

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

EXAMINATION REPORT NO. 50-170/85-01 (OL)

FACILITY DOCKET NO. 50-170

FACILITY LICENSE NO. R-84

LICENSEE: Defense Nuclear Agency Armed Forces  
Radiobiology Research Institute  
Bethesda, Maryland 20014

FACILITY: AFFRI

EXAMINATION DATES: March 11, 1985

CHIEF EXAMINER:

*F. Dudley*  
F. Dudley, Lead Reactor Engineer 5/14/85  
date

REVIEWED BY:

*R. M. Keller*  
R. M. Keller, Chief, Projects Section 1C 5/14/85  
date

APPROVED BY:

*H. B. Kister*  
H. B. Kister, Chief, Projects Branch No. 1 5/14/85  
date

SUMMARY: Two examinations were administered. One RO and one SRO license were issued.

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PDR ADDCK 05000170  
Q PDR

REPORT DETAILS

TYPE OF EXAMS: Replacement   X  

EXAM RESULTS:

|              | RO<br>Pass/Fail | SRO<br>Pass/Fail |
|--------------|-----------------|------------------|
| Written Exam | 1/0             | 1/0              |
| Oral Exam    | 1/0             | 1/0              |
| Overall      | 1/0             | 1/0              |

1. Chief Examiner at Site: N. Dudley, NRC
2. Summary of generic strengths of deficiencies noted on oral exams:  

Candidates did not demonstrate a complete understanding of the facility or offsite electrical distribution system.

Both candidates used out of date P&ID's to evaluate plant systems.
3. Personnel Present at Exit Interview:  

NRC Personnel

N. Dudley, Examiner

Facility Personnel

Colonel B. Adcock, Institute Director  
M. Moore, Reactor Facility Director  
M. Dougherty, Training Coordinator

## 4. Summary of NRC Comments made at Exit Interview:

The names of the two candidates who were definite passes on the oral examinations and the generic weaknesses noted were presented to the facility.

The facility requested a certificate presentation for the presently licensed operators and a tentative date was established for sometime in June.

## 5. Changes made to Written Exam During Examination Review:

| <u>Answer No.</u>                    | <u>Change</u>  | <u>Reason</u>   |
|--------------------------------------|--|---|
| B.01<br>I.02<br>F.05<br>L.02<br>L.06 | Delete   | Pneumatic tube system has been removed.                                       |
| A.01                                 | Add "water and fuel density decreases..."                                  | Incorporates concept that that fuel density affects power coefficient.        |
| A.03a                                | Add "and controlled approach to criticality"                               | Includes additional reason for need for startup source.                       |
| B.04a                                | Add "lower water level alarm and scram"                                    | Provides additional indication for a reactor tank leak.                       |
| C.04                                 | Add "rod withdrawal prohibit and indication light"                         | Provides additional results of a loss of secondary system.                    |
| D.01a<br>b                           | Change to "reads off scale high"<br>Change to "reads temperature at short" | Correct answer for design of thermocouples.                                   |
| D.02a and<br>J.10                    | Change "fission chamber" to "Log Channel"                                  | Provides correct description of instrumentation channel.                      |
| D.02d and<br>J.10d                   | Change to "No effect if in automatic or power will decrease if in manual"  | Provides correct effect on nuclear instruments if pool temperature increased. |

| <u>Answer No.</u> | <u>Change</u>   | <u>Reason</u>  |
|-------------------|---|--|
| D.04 and<br>J.09  | Change "Rx Period" to "Log Power". Change "Power (fission chamber)" to "linear power". Delete "Power" in line III.c.                    | Provides correct instrumentation displays for each position of the mode selector switch. |
| D.06 and<br>J.04  | Change to "Turn on secondary system"  | Provides operation means for controlling pool temperature.                               |
| E.01c             | Insert "Stop rod withdrawal if period is less than 3 sec."  | Inserts a correct response.  |
| E.03              | Add "Stop startup attempt and inform facility director."  | Expands answer to include other required actions.  |
| E.05a             | Add "Prevent accidental exposure"   | Expands answer to include the major reason for cautions and limitations on moving core.  |
| E.06c             | Insert "Nothing. Detector used for indication only"   | Inserts facility provided response.  |
| F.03a             | Change to "Water level. Results in loss of shielding and high radiation levels"   | Sets correct priorities for various abnormal conditions.                                 |
| F.04a             | Insert "Prevent activation of tool"   | Inserts facility provided response.  |
| G.03              | Change to "Secure valves to isolate leak; notify RFD; Monitor"  | Changes answer to the facility expected responses to a primary leak.                     |
| H.02a             | Change to "Since Rx is critical at 20 watts and 40 watts, no addition is needed to raise power until reaching the point of adding heat" | No negative reactivity feedback mechanism exists at these power levels.                  |

| <u>Answer No.</u> | <u>Change</u>   | <u>Reason</u>   |
|-------------------|---|---|
| H.02b             | Change "30%" to "35%"<br>and "linear" to "not<br>linear"  | The power coefficient curve<br>is non-linear.   |
| H.07a             | Change "0.56" to "0.46"   | Corrects graph reading.   |
| H.08              | Change to "Conduction<br>through fuel (Radiation<br>across fuel gap);<br>conduction through<br>laminar layer to water;<br>convection to pool and<br>atmosphere" | Modifies answer to natural<br>circulation instead of forced<br>circulation.                           |
| G.04 and<br>I.05  | Change "Wash out wound"<br>to "Call for help"   | Changes answer to the<br>facility expected responses<br>for an injured contaminated<br>person.        |
| G.05              | Correct math  | Changes math calculations to<br>account for not using an<br>efficiency factor for radiac<br>readings. |
| H.02a Question    | Change "cps" to "watts"   | Changes units of N.I. readout<br>to correspond to facility<br>instrumentation.                        |
| I.06a             | Change<br>"2.13 ft (-1) x 3 ft"<br>to<br>"0.07 cm (-1) x 91 cm"   | Changes coefficients to<br>values which can be read off<br>supplied table.                            |
| b                 | Change ".91 cm (-1)"  |   |
| K.01a             | Add "(flattens flux,<br>extends core life)"   | Provides additional informa-<br>tion on the effect of<br>samarium wafers.                             |
| K.05              | Change "Ring B + Ring C<br>+ Ring D" to "Measured<br>excess - Ring E - Ring F"<br>Change "+ \$3.21" to<br>"- (- \$17.84)"                                       | Computers shutdown margin<br>from available data.   |
| L.04b             | Delete  | Facility does not have<br>compensated ion chambers.   |

| <u>Answer No.</u> | <u>Change</u>                                | <u>Reason</u>                        |
|-------------------|--|--------------------------------------|
| L.07              | Delete "0425; start primary pump; black ink" | Starting of equipment is not logged. |

Attachment: Written Examination(s) and Answer Key(s) (SRO/RO)

U. S. NUCLEAR REGULATORY COMMISSION  
 REACTOR OPERATOR LICENSE EXAMINATION

FACILITY: ARMED FORCES RADIOBIO. RES  
 REACTOR TYPE: TRIGA  
 DATE ADMINISTERED: 85/03/12  
 EXAMINER: DUDLEY, N.  
 APPLICANT:

INSTRUCTIONS TO APPLICANT:

Use separate paper for the answers. Write answers on one side only. Staple question sheet on top of the answer sheets. Points for each question are indicated in parentheses after the question. The passing grade requires at least 70% in each category and a final grade of at least 80%. Examination papers will be picked up six (6) hours after the examination starts.

| CATEGORY VALUE | % OF TOTAL | APPLICANT'S SCORE | % OF CATEGORY VALUE | CATEGORY                                       |
|----------------|------------|-------------------|---------------------|--|
| 14.00          | 14.23      |                   |                     | A. PRINCIPLES OF REACTOR OPERATION             |
| 14.00          | 14.23      |                   |                     | B. FEATURES OF FACILITY DESIGN                 |
| 14.00          | 14.23      |                   |                     | C. GENERAL OPERATING CHARACTERISTICS           |
| 14.40          | 14.63      |                   |                     | D. INSTRUMENTS AND CONTROLS                    |
| 14.50          | 14.74      |                   |                     | E. SAFETY AND EMERGENCY SYSTEMS                |
| 14.00          | 14.23      |                   |                     | F. STANDARD AND EMERGENCY OPERATING PROCEDURES |
| 13.50          | 13.72      |                   |                     | G. RADIATION CONTROL AND SAFETY                |
| 98.40          | 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 A.01 (3.00)

The safety of a TRIGA reactor derives from its large prompt negative coefficient which is primarily due to an intrinsic characteristic of the fuel. List the THREE contributions (not necessarily all from the fuel) which account for the prompt negative coefficient and explain how each of them inserts reactivity on a power increase.

## QUESTION A.02 (2.00)

Following a scram there is an initial prompt drop in power level followed by a power decrease and a negative period. What is the value of this period and why is it always the same?

## QUESTION A.03 (3.00)

- a. Why is a neutron source necessary in the reactor?
- b. What is the neutron source made of and how does it produce neutrons?

## QUESTION A.04 (3.00)

How much reactivity has been added to a subcritical reactor if the count rate has increased from 100 cps to 150 cps and if the initial value of  $K_{eff}$  was .95?

## QUESTION A.05 (2.00)

If after achieving criticality the operator were to raise power to 50 kw, immediately establish an infinite period, and verify that the power level indication was steady with no rod motion, he would observe an increase in power after waiting a few minutes. Explain why.

## QUESTION A.06 (1.00)

Why is the build up of xenon poison during power operations neglected at AFRRI?



QUESTION B.01 (2.00) *DELETE*

Describe the TWO features of the pneumatic tube system that would minimize the release of radioactive materials into the reactor building atmosphere if failure of an experiment in the tube system occurred.

## QUESTION B.02 (2.00)

Explain how the amount of reactivity for a pulse is controlled.

## QUESTION B.03 (3.00)

Draw a simple schematic flow diagram of the complete Water Cooling and Purification System. Label all major components and indicate directions of flow.

## QUESTION B.04 (2.50)

Assume a leak developed from the reactor tank into an exposure room during a normal working day.

- a. What TWO devices, other than visual, would alert the staff to this situation? (1.5)
- b. What safety feature is available at AFRI to prevent uncovering the core due to this failure? (1.0)

## QUESTION B.05 (2.00)

Describe THREE materials which line Exposure Room 1 and explain why each is used.

## QUESTION B.06 (2.50)

- a. What effect, if any, would the loss of both air compressors have on the reactor building ventilation system? (1.0)
- b. Describe THREE features of the reactor building ventilation system which prevent the release of contamination to the environment and explain how these features work. Include both normal and emergency features. (1.5)

## QUESTION C.01 (2.00)

How does the burnable poison in the fuel elements affect reactor operation? Explain.

## QUESTION C.02 (2.00)

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

## QUESTION C.03 (2.50)

- a. Assuming the reactor is at 125 watts and on a stable sustained period of 50 seconds, how long will it take to reach 1 MW? Show your work. (1.0)
- b. Assuming the reactor is at 125 watts and is placed on a 50 sec period, explain how the reactor will respond if no further operator actions are taken? (1.5)

## QUESTION C.04 (2.50)

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

## QUESTION C.05 (3.00)

After the reactor has been brought critical at 1 watt, the operator withdraws the reg rod sufficiently to add about 0.003 delta K of reactivity. Assuming no further control rod manipulations or linear scrams, explain and sketch the response of the POWER LEVEL and PERIOD. (Do not calculate the period but show approximate value.)

QUESTION C.06 (2.00)

- a. An experiment is loaded into the B-ring of the core when the reactor is operating at 1 MW. After loading the experiment, the reactor power level decreases to 500 KW. How much reactivity was added by the experiment? Neglect reactivity effects of heating. (0.8)
- b. If the experiment had been loaded in the outer ring would you expect the final power level to be different from 500 KW? Explain. (1.2)

## QUESTION D.01 (1.50)

- a. What will happen to the indication of fuel temperature if the thermocouple develops an open circuit?
- b. What will happen to the indication of fuel temperature if the thermocouple develops a short circuit?

## QUESTION D.02 (3.20)

What affect, if any, will the following changes have on nuclear power indications. Explain each answer.

- a. The count rate portion of the fission chamber signal processing circuitry provides no signal at 500 KW.
- b. The cambelling portion of the fission chamber signal processing circuitry provides no signal at 100 watts.
- c. The Primary flow rate increases from 250 gpm to 350 gpm.
- d. The pool temperature increases 10 degrees.

## QUESTION D.03 (2.00)

If the following indications are present for the shim rod, where is the shim rod? Explain the inconsistencies of the indications.

|                   |        |
|-------------------|--------|
| ROD DOWN LIGHT    | ON     |
| MAGNET UP LIGHT   | ON     |
| MAGNET DOWN LIGHT | OFF    |
| MAGNET CURRENT    | NORMAL |

## QUESTION D.04 (3.20)

For each of the four positions of the mode selector switch, IA Steady State Automatic, I Steady State Manual, II Square Wave, and III Pulse, provide the following information:

- a. The rods which receive control signals from the fission chambers.
- b. Information displayed by the RED pen recorder.
- c. Information displayed by the BLUE pen recorder.
- d. The detectors which supply scram signals through the switch.

QUESTION D.05 (3.00)

- a. Explain the mechanism by which the transient control rod is dropped into the core on a scram signal.
- b. Explain how the anvil is positioned without moving the transient control rod.

QUESTION D.06 (1.50)

Explain how the pool temperature is controlled during plant operations at 1 MW.

## QUESTION E.01 (3.50)

For each of the following rod interlocks indicate what conditions produce the interlock and what interlock is activated.

- a. One kilowatt interlock
- b. Source level
- c. Three second period
- d. Operational high voltage
- e. Pool water temperature

## QUESTION E.02 (1.50)

If the vent on the primary cooling pump was left open, and the pump was secure, could the core be uncovered? Explain.

## QUESTION E.03 (1.50)

During a reactor startup a scram occurs for no obvious reason. The operator finds he cannot reenergize the magnetic power to the control rods and resets the reactor consol. Prior to reattempting the startup the operator notes he has regained a scram indication. What action, if any, should the operator take?

## QUESTION E.04 (2.00)

Should the reactor scram in each of the following independent situations? No explanation is required.

- a. A safety channel UIC fails to 50% of actual power level while operating in Mode I at 1 MW.
- b. The third independent ion chamber above the core loses High Voltage while in mode IA at 500 KW.
- c. The C-ring thermocouple fails high in Mode II at 1 MW.
- d. The wide-range log channel is placed in test while in Mode I at 100 KW.

QUESTION E.05 (3.00)

- a. What is the purpose of the Facility Interlock System? (1.0)
- b. Explain where the reactor core is when it is in Region 1, Region 2, and Region 3. (2.0)

QUESTION E.06 (3.00)

Explain what potential safety problems, if any, will result in each of the following situations.

- a. The secondary system pressure drops to 10 psi due to degradation of the pump. Secondary flow is 700 gpm.
- b. CUND filter differential pressure of 8 psi.
- c. The gamma probe is inoperable.
- d. The flow through the demineralizer is 15 gpm.

## QUESTION F.01 (2.00)

The facility requirements state that an annual calibration of the power level monitoring channels will be made by the calorimetric method.

- a. What is the purpose of this calibration?
- b. Outline the procedures involved in the calorimetric method.

## QUESTION F.02 (4.00)

- a. What actions are taken for a Reactor Emergency?
- b. What actions are taken for an AFRRRI Complex Emergency Evacuation?

## QUESTION F.03 (3.00)

The following alarms are received simultaneously; water temperature high, stack gas activity high, water level low.

- a. Which one should be investigated first? Justify your answer. (1.0)
- b. What actions, if any, should be taken to control the situation and determine the problem? (2.0)

## QUESTION F.04 (2.00)

- a. Why is the use of the extraction tool to lower the rabbit into the Core Experiment Tube prohibited while at power? (0.8)
- b. What precautions are taken and what instrumentation is monitored when retrieving the rabbit. (1.2)



## QUESTION F.05 (3.00)

For each of the following situations indicate whether a completed RUR (Reactor Use Request) is required.

- a. Maintenance in Exposure Room #1 when the reactor is secured.
- b. Movement of the reactor to a new location.
- c. Checking operation of the pneumatic tube system using an experimental mockup while at 1 KW. ~~DELETE~~
- d. Conducting K excess measurements.
- e. Loading an additional instrumentation package into the pool prior to reactor startup.
- f. Determining the reactivity worth of a new transient rod.

## QUESTION G.01 (2.50)

A gamma source emits 8 R/hr at one foot. How long could a person work at a distance of 4 feet from the source without exceeding the quarterly limit whole body in 10 CFR 20? Show your work.

## QUESTION G.02 (2.00)

- a. Why must a Quality Factor be used when calculating exposures from measurements taken in RADs? (1.0)
- b. What steps should be taken to avoid contamination while swiping a potentially contaminated surface? (1.0)

## QUESTION G.03 (2.00)

What immediate actions should an operator take if he discovers a 5 gpm leak from the primary side of the heat exchanger while making plant rounds?

## QUESTION G.04 (3.00)

What actions, if any, should be taken if a experimenter, who is in a contaminated area of the hot cell, has been severely cut and the bleeding cannot be stopped. The person is in protective clothing which is contaminated, there are no other experimenters or support personnel at the facility, and only the minimum operations staff required to operate the facility are available.

## QUESTION G.05 (4.00)

After an incident, a survey is made of the affected area with a survey meter. The window open indication is 5.3 R/hr, window closed is 3.5 R/hr at 2 feet.

- a. What is the Beta dose rate? (0.8)
- b. How long can you remain in this area without exceeding your normal quarterly whole body limit? (1.2)
- c. Under what emergency conditions can quarterly whole body limits be exceeded? (1.0)
- d. What would be the reading on the Cutie-Pie if it were moved back to 10 feet? (1.0)

ANSWERS -- ARMED FORCES RADIOBIO. RES-85/03/12-DUDLEY, N.

ANSWER A.01 (3.00)

ZrH disadvantage factor [0.4] as temperature raises the ZrH becomes less effective as a moderator. [0.6]

Doppler effect [0.4] absorption cross sections of resonance peaks broaden as temperature increases. [0.6]

Water displacement [0.4] water <sup>AND FUEL</sup> density decreases and fuel expands to displace water which ~~which~~ decreases moderation. [0.6]

REFERENCE

170: Nuclear Theory II.B.4

ANSWER A.02 (2.00)

-80 seconds. [0.5] Power cannot decrease faster than mean life time of longest lived precursor. [1.5] (This is  $1.44 \times 55 \text{ sec } 1/2$  life of Br)

REFERENCE

170: Nuclear Theory II B.2.c

ANSWER A.03 (3.00)

- a. The source is need for reactor startup [0.6] to insure instrument response remains on scale at lowest power level. [0.9] *AND CONTROLLED APPROACH TO CRITICALITY*
- b. Am-Be. [0.5] Am decays via alpha emission. [0.5] The alpha interacts with Be to produce carbon and a neutron. [0.5]

REFERENCE

170: SAR p 4-8

ANSWER A.04 (3.00)

$$cr1 / cr2 = (1 - Keff2) / (1 - Keff1) \quad [0.9]$$

$$100/150 = (1 - Keff2) / (1 - 0.95) \quad [0.5]$$

$$1 - Keff2 = 10/15 \times 0.05$$

$$Keff2 = 0.967 \quad [0.1]$$

$$\text{change in reactivity} = [1 - Keff2 / Keff2] - [1 - Keff1 / Keff1] \quad [0.9]$$

$$= Keff2 - Keff1 / Keff1 \times Keff2 \quad [0.6]$$

$$= 0.967 - 0.95 / 0.95 \times 0.967 \quad [0.6]$$

$$= 1.85 \% \text{ delta } K/K \quad [0.1]$$

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ANSWERS -- ARMED FORCES RADIOBIO. RES-85/03/12-DUDLEY, N.

REFERENCE

170: Reactor Theory II A.4

ANSWER A.05 (2.00)

When rods were inserted only prompt neutrons were affected and reactor power was stabilized. [1.0]  
After a few minutes the delayed neutrons contributed to the overall neutron population [1.0] thus power increased.

REFERENCE

470:C-E Reactor Theory pgs. 74-76

054:Nuclear Energy Training, Module 3 Rx Ops, Unit 5.5

170:Nuclear Theory II B.1

ANSWER A.06 (1.00)

AFRRI does not run at high enough power levels long enough to generate xenon. [1.0] (Max effect  $\approx -0.05$ )

REFERENCE

170:Questions and Answers A.7.b

ANSWERS -- ARMED FORCES RADIOBIO. RES-85/03/12-DUDLEY, N.

ANSWER B.01 (2.00) ~~DELETE~~

Absolute filter on blower [1.0]  
Tube system exhausts to stack [1.0]

REFERENCE

170: Operations Manual p 180

ANSWER B.02 (2.00)

Determine Delta P desired, [0.3] calculate transient rod position  
from worth curve, [0.3] Position anvil by mech. drive to allow  
withdrawal to that point [1.0] - fire rod with air pressure, [0.4]

REFERENCE

170: Ops. Procedures VIII Tab E

ANSWER B.03 (3.00)

Operations Manual Fig. 3.1

REFERENCE

170: Operations Manual Fig. 3.1

ANSWER B.04 (2.50)

a. R-1 alarms ~~[0.75]~~

CAM alarms ~~[0.75]~~  
LOWER WATERLEVEL ALARM AND SCRAM [any 2 @ 0.75 each]

b. Connection from the fire hydrant to suction of MCP. [1.0]

REFERENCE

170: Operations Manual pp 112,125

ANSWER B.05 (2.00)

Cd shield on bulge [0.3] to absorb thermal neutrons [0.4]

Gadolinium paint on walls and floors [0.2] to absorb neutrons [0.4]

One foot thick wood [0.3] to thermalize neutrons so not to activate  
concrete [0.4]

REFERENCE

170: Questions and Answers B.6

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ANSWERS -- ARMED FORCES RADIOBIO. RES-85/03/12-DUDLEY, N.

ANSWER B.06 (2.50)

- a. The supply dampers (S1, S2, and S3) and the exhaust damper (E1) would shut [1.0]
- b. Supply and exhaust dampers close on high CAM alarm preventing release of radioactivity [0.6]  
Exhaust air is passed through prefilter, roughing filter, and absolute filter which remove contamination (particulate matter) from the air. [0.6]  
A negative pressure is maintained in contaminated areas to reduce spread of contamination out of those areas. [0.3]

REFERENCE

170:Operations Manual pp 63, 68

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 ANSWERS -- ARMED FORCES RADIOBIO. RES-85/03/12-DUDLEY, N.

ANSWER C.01 (2.00)

Burnable poison allows more fuel to be loaded [0.5] and thus extends life.[0.5] As poison burns, it acts as a positive reactivity addition and therefore minimizes reactivity changes resulting from fission product buildup and fuel burnup. [1.0]

REFERENCE

170: SAR p 4-12

ANSWER C.02 (2.00)

- a. No difference [0.4] because the reactor is below heat range and the power coefficient does not add any negative reactivity. [0.6]
- b. Rods would be higher at 1000 KW [0.4] to compensate for the negative reactivity added by the power coefficient. [0.6]

REFERENCE

170: Reactor Theory II B.4

ANSWER C.03 (2.50)

- a.  $P = P_0 e^{(t/\tau)}$  [0.4]  
 $1 \text{ MW} = 1.25E-4 e^{(t/50)}$  [0.4]  
 $\ln[8 \text{ E}3] = \ln[e^{(t/50)}]$   
 $8.987 = t/50$   
 $t = 449 \text{ sec or } 7.48 \text{ min.}$  [0.2]
- b. Power coefficient would lengthen period and would eventually stabilize power. [1.5]

REFERENCE

054: Nuclear Energy Training, Module 3 Rx Ops., Chap 4.3-1 and 6.3  
 170: Reference Package, Reactor parameters  
 Nuclear Theory II B.2



ANSWERS -- ARMED FORCES RADIOBIO. RES-85/03/12-DUDLEY, N.

ANSWER C.04 (2.50)

Pool temperature will increase adding negative reactivity. [0.75]

Reactor power will decrease. [0.75]

Pool high temperature alarm activated [0.5]

No scram. [0.5]

<sup>A</sup> S RWP AND INDICATION LIGHT

REFERENCE

054: TS p. 9

DS-01-1 and DS 02-2

170: Operations Manual, Chap. 3 - Reactor Water Systems

Reference Package, Reactor Parameters

ANSWER C.05 (3.00)

see attached figure:  $\Delta K/K = 43$  cents;  $T \sim 17$  sec;  $P = 86$  KW

REFERENCE

170: Questions and Answers C.7

ANSWER C.06 (2.00)

a. \$1.13 [0.8]

b. Final power level would be higher than 500 KW [0.4]

The core outer ring has a lower flux and therefore the experiment would not be worth as much. [0.8]

REFERENCE

170: Questions and Answers C.15

ANSWERS -- ARMED FORCES RADIOBIO. RES-85/03/12-DUDLEY, N.

ANSWER D.04 (3.20)

|     | a.          | b.                   | c.                                 | d.                            |
|-----|-------------|----------------------|------------------------------------|-------------------------------|
| IA  | REG ROD     | <del>LOW POWER</del> | <del>LINEAR POWER</del>            | UIC (both)                    |
| I   | None        | <del>RX PERIOD</del> | <del>Power (fission chamber)</del> | UIC (both)                    |
| II  | REG + TRANS | <del>RX PERIOD</del> | <del>Power (fission chamber)</del> | UIC (both)                    |
| III | None        | FUEL TEMP            | <del>Power Pulsing UIC</del>       | Pulsing UIC (1)<br>[0.2 each] |

## REFERENCE

170: Question and Answers Fig. D-1

ANSWER D.05 (3.00)

- a. Scram signal deenergizes a three way air solenoid valve [0.6] which interrupts the air supply and relieves pressure on the air cylinder [0.6] allowing the piston to drop by gravity. [0.3]
- b. AC electric motor [0.4] drives a ball-nut drive assembly [0.4] which raises the air cylinder [0.4] independent of the piston and control rod. [0.3]

## REFERENCE

170: Operations Manual pp 28-33

ANSWER D.06 (1.50)

~~\* The number of operating fans in the cooling tower is adjusted. [1.5]~~  
 TURN ON SECONDARY SYSTEM

## REFERENCE

170: Operations Manual p 41

ANSWERS -- ARMED FORCES RADIOBIO. RES-85/03/12-DUDLEY, N.

ANSWER E.01 (3.50)

- a. Prevents application of air to the transient rod [0.4] unless reactor power < 1 KW. [0.3]
- b. Prevents any rod withdrawal [0.3] unless the operational channel sees source level neutrons. [0.4]
- c. STOP ROD WITHDRAWAL IF PERIOD IS LESS THAN 3 SEC. [0.4]
- d. Prevents rod withdrawal [0.3] when high voltage is loss to an operational channel detector. [0.4]
- e. Prevents rod withdrawal [0.3] if tank temperature is above 50 C. [0.4]

REFERENCE

170: Operations Manual pp 92-93

ANSWER E.02 (1.50)

No. [0.5] There is small hole drilled in piping 4" below surface of pool which will prevent siphoning. [1.0]

REFERENCE

170: Operations Manual p 41

ANSWER E.03 (1.50)

Check for a person in the exposure rooms. ~~1.0~~ [0.5] STOP STARTUP ATTEMPTS  
INFORM FACILITY DIRECTOR [0.5]

REFERENCE

170: Safety Analysis Report p 4-27  
Operations Manual p 101

ANSWER E.04 (2.00)

- a. No [0.5]
- b. Yes [0.5]
- c. Yes [0.5]
- d. No [0.5]

REFERENCE

170: Safety Analysis Report pp 4-23, 4-24  
Operations Manual p 83

-----  
ANSWERS -- ARMED FORCES RADIOBIO. RES 85/03/12-DUDLEY, W.

ANSWER E.05 (3.00)

- a. Prevents contact or impact between the reactor tank lead shielding door and the reactor core shroud. [~~1.03~~ 0.5] PREVENT ACCIDENTAL EXPOSURE [0.5]
- b. Region 1: 12" of the maximum travel distance of core doll~~y~~  
carriage at ER #1. [0.7]  
Region 2: Between Region 1 and 3. [0.6]  
Region 3: 12" of the maximum travel distance of core doll~~y~~  
carriage at ER #2. [0.7]

## REFERENCE

170: SAR pp 4-25, 4-26

ANSWER E.06 (3.00)

- a. Leak of primary water into the secondary coolant. [0.75] (*due to flow stoppage*)
- b. Contaminated particulates not removed from the primary. [0.75]
- c. ~~DOES NOTHING~~. DETECTOR USED FOR INDICATION ONLY [0.75]
- d. Produces channelling of the resin which reduces effectiveness of ion removal. [0.75]

## REFERENCE

170: Operations Manual pp 41-45

-----  
 ANSWERS -- ARMED FORCES RADIOBIO. RES-85/03/12-DUDLEY, N.

ANSWER F.01 (2.00)

- a. Assures that reactor is to operate at the authorized power level. [1.0]
- b. \*Bring the reactor to 100 KW and measure the amount of time for the pool to heat. [1.0]

REFERENCE

170: T.S. 4.2.2

ANSWER F.02 (4.00)

- a. Scram reactor. [0.5]  
 Check radiation monitors and use portable survey instruments to assess situation, if necessary. [0.5]  
 Notify EAS Commander of situation. [0.5]  
 Activate emergency organization. [0.5]
- b. Scram reactor. [0.5]  
 Secure exposure facilities which are in use. [0.5]  
 Remove logbook, emergency guide and keys; report to EAS [0.5]  
 Do NOT lock reactor area doors. [0.5]

REFERENCE

170: Ops Procedures VI

ANSWER F.03 (3.00)

- a. ~~Stack gas activity~~ [0.5] ~~since it poses a threat to public health~~ [0.5]  
~~WATER LEVEL~~ RESULTS IN LOSS OF SHIELDING AND HIGH RADIATION LEVELS
- b. Take steps for reactor emergency. [0.5]  
 Isolate reactor room [0.5]  
 Investigate [0.5]  
 Perform emergency PLAN [0.5]

ANSWER F.04 (2.00)

- a. ~~SAF~~ PREVENT ACTIVATION OF TOOL [0.8]
- b. Do not remove rabbit from ~~pool~~ <sup>CET</sup> if radiation levels are high. [0.6]  
 Monitor SAF which has teletector positioned near the CET top. [0.6]  
 (Place rabbit in lead pig)

-----  
ANSWERS -- ARMED FORCES RADIOBIO. RES-85/03/12-DUDLEY, N.

REFERENCE

170: Operating Procedures I, Tab B

ANSWER F.05 (3.00)

a. Not required

b. Not required

c. Required ~~DELETE~~

d. Not required

e. Required

f. Not required

[0.5 each]

REFERENCE

170: Operating Procedure I  
Questions and Answers, F.12

ANSWERS -- ARMED FORCES RADIOBIO. RES-85/03/12-DUDLEY, N.

ANSWER G.01 (2.50)

$$D1 \times (R1)^2 = D2 \times (R2)^2 \quad [0.6]$$

$$8 \text{ R/hr} \times 1 \text{ sqft} = D2 \times 16 \text{ sqft} \quad [0.4]$$

$$D2 = .5 \text{ R/hr} \quad [0.1]$$

$$\begin{aligned} \text{stay time} &= \text{total allowed dose} / \text{dose rate} && [0.6] \\ &= 1.25 \text{ R} / .5 \text{ R/hr} && [0.4] \quad [0.3 \text{ for limit}] \\ &= 2.5 \text{ hr} && [0.1] \end{aligned}$$

REFERENCE

170: 10CFR20.101

ANSWER G.02 (2.00)

- a. RADs measure amount of energy deposited in material while exposure rates indicate amount of biological damage. [0.6] Different types of radiation produce greater biological damage which must be corrected for by Quality Factors. [0.4]
- b. Handle swipes with gloves [0.5] and wear appropriate anti-contamination clothing. [0.5]

REFERENCE

Questions and Answers G. 18

ANSWER G.03 (2.00)

- ~~\*Notify all other persons in the area at once. [0.5] ✓~~
- ~~\*Isolate area and evacuate. [0.5] ✓~~
- ~~\*Notify Area Supervisor and HP. [0.5] ✓~~
- ~~\*Make sure all access to area is controlled. Post warnings. [0.5] ✓~~

REFERENCE

054:EP-05-1

170:Emergency Plan p 77

SECURE VALVES TO ISOLATE LEAK [0.8]

NOTIFY RFD [0.8]

MONITOR [0.4]

ANSWERS -- ARMED FORCES RADIOBIO. RES-85/03/12-DUDLEY, N.

ANSWER G.04 (3.00)

Remove clothing <sup>IF POSSIBLE</sup> and save dosemeter [0.5]

Dress to reduce spread of contamination [0.5]

~~Wash out wound [0.5]~~ CALL FOR HELP [0.5]

Call hospital to prepare for contaminated person [0.5]

Move to clean area [0.5]

HF accompanies injured person in the ambulance to the hospital [0.5]

REFERENCE

054: EP-07-1

170: Emergency Plan pp 60-62

ANSWER G.05 (4.00)

a. Beta rate = (open - closed) ~~× efficiency factor~~ [0.4]

= (5.3 - 3.5) ~~× 10 R/hr~~ [0.3]

= 1.8 R/hr [0.1] (0.8)

b. Quarterly limit 1.25 R [0.5]

time = (1.25 R / 3.5 R/hr) × 60 min/hr [0.6]

= 21.4 min [0.1] (1.2)

c. To save a life <sup>75</sup> (100 R) [0.5]

To protect equipment (25 R) [0.5] (1.0)

d. DXR(2) = DXR(2) [0.4]

3.5 R/hr × (2 ft)<sup>2</sup> = Dose × (10 ft)<sup>2</sup> [0.5]

Dose = 3.5 × 4 / 100 R/hr

= .14 R/hr [0.1] (1.0)

REFERENCE

10CFR20.101

170: Emergency Plan p 34



## TEST CROSS REFERENCE

PAGE 1

| QUESTION | VALUE | REFERENCE  |
|----------|-------|------------|
| A.01     | 3.00  | DUD0000684 |
| A.02     | 2.00  | DUD0000685 |
| A.03     | 3.00  | DUD0000686 |
| A.04     | 3.00  | DUD0000696 |
| A.05     | 2.00  | DUD0000709 |
| A.06     | 1.00  | DUD0000710 |
| -----    |       |            |
|          | 14.00 |            |
| B.01     | 2.00  | DUD0000689 |
| B.02     | 2.00  | DUD0000690 |
| B.03     | 3.00  | DUD0000691 |
| B.04     | 2.50  | DUD0000692 |
| B.05     | 2.00  | DUD0000711 |
| B.06     | 2.50  | DUD0000712 |
| -----    |       |            |
|          | 14.00 |            |
| C.01     | 2.00  | DUD0000693 |
| C.02     | 2.00  | DUD0000694 |
| C.03     | 2.50  | DUD0000713 |
| C.04     | 2.50  | DUD0000715 |
| C.05     | 3.00  | DUD0000716 |
| C.06     | 2.00  | DUD0000717 |
| -----    |       |            |
|          | 14.00 |            |
| D.01     | 1.50  | DUD0000698 |
| D.02     | 3.20  | DUD0000721 |
| D.03     | 2.00  | DUD0000722 |
| D.04     | 3.20  | DUD0000723 |
| D.05     | 3.00  | DUD0000726 |
| D.06     | 1.50  | DUD0000727 |
| -----    |       |            |
|          | 14.40 |            |
| E.01     | 3.50  | DUD0000724 |
| F.02     | 1.50  | DUD0000725 |
| E.03     | 1.50  | DUD0000728 |
| E.04     | 2.00  | DUD0000729 |
| E.05     | 3.00  | DUD0000730 |
| F.06     | 3.00  | DUD0000731 |
| -----    |       |            |
|          | 14.50 |            |
| F.01     | 2.00  | DUD0000701 |
| F.02     | 4.00  | DUD0000702 |
| F.03     | 3.00  | DUD0000703 |
| F.04     | 2.00  | DUD0000732 |
| F.05     | 3.00  | DUD0000733 |

## TEST CROSS REFERENCE

PAGE 2

| QUESTION | VALUE | REFERENCE  |
|----------|-------|------------|
|          | 14.00 |            |
| G.01     | 2.50  | DUD0000697 |
| G.02     | 2.00  | DUD0000705 |
| G.03     | 2.00  | DUD0000718 |
| G.04     | 3.00  | DUD0000719 |
| G.05     | 4.00  | DUD0000720 |
|          | 13.50 |            |
|          | 98.40 |            |

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

FACILITY: ARMED FORCES RADIOBIO. RES  
 REACTOR TYPE: TRIGA  
 DATE ADMINISTERED: 85/03/12  
 EXAMINER: DUDLEY, N.  
 APPLICANT:

INSTRUCTIONS TO APPLICANT:

Use separate paper for the answers. Write answers on one side only. Staple question sheet on top of the answer sheets. Points for each question are indicated in parentheses after the question. The passing grade requires at least 70% in each category and a final grade of at least 80%. Examination papers will be picked up six (6) hours after the examination starts.

| CATEGORY VALUE | % OF TOTAL | APPLICANT'S SCORE | % OF CATEGORY VALUE | CATEGORY   |
|----------------|------------|-------------------|---------------------|--|
| 20.00          | 20.00      |                   |                     | H. REACTOR THEORY  |
| 19.10          | 19.10      |                   |                     | I. RADIOACTIVE MATERIALS HANDLING DISPOSAL AND HAZARDS   |
| 23.40          | 23.40      |                   |                     | J. SPECIFIC OPERATING CHARACTERISTICS                    |
| 17.50          | 17.50      |                   |                     | 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 (2.00)

If after achieving criticality the operator were to raise power to 50 kw, immediately establish an infinite period, and verify that the power level indication was steady with no rod motion, he would observe an increase in power after waiting a few minutes. Explain why.

## QUESTION H.02 (3.00)

- With an initial count rate of 20 ~~cps~~<sup>watts</sup>, reactivity is added to increase the count rate to 40 ~~cps~~<sup>watts</sup>. What would be the effect of adding the same amount of reactivity again? Explain your answer.
- With an initial power level of 10%, reactivity is added to raise power to 20%. What would be the effect of adding the same amount of reactivity again? Explain your answer.

## QUESTION H.03 (2.00)

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

## QUESTION H.04 (3.00)

The safety of a TRIGA reactor derives from its large prompt negative coefficient which is primarily due to an intrinsic characteristic of the fuel. List the THREE contributions (not necessarily all from from the fuel) which account for the prompt negative coefficient and explain how each of them inserts reactivity on a power increase.

## QUESTION H.05 (3.00)

How much reactivity has been added to a subcritical reactor if the count rate has increased from 100 cps to 150 cps and if the initial value of  $K_{eff}$  was .95?

## QUESTION H.06 (2.00)

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

## QUESTION H.07 (2.00)

- a. An experiment is loaded into the B-ring of the core when the reactor is operating at 1 MW. After loading the experiment, the reactor power level decreases to 750 KW. How much reactivity was added by the experiment? Neglect reactivity effects of heating. (0.8)
- b. If the experiment had been loaded in the outer ring would you expect the final power level to be different from 750 KW? Explain. (1.2)

## QUESTION H.08 (3.00)

Explain the different modes of heat transfer by which the heat of fission is removed from the fuel. Include major components involved in the heat removal process starting with the fuel and ending at the ultimate heat sink.

## QUESTION I.01 (2.10)

Indicate which radiation monitoring system, if any, is used to:

- a. Detect streaming radiation from Exposure Room #2.
- b. Detect fuel element failure.
- c. Ensure facility yearly airborne releases are within limits.

QUESTION I.02 (2.00) *DELETE*

Describe the TWO features of the pneumatic tube system that would minimize the release of radioactive materials into the reactor building atmosphere if failure of an experiment in the tube system occurred.

## QUESTION I.03 (2.00)

- a. Why is the use of the extraction tool to lower the rabbit into the Core Experiment Tube prohibited while at power? (0.8)
- b. What precautions are taken and what instrumentation is monitored when retrieving the rabbit? (1.2)

## QUESTION I.04 (2.50)

A gamma source emits 8 R/hr at one foot. How long could a person work at a distance of 4 feet from the source without exceeding the quarterly limit whole body in 10 CFR 20? Show your work.

## QUESTION I.05 (3.00)

What actions, if any, should be taken if a experimenter, who is in a contaminated area of the hot cell, has been severely cut and the bleeding cannot be stopped. The person is in protective clothing which is contaminated, there are no other experimenters or support personnel at the facility, and only the minimum operations staff required to operate the facility are available.

## QUESTION I.06 (4.50)

A fuel element is suspended in the Reactor Pool approximately 3 feet under water. A radiation survey meter held at the surface of the water reads 100 mrem/hr.

- a. Ignoring buildup, what radiation level would you expect if the fuel element broke the water?
- b. If the fuel element was placed in a 1 inch lead shield cask, what would the radiation level be at the surface?
- c. If the radioactive isotopes in the fuel element had an average half life of 30 minutes, how long it take for the radiation level at the surface of the WATER to drop to 20 mrem/hr?

## QUESTION I.07 (3.00)

An experimenter wants to make the following changes to an experiment after it has been approved for irradiation by the CET. For each proposed change explain HOW and WHY the change would affect the radiological hazards associated with the experiment.

- a. Use of an aluminum rabbit instead of a plastic rabbit.
- b. Use of acetone  $(CH_3)_2CO$  instead of alcohol  $C_2H_5OH$  to clean experiment.
- c. Use of a gold-silver capsule with a sodium chloride solution instead of a quartz glass capsule with a distilled water solution to contain experiment.
- d. The run is reduced from 1 MW-hr to 55 min at 1 MW.

## QUESTION J.01 (1.00)

Under what conditions, if any, can the reactor be operated if the ventilation system is inoperable? Explain.

## QUESTION J.02 (2.50)

- a. What effect, if any, would the loss of both air compressors have on the reactor building ventilation system? (1.0)
- b. Describe THREE features of the reactor building ventilation system which prevent the release of contamination to the environment and explain how these features work. Include both normal and emergency features. (1.5)

## QUESTION J.03 (2.50)

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

## QUESTION J.04 (1.50)

Explain how the pool temperature is controlled during plant operations at 1 MW.

## QUESTION J.05 (1.50)

During a reactor startup a scram occurs for no obvious reason. The operator finds he cannot reenergize the magnetic power to the control rods and resets the reactor console. Prior to reattempting the startup the operator notes he has regained a scram indication. What action, if any, should the operator take?



## QUESTION J.06 (2.00)

Should the reactor scram in each of the following independent situations? No explanation is required.

- a. A safety channel UIC fails to 50% of actual power level while operating in Mode I at 1 MW.
- b. The third independent ion chamber above the core loses High Voltage WHILE in mode IA at 500 KW.
- c. The C-ring thermocouple fails high in Mode II at 1 MW.
- d. The wide-range log channel is placed in test while in Mode I at 100 KW.

## QUESTION J.07 (3.00)

The following alarms are received simultaneously: water temperature high, stack gas activity high, water level low.

- a. Which one should be investigated first? Justify your answer. (1.0)
- b. What actions, if any, should be taken to control the situation and determine the problem? (2.0)

## QUESTION J.08 (3.00)

- a. What is the expected position of each of the FOUR rods at the time that the reactor becomes critical during K - Excess operations? (1.5)
- b. In square wave operations (Mode II) where should the anvil be set for a 75 cent insertion if the transient rod is not used for criticality? (0.75)
- c. In pulse (Mode III) operations where should the anvil be set for a 42 insertion? (0.75)

## QUESTION J.09 (3.20)

For each of the four positions of the mode selector switch, IA Steady State Automatic, I Steady State Manual, II Square Wave, and III Pulse, provide the following information:

- a. The rods which receive control signals from the fission chambers.
- b. Information displayed by the RED pen recorder.
- c. Information displayed by the BLUE pen recorder.
- d. The detectors which supply scram signals through the switch.

## QUESTION J.10 (3.20)

What effect, if any, will the following changes have on nuclear power indications. Explain each answer.

- a. The count rate portion of the fission chamber signal processing circuitry provides no signal at 500 KW.
- b. The cambelling portion of the fission chamber signal processing circuitry provides no signal at 100 watts.
- c. The Primary flow rate increases from 250 gpm to 350 gpm.
- d. The pool temperature increases 10 degrees.

## QUESTION K.01 (2.40)

What is the purpose of each of the following fuel element segments?

- a. Samarium wafers
- b. Graphite plug
- c. Zirconium rod
- d. Stainless steel tube

## QUESTION K.02 (2.00)

For each of the following conditions indicate on the attached moderator to fuel ratio graph approximately where the reactors would be operating. Assume X is the operating position for a fully loaded core and a pool temperature of 90 F.

- a. A fully loaded core and pool temperature 100 F.
- b. Rings B, C, D, and E fully loaded and pool temperature 90 F.  
(fuel elements removed from outer face of core)
- c. Rings C, D, E, and F fully loaded and pool temperature 90 F.  
(fuel elements removed from center of core)

## QUESTION K.03 (1.50)

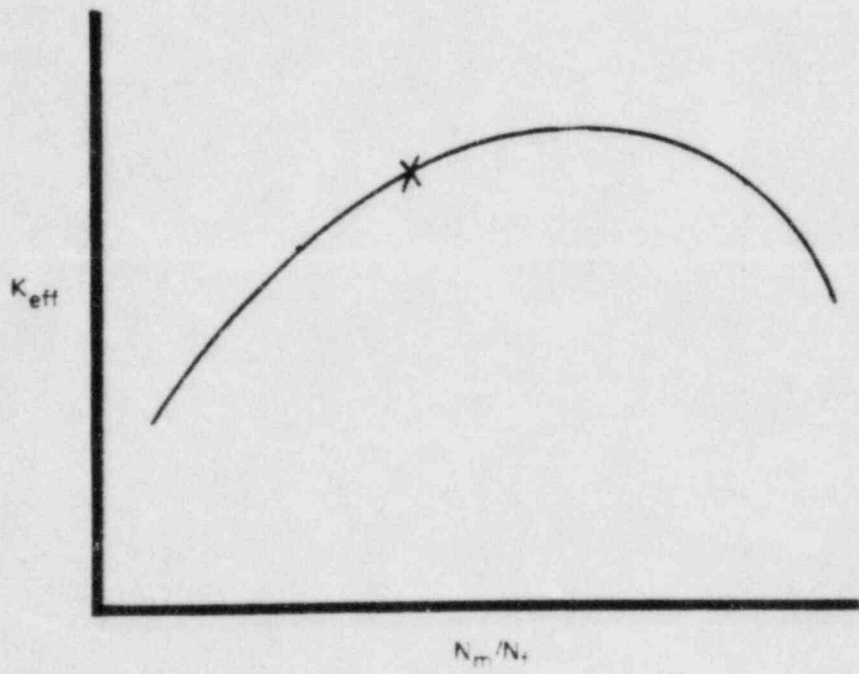
If the vent on the primary cooling pump was left open during refueling could the core be uncovered? Explain.

## QUESTION K.04 (1.60)

The inspection of the control rods required annually is scheduled this week. The three previous inspections were conducted 13, 24, and 39 months ago. Can an experiment be run this week without inspecting the control rods? Justify your answer.

## QUESTION K.05 (2.00)

Estimate the shutdown margin, which would be used to meet the Technical Specifications, of an AFFRI core in which Rings B, C, and D were loaded. State any assumptions and show work.



1.0

.9

.8

.7

.6

.5

.4

.3

.2

.1

5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90

NUMBER OF FUEL ELEMENTS

## QUESTION K.06 (4.00)

The following data was taken during a core loading:

| # of elements | Detector A (CPM) |     | Detector B (CPM) |     |
|---------------|------------------|-----|------------------|-----|
|               | Rods             |     | Rods             |     |
|               | in               | out | in               | out |
| 0             | 16               | 16  | 30               | 30  |
| 12            | 19               | 22  | 31               | 31  |
| 24            | 23               | 29  | 32               | 34  |
| 36            | 28               | 45  | 35               | 40  |
| 42            | 37               | 70  | 40               | 50  |

- How many elements will be required for a critical mass? Graph paper is attached.
- Which curve did you use to base your prediction? Justify your choice.

## QUESTION K.07 (2.50)

What personnel are required to be present and where are they to be stationed for fuel manipulations within the core and near the core region?

## QUESTION K.08 (1.50)

- Explain how moving the core to a different position can change its excess reactivity. (1.0)
- At what position I, II, or III is the core worth a maximum? (0.5)

## QUESTION L.01 (2.50)

- a. What is the Safety Limit for AFFRI? (0.6)
- b. What is the objective of the safety limit? (0.7)
- c. What is done to prevent exceeding the safety limit? (1.2)

## QUESTION L.02 (3.00)

For each of the following situations indicate whether a completed RUR (Reactor Use Request) is required.

- a. Maintenance in Exposure Room #1 when the reactor is secured.
- b. Movement of the reactor to a new location.
- c. Checking operation of the pneumatic tube system using an experimental mockup while at 1 KW. ~~DELETE~~
- d. Conducting K excess measurements.
- e. Loading an additional instrumentation package into the pool prior to reactor startup.
- f. Determining the reactivity worth of a new transient rod.

## QUESTION L.03 (2.50)

- a. What is the minimum staff required when the reactor is not secured? (2.0)
- b. What actions, if any, must be taken if one of these people becomes incapacitated. (0.5)

## QUESTION L.04 (3.00)

Indicate whether each of the following situations would require immediate shutdown of the reactor. Consider each situation separately and justify your answer.

- a. Reactor power spiked to 1.15 MW during Mode I operations and is now at 900 KW.
- b. A compensated ion chamber becomes inoperable while at 100% power. ~~DELETE~~
- c. Power increases as rods are manually driven into the core while at 500 kw. Pool temperature is 95 F and the primary and secondary pumps are operating.
- d. An area radiation monitor in the reactor building is found to be inoperable.

## QUESTION L.05 (3.00)

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

- a. A change to an experimental procedure which loads a sample in a symmetric location in the core from the original location. No other information is available concerning the reactivity value for the sample in the symmetric location or the intent of the experiment.
- b. A temporary change to the startup procedure which allows pulling two rods at once.
- c. A change to a maintenance procedure which changes the specifications for the container to collect water from a flush of secondary piping.

## QUESTION L.06 (3.00)

For each of the following situations indicate who, if anyone, is responsible:

- a. Final approval on a Reactor Use Request.
- b. Approving an entry into an Exposure Room.
- ~~c. Retrieval of an experiment from the pneumatic transfer system.~~
- d. Insertion of an in-core experiment.
- e. Core loading.

## QUESTION L.07 (3.00)

Make the proper log entries for the following situation indicating what colored ink should be used for each entry. The control room operator starts the primary pump at 0430 am. The reactor is shut down and the console is UNlocked. The pump fails to start and the operator faints. The second operator returns 10 minutes later after loading an experiment and helps the second operator to recover.



ANSWERS -- ARMED FORCES RADIOBIO. RES-85/03/12-DUDLEY, N.

ANSWER H.01 (2.00)

- a. When rods were inserted only prompt neutrons were affected and reactor power was stabilized. [1.0]  
After a few minutes the delayed neutrons contributed to the overall neutron population [1.0] thus power increased.

REFERENCE

470:C-E Reactor Theory pgs. 74-76

054:Nuclear Energy Training, Module 3 Rx Ops, Unit 5.5

ANSWER H.02 (3.00)

- SINCE RX IS CRITICAL AT 10 WATTS AND 40 WATTS, NO ACTIVITY ADDITION IS NEEDED TO RAISE POWER UNTIL REACHED THE POINT OF ADDING HEAT.*
- a. ~~Reactor would be supercritical. [0.75] By doubling count rate~~  
~~1-Keff is halved~~  
Assume  $K_{eff} = 0.90$  at 20 cps then  $K_{eff} = 0.95$  at 40cps  
change in reactivity =  $0.05 / (0.9 \times 0.95) = 5.85\%$  delta K/K  
reactivity need for criticality =  $0.05 / (0.9 \times 1.0) = 5.26\%$  delta K/K  
~~5% delta K/K excess reactivity would be added. [0.75]~~  
(Calculations not required for full credit)

- b. <sup>35%</sup> ~~30%~~ power [0.75]  
power coefficient of reactivity is <sup>NOT</sup> linear ~~(+3.43 from 15u to 1MW)~~ [0.75]  
(READ FROM POWER COEFFICIENT CURVE)

REFERENCE

054:Nuclear Energy Training, Module 3 Rx Ops, Unit 12.1

DS-01-1

170:Nuclear Theory II A.4

Reference Package, Reactor Parameters

ANSWER H.03 (2.00)

- Below 325 mW the source is adding more neutrons than it is absorbing and it has a positive worth. [0.7]  
At 325 mW the source is adding the same number of neutrons as it is absorbing and has a zero worth. [0.7]  
Above 325 mW the source absorbs more neutrons than it absorbs and has a negative worth. [0.7]

REFERENCE

170: Question and Answers J.15

ANSWERS -- ARMED FORCES RADIOBIO. RES-85/03/12-DUDLEY, N.

ANSWER H.04 (3.00)

ZrH disadvantage factor [0.4] as temperature raises the ZrH becomes less effective as a moderator. [0.6]

Doppler effect [0.4] absorption cross sections of resonance peaks broaden as temperature increases. [0.6]

Water displacement [0.4] water density decreases and fuel expands to displace water which which decreases moderation. [0.6]

REFERENCE

170:Nuclear Theory II.B.4

ANSWER H.05 (3.00)

$$cr1 / cr2 = (1 - Keff2) / (1 - Keff1) \quad [0.9]$$

$$100/150 = (1 - Keff2) / (1 - 0.95) \quad [0.5]$$

$$1 - Keff2 = 10/15 \times 0.05$$

$$Keff2 = 0.967 \quad [0.1]$$

$$\text{change in reactivity} = [1 - Keff2/Keff2] - [1 - Keff1/Keff1] \\ = Keff2 - Keff1 / Keff1 \times Keff2 \quad [0.9]$$

$$= 0.967 - 0.95 / 0.95 \times 0.967 \quad [0.6]$$

$$= 1.85 \% \text{ delta } K/K \quad [0.1]$$

REFERENCE

170: Reactor Theory II A.4

ANSWER H.06 (2.00)

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

b. Rods would be higher at 1000 KW [0.4] to compensate for the negative reactivity added by the power coefficient. [0.6]

REFERENCE

170: Reactor Theory II B.4

-----  
 ANSWERS -- ARMED FORCES RADIOBIO. RES-85/03/12-DUDLEY, R.

ANSWER H.07 (2.00)

~~SC. 46~~  
 a. ~~0.56~~ [0.8]

b. Final power level would be higher than 750 KW [0.4]

The core outer ring has a lower flux and therefore the experiment would not be worth as much. [0.8]

REFERENCE

170: Questions and Answers C.15

ANSWER H.08 (3.00)

Conduction through fuel. (Radiation across fuel gap) [0.5]

Conduction transfer from fuel to coolant. [0.5]

Forced convection through holdup tank, primary pump, to HX. [0.5]

Conduction across HX. [0.5]

Forced convection to cooling towers. [0.5]

Evaporation to atmosphere. [0.5]

REFERENCE

054: Nuclear Engineering Training, Module 4 Plant Performance, Unit 3.1  
 Flow Diagram Reactor Cooling

170: Operations Manual pp 37,41

CONDUCTION THROUGH FUEL (RADIATION ACROSS FUEL GAP) [1.0]

CONDUCTION THROUGH LAMINAR LAYER TO WATER [1.0]

CONVECTION TO COOL AND ATMOSPHERE [1.0]

-----  
 ANSWERS -- ARMED FORCES RADIOID, RES-85/03/12-DUDLEY, N.

ANSWER I.01 (2.10)

- a. Area Radiation Monitoring System. [0.7]
- b. Air Particulate Monitor. [0.7]
- c. Environmental Radiation Monitor Program. [0.7]

REFERENCE

170: T.S. Sec. 3.5

ANSWER I.02 (2.00) ~~DELETE~~

- Absolute filter on blower [1.0]
- Tube system exhausts to stack [1.0]

REFERENCE

170: Operations Manual p 180

ANSWER I.03 (2.00)

- a CAF [0.8]
- b. Do not remove rabbit from pool if radiation levels are high. [0.6]  
 Monitor SAF which has teletector positioned near the CET top. [0.6]  
 (Place rabbit in lead pig)

REFERENCE

170: Operating Procedures I, Tab B

ANSWER I.04 (2.50)

$$D1 \times (R1)^2 = D2 \times (R2)^2 \quad [0.6]$$

$$8 \text{ R/hr} \times 1 \text{ sqft} = D2 \times 16 \text{ sqft} \quad [0.4]$$

$$D2 = .5 \text{ R/hr} \quad [0.1]$$

$$\begin{aligned} \text{stay time} &= \text{total allowed dose} / \text{dose rate} && [0.6] \\ &= 1.25 \text{ R} / .5 \text{ R/hr} && [0.4] \quad [0.3 \text{ for limit}] \\ &= 2.5 \text{ hr} && [0.1] \end{aligned}$$

REFERENCE

170: 10CFR20.101

ANSWERS -- ARMED FORCES RADIOBIO. RES-85/03/12-DUDLEY, N.

ANSWER I.05 (3.00)

Remove clothing <sup>if possible</sup> ~~and save decontamination~~ [0.5]

Dress to reduce spread of contamination [0.5]

~~Wash out wound [0.5]~~ CALL FOR HELP [0.5]

Call hospital to prepare for contaminated person [0.5]

Move to clean area [0.5]

HP accompanies injured person in the ambulance to the hospital [0.5]

## REFERENCE

054: EP-07-1

170: Emergency Plan pp 60-62

ANSWER I.06 (4.50)

a.  $I = I_0 e^{-ux}$   $0.07 \text{ cm}^{-1} \times 91 \text{ cm}$  [0.6]

500 mrem/hr =  $I_0 e^{-2.13}$   ~~$(1) 91 \text{ cm}$~~  [0.6]

$I_0 = 60.23 \text{ R/hr}$  [0.3]

b.  $I = I_0 e^{-ux}$  [0.6]

=  $60.23 \text{ R/hr} e^{-0.91 \text{ cm}^{-1} \times 2.54 \text{ cm}}$  [0.6]

=  $7.9 \text{ R/hr}$   $0.8 \text{ cm}^{-1} \times 2.54 \text{ cm}$  [0.3]

c.  $A = A_0 e^{-\lambda t}$  [0.6]

$t = (\ln A/A_0) / \lambda = \ln(20/500) / 1.39 \text{ per hr}$  [0.6]

$t = 1.16 \text{ hr}$  or  $70 \text{ MIN}$   $1.39$  [0.3]

## REFERENCE

170: Questions and Answers I.3

ANSWER I.07 (3.00)

a. Increase hazard [0.3] Al activates but has a short half life so must allow time for sample to decay. [0.45]

b. No change [0.3] both evaporate rapidly and are similar chemically [0.45]

c. Increase hazard [0.3] gold and silver will activate under any amount of neutron flux. [0.45]

d. No change [0.3] the length of time of exposure will not affect activation of experiment. [0.45]

## REFERENCE

170: Questions and Answers I.5

-----  
ANSWERS -- ARMED FORCES RADIOBIO. RES-85/03/12-DUDLEY, N.

ANSWER J.01 (1.00)

To test or premit minor repairs of the system (not to exceed 48 hrs).[0.6]  
Dampers will be shut during this period so no release is possible. [0.4]

REFERENCE

170: T.S., Sec 3.4

ANSWER J.02 (2.50)

- a. The supply dampers (S1,S2, and S3) and the exhaust damper (E1) would shut [1.0]
- b. Supply and exhaust dampers close on high CAM alarm preventing release of radioactivity [0.6]  
Exhaust air is passed through prefilter, roughing filter, and absolute filter which remove contamination (particulate matter) from the air. [0.6]  
A negative pressure is maintained in contaminated areas to reduce spread of contamination out of those areas. [0.3]

REFERENCE

170:Operations Manual pp 63, 68

ANSWER J.03 (2.50)

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

REFERENCE

054: TS p. 9

DS-01-1 and DS 02-2

170: Operations Manual, Chap. 3 - Reactor Water Systems  
Reference Package, Reactor Parameters

ANSWER J.04 (1.50)

~~\* The number of operating fans in the cooling tower is adjusted. [1.5] C~~  
~~TURN ON SECONDARY SYSTEM~~

REFERENCE

170: Operations Manual p 41

ANSWERS -- ARMED FORCES RADIOBIO. RES-85/03/12-DUDLEY, N.

ANSWER J.05 (1.50)

Check for a person in the exposure rooms. [1.5]

REFERENCE

170: Safety Analysis Report p 4-27  
Operations Manual p 101

ANSWER J.06 (2.00)

- a. No [0.5]
- b. Yes [0.5]
- c. Yes [0.5]
- d. No [0.5]

REFERENCE

170: Safety Analysis Report pp 4-23, 4-24  
Operations Manual p 83

ANSWER J.07 (3.00)

- a. Water level [0.5] results in loss of shielding and high radiation levels. [0.5]
- b. Take steps for reactor emergency. [0.5]
  - Isolate reactor room [0.5]
  - Investigate [0.5]
  - Perform emergency [0.5]

REFERENCE

170: Questions and Answers J.13

ANSWER J.08 (3.00)

- a. Safety and Shim rods 100% [0.7]
  - Transient rod 25% [0.4]
  - Regulating Rod 0 to 100% [0.4]
- b. 260 Units [0.75]
- c. 490 Units [0.75]

REFERENCE

170: Operations Procedures VIII, Tabs C, D, and E  
Reference Package, Fig. 6.8

ANSWERS -- ARMED FORCES RADIOBIO. RES-85/03/12-DUDLEY, N.

ANSWER J.09 (3.20)

|     |             |                            |                                    |                 |
|-----|-------------|----------------------------|------------------------------------|-----------------|
|     | a.          |                            |                                    | d.              |
| IA  | REG ROD     | <sup>b.</sup><br>LOW POWER | <sup>c.</sup><br>LINEAR POWER      | UIC (both)      |
| I   | None        | <del>RX PERIOD</del>       | <del>Power (fission chamber)</del> | UIC (both)      |
| II  | REG + TRANS | <del>RX PERIOD</del>       | <del>Power (fission chamber)</del> | UIC (both)      |
| III | None        | <del>RX PERIOD</del>       | <del>Power (fission chamber)</del> | Pulsing UIC (1) |
|     |             | FUEL TEMP                  | <del>Power</del> Pulsing UIC       | [0.2 each]      |

REFERENCE

170: Question and Answers Fig. D-1

ANSWER J.10 (3.20)

- a. Reduces indication on <sup>LCV CHANNEL</sup> ~~fission chamber~~ [0.3]  
Count rate provides constant input to signal when it saturates. [0.5]
- b. No affect [0.3]  
Only provides signal in upper four decades of indicating range. [0.5]
- c. No affect [0.3]  
Flow has no affect on any nuclear power indication. [0.5]
- d. ~~Indicated power will increase on the UIC [0.3]~~  
~~Fast leakage would increase and detector measure fast neutron leakage. [0.5]~~

NO EFFECT IF IN AUTOMATIC [0.9]

OR

POWER WILL DECREASE IF IN MANUAL [0.8]

REFERENCE

170: Operations Manual pp 83-89



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ANSWERS -- ARMED FORCES RADIOBIO. RES-85/03/12-DUDLEY, N.

ANSWER K.01 (2.40)

- a. Minimizes changes [0.2] resulting from fission product buildup [0.2] and fuel burnup. [0.2] (*FLATTENS FLUX, EXTENDS CORE LIFE*)
- b. Act as top and bottom axial reflectors. [0.6]
- c. Provides structural support. [0.6]
- e. Container for all fuel element segments. [0.6]

REFERENCE

170: SAR p 4-12

ANSWER K.02 (2.00)

[0.66 each]

REFERENCE

054:Nuclear Energy Training, Module 3 Rx Ops, Unit 8.4

170:Nuclear Theory II A.1.b.(6)

Reference Package, Reactor Parameters

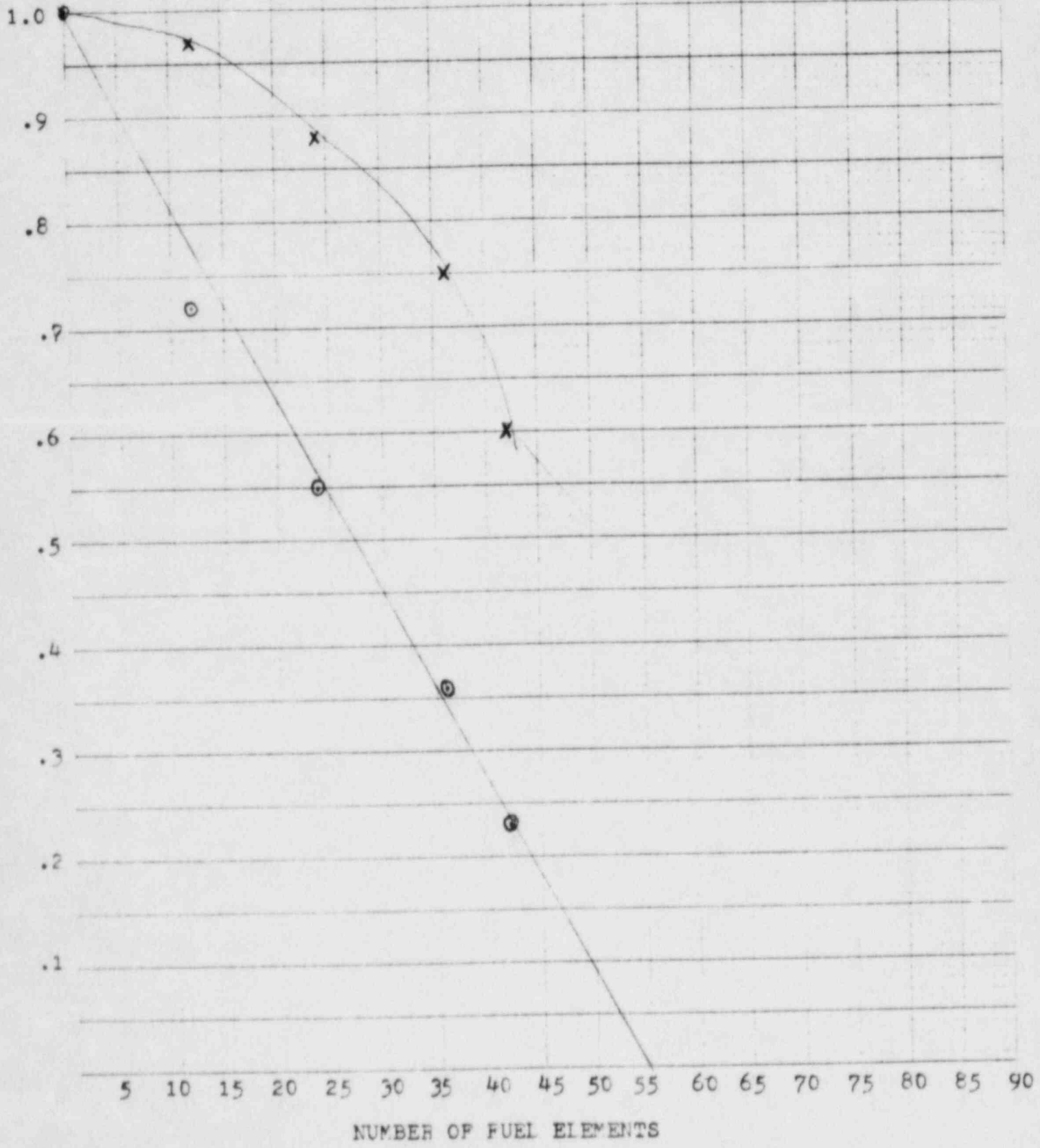
ANSWER K.03 (1.50)

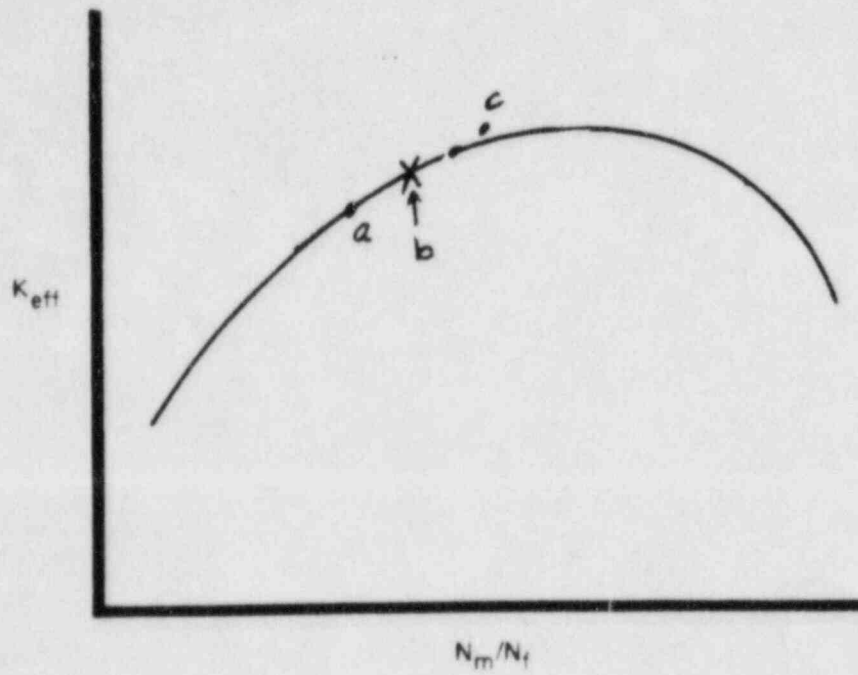
No. [0.5] There is small hole drilled in piping 4" below surface of pool which will prevent siphoning. [1.0]

REFERENCE

170: Operations Manual p 41

| # of<br>Purs. | OET<br>A(0) | OET<br>B(x) |
|---------------|-------------|-------------|
| 0             | 1           | 1           |
| 12            | .72         | .97         |
| 24            | .55         | .88         |
| 36            | .36         | .75         |
| 42            | .23         | .6          |





ANSWERS -- ARMED FORCES RADIOBIO. RES-85/03/12-DUDLEY, N.

ANSWER K.04 (1.60)

Yes. [0.7] TS surveillance is one year not to exceed 15 months. [0.9]  
 (TS do not include 3.25 x interval requirement.)

## REFERENCE

170: T.S. sec 4.1

ANSWER K.05 (2.00)

Shut down margin calculated with most reactive rod stuck at top of core.

$$\begin{aligned} \text{reactivity of controls} &= \text{rod worth} \times 3 && [0.3] \\ &= 1.89 \times 3 && [0.3] \\ &= 5.67 && [0.1] \end{aligned}$$

$$\begin{aligned} \text{Core excess reactivity} &= \text{Ring B} + \text{Ring C} + \text{Ring D} && [0.3] \\ &= 1.25 \times 6 + 1.07 \times 12 + 0.89 \times 15 && [0.3] \\ &= 3.21 + 12.84 + 13.35 && [0.1] \\ &= 19.40 && [0.1] \end{aligned}$$

$$\begin{aligned} \text{Shutdown margin} &= \text{reactivity of rods} - \text{core excess reactivity} && [0.3] \\ &= 5.67 - 19.40 && [0.2] \\ &= -13.73 && \end{aligned}$$

## REFERENCE

170: T.S. 3.1

Reference Package, Reactor Parameters

ANSWER K.06 (4.00)

- a. 55 elements [0.8]  
 proper calculation of Co/C [0.6]  
 proper plotting of points [0.6]
- b. Detector A curve. [0.8] Detector curve B is nonconservative [0.6]  
 because the tangent to the curve has a continually increasing slope. [0.6]

## REFERENCE

170: Questions and Answers K.5

ANSWER K.07 (2.50)

- Minimum of two licensed operators [0.6]  
 SRD in direct supervision [0.7]  
 \*One in Control (monitoring count rate channel) [0.6]  
 \*One SRD on bridge [0.6]  
 IN REACTOR ROOM

-----  
ANSWERS -- ARMED FORCES RADIOBIO. RES-85/03/12-DUDLEY, N.

REFERENCE

054:RM-10-6

ANSWER K.08 (1.50)

- a. Different amounts of neutrons are reflected back into the core depending on the position of the core. [1.0]
- b. In position II. [0.5]

REFERENCE

170:Reference Package, Reflector Coefficient

ANSWERS -- ARMED FORCES RADIOBIO. RES-65/03/12-DUDLEY, N.

ANSWER L.01 (2.50)

- a. Maximum fuel temperature < 1000 C. [0.6]
- b. Prevent fuel element cladding damage. [0.7]
- c. Plant is operated within LCO's. [0.6]  
Safety system settings are below the limiting safety settings. [0.6]

REFERENCE

170: T.S., Sec 2

ANSWER L.02 (3.00)

- a. Not required
- b. Not required
- c. Required ~~DELETE~~
- d. Not required
- e. Required
- f. Not required

[0.5 each]

REFERENCE

170: Operating Procedure I  
Questions and Answers, F.12

ANSWER L.03 (2.50)

- a. SRD on call [0.5]  
RO or SRD in the main control room. [0.5]  
Radiation Control Technician on call. [0.5]  
Another body. [0.5]
- b. Secure the reactor. [0.5]

REFERENCE

054:RM-04-1  
170:T.S. sec e.1.3.2

ANSWERS -- ARMED FORCES RADIOBIO. RES-85/03/12-DUDLEY, W.

ANSWER L.04 (3.00)

- a. Shutdown [0.35] since safety feature has failed to operate. [0.4]
- b. Continue to operate [0.35] 1 required instrument is still operable [0.4] ~~DELETE~~
- c. Shutdown [0.35] operator cannot exercise effective control of the reactor. [0.4]
- d. Shutdown [0.35] two detectors in the Reactor Building are required for operation. [0.4]

REFERENCE

054:RM-04-4 to 5  
EP-03-3

170:T.S. sec. 3.2.1, 3.2.2, 3.5.1

ANSWER L.05 (3.00)

- a. No [0.6] Procedure changes the intent of the experiment [0.4]
- b. No [0.6] Procedure change effects safe operation of the plant. [0.4]
- c. Yes [0.6] Does not change intent of procedure. [0.4]

REFERENCE

054:AD-01-3

170:Operating Procedure 0

ANSWER L.06 (3.00)

- a. Reactor Facility Director
- b. Reactor Staff
- c. Reactor Operator ~~DELETE~~
- d. SR0
- e. Reactor Facility Director

[0.6 each]

REFERENCE

170: Operations Procedure I, Tabs A, D, and E  
Operations Procedure VII

-----  
ANSWERS -- ARMED FORCES RADIOBIO. RES-85/03/12-DUDLEY, N.

ANSWER L.07 (3.00)

- ~~+ 0425 [0.2] Start primary pump [0.3] black ink [0.1]~~
- ++ 0440 [0.2] Relieved the Control room Operator, *Secured Console*  
Signed by second operator [0.3] black ink [0.1]
- + 0430 (late entry) [0.2] Primary pump failed to start [0.3] green ink [0.1]
- ++ 0435 (late entry) [0.2] Load experiment in core [0.3] red ink [0.1]

REFERENCE

170: Procedure VIII, Tab A



## TEST CROSS REFERENCE

PAGE 1

| QUESTION | VALUE | REFERENCE  |
|----------|-------|------------|
| H.01     | 2.00  | DUD0000742 |
| H.02     | 3.00  | DUD0000742 |
| H.03     | 2.00  | DUD0000743 |
| H.04     | 3.00  | DUD0000744 |
| H.05     | 3.00  | DUD0000745 |
| H.06     | 2.00  | DUD0000748 |
| H.07     | 2.00  | DUD0000750 |
| H.08     | 3.00  | DUD0000753 |

-----  
20.00

|      |      |            |
|------|------|------------|
| I.01 | 2.10 | DUD0000735 |
| I.02 | 2.00 | DUD0000746 |
| I.03 | 2.00 | DUD0000759 |
| I.04 | 1.50 | DUD0000761 |
| I.05 | 3.00 | DUD0000762 |
| I.06 | 4.50 | DUD0000763 |
| I.07 | 3.00 | DUD0000764 |

-----  
19.10

|      |      |            |
|------|------|------------|
| J.01 | 1.00 | DUD0000738 |
| J.02 | 2.50 | DUD0000747 |
| J.03 | 2.50 | DUD0000749 |
| J.04 | 1.50 | DUD0000754 |
| J.05 | 1.50 | DUD0000756 |
| J.06 | 2.00 | DUD0000757 |
| J.07 | 3.00 | DUD0000758 |
| J.08 | 3.00 | DUD0000734 |
| J.09 | 3.20 | DUD0000752 |
| J.10 | 3.20 | DUD0000751 |

-----  
23.40

|      |      |            |
|------|------|------------|
| K.01 | 2.40 | DUD0000738 |
| K.02 | 2.00 | DUD0000741 |
| K.03 | 1.50 | DUD0000755 |
| K.04 | 1.60 | DUD0000765 |
| K.05 | 2.00 | DUD0000766 |
| K.06 | 4.00 | DUD0000767 |
| K.07 | 2.50 | DUD0000768 |
| K.08 | 1.50 | DUD0000773 |

-----  
17.90

|      |      |            |
|------|------|------------|
| L.01 | 2.50 | DUD0000737 |
| L.02 | 3.00 | DUD0000760 |
| L.03 | 2.50 | DUD0000769 |
| L.04 | 3.00 | DUD0000770 |
| L.05 | 3.00 | DUD0000772 |

## TEST CROSS REFERENCE

PAGE 2

| QUESTION | VALUE  | REFERENCE  |
|----------|--------|------------|
| L.06     | 3.00   | DUD0000740 |
| L.07     | 3.00   | DUD0000739 |
|          | 20.00  |            |
|          | 100.00 |            |