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: AFRRI

EXAMINATION DATES: March 11, 1985

CHIEF EXAMINER: R. F. Dudley, Lead Reactor Engineer — 5/14/85 date

REVIEWED BY: R. M. Keller, Chief, Projects Section 1C — 5/14/85 date

APPROVED BY: 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.

REPORT DETAILS

TYPE OF EXAMS: Replacement X

EXAM RESULTS:

	RO Pass/Fail	SRO 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 or 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   Both candidates used out of date P&ID's to evaluate plant systems.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:

Answer No.	Change	Reason
B.01 I.02 F.05 L.02 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 b	Change to "reads off scale high" Change to "reads temperature at short"	Correct answer for design of thermocouples.
D.02a and J.10	Change "fission chamber" to "Log Channel"	Provides correct description of instrumentation channel.
D.02d and 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.

Answer No.	Change	Reason
D.04 and 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 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.

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

Answer No.	Change	Reason
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)

MASTER

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 Keff was .95?

QUESTION A.05 (2.00)

If after acheiving 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 AFRRI 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 at100 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 affect 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 developes 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 prossessing circuitry provides no signal at 500 KW.

b. The cambelling portion of the fission chamber signal prossessing 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 inconsistancies 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.

E. SAFETY AND EMERGENCY SYSTEMS

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 expaination 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 Volatge WHILE in mode IA at 500 KW.

c. The C-ring thermocouple fails high in Mode Il 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. CUNO 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 AFRRI Complex Emergency Evacuation?

QUESTION F.03 (3.00)

The following alarms are received simutaneously; 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 severly 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 AND FUEL 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 x 55 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) [0.9]
100/150 = (1-Keff2) / (1-0.95) [0.5]
1-Keff2 = 10/15 x 0.05
Keff2 = 0.967 [0.1]

change in reactivity = [1-Keff2/Keff2] - [1-Keff1/Keff1]
= Keff2 - Keff1 / Keff1 x Keff2 [0.9]
= 0.967 - 0.95 / 0.95 x 0.967 [0.6]
= 1.85 % delta K/K [0.1]

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 stablized.[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 $-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 withdrawl 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 WATER LEVEL 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

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

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. $P = P_o e^{(t/T)}$ [0.4]
$1\ MW = 1.25E-4\ e^{(t/50)}$ [0.4]
$\ln[8\ E3] = \ln[e^{(t/50)}]$
$8.987 = t/50$
$t = 449$ sec or 7.48 min. [0.2]

b. Power coefficient would lengthen period and would eventually stabalize 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]

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 ~ 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	~~RX PERIOD~~ LOG POWER	~~Power (fission chamber)~~ LINEAR POWER	UIC (both)
I	None	~~RX PERIOD~~	~~Power (fission chamber)~~	UIC (both)
II	REG + TRANS	~~RX PERIOD~~	~~Power (fission chamber)~~	UIC (both)
III	None	FUEL TEMP	~~Power~~ Pulsing UIC	Pulsing UIC (1)

[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. ~~[1.5]~~ [0.5] STOP STARTUP ATTEMPT [0.5] 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, N.

ANSWER E.05 (3.00)

a. Prevents contact or impact between the reactor tank lead shielding door and the reactor core shroud. [~~1.0~~ 0.5] PREVENT ACCIDENTAL EXPOSURE [0.5]

b. Region 1: 12" of the maximum travel distance of core dolly 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 dolly 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. ~~CAN~~ 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 oplerate 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~~ WATER LEVEL [0.5] ~~since it posses a threat to public health~~ 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 PLAN [0.5]

ANSWER F.04 (2.00)

a. ~~EAR~~ PREVENT ACTIVATION OF TOOL [0.8]

b. Do not remove rabbit from ~~pool~~ CET if radiation levels are high. [0.6]
Monitor SAF which has teletector positoned 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 x (R1)2 = D2 x (R2)2 [0.6]
8 R/hr x 1 sqft = D2 x 16 sqft [0.4]
D2 = .5 R/hr [0.1]

stay time = total allowed dose / dose rate [0.6]
= 1.25 R / .5 R/hr [0.4] [0.3 for limit]
= 2.5 hr [0.1]

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]~~ C
~~*Isolate area, and evacuate. [0.5]~~ C
~~*Notify Area Supervisor and HP. [0.5]~~ C
~~*Make sure all access to area is controlled. Post warnings. [0.5]~~ C

REFERENCE
054:EP-05-1
170:Emergency Plan p 77

SECURE VALVES TO ISOLATE LEAK [0.8]
NOTIFY RFO [0.8]
MONITOR [0.4]

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

ANSWER G.04 (3.00)

Remove clothing ~~and save dosemitryc~~ IF POSSIBLE [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) ~~x efficiency factor~~ [0.4]
= (5.3 - 3.5) ~~x 10 R/hr~~ [0.3]
= 18 R/hr [0.1] (0.8)

b. Quarterly limit 1.25 R [0.5]
time= (1.25 R / 3.5 R/hr) X 60 min/hr [0.6]
= 21.4 min [0.1] (1.2)

c. To save a life (~~100~~ 75 R) [0.5]
To protect equipment (25 R) [0.5] (1.0)

d. DXR(2)=DXR(2) [0.4]
3.5 R/hr X (2 ft)2 = Dose x (10 ft)2 [0.5]
Dose= 3.5 X 4 / 100 R/hr
= .14 R/hr [0.1] (1.0)

REFERENCE
10CFR20.101
170: Emergency Plan p 34

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

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	

MASTER

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

FACILITY: ARMED FORCES RADIOBIO. RES ES

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 acheiving 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)

a. With an initial count rate of 20 ~~cps~~ WATTS, reactivity is added to increase the count rate to 40 ~~cps~~ WATTS. What would be the effect of adding the same amount of reactivity again? Explain your answer.

b. 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 Keff 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 severly 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 (CH3)2CO instead of alcohol C2H5OH 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 vetil ation 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 affect 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 consol. 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 expaination is required.

a. A safety channel U1C 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 Volatge WHILE in mode IA at 500 KW.

c. The C-ring thermocouple fails high in Mode Il 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 simutaneously; 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 critial 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 $2 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 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 prossessing circuitry provides no signal at 500 KW.

b. The cambelling portion of the fission chamber signal prossessing 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)

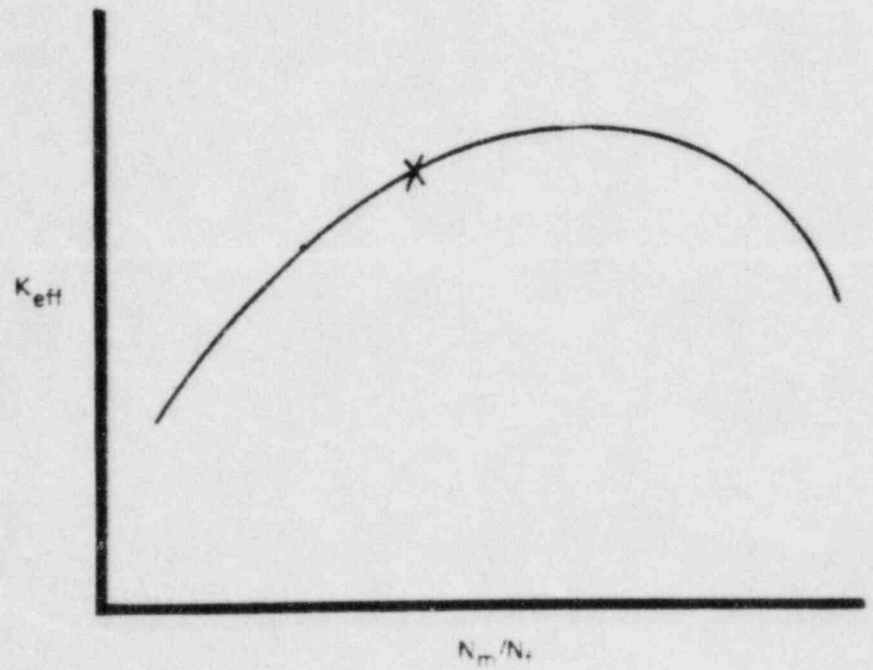
If the vent on the primary cooling pump was left open during refueling could the core be uncovered? Explain.

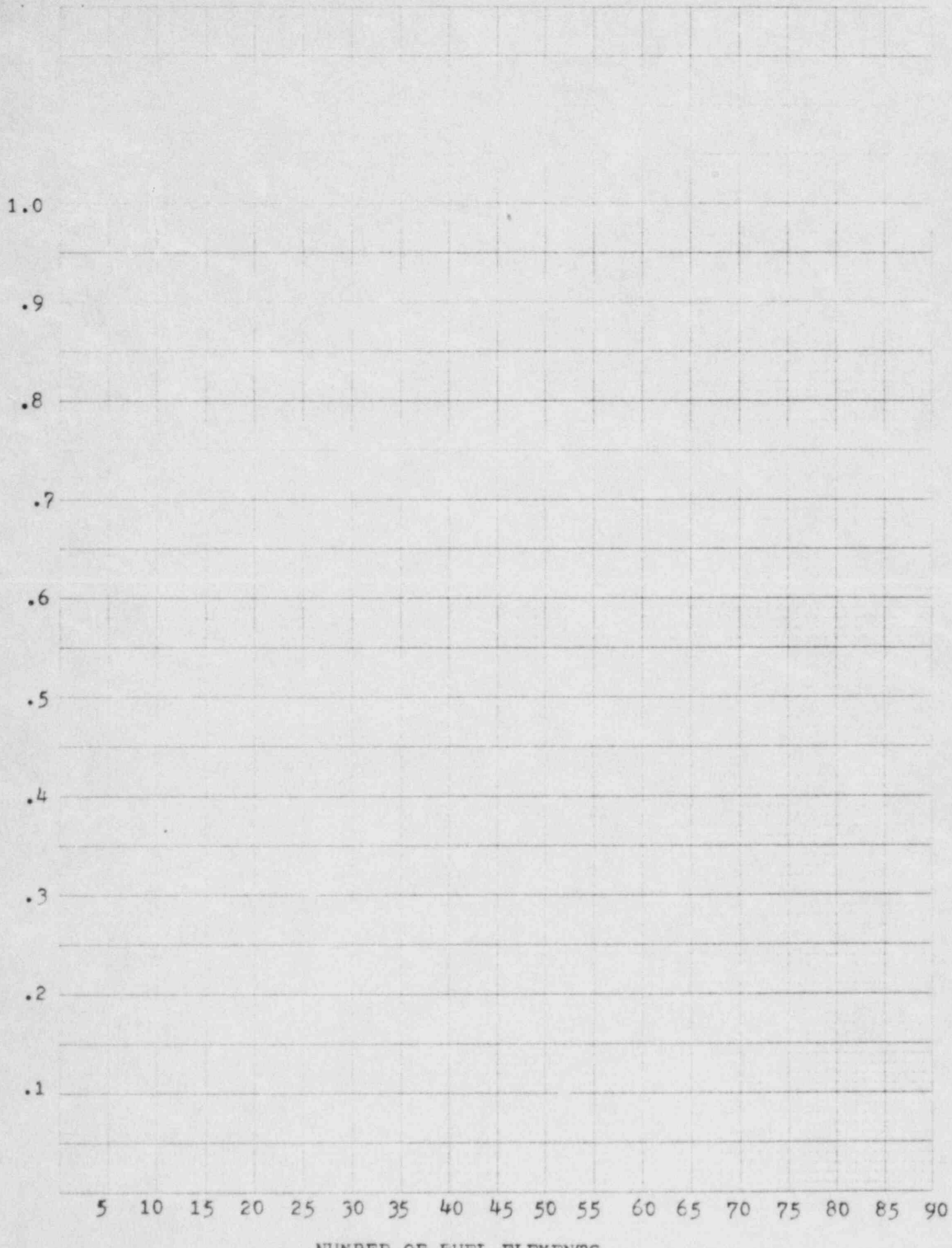
QUESTION K.04 (1.60)

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 anwer.

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.


K_{eff}
N_m/N_o


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) Rods		Detector B (CPM) 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

a. How many elements will be required for a critical mass? Graph paper is attached.

b. 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)

a. Explain how moving the core to a different positon can change its excess reactivity. (1.0)

b. 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 seperately 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 SRO. Justify your answer.

a. A change to an experimental procedure which loads a sample in a symetric location in the core from the original location. No other information is available concerning the reactivity value for the sample in the symetric 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 stablized.[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)

a. ~~Reactor would be supercritical. [0.75] By doubling count rate 1-Keff is halved~~
SINCE RX IS CRITICAL AT 20 CPS AND 40 CPS, NO ACTIVITY ADDITION IS NEED TO RAISE POWER UNTIL REACHING THE POINT OF ADDED HEAT.
~~Assume Keff = 0.90 at 20 cps then Keff = 0.95 at 40cps~~
~~change in reactivity = 0.05/(0.9 X 0.95) = 5.85% delta K/K~~
~~reactivity need for criticality= 0.05/(0.9 X 1.0) = 5.26% delta K/K~~
~~.5% delta K/K excess reactivity would be added. [0.75]~~
~~(Calculations not required for full credit)~~

b. 35% ~~30%~~ power [0.75]
power coefficient of reactivity is NOT linear ~~(-3.43 from 15v 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 then 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 then 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)	[0.9]
100/150	= (1-Keff2) / (1-0.95)	[0.5]
1-Keff2	= 10/15 x 0.05	
Keff2	= 0.967	[0.1]

change in reactivity = [1-Keff2/Keff2] - [1-Keff1/Keff1]
= Keff2 - Keff1 / Keff1 x Keff2 [0.9]
= 0.967 - 0.95 / 0.95 x 0.967 [0.6]
= 1.85 % delta K/K [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, N.

ANSWER H.07 (2.00)

a. ~~$0.56~~ $C.46 [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, Mudule 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 POOL AND ATMOSPHERE [1.0]

ANSWERS -- ARMED FORCES RADIOBIO. 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. Enviornmental 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 positoned near the CET top. [0.6]
(Place rabbit in lead pig)

REFERENCE
170: Operating Procedures I, Tab B

ANSWER I.04 (2.50)

D1 x (R1)2 = D2 x (R2)2 [0.6]
8 R/hr x 1 sqft = D2 x 16 sqft [0.4]
D2 = .5 R/hr [0.1]

stay time = total allowed dose / dose rate [0.6]
= 1.25 R / .5 R/hr [0.4] [0.3 for limit]
= 2.5 hr [0.1]

REFERENCE
170: 10CFR20.101

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

ANSWER I.05 (3.00)

Remove clothing ~~and save docemitry~~ [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. $I = Io\ e^{(-ux)}$ $0.07 cm^{-1} \times 9 cm$ [0.6]
500 mrem/hr = Io e(~~-2.13 ft(-1) 9 ft~~) [0.6]
Io = 60.23 R/hr [0.3]

b. $I = Io\ e^{(-ux)}$ [0.6]
= 60.23 R/hr e (~~-.91 cm(-1) 2.54 cm~~) [0.6]
= 7.9 ~~m~~rem/hr $0.08\ cm^{-1}$ 2.54cm [0.3]

c. $A = Ao\ e^{(-lamda\ t)}$ [0.6]
t = (ln A/Ao) / lamda = ln (20/~~500~~) / ~~2~~ per hr [0.6]
t = 1.16 hr or 70 MIN 100 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]~~
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.	b.	c.	d.
IA	REG ROD	~~RX PERIOD~~ LOG POWER	~~Power (fission chamber)~~ LINEAR POWER	UIC (both)
I	None	~~RX PERIOD~~	~~Power (fission chamber)~~	UIC (both)
II	REG + TRANS	~~RX PERIOD~~	~~Power (fission chamber)~~	UIC (both)
III	None	FUEL TEMP	~~Power~~ Pulsing UIC	Pulsing UIC (1)

[0.2 each]

REFERENCE
170: Question and Answers Fig. D-1

ANSWER J.10 (3.20)

a. Reduces indication on ~~fission chamber~~ LOG CHANNEL [0.3]
Count rate provides constant input to signal when it saturares. [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 will 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

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)

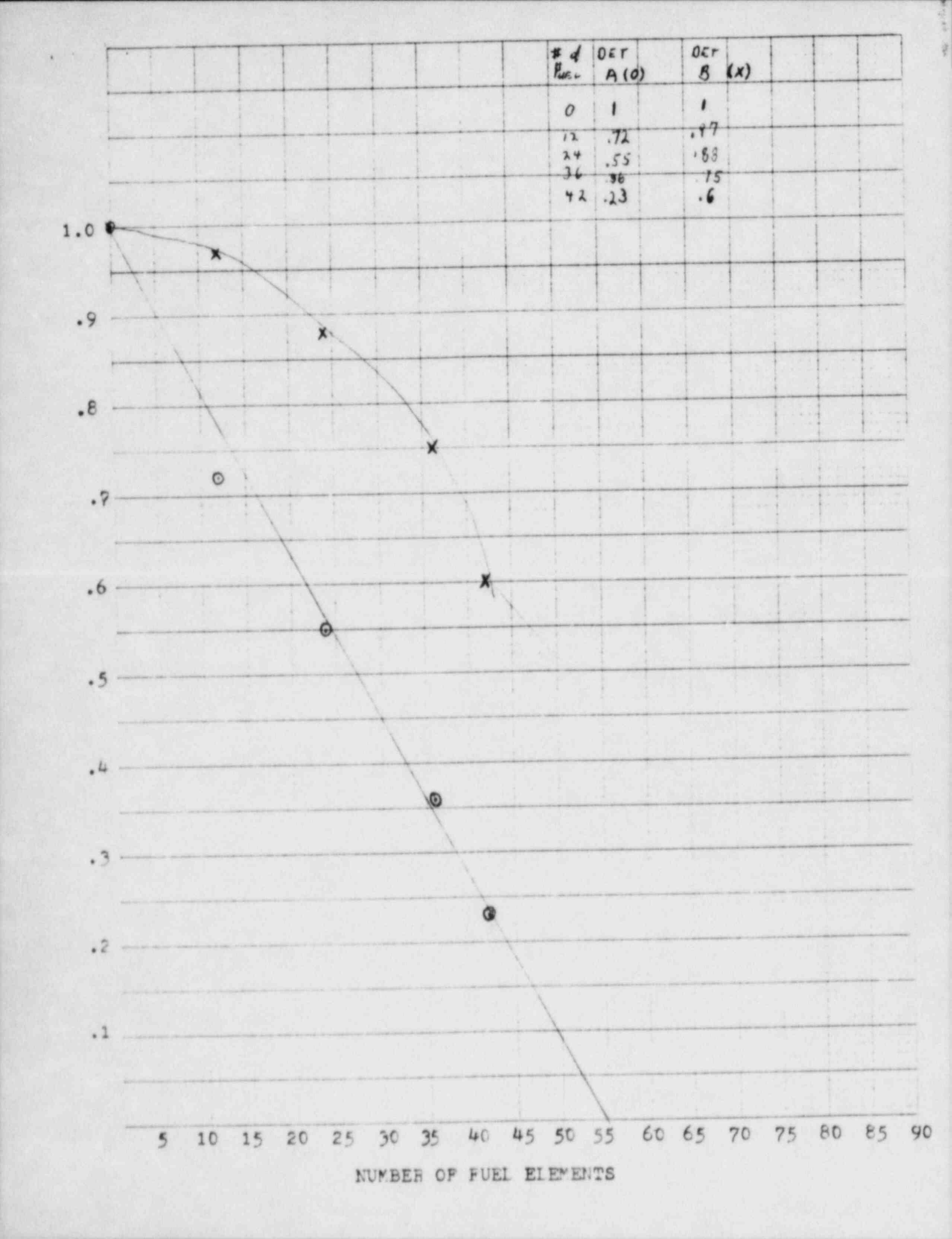
[0.66 each]

REFERENCE
054:Nuclear Energy Training, Module 3 Rx Ops, Unit 8.4
170:Nuclear Theory II A.1.b.(6)
Reference Package, Reactor Parameters

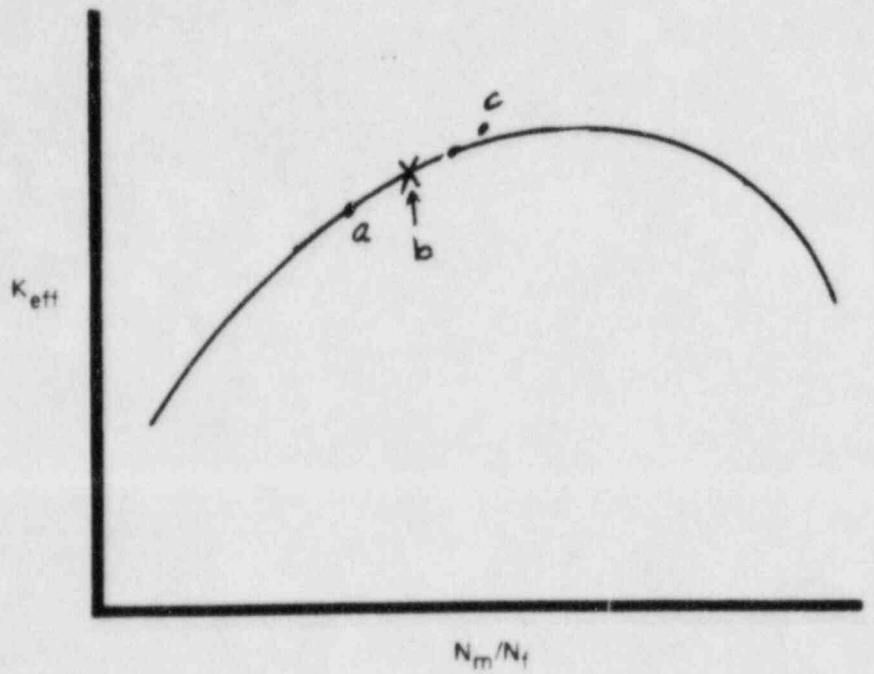
ANSWER K.03 (1.50)

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 Fuel	DET A (O)	DET B (X)
0	1	1
12	.72	.97
24	.55	.88
36	.36	.75
42	.23	.6


c
a
b
K_{eff}
N_m/N_t

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

ANSWER K.04 (1.60)

Yes. [0.7] TS surviellance 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.

reactivity of controls= rod worth x 3 [0.3]
= $1.89 x 3 [0.3]
= $5.67 [0.1]

Core excess reactivity= ~~Ring B + Ring C + Ring D~~ + MEASURED EXCESS - RODS E - RODS F [0.3]
= ~~$1.25 x 6 + $1.07 x 12 + $0.89 x 5~~ + 4.0 - 1.51 - 0.32 [0.3]
= ~~$9.21~~ ~~23.84~~ ~~21.84~~ 17.84 [0.1]

Shutdown margin = reactivity of rods - core excess reactivity [0.3]
= $5.67 - ~~$9.21~~ ~~21.84~~ (17.84) [0.2]
= ~~-27.51~~ 23.51

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]
SRO in direct supervison [0.7]
*One in Control (monitoring count rate channel) [0.6]
*One ~~SRO on bridge~~ IN REACTOR ROOM [0.6]

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-05/03/12-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. SRO on call [0.5]
RO or SRO 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 6.1.3.2

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

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. SRO
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 Contol room Operator, Secured Console
Signed by second operator [0.3] black ink [0.1]

+ 0430 (late entry) [0.2] Pimary 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

QUESTION	VALUE	REFERENCE
H.01	2.00	DUD0000742
H.02	3.00	DUD0000744
H.03	2.00	DUD0000745
H.04	3.00	DUD0000746
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	2.50	DUD0000761
I.05	3.00	DUD0000762
I.06	4.50	DUD0000763
I.07	3.00	DUD0000764
	19.10	
J.01	1.00	DUD0000736
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
	17.50	
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

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