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

EXAMINATION REPORT NO. 86-01

FACILITY DOCKET NO. 50-170

FACILITY LICENSE NO.

LICENSEE: Defense Nuclear Agency
Bethesda, Maryland 20014

FACILITY: Armed Forces Radiobiology Research Institute

EXAMINATION DATES: January 7 and 8, 1986

CHIEF EXAMINER: N J Dudley — 1-31-86
N. Dudley, Lead Reactor Engineer — Date

REVIEWED BY: RM Keller — 2/3/86
Robert M. Keller, Chief, Projects Section 1C — Date

APPROVED BY: HB Kister — 2/6/86
Harry B. Kister, Chief, Projects Branch No. 1 — Date

SUMMARY: Examinations were administered to two Senior Reactor Operator Candidates and two licenses were issued. Problems were identified with housekeeping and maintenance control for areas outside the reactor area.

REPORT DETAILS

TYPE OF EXAMS: Replacement

EXAM RESULTS:

	SRO Pass/Fail
Written Exam	2/0
Oral Exam	2/0
Overall	2/0

1. CHIEF EXAMINER AT SITE: N. Dudley, NRC

1. Summary of generic strengths or deficiencies noted on oral examinations:

Although candidates were knowledgeable of reactor systems and operations they did not display a strong working knowledge of the electrical distribution system, the radiological waste disposal system, or the ventilation system. Neither candidate was able to correctly determine whether the discharge pressure of the supply fan to the reactor room was sufficient to lift the building overpressure relief valve if the exhaust damper was shut, and whether a release through the relief system would be unmonitored. Neither candidate was able to locate up-to-date, as-built, drawings to evaluate the consequences of the hypothesized malfunctions.

Candidates were unable to identify out of service equipment connected with auxiliary and support systems not directly addressed by the Technical Specifications. Candidates stated that there is no management system available to the operators to track out of service equipment which is not directly under the cognizance of the operations department.

Housekeeping outside the reactor building is inadequate. In the Reactor Control Area Room there was a hose which the operator was forced to step on and over during completion of the startup check-list. There were rusting cans and buckets on the floor, a fan belt hung from a valve stem, and an overflowing trash barrel was in the middle of the room. In the second floor ventilation room valve bodies and diaphragms were laying loose on top of ventilation equipment.

2. Personnel Present at Exit Interview:

   <u>NRC Personnel</u>

   N. Dudley

   <u>Facility Personnel</u>

   M. Moore, Reactor Facility Director

3. Summary of NRC Comments made at exit interview:

   A discussion was held concerning the details of facility operations to clarify questions which arose during the oral examinations. Also, a discussion of facility comments on the written examination was conducted.

   The examiner questioned why fire extinguishers had been checked monthly until August of 1985 and had not been checked for five months. The Reactor Facility Director explained that the fire department had lengthened the surveillance periodicity on the fire extinguishers to six months.

   The examiner noted that housekeeping outside the reactor area was unsatisfactory. The Reactor Facility Director agreed but stated he had no control over the cleanliness of those areas since they had been turned over to contractors for facility modifications.

   The examiner noted that there was an apparent lack of management control for facility maintenance and modifications. Indications of the lack of management control included unavailability of as-built prints and the lack of an out of service equipment tracking system. The Reactor Facility Director stated that the operations department does not track "non-required systems" because there is no requirements and that it is too difficult to obtain information from the other departments. He continued, that there is no integrated control system at the facility to monitor and track maintenance being conducted by each department.

4. Unresolved Items:

   The status of housekeeping outside the reactor area will be evaluated during future inspections. (50-170-86-01-01)

   The apparent lack of management controls for facility maintenance and modifications may result in the inability to identify the effects of planned maintenance on the safety of the reactor area. This is an unresolved item pending further discussions between the licensee and NRC Region I. (50-170/86-01-02)

5. Changes made to written exam during examination review:

Consideration was made of facility comments. However, not all comments resulted in change to the answer key.

Answer No.	Change	Reason
K.6	Change to "2, 4, 3,1"	In practice, calibration of the transient rod is performed after a full core load.
K.10	Add "Presently one top and one center thermocouple are selected."	Statement of present plant configuration is required for full credit.
K.14	Add "for worth per rod; D - most reactive ring".	Allows answer for highest rod worth or highest ring worth.
L.2	Add "4. Do not lock reactor door".	Corresponds to newly revised procedures.
L.7	Change "15 Watts" to "above source level".	Corresponds to newly revised procedures.

1. Written Examination and Answer Key (SRO)
2. Facility Comments on Written Examinations made after Exam Review

Attachment 1
MASTER

U. S. NUCLEAR REGULATORY COMMISSION

SENIOR REACTOR OPERATOR LICENSE EXAMINATION

Facility: AFRRI

Reactor Type: TRIGA

Date Administered: ______

Examiner: NOEL DUDLEY

Candidate: ______

INSTRUCTIONS TO CANDIDATE:

Use separate paper for the answers. Write 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. Examination papers will be picked up six (6) hours after the examination starts.

Category Value	% of Total	Candidate's Score	% of Cat. Value	Category
20	20			H. Reactor Theory
20	20			I. Radioactive Materials Handling, Disposal, and Hazards
20	20			J. Specific Operating Characteristics
20	20			K. Fuel Handling and Core Parameters
20	20			L. Administrative Procedures, Conditions, and Limitations
100				TOTALS

Final Grade ______ %

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

______
Candidate's Signature

H.0 REACTOR THEORY (20 POINTS)

H.1 Assume the reactor is critical at 1 watt. What effect, if any, will be observed if the source is removed at this point? Explain. (1.5)

H.2 Calculate how long it will take to increase the reactor period from 15 W to 1 MW on a stable 5 second period. (1.5)

H.3 Estimate the shutdown margin of a fully loaded AFRRI core using given data. (1.5)

Rod worth

Trans	\$3.63
Safe	\$1.88
Shim	\$1.90
Reg	\$1.87

Normal excess infinite H_2O = \$4.25

H.4 Natural convection of the water in the reactor tank cools the reactor core. Explain how natural convection takes place, including how a doubling of power would affect the flow past the elements and the change in temperature between the bottom and top of the core. (3.0)

H.5 A K excess is measured on Monday morning (no weekend operations). The reactor is then operated at full power for 5 hrs, shut down, and K excess is measured 4 hours later. Would you expect the K excess to be greater or less than that measured in the morning? Why? (2.0)

H.6 Explain where the large negative temperature coefficient of reactivity comes from, give all three (3) components, and briefly describe each one. List in order of importance. (4.0)

H.7 The following statements are concerned with subcritical multiplication. Choose the one underlined word that will make the sentence correct.

a. As K_{eff} approaches unity, a larger/smaller change in neutron level results from a given change in K_{eff}. (0.5)

b. As K_{eff} approaches unity, a shorter/longer period of time is required to reach the equilibrium neutron level for a given change in K_{eff}. (0.5)

- Section H Continued on Next Page -

H.8 Answer the following True or False:

a. A week after a reactor shutdown, a Xe-135-free core is also an I-135-free core. (0.5)

b. The equilibrium Xe-135 reactivity at 70% power is less than twice the equilibrium Xe-135 reactivity at 35% power. (0.5)

H.9 The reactor is shut down by 6% delta K/K with a source range neutron count rate indication of 50 CPS. How much reactivity will have to be added through rod withdrawal to raise the source range count rate indication to 300 CPS? (2.0)

H.10 Why does Xenon peak later following a shutdown from high power than it does when following a shutdown from a low power level? (2.0)

H.11 According to Fuch's Pulse Model Equations, which parameter given below is the pulse power proportional to: Select one.

a. The initial temperature T_o
b. The square root of reactivity inserted
c. The reactivity inserted
d. The square of reactivity inserted
e. Beta-effective (0.5)

- End of Category H -

I.0 RADIOACTIVE MATERIALS HANDLING DISPOSAL AND HAZARDS (20 POINTS)

I.1 If the reactor was operating at 1 MW and a fuel element developed a crack in the cladding, how would the operator first receive an indication of the failure? As the senior reactor operator on duty, what would be your immediate actions upon suspecting the cladding had failed? (3.0)

I.2 You are the SRO on duty. You learn that an experimenter has made the following changes in his experiment after it had been approved for irradiation in the Core Experiment Tube (CET).

1. He will use an aluminum rabbit instead of plastic.
2. He will clean the experiment with acetone $(CH_3)_2CO$ rather than alcohol C_2H_5OH.
3. He will place the experiment in a gold-silver capsule with a sodium chloride solution instead of a quartz glass with a distilled water solution.
4. The run will be reduced from 1 MW hr to 55 min at 1 MW.

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a. Will you permit the experimenter to place this experiment in the Core Experiment Tube (CET)? Briefly explain your answer. (1.0)

b. For the changes 1-4 explain how and why each would affect the radiological hazards associated with the experiment (i.e., no significant change, or increase or decrease hazard and reason for change). (3.0)

c. If the experiment as changed is eventually performed, what precautions would you suggest for handling the rabbit after exposure? (1.0)

I.3 Explain the operation of the N-16 Diffuser System and why the system is rarely used. (2.0)

I.4 True or False: The Remote Area Monitor (RAM) System consists of detectors to measure neutron radiation levels in various areas of the plant where radiation hazards may exist. (0.5)

- Section I Continued on Next Page -

I.5 List the three (3) principal nuclides potentially present in the gaseous effluent measured by the stack gas monitoring system. Also state the primary source for each. (2.5)

I.6 Why are all six (6) surfaces of the exposure room lined with a 1-foot thick wood lining? (2.0)

I.7 What prevents upward streaming of radiation from the Core Experiment Tube (CET)? (1.0)

I.8 Two identical samples are irradiated in the same flux; one for 20 minutes, and the other for 10 minutes. What will determine the ratio of activities of the two samples following irradiation? Explain. (2.0)

I.9 The radiation level in a planned maintenance work area is 150 mrem/hr. Work in that area is expected to take three (3) people working 5 hours apiece. For each of the following options, calculate the expected total man-rem exposure (including maintenance work).

a. Temporary shielding is installed by two (2) workers who stay one hour in the 150 mrem/hr area, then the maintenance work begins. A tenth thickness of shielding is installed. (1.0)

b. The radiation source is found to be a point source, where the 150 mrem/hr is the exposure at four (4) feet. By using extender tools, half the work is done at four (4) feet and half the work is done at eight (8) feet. (1.0)

- End of Category I -

J.0 SPECIFIC OPERATING CHARACTERISTICS (20 POINTS)

J.1 Given the following rod configurations: safe-up, shim 60%, reg-up, trans servoing at steady 800 KW - what changes, if any, will occur if the shim rod up switch is depressed? If the safe down switch is depressed? Explain. (2.0)

J.2 Explain the "isolation" capabilities of the air system in the reactor room. (2.0)

J.3 List five (5) conditions that will cause a RWP (Rod Withdrawal Permit) for one or all rods. (2.5)

J.4 What design feature minimizes the bottoming impact of a control rod drive piston? (1.0)

J.5 Explain the difference between Safety Channel 1 and Safety Channel 2. (1.5)

J.6 a. What is the range of the wide range log channel in the nuclear instrumentation system? (1.0)

b. What two (2) techniques are used for covering the upper and lower ranges? (1.0)

J.7 For the electrical loads listed below, indicate whether power comes from Transformer 42A or 42B.

a. Reactor Console
b. Cooling tower fan motors
c. Radiation Monitor Power Panel
d. Lighting. (2.0)

J.8 Briefly describe the differences in physical operation between the regulating rod drive mechanism and that of the shim and safety rod drives. (1.5)

J.9 Why is air pressure at 9 psi supplied to the shield door bearings? (1.0)

J.10 On a loss of air pressure, what will happen to the supply dampers (S1, S2, and S3) and to the exhaust damper (E1) located in the heating and ventilating ducts of the Reactor Room? (1.0)

- Section J Continued on Next Page -

J.11 What are the three (3) basic functions of the water purification system? (1.5)

J.12 Two items, frequently associated with in-tank experimental devices, are mercury thermometers and dosimetry devices. Why is it important to ensure neither of these items are introduced into the reactor coolant? (1.0)

J.13 What would happen if the rods failed to scram after a pulse? Draw or describe in detail the power response. (1.0)

- End of Category J -

K.0 FUEL HANDLING AND CORE PARAMETERS (20 POINTS)

K.1 Briefly describe the procedure to be used in determining a steady state power coefficient of reactivity? (3.0)

K.2 True or False: In-core experiments shall not be placed in adjacent fuel positions of the B-ring and/or C-ring. (0.5)

K.3 a. What is the minimum number of nuclear instrument channels (with capability to detect source neutrons) needed for fuel movement during core loading? (0.5)

b. During unloading? (0.5)

K.4 a. In what order are the rings loaded? (1.0)

b. How many elements are loaded per step until critical loading is achieved? (0.5)

K.5 What three (3) inspections and measurements must be conducted on a new fuel element received at AFRRI prior to it being loaded into the core? (1.5)

K.6 The following steps are taken from the AFRRI operating procedure for reactor core loading. Rearrange in the order that they will be performed.

1. Calibrate the transient rod
2. Load elements until critical loading is achieved
3. Load core to full operational load
4. Load core to $2.00 excess reactivity. (2.0)

K.7 How does the operator ensure that the fuel element is properly seated in the lower grid plate during the loading of F28 during Core Experiment Tube (CET) removal from the core? (1.0)

K.8 According to the AFRRI Reactor Core Loading and Unloading Procedure (VII), who are the minimum personnel that must be present for the core loading operation? (2.0)

- Section K Continued on Next Page -

K.9 What is the purpose of the graphite slugs at each end of the fuel-moderator rods? (1.0)

K.10 Which fuel temperature thermocouple readings are fed to fuel safety channels one and two? (2.0)

K.11 What would happen if while operating at 1 MW the CET came loose and popped out of the core? Why? (2.0)

K.12 What is the maximum allowable K excess with a fully loaded core? (0.5)

K.13 Why is samarium included in each fuel element? (1.0)

K.14 Which fuel element ring has the highest worth? (1.0)

- End of Category K -

L.0 ADMINISTRATIVE PROCEDURES, CONDITIONS AND LIMITATIONS (20 POINTS)

L.1 List five (5) items that require daily checks for operation by the Technical Specifications. (2.5)

L.2 List three (3) things an operator must do upon hearing a fire alarm. (1.5)

L.3 What conditions must be met for the reactor to be considered SECURED? (3.5)

L.4 Who is allowed unescorted access to the reactor Controlled Access Area (CAA)? (1.0)

L.5 What actions must an operator take on an AFRRI Complex Emergency Evacuation according to Procedure VI (Emergency Procedures)? Include what actions are taken with reactor area doors. (2.0)

L.6 Entries to the Reactor Operations Logbook are occasionally made in Red or Green colors. Give two (2) examples for each color (red, green) of an entries that might be designated by that color indication. (3.0)

L.7 a. What is the maximum power limit for square wave operation? (0.5)

b. What is the maximum power allowable before pulse (Mode III) operation? What is the minimum power? (1.0)

L.8 According to the AFRRI Emergency Plan, define both Emergency Action Levels (EAL's) and Emergency Classes? (2.5)

L.9 What is the order of succession for the Emergency Command Post (ECP) Commander? (1.5)

L.10 According to Technical Specifications, what are the minimum number of fuel elements that are required in a closely packed array to achieve criticality? Select one.

a. 12 elements
b. 33 elements
c. 67 elements
d. 87 elements. (1.0)

- End of Category L -

- END OF EXAM -

EQUATION SHEET

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

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

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

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

$P = P_o10^{(SUR)(t)}$ $P = P_oe^{t/T}$ $SUR = \frac{26.06}{T}$ $T = \frac{(B-p)t}{p}$

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

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

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decay constant $= \frac{\ln(2)}{t_{1/2}} = \frac{0.693}{t_{1/2}}$ $A_1 = A_oe^{-(\text{decay constant})x(t)}$

Water Parameters

1 gallon = 8.345 lbs
1 gallon = 3.78 liters

1 ft^3 = 7.48 gallons

Density = 62.4 lbm/ft^3
Density = 1 gm/cm^3

Heat of Vaporization = 970 Btu/lbm
Heat of Fusion = 144 Btu/lbm
1 Atm = 14.7 psia = 29.9 in Hg

Miscellaneous Conversions

1 Curie = 3.7×10^{10} dps
1 kg = 2.21 lbs

1 hp = 2.54×10^3 Btu/hr

1 MW = 3.41×10^6 Btu/hr
1 Btu = 778 ft-lbf

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

MASTER

U. S. NUCLEAR REGULATORY COMMISSION

SENIOR REACTOR OPERATOR LICENSE EXAMINATION

Facility: AFRRI

Reactor Type: TRIGA

Date Administered: ______

Examiner: NOEL DUDLEY

Candidate: ANSWER KEY

INSTRUCTIONS TO CANDIDATE:

Use separate paper for the answers. Write 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. Examination papers will be picked up six (6) hours after the examination starts.

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

Final Grade ______%

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

______
Candidate's Signature

H.0 REACTOR THEORY (20 POINTS)

H.1 If source is removed when critical at 1 W, a slight positive period will result due to the source having a negative reactivity (about 5 cents) worth at this power level (source absorbs more neutrons than producing).

Reference: AFRRI Question Bank A.16

H.2

$$P = Poe^{t/T}$$

$$\ln\left|\frac{10^6}{15}\right| .5 \text{ sec} = 55.5 \text{ sec}$$

Reference: AFRRI Question Bank A.14

H.3

Total rod worth	\$9.28
K excess	-4.25
Shutdown	\$5.03

Reference: AFRRI Question Bank K.8

H.4 Natural convection is caused by the principle that as water is heated it becomes lighter and rises causing flow past the elements - 1.5 pts. The heat removed is equal to mCp ($T_{top}-T_{bottom}$) - .75 pts. Therefore, as the power is doubled, the heat removed will be doubled. ($T_{top}-T_{bottom}$) will nearly double and m will increase, but not quite double - .75 pts.

Reference: Basic Fluid Theory / Equation Sheet

H.5 K excess less (1 pt) due to:
1. heat up of core (because of increase in H_2O temp) - .5 pts.
2. slight buildup of xenon - .5 pts.

Reference: AFRRI Question Bank H.7

H.6 ZrH disadvantage factor. The heatup of the zirconium hydride prevents neutrons from scattering down to reach thermal energy.

Doppler broadening. The apparent increase in width of the resonance capture integrals of U^{238} causes the loss of neutrons thru resonance capture.

Density. The thermal expansion causes a loss of moderator effectiveness thereby decreasing the neutrons reaching thermal energy.

1 pt each description
1 pt order

Reference: AFRRI Question Bank J.9

H.7 a. larger
b. longer

Reference: Basic Reactor Theory

H.8 a. True
b. True

Reference: Basic Reactor Theory

H.9 Given (delta K) = - 6%, Ci = 50 cps, Cf = 300 cps

$$K = \frac{1}{1-(\text{delta } K)} = \frac{1}{1.06} = .943$$ / Assumption (delta K) = K-1 ok

$$\frac{C_1}{C_2} = \frac{1-K_2}{1-K_1} = \frac{50}{300} = \frac{1-K_2}{1-.943}$$

$$\frac{50(.057)}{300} = 1-K_2 \quad \therefore \; K_2 = .9905$$

$$(\text{delta } K) = \frac{K-1}{K} = \frac{.9905-1}{.9905} = -.00959$$ or about 1% S/D

Reference: AFRRI Reference Package, p. 1
Formula Sheet

H.10 Equilibrium iodine is proportional to power, while equilibrium xenon is not. Therefore, you have a higher ratio of I to Xe at higher power levels. The greater the I to Xe ratio, the longer it takes for sufficient I to decay to Xe such that an equilibrium production and decay of Xe is occurring (i.e., the peak).

Reference: Basic Reactor Theory

H.11 d. The square of the reactivity inserted.

Reference: AFRRI Reference Package, p. 1

I.0 RADIOACTIVE MATERIALS HANDLING DISPOSAL AND HAZARDS (20 POINTS)

I.1 Reactor room CAM. Fission product gasses decay to particulate and collect on the CAM filter. R1 would probably not alarm (unless levels are greater than 500 mR/hr). Criticality monitor also would not alarm (unless levels at room are greater than 10 mR/hr) - 1 pt.

Scram the reactor. Activate emergency plan. Isolate area. Insure CAM alarm triggered close of dampers. Assess and evaluate situation - 2 pts.

Reference: AFRRI Question Bank I.8

I.2 a. No. It is not the same experiment. There will have to be a new RUR.

b. 1. Significant change, Al will activate but short lived so not a large problem if decay is allowed.

2. No significant change as both will evaporate but they are very similar chemically.

3. The capsule will be a very significant change as the gold and silver will activate. Although the gold is practically opaque to neutrons, if the solution is exposed to any flux at all, it will activate. Gold will activate with a high cross section.

4. No significant change.

c. Leave experiment in CET for short lived isotopes to decay off. Afterwards use Time/Distance/Shielding when working with rabbit. Have a lead cask nearby as necessary.

Reference: AFRRI Question Bank I.5

I.3 The diffuser system is a pump mounted on the carriage above the reactor tank. The piping of the diffuser system, located on the inside of the core-support structure, passes pool water through an opening in the side approximately 4 feet from the top of the support cylinder. The water, discharged inside the support structure in a tangential direction, causes the water above the core to swirl. This action breaks up the vapor formations, thereby increasing bubble rise time and reducing the radiation level at the top of the reactor pool. This system does not reduce the levels by more than about 25% and it is therefore rarely used.

1.5 pts - description of system
0.5 pts - why not used.

Reference: AFRRI Manual 82-1, p. 48

I.4 False - measure gamma

Reference: AFRRI Manual 81-1, p. 111

I.5

AR-41	Reactor
O -15	LINAC
N -13	LINAC

0.5 for each gas; 1/3 point for each source.

Reference: AFRRI Manual 82-1, p. 139

I.6 It is there to prevent activation of the 12-foot thick concrete biological shield by thermalizing the fast neutrons and thereby reducing the secondary gamma radiation emitted from the concrete.

Reference: AFRRI Manual 82-1, p. 157

I.7 The tube has a large "S" bend in it.

Reference: AFRRI Manual 82-1, p. 188

I.8 Activity is proportional to lambda, the decay constant for the material. ℓ = lambda.

$$A = A_0 e^{-\ell t} + \text{(flux) N (cross section)} (1-e^{-\ell t})$$

If you double the time a material is irradiated, you will not double the activation. Because it is a LN function. The lower the lambda (higher the half life), the closer you will come to almost having a doubling.

Reference: AFRRI Reference Package, p. 1

1.9 a. EXP = (2 men)x(150 mrem/hr)x(1 hr)
+ (.1)x(3 men)x(5 hrs)x(150 mrem/hr)

= 300 mrem + 225 mrem

= 525 mrem or .525 Man-Rem

b. EXP = (3 men)x(2.5 hrs)x(150 mrem/hr)
+ (.25)x(3 men)x(2.5 hrs)x(150 mrem/hr)

= 1125 mrem + 281.25 mrem

= 1406.25 mrem or 1.40625 Man-Rem

Reference: ALARA and Shielding/Attenuation Basic Theory

J.0 SPECIFIC OPERATING CHARACTERISTICS (20 POINTS)

J.1 If shim up switch is depressed, no change will occur (in square wave the trans rod will servo, all other rods up, movement is prevented).

If safe down is depressed, trans will servo out further to compensate since downward movement is allowed.

Reference: AFRRI Question Bank A.17

J.2 During any alarm from the primary reactor room CAM, the positive sealing dampers of the reactor air system will close. The dampers can also be closed manually. The doors and hatch to the reactor room are sealed with gaskets to prevent air leakage from the reactor room.

Reference: AFRRI Question Bank B.21

J.3
- . HV loss on fission chamber
- . fast period 3 sec
- . pool water temp 50 C
- . source level (RWP unless operational channel sees source level neutrons)
- . 1KW interlock - no air to trans rod
- . operational calibrate - if operational channel is in any mode except operate.

Reference: AFRRI Manual 82-1, pp. 92-23
AFRRI Question Bank J.18

J.4 The upper portion of the barrel is well ventilated by slotted vents, so the piston moves freely in this range. However, when the piston is within 2 inches of the bottom of its travel, its movement is restrained by a dashpot action of the graded vents in the lower end of the barrel. This action reduces the bottoming impact.

Reference: AFRRI Manual 82-1, p. 27

J.5 Safety channel two operates exactly like safety channel one in the steady-state modes. In pulse mode, however, the safety channel input is changed so that a separate ion chamber or other detector is placed on the channel input. This channel reads the peak output on the console recorder blue pen and the energy produced during the pulse on the NVT meter in the right drawer, and supplies the scram signal based on a 110% current signal from the detector.

Reference: AFRRI Manual 82-1, p. 89

J.6 a. 10^{-3} watt to 1 MW (ten decades)

b. The lower six decades uses a pulse log-count technique; the upper four decades uses a log campbelling technique.

Reference: AFRRI Manual 82-1, p. 83

J.7 a. 42A
b. 42B
c. 42B
d. 42A

Reference: AFRRI Manual 82-1, p. 70 + 74

J.8 The regulating rod has a unique drive motor and drive control circuitry. A tachometer feedback drive motor moves the regulating rod. This system interacts with the servo controller circuit in the control console. The tachometer feedback drive motor is actuated by a variable signal from the output of the servo controller. The tachometer in turn feeds back information on its rate and direction of travel to the servo controller circuit.

Reference: AFRRI Manual 82-1, p. 28

J.9 To minimize the likelihood of water leaking into the housing if the seal should rupture.

Reference: AFRRI Manual 82-1, p. 68

J.10 The air dampers are spring-loaded with pneumatic solenoids. Air pressure is required to hold them open; when the air pressure is removed, the dampers spring closed.

Reference: AFRRI Manual 82-1, p. 68

J.11 . It maintains low electrical conductivity of the reactor coolant to minimize the corrosion of all reactor components.

. It reduces radioactivity in the water by removing particulates and soluble impurities.

. It helps to maintain the optical clarity of the water.

Reference: AFRRI Manual 82-1, p. 41

J.12 Both are highly corrosive agents on the aluminum tank and components (dosimeters contain salt).

Reference: AFRRI Question Bank, A.19

J.13 The pulse would terminate and convert to a steady state condition the power of which would be determined by the amount inserted to cause the pulse. For example, a $3.40 pulse would convert to 1 MW steady state run after a few seconds.

Reference: AFRRI Question Bank, J.13

K.0 FUEL HANDLING AND CORE PARAMETERS (20 POINTS)

K.1 The procedure to determine a steady state power coefficient of reactivity is as follows:

1. Bring the reactor to a cold critical condition.

2. Bring reactor critical at desired higher power, measure and record the worth of control rod used to achieve this level or

   2a. Using current control rod worth curves, insert a set amount of reactivity (by withdrawing a rod to the appropriate position).

3. Plot these values on a curve of power vs. reactivity in dollars.

Reference: AFRRI Exam Bank A.3

K.2 True

Reference: AFRRI SP 84-2, p. 27

K.3 a. 2
b. 1

Reference: AFRRI Operating Procedures VII, p. 1

K.4 a. B-------->F
b. 2

Reference: AFRRI Operating Procedure VII, p. 2

K.5 1. visual defects (after cleaning)
2. length measurement
3. bow measurement.

Reference: AFRRI Operating Procedures, Procedure VII

K.6 2, 4, ~~1, 3~~
3, 1

Reference: AFRRI Operating Procedures, Procedure VII

K.7 There should be an audible "double click."

Reference: AFRRI Operating Procedure, TAB B

K.8 a. The Reactor Facility Director or the Reactor Operations Supervisor.

b. One other licensed SRO or RO.

Reference: AFRRI Operating Procedure, VII

K.9 They are reflectors.

Reference: AFRRI Operations Manual, p. 20

K.10 Instrumented fuel elements, with three thermocouples each, are located at selected positions in the B and C rings. Generally, the center thermocouple (the one physically located in the center of the fuel section), of the hottest reading element from one B ring and one C ring, is fed to fuel safety channels one and two, respectively. PRESENTLY ONE TOP AND ONE CENTER THERMOCOUPLE ARE SELECTED.

Reference: AFRRI Manual 82-1, p. 89

K.11 Especially if experiment was in CET (usually neg) a pos insertion is made. The position of the CET occupied is then replaced with water which is a reflector which is also positive worth. Therefore the power would increase unless in servo whereby the reg rod would lower.

Reference: AFRRI Question Bank, J.10

K.12 $5.00

Reference: AFRRI Operating Procedures, VII

K.13 As a burnable poison to minimize reactivity changes resulting from fission-product buildup and fuel burnup.

Reference: AFRRI Manual 82-1, p. 20

K.14 B - all worths decrease going from B to F. FOR WORTH PER ROD, D - MOST REATIVE RING

Reference: AFRRI Reference Package, Reactor Parameters

L.0 ADMINISTRATIVE PROCEDURES, CONDITIONS AND LIMITATIONS (20 POINTS)

L.1
1. Functional performance check of the transient rod system
2. Measurement of core excess reactivity
3. Check of the scram function of the high-flux safety channels
4. Check of the fuel temperature scrams
5. Pool water temperature measured at inlet to the purification system
6. Channel check of RAMs and CAMs.

Reference: AFRRI Question Bank L.14

L.2
1. Scram the reactor (if operating)
2. Secure any exposure facilities open or in use
3. Remove the: log book, keys, AFRRI Fire and Emergency Evacuation Information Guide. Carry them to the Emergency Action Station and prepare to support emergency actions as required.
4. DO NOT LOCK REACTOR DOOR

Reference: AFRRI Question Bank L.18

L.3
a. The reactor is shut down - 1 pt.

b. The console key switch is in the "off" position, and the key is removed from the console and is under the control of a licensed operator, or is stored in a locked storage area - 1 pt.

c. No work is in progress involving in-core fuel handling or refueling operations, maintenance of the reactor or its control mechanisms, or insertion or withdrawal of in-core experiments, unless sufficient fuel is removed to insure a $0.50 (or greater) shutdown margin with the most reactive control rod removed - 1.5 pts.

Reference: AFRRI Question Bank L.1
AFRRI SP84-2, p. 3

L.4 Reactor staff and any other person who is designated on the Reactor Access Roster.

Reference: AFRRI Operating Procedure V

L.5 1. Scram reactor.

2. Secure any exposure facilities which are in use.

3. Remove logbook, emergency guide and keys; and report to EAS.

4. Do NOT lock reactor area doors.

Reference: AFRRI Operating Procedures VI

L.6 RED

1. K-excess measurements, to include experiment worth determinations.

2. Actions which affect reactivity:

   a. Core movement.
   b. Fuel movement.
   c. Control rod physical removal for maintenance.
   d. Experiment loading and removal from the CET, PTS, Pool, or Core.

GREEN

1. Reactor malfunction, to include the reactor systems and support equipment taken out of service for maintenance and returned to service.

2. Additional items entered at the discretion of the operator such as addition of makeup water to the reactor pool, etc.

Reference: AFRRI Operating Procedures, TAB A, p. 2

L.7 a. 900 KW
b. 1 KW / ~~15 Watts.~~ ABOVE SOURCE LEVEL

Reference: AFRRI Operating Procedure, TAB D (b)
TAB E (a)

L.8 Emergency Action Levels (EAL's). "EAL's" are specific reactor-related instrument readings, or observations; radiological dose or dose rates; or specific contamination levels of airborne, waterborne, or surface-deposited radioactive materials, which relate to the AFRRI Reactor Facility, that are used as thresholds for establishing and achieving emergency classes and initiating appropriate emergency measures or procedures under this Emergency Plan - 1 pt.

Emergency Classes. "Emergency classes" are generally accepted classification labels for accident situations grouped by severity level for which predetermined emergency measures or procedures have been addressed, considered, or provided - .5 pts. The four emergency classes are: (1) Notification of Unusual Event; (2) Alert; (3) Site Area Emergency; and (4) General Emergency - 1 pt.

Reference: AFRRI Emergency Plan, p. 9 + 35

L.9
1. Director, AFRRI
2. Deputy Director, AFRRI
3. Senior Military Officer present in the AFRRI chain-of command.

Reference: AFRRI Emergency Plan, p. 22

L.10 c. 67 - other answers obviously wrong.

Reference: AFRRI Tech Specs, p. 28

-END of KEY-

H.4 Heat transfer is not a major factor at the AFRRI 1MW research facility. Because core cooling capability is so overdesigned (capable of natural convective cooling in air in emergency our operators don't need or expect detailed knowledge of heat transfer equations. Therefor part two of the question is in greater depth than we require or give in the training program,

H.5 During a normal 5 hr power run the heat exchange system would normally be operated, otherwise heat build up and temperature rise would require a shutdown of the reactor. If the pumps were not run heat would make answer 1 correct, however in normal operational configuration with the secondary system utilized only a slight Xenon poisoning would be evident,

H.9 Comment; if the assumption ($\Delta K \cong K-1$) is used the answer will be slightly different than full calculation (.01)

H.10 This is similar to a power plant question or at least one for a much higher power research reactor. Since we are barely able to see Xenon effects we do not expect our operators to have ~~an~~ indepth knowledge of power equilibrium curves. In AFRRI's history we have never even approached Iodine equilibrium therefor this question is not entirely relevant to the AFRRI Facility.

H.11 Fuchs model equations are not expected to be memorized (there are quite a few of them and not used very often) and alway available to the operator. In the absence of these equations, I would expect my operators to know that power was related to reactivity inserted and would therefor accept answers b, c, or d

I 8 Unless the isotope has a very short halflife a doubling of time will be so close to doubling the activity that we routinely use that for isotopes produced here. When computing activity ~~from~~ from exposed isotopes we use a different form of the Activation equation than you have in the answer.

I.9 There are two ways to read this question. Are the two workers who installed the shield part of the three that do the work? An alternative calculation is attached.

BASIC ACTIVATION EQUATION

$$A = N \sigma \phi e^{-\lambda t_d} (1 - e^{-\lambda t_i})$$

A = Activity of Irradiated Nuclide.
N = No/Atoms of Irradiated Nuclide
σ = X-section " " "
ϕ = Neutron Flux.
λ = Decay constant of irradiated nuclide
t_d = Time of Decay (time after irradiation)
t_i = Time of Irradiation

if $t_d = \phi$ (No decay time):

$$A = N \sigma \phi (1 - e^{-\lambda t_i})$$

Ref: NCRP Report No. 58

I.9.

Assumption: Sections a + b are sequential continuations of the same scenario.

(a) 1 hour x 2 men x 150 $\frac{mREM}{HR}$

300 man-mREM

assumptions: ① All of the work was done in the 150 $\frac{mREM}{HR}$ radiation field.

② a 1/10 thickness was assembled and in place before the remaining 13 man-hr of work

(b)

$\frac{150}{10} = 15 \frac{mrem}{hr}$

(b.) $\frac{15-2}{2}$ = 6.5 man-hr at ~~15 mRem/HR~~ at 4 ft

$\frac{15-2}{2}$ = 6.5 man-hr at ~~3.75 mREM/HR~~ 3.75 $\frac{mrem}{hr}$ at 8 ft.

$$D_1 R_1^2 = D_2 R_2^2$$

$$(15 \frac{mREM}{HR})(4ft)^2 = (D_2)(8ft)^2$$

$$D_2 = 3.75 \frac{mRem}{HR} \text{ at } 8ft$$

$$(6.5 \text{ man-hr})(15 \frac{mREM}{HR}) = 97.5 \text{ man-mRem}$$

$$(6.5 \text{ man-hr})(3.75 \frac{mRem}{hr}) = 24.4 \text{ man-mREM}$$

Total = (300 + 97.5 + 24.4) man-mREM

421.9 man-mREM = 0.4219 man REM

J.6 The word "log" does not belong in the answer

K-3 The new ops procedures (attached) give

1 and 1

K-6 In practice we also calibrate after full loading therefor a correct answer could also be

2, 4, 3, 1

K-10 We use the hottest thermocouple element in the fuel (it is not always in the center) in fact the current hookup has one center ~~ele~~ element and one ~~loop~~ element.

K-14 The way the question is written the answer would be "D" because the "ring" worth is all elements, however if you mean worth per individual element then "B" is correct

	element worth	# of ele/ring	Ring total worth
B ring	1.24	6	7.44
C ring	1.07	12	12.84
D ring	.89	15	13.35
E ring	.51	24	12.24
F ring	.31	30	9.30

L-2 add a fourth "Do not lock the reactor doors" from reference package Procedures VI 2d

L.7 The new procedures allow subcritical pulsing therefor "b" should be

1KW / source level or a fraction of watt

L.8 If you continue on reading where this reference is taken from you will find a 5th (Φ) class. Then on page 37 (section 4.4 + 4.5 we state that class 3 + 4 are not credible at AFRRI and therefor are not considered in the plan. The answer then should be:

Class Φ - Events less sever than the lowest Cat
Class 1 - Notification of an unusual event
Class 2 - Alert

Note: Since there are no class 3 or 4 there are no EAL's (pg 42)