimen lifting assembly.

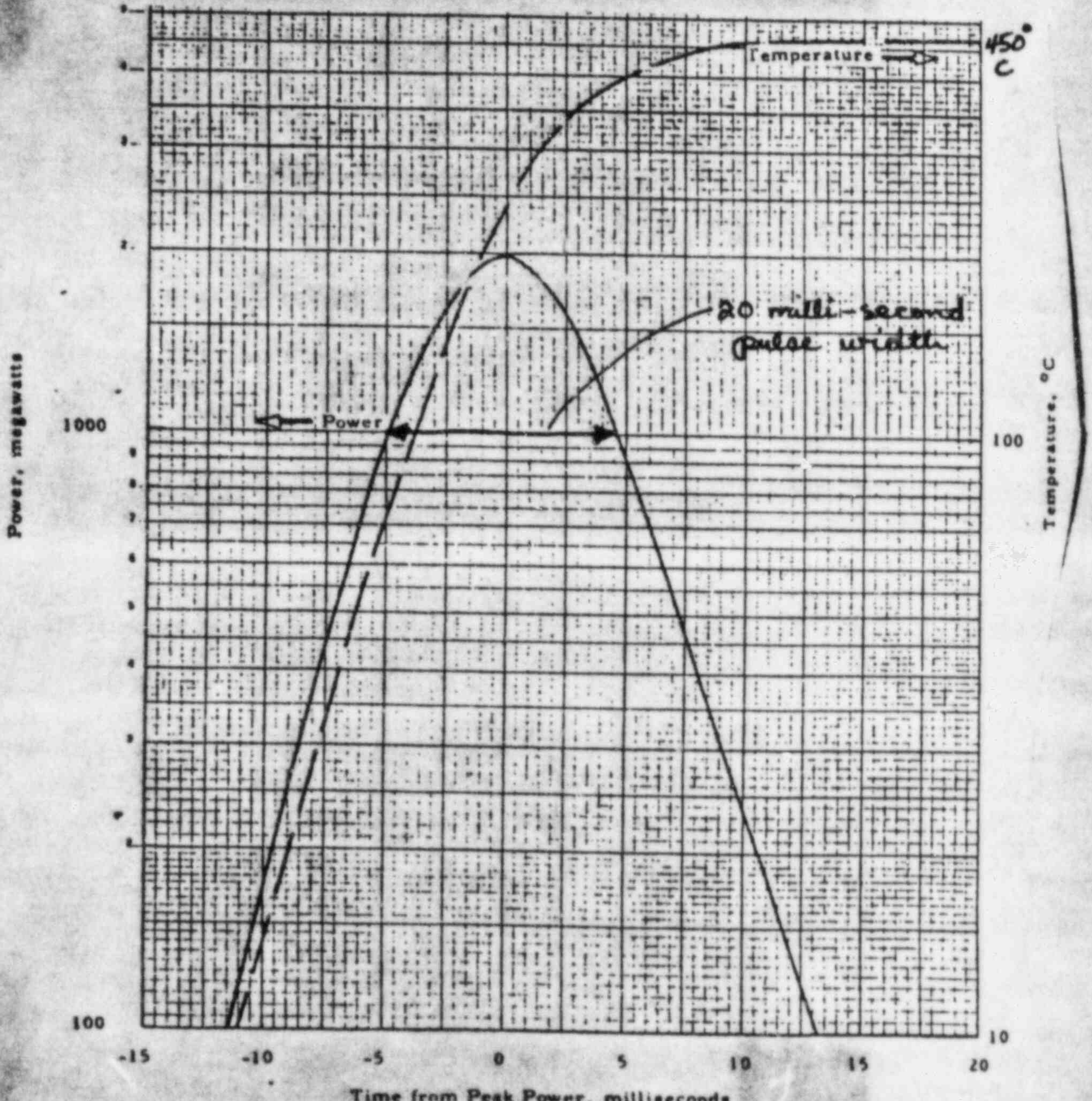
----

a. Horizontal thermal column
b. Vertical thermal column
c. Isotope production facility
d. Beam port facility (1.0)

c.

Ref: SAR, p.4-10

J.14 Plot power and fuel temperature versus time for a $3.00 pulse. Assume that the pulse peaks at 2000 MW, peak fuel temperature is 450 degrees C, and the pulse width (as defined in the UC Berkeley SAR) is 20 milli-seconds. (2.0)



.5 - knowing pulse width
.5 - general curve shapes
1.0 - temp peaking after power decrease

Ref: SAR, Fig. 5-10, between pp. 5-8 and 5-9

J.15 The maximum fuel temperature experienced by the TRIGA fuel following a Loss of Coolant accident has been conservatively estimated in the SAR as:

a. 200 to 300 degrees C
b. 550 to 700 degrees C
c. 900 to 1050 degrees C
d. 1250 to 1400 degrees C (1.0)

b.

Ref: SAR, 7-85

K.0 FUEL HANDLING AND CORE PARAMETERS (25 POINTS)

K.1 What design feature prevents a rod from dropping out of the bottom of the core ? (1.0)

An aluminium safety plate attached to the shroud beneath the lower grid plate.

Ref. SAR, p. 3-12

K.2 Describe the location of the fuel element thermocouples, including why they are sited where they are. (1.5)

Horizontal C/h at the center of the fuel section, 1 inch above, and 1 inch below. This allows for controlled measurement of highest temperature, irrespective of any axial power imbalance.

Ref: SAR, p. 3-11

1.0 - Knowing there are 3 and ± 1 in.
.5 - Knowing max. temp may not be exactly at centerline

K.3 TRUE or FALSE: All control rods have a stroke of 15 inches. (0.5)

True

Ref: SAR, p. 3-13

K.4 Match the control rod worth (letter) with the appropriate value (Number) listed below. (1.5)

a. Net change in reactivity caused by the withdrawal of a safety rod.

b. Net worth of each of the shim and regulating rods.

c. Net change in reactivity that can be caused by the operational withdrawal of the transient rod.

---

1. 1.8% delta K/K
2. 2.1% delta K/K
3. 2.7% delta K/K

a. #3
b. #1
c. #2

Ref: SAR, p. 3-14

K.5 TRUE or FALSE: In the Transient Rod Drive System, the piston that strikes the anvil at the upper limit stop is the same one that strikes the bottom limit. (1.0)

False - they are separate

Ref: SAR, p. 3-17

K.6 TRUE or FALSE: During pulsing mode operation only the transient rod can be moved. (1.0)

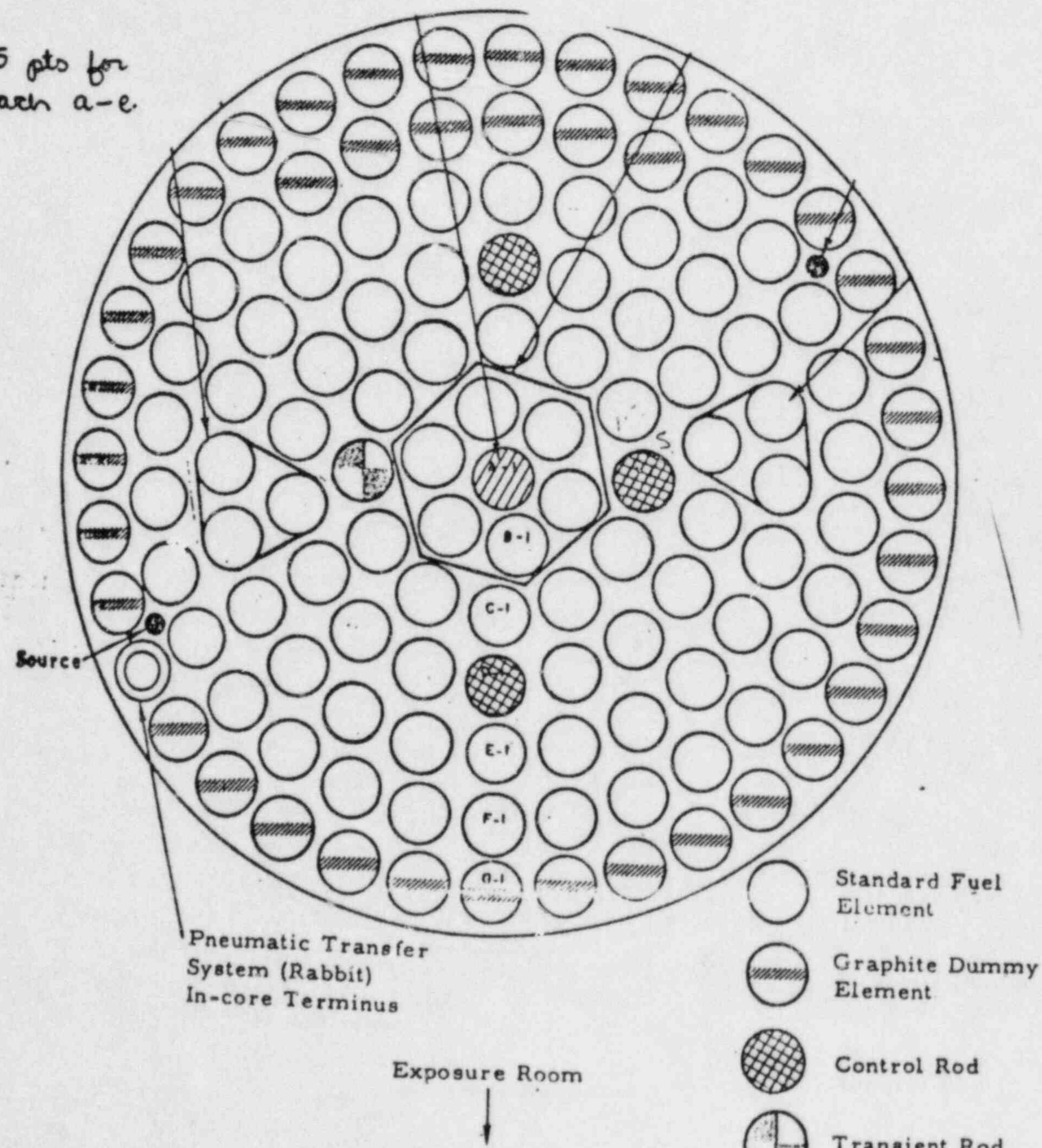
True

Ref: SAR, p.3-22

K.7 Draw a top view of the reactor core grid array showing location of the:

a. Source
b. Core orientation relative to the exposure room
c. Three control rods
d. Transient rod
e. Pneumatic transfer system (rabbit) in-core terminus (2.5)

.5 pts for each a-e.



Ref: SAR, Fig. 3.12 between p.3-26 + 27

K.8 How does the fuel element worth (compared to water) change as you move from core ring G to F to E to D to C to B ? (1.0)

It increases

Ref: NERL - 16, p. 3

K.9 In the event of a fuel element failure, which of the isotopes listed below will escape to the control room? Note: More than one answer may be correct.

a. Bromine
b. Iodine
c. Xenon
d. Krypton (1.0)

c and d

Ref: SAR, p. 7-33

K.10 During fuel handling, by what amount must the reactor be subcritical ?

a. 0.50% delta K/K
b. 0.70% delta K/K
c. 1.00% delta K/K
d. 3.46% delta K/K (1.0)

b.

Ref: NERL-16, p.1

K.11 TRUE or FALSE: Pool water level can be lowered to 10 to 20 inches from maximum to facilitate fuel and control rod handling. (1.0)

True

Ref: NERL-16, p.3

K.12 When moving a fuel element, what is the minimum water level that should be maintained over the element to provide adequate shielding ?

a. 1 to 2 feet
b. 3 to 4 feet
c. 5 to 6 feet
d. 8 to 9 feet (1.0)

c.

Ref: NERL-16, p.4

K.13 Which of the following are not precautions listed in the Reactor Handling Equipment section of the Operations Manual ?

a. Never force the handle into or out of a locking position. If it does not rotate easily, push or pull the handle slightly, then try again.
b. When inserting or removing elements, be certain the handle is locked.
c. When an element is engaged in the grapple mechanism, the handle end of the tool should never be laid on the floor or on the tank covers.
d. When an element is engaged in the grapple mechanism, never coil the control cable in a circle of a diameter greater than about two (2) feet. (1.0)

d. is not a precaution / it is the opposite of one

Ref: Reactor Handling Equip. Proc., p. 6-1-3

K.14 Fuel elements which have bowing in excess of __?__ inch and longitudinal growth in excess of __?__ inch should be removed from the core prior to conducting any further pulsing operations.

a. .620, .010
b. .100, .062
c. .062, .100
d. .010, .620 (1.0)

c.

Ref: Fuel Element Inspection Tool Procedure, p. 6-5-3

K.15 When inspecting a fuel element, which is done first; the "bow test" or the "length measurement ?" (0.5)

Bow Test

Ref: Fuel Element Insp. Tool Procedure, p. 6-5-5

K.16 Describe how a control rod calibration is performed. (2.5)

1. Take reactor critical with 3 rods, leaving the rod to be calibrated (x) in the down (o) position.
2. Remove the neutron source.
3. Adjust the reactor power to 1.5W and wait a minimum of 4 minutes for the reactor to stabilize.
4. Insert enough reactivity with rod x to establish a stable period between 25 and 40 seconds (this corresponds to t-50 times of 10 to 16s).
5. By switching the Reactor Power control of the linear channel, obtain at least 6 data points for the value of t-50. Do not include the first reading.
6. Without moving rod x, return the reactor power to 1.5W and repeat the procedure from step 3 until the entire rod worth has been measured.
7. Return neutron source to core.

Note: t-50 is defined as the time for the reactor power to increase by a factor of 1.5: P(t+t-50) = 1.5 P(t).

Ref: App. 5 to NERL 27

Each underlined part worth .4, except 7 which is .1.

K.17 According to the TRIGA Mk III Technical Specifications, fuel elements being stored shall always be arranged in a geometrical array where the K-effective is less than __?__ for all conditions of moderation.

a. .98
b. .93
c. .88
d. .80

(1.0)

d.

Ref: T.S., p.26

K.18 Which of the following rods may incorporate a fueled follower ? More than one response may be correct. If so, list all that are.

a. Shim Rod
b. Safety Control Rod
c. Regulating Control Rod
d. Transient Control Rod (1.0)

a, b, c

Transient Control rod does not.

Ref: SAR, p. 3-13

(Each worth .33)

K.19 TRUE or FALSE: Fuel element bowing that results in touching will directly lead to a rapid fuel element failure. (1.0)

False

Ref: T.S., p.22

K.20 According to Technical Specifications, the reactivity worth of any single experiment shall be less than ___?___ dollars. Fill in the blank. (1.0)

$3.00

Ref: T.S., p.15

K.21 a. According to Technical Specifications, what is the fuel element thermocouple temperature limiting safety system setting ?

1. 500 degrees F
2. 900 degrees F
3. 930 degrees F
4. 1000 degrees F (1.0)

b. In which ring(s) should the thermocouple be placed ?

1. A
2. B or C
3. D or E
4. F or G
5. Any (1.0)

a. #3
b. #2

Ref: T.S., p.7

L. ADMINSTRATIVE PROCEDURES, CONDITIONS AND LIMITATIONS (15)

L.1 List all those statements below which are correct for the Berkeley TRIGA Reactor facility. (2.0)

(a.) NRC and State regulations require that all persons working in or frequenting a radiation area shall be informed of the presence of radioactivity.

(b.) Authorized Users working under the jurisdiction of a NRC license shall inform all female workers and/or students of the contents of NRC Regulatory Guide 8.13, Instructions Concerning Prenatal Radiation Exposure.

(c.) High Radiation Areas shall be properly and conspicuously posted; Radiation Areas and areas with even less potential dose levels need not be posted.

(d.) Current Radiation Use Authorizations shall be posted in the laboratories covered by the Authorization.

a. True

Ref: Rad Safety Manual, p.28

b. True

Ref: Rad Safety Manual, p.28

c. False - both must be

Ref: Rad Safety Manual, p.28

d. True

Ref: Rad Safety Manual, p.28

L.2 List those statements which are correct for the Berkeley TRIGA Reactor facility. (2.0)

(a.) All shipments of radioactive materials must have the prior approval of the Office of EH&S.

(b.) Packaging, monitoring and labeling of radioactive materials for shipment is the sole and direct responsibility of the Authorized User.

(c.) No radioactive material may be transferred from one person, department or project to another within the campus jurisdiction without the approval of the Radiation Safety Officer.

(d.) Approval must be obtained in advance from the Office of EH&S for special handling of shipments containing perishable or short half-life materials.

a. True

Ref: Rad Safety Manual, p.35

b. False

Ref: Rad Safety Manual, p.35

c. True

Ref: Rad Safety Manual, p.35

d. True

Ref: Rad Safety Manual, p.30

L.3 You are the reactor operator when a spill of radioactive material occurs. The accident could be classified as a major radiation incident or as a minor radiation incident. This accident could occur during normal working hours or during off-normal working hours.

a. Explain major radiation incidents and minor radiation incidents. (1.0)

b. What notification actions should you take ? (1.0)

a. Major Incidents are those requiring notification of either State or Federal regulatory agencies and are defined in the appropriate regulations. Minor Incidents are those where the internal or external exposure, area contamination, or other factors are such that the circumstances should be documented. Classification will be made by the Radiation Safety Officer or his designee.

Acceptable answer also would be "events as listed in Rad. Safety Manual, Section 5.

b. Major incidents are those which must be reported either to the State Department of Health Services or the Nuclear Regulatory Commission. (0.5)

Ref: Rad Safety Manual, p.42

Each actual or suspected incident shall be reported to the Office of EH+S. (0.5)

Ref: Rad Safety Manual, p.44

L.4 From the following statements, choose the one statement that is the most correct. (1.0)

(a.) All experiments that are to be conducted with the use of the reactor are classified into five experimental classes (A,B,C,D and E).

(b.) If an experimenter plans to take any part of his experiment which has been activated as part of or incidental to the experiment out of the Reactor Facility, he ~~must~~ need only have the approval of the reactor operator..

(c.) Experiments in Class A shall be subject to the restriction of no reactivity change larger than 0.7 % delta K/K.

(d.) All experiments that require the use of the exposure room must be classified as Class C or a more severe class.

a. False - just 4

Ref: Ops Manual, p. 19

b. False - others needed including Reactor Health Physicist

Ref: Ops Manual, p. 20

c. True

Ref: Ops Manual, p. 20

d. False - Class B

Ref: Ops Manual, p. 22

L.5 Explain the difference between the A-List of personnel and the B-List with respect to entry to the reactor. (1.0)

A List Personnel: Authorized unescorted entry during regular working hours and afterhours - most of these personnel are key holders. May authorize escorted access to the security areas.

B List Personnel: Authorized unescorted entry during regular working hours.

Ref: Ops Manual, p.5

(Each worth .5)

L.6 List the two (2) personnel required to be present at the beginning of a Class B experiment. (1.0)

1. SRO and 2. Experimenter-in-Charge

Ref: Ops Manual, p. 27

L.7 List the three (3) personnel required to be present at the beginning of a Class C experiment. (1.0)

1. Reactor Supervisor
2. Experimenter-In-Charge
3. Health Physicist

Ref: Ops Manual, p.27.

L.8 When the TRIGA reactor is operating, explain the responsibilities of the

a. Senior-Operator-in-Charge (0.5)

b. Reactor Operator. (0.5)

a. SRO designated by the Reactor Supervisor who will be in Etcheverry Hall (.2), be in communication with the console (.1), and will assume responsibility for direction of reactor operations including manipulation of controls, reading of various recording devices, and reactor maintenance and calibration (.2).

b. Direct charge of the console at all times (.4) plus maintain complete and accurate logs and records of reactor operation (.1)

Ref: Ops Manual, p.29

L.9 List the letter designations of all those statements given below that are correct statements. (2.0)

(a.) A copy of GA6600 - TRIGA Mk III Instrumentation Manual is kept at the reactor console.

(b.) All unexplained reactor trips (scrams) must be reported to the Reactor Supervisor and his approval obtained before the reactor may be restarted.

(c.) The excess reactivity of the reactor will be measured and recorded in the Reactor-Operations Log Book after any change that is calculated to affect the reactivity of the core by more than 7 % delta K/K.

(d.) At least two persons will be present whenever any maintenance work is being performed on the reactor.

a. True
Ref: Ops Manual, p.38

b. True
Ref: Ops Manual, p.38

c. False - 1%
Ref: Ops Manual, p.37

d. True

Ref: Ops Manual, p.36

L.10 In the event of a fire in the reactor room which is detected while you are at the control console, list your required actions. Consider the possibility that the fire cannot be controlled by the operating staff. (2.0)

1. SCRAM the reactor (1.0)
2. Lab personnel will fight the fire
3. If beyond personnel capability, SRO or operator will notify campus police. (.5)
4. If necessary order evacuation (.35)
5. Continue monitoring during (.15) fire fighting.

Ref: Ops Manual, p. 61