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

EXAMINATION REPORT NO: 88-04(OL)

FACILITY DOCKET NO: 50-223

FACILITY LICENSE NO: R-125

LICENSEE: University of Lowell

FACILITY: University of Lowell Reactor

EXAMINATION DATES: August 3-5, 1988

CHIEF EXAMINER: D. Wallace — 9-28-88
David Wallace — Date
Operations Engineer (Examiner)

APPROVED BY: James A. Prell for — 9-28-88
Peter W. Eselgroth, Chief — Date
PWR Section, Operation Branch, DRS

SUMMARY: Written and operating examinations were administered to one Senior Reactor Operator (SRO) and two Reactor Operator (RO) candidates. All candidates passed the operating examinations. The SRO and one RO passed the written examination, however, one RO failed Section G of the written examination.

TYPE OF EXAMINATIONS: Retake

EXAMINATIONS RESULTS:

	RO PASS/FAIL	SRO PASS/FAIL
WRITTEN	1/1	1/0
OPERATING	2/0	1/0
OVERALL	1/1	1/0

1. Chief Examiner At Site: David Wallace

2. Personnel Present at Exit Meeting:

   US NUCLEAR REGULATORY COMMISSION

   David Wallace

   UNIVERSITY OF LOWELL

   Tom Wallace

3. Summary of Exit Meeting comments and conclusions based on written and operating examination results:

   The candidates did not exhibit adequate knowledge of the ULR administrative radiation exposure limit.

   The RO candidates were reluctant to use procedures, especially during emergency scenarios. Although no candidate failed the operating test because of this reluctance, the operator candidates' use of emergency procedures was characterized by the Examiner as being one of using the procedures only as a last resort.

   None of the operator candidates had an adequate knowledge of the use of Safety Tags for control of maintenance and other work. This weakness can be attributed to the absence of formal controls over safety tagging of equipment.

Attachments:

1. RO Written Examination and Answer Key
2. SRO Written Examination and Answer Key
3. Facility Comments and NRC Resolution for RO and SRO Written Examinations

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

FACILITY: UNIVERSITY OF LOWELL

REACTOR TYPE: TEST

DATE ADMINSTERED: 88/08/03

MASTER COPY

EXAMINER: ROESENER, S.

CANDIDATE

INSTRUCTIONS TO CANDIDATE:

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. Examination papers will be picked up six (6) hours after the examination starts.

CATEGORY VALUE	% OF TOTAL	CANDIDATE'S SCORE	% OF CATEGORY VALUE		CATEGORY
19.00	19.00			H.	REACTOR THEORY
18.50	18.50			I.	RADIOACTIVE MATERIALS HANDLING DISPOSAL AND HAZARDS
22.50	22.50			J.	SPECIFIC OPERATING CHARACTERISTICS
20.00	20.00			K.	FUEL HANDLING AND CORE PARAMETERS
20.00	20.00			L.	ADMINISTRATIVE PROCEDURES, CONDITIONS AND LIMITATIONS
100.0		Final Grade		%	Totals

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

MASTER COPY

Candidate's Signature

NRC RULES AND GUIDELINES FOR LICENSE EXAMINATIONS

During the administration of this examination the following rules apply:

1. Cheating on the examination means an automatic denial of your application and could result in more severe penalties.
2. Restroom trips are to be limited and only one candidate at a time may leave. You must avoid all contacts with anyone outside the examination room to avoid even the appearance or possibility of cheating.
3. Use black ink or dark pencil only to facilitate legible reproductions.
4. Print your name in the blank provided on the cover sheet of the examination.
5. Fill in the date on the cover sheet of the examination (if necessary).
6. Use only the paper provided for answers.
7. Print your name in the upper right-hand corner of the first page of each section of the answer sheet.
8. Consecutively number each answer sheet, write "End of Category __" as appropriate, start each category on a new page, write only on one side of the paper, and write "Last Page" on the last answer sheet.
9. Number each answer as to category and number, for example, 1.4, 6.3.
10. Skip at least three lines between each answer.
11. Separate answer sheets from pad and place finished answer sheets face down on your desk or table.
12. Use abbreviations only if they are commonly used in facility literature.
13. The point value for each question is indicated in parentheses after the question and can be used as a guide for the depth of answer required.
14. Show all calculations, methods, or assumptions used to obtain an answer to mathematical problems whether indicated in the question or not.
15. Partial credit may be given. Therefore, ANSWER ALL PARTS OF THE QUESTION AND DO NOT LEAVE ANY ANSWER BLANK.
16. If parts of the examination are not clear as to intent, ask questions of the examiner only.
17. You must sign the statement on the cover sheet that indicates that the work is your own and you have not received or been given assistance in completing the examination. This must be done after the examination has been completed.

18. When you complete your examination, you shall:

a. Assemble your examination as follows:

(1) Exam questions on top.

(2) Exam aids - figures, tables, etc.

(3) Answer pages including figures which are part of the answer.

b. Turn in your copy of the examination and all pages used to answer the examination questions.

c. Turn in all scrap paper and the balance of the paper that you did not use for answering the questions.

d. Leave the examination area, as defined by the examiner. If after leaving, you are found in this area while the examination is still in progress, your license may be denied or revoked.

QUESTION H.01 (3.00)

a. State the two reactions that produce neutrons in the installed neutron source. Either a word explanation or an equation is acceptable. (2.00)

b. If the installed source was removed, what TWO phenomena would be responsible for the continued production of neutrons in the core? (1.00)

QUESTION H.02 (1.00)

TRUE or FALSE?

a. As Keff approaches unity, a larger change in neutron population results from a given change in Keff.

b. As Keff approaches unity, a shorter period of time is required to reach the equilibrium neutron level for a given change in Keff.

QUESTION H.03 (1.50)

What would the startup counter indicate with the control blades at 12 inches and the regulating rod at 10 inches? Assume that with all rods in the counter reads 30 counts per second and that the reactor is shutdown by 9% Delta K/K. Show all work.

QUESTION H.04 (1.00)

Define the effective delayed neutron fraction.

(***** CATEGORY H CONTINUED ON NEXT PAGE *****)

QUESTION H.05 (1.50)

If the reactor was operating at 1 MW when one of the control blades was dropped, the power would immediately drop to about 200 kW and then decay slowly to a final steady state value of a few hundred counts per second.
(Note: in answering the questions below, calculations are neither required nor desired.)

a. The loss of what component of the neutron flux causes the sharp drop in power?

b. What determines the rate of power decrease at about five minutes after the rod is dropped?

c. Why does the power stabilize after approximately one hour when Keff is less than 1.0?

QUESTION H.06 (0.50)

Why is graphite a better reflector than water?

QUESTION H.07 (1.00)

The secondary side of the heat exchanger is designed to supply water at 80 F and return it at 91.4 F with a flow rate of 1500 gpm. Based on these values, calculate the heat removal capacity of the heat exchanger in MW. State all assumptions. Show all work. Assume 8 lbm/gal.

QUESTION H.08 (1.00)

Multiple Choice

The axial position in the core where the peak clad temperature occurs for the forced convection mode is (SELECT best answer):

a. in the center of the core where the highest heat flux occurs.

b. independent of the flow rate through the core.

c. independent of the specific heat of the fluid and the heat transfer coefficient.

d. displaced slightly away from the core center in the direction of the flow.

QUESTION H.09 (1.00)

Why is the differential worth of a control blade greater in the center of the blade's travel than at the beginning or end of its travel?

QUESTION H.10 (3.00)

The reactor is just critical (Keff=1) at an initial power of 1 kW steady state in preparation for rod worth calibrations. The regulating rod is then withdrawn a measured amount to place the reactor on a positive period. The doubling time from 1 kW to 2 kW is 20 seconds and the doubling time from 2 kW to 4 kW is 35 seconds.

a. Why is the first doubling time shorter than the second doubling time?

b. What is the reactor period during the second doubling time? Show all work.

c. Why are the rod worth calibrations done in the watt or low kW range instead of the MW range?

QUESTION H.11 (2.50)

a. What are the TWO processes that produce xenon during reactor operation? (1.00)

b. What are the TWO processes that remove xeron during reactor operation? (1.00)

c. On Monday , after a weekend shutdown, the reactor is operated for one hour at 1 MW and then shutdown. How long after the Monday shutdown will peak xenon occur (+/- 1 hour)? (0.50)

QUESTION H.12 (2.00)

Assuming and undermoderated core, what is the effect (INCREASE or DECREASE) of an increase in temperature on:

a. L_f (Fast non-leakage probability).

b. f (Thermal utilization factor).

c. p (Resonance escape probability).

d. keff.

(***** END OF CATEGORY H *****)

QUESTION I.01 (0.50)

Why is the core end of a typical beamport plugged with a nitrogen filled canister?

QUESTION I.02 (0.50)

What is indicated by the presence of Na-24 in the daily secondary sample?

QUESTION I.03 (0.50)

What is the greatest source of gamma radiation in the primary coolant during operation?

QUESTION I.04 (1.00)

Multiple Choice

What is the typical contact rate of exposure of spent cleanup system resins?

a. Less than 1 mR/hr.

b. 10 to 20 mR/hr.

c. 300 to 500 mR/hr.

d. Greater than 1 R/hr.

QUESTION I.05 (1.50)

Answer the following questions for BOTH of the stack effluent monitors.

a. What type of detector is used? [0.50 each]

b. What is the high level trip setpoint? [0.25 each]

(***** CATEGORY I CONTINUED ON NEXT PAGE *****)

QUESTION I.06 (1.50)

State the location of the THREE meter readouts for the third floor constant air monitor.

QUESTION I.07 (1.00)

Multiple Choice

How long would it take the 3rd floor CAM to reach the high alarm set point if the airborne concentration of fission products in the containment was to jump immediately to 10 times MPC due to a fuel element failure?

a. 1 second.

b. 10 seconds.

c. 1 minute.

d. 10 minutes.

QUESTION I.08 (2.50)

A 28 year old maintenance worker has accumulated a lifetime exposure through last quarter of 48 REM as recorded on the worker's NRC Form 4; additionally, he has accumulated 1.0 REM so far this quarter.

a. Assuming the worker must perform maintenance inside the ULR containment in a radiation field of 850 <u>mREM/hr</u> gamma and <u>30 mrad/hr</u> thermal and fast neutron, how long can the worker work in the area before exceeding a 10CFR20 dose limit? Consider all pertinent limits. Show all work and state all assumptions.

b. During a declared emergency, this individual volunteers to enter a high radiation area and perform work necessary to prevent further effluent release. In accordance with the Emergency Plan, what is the maximum allowed whole body exposure?

QUESTION I.09 (0.50)

An irradiation sample is to be removed from the pneumatic systom. At what potential contact reading (mREM/hr) is Health Physics coverage required?

QUESTION I.10 (0.50)

What is the primary contributor to the dose rate at the pool surface after a loss-of-flow scram?

QUESTION I.11 (3.00)

a. In accordance with Standing Order #6, "Sample Handling Procedures," what are the THREE features of an acceptable "minimally shielded container?"

b. What THICKNESS of shielding would be required to reduce an activated sample to below the limits required for transfer from the facility assuming that its unshielded radiation level was 25 mREM/hr at one foot? The shield material to be used has a tenth thickness of two inches. Show all work.

QUESTION I.12 (2.50)

a. In accordance with 10CFR20, in addition to a lock, what are the TWO alternative ways of controlling access to a permanent high radiation area? (2.00)

b. In accordance with 10CFR20, in addition to the controls for a permanent high radiation area, how may access be controlled for a high radiation area that is to be established for a period of 30 days or less? (0.50)

QUESTION I.13 (1.50)

In accordance with the procedure entitled, "Laboratory Accidents," what THREE actions would you take to "Confine the Hazard," if you were to spill a dry irradiated sample?

(***** CATEGORY I CONTINUED ON NEXT PAGE *****)

QUESTION I.14 (1.00)

In accordance with Standing Order #8, "Installation or Removal of Flux Wires or Foils":

a. What special dosimetry is required in addition to a TLD and a pocket dosimeter?

b. When (at a minimum) should the pocket dosimeter be read?

QUESTION I.15 (0.50)

In accordance with E.O.1, "Radiation Emergency," what ONE action should you always take before exiting the containment if you are the on duty SRO and you are in the plant when the evacuation alarms sounds?

(***** END OF CATEGORY I *****)

QUESTION J.01 (1.00)

If the reactor is operating at 1 MW when the SECONDARY pump trips, what automatic scram will shutdown the reactor? Assume no operator action.

QUESTION J.02 (1.50)

Following a normal reactor startup at the beginning of the day, with the reactor critical at .01 watt, what behavior/trend would you expect to observe on the following instruments?

a. Rod position indications.

b. Period meter.

c. Starutup channel count rate.

QUESTION J.03 (1.00)

During a normal startup the reactor is taken to .5 MW on a thirty-five second period. When the power level reading of the controlling picoammeter matches the reading on the Power Schedule Meter the Auto switch is placed in auto. Sketch the trace that would be created on the power level indicator in response to this transient from the point of placing the rod control system in auto to the point of steady reactor power.

QUESTION J.04 (1.50)

What infomation does the console operator need in order to calculate the actual worth of an experimental sample which is inserted into the reactor via the pneumatic system?

(***** CATEGORY J CONTINUED ON NEXT PAGE *****)

QUESTION J.05 (3.00)

On Monday morning, a normal start-up is performed such that by 0900 the reactor is at 1 MW. What change (INCREASE, DECREASE, or NO CHANGE) would you expect to see in the following parameters between 0900 and 1400 if the reactor is operated at a constant power of 1 MW with normal console operator control?

a. Control blade height.

b. Primary flow.

c. Secondary flow.

d. Pool temperature.

QUESTION J.06 (1.00)

Following a normal shutdown after eight hours of full power operation, what would be the abnormal indication of a compensated ion chamber that was overcompensated?

QUESTION J.07 (3.00)

State FOUR of the FIVE control blade rod withdrawal interlocks? Include the associated setpoints in your answer.

QUESTION J.08 (1.00)

With the "MASTER SWITCH" in the "test" position and the regulating blade "OUT" light energized, what is the position of the regulating blade?

QUESTION J.09 (1.00)

What is the relationship between the primary flow and the output of the primary flow transmitter?

(***** CATEGORY J CONTINUED ON NEXT PAGE *****)

QUESTION J.10 (3.00)

a. State FIVE of the SEVEN scrams that are disabled by placing the range switch (7S5) in the "0.10 MW" position. Setpoints are NOT desired or required. (2.50)

b. What ONE scram is enabled by placing the range switch (7S5) in the "0.1 MW" position? (0.50)

QUESTION J.11 (3.00)

a. In what position (OPEN, SHUT, or AS IS) do the following valves fail on a loss of air?

1. Sanitary system vent isolation valve (G).

2. Emergency exhaust isolation valve (D).

b. In what position (OPEN, SHUT, or AS IS) do the following valves fail on a loss of power?

1. Ventilation supply bypass valve (F).

2. Emergency exhaust isolation valve (D).

QUESTION J.12 (1.50)

What is the series of events that takes place to cause a loss of power to the control blade magnets when the P-4 valve is opened with the core located in the stall?

QUESTION J.13 (1.00)

What indication would the console operator have in the control room that the truck door seal had failed assuming that the associated scram was inoperable?

(***** END OF CATEGORY J *****)

QUESTION K.01 (2.00)

Match the reactivity worth effect listed in Column B with the action that in Column A. Each action listed in Column A has only one correct response from Column B. Column B rnsponses may be used more than once.

Column A	Column B
a. Adding one fuel element to core.	1. -8.0 DeltaK/K
b. Flooding of one beam port.	2. -3.4 DeltaK/K
c. Removal of one graphite element.	3. -0.2 DeltaK/K
d. Replacing center fuel element with water.	4. +0.06 DeltaK/K
	5. +2.0 DeltaK/K

QUESTION K.02 (3.00)

In accordance with Technical Specifications, state THREE of the FOUR conditions that must be satisfied for the reactor to be considered secured. Assume a normal core loading and configuration.

QUESTION K.03 (0.50)

According to Technical Specifications, what is the maximum allowable worth of a single movable experiment?

QUESTION K.04 (2.50)

Using the attached Figure Q-1, show where the following components are located:

a. Proportional counter. (0.50)
b. Startup source. (0.50)
c. Regulating rod. (0.50)
d. Fuel elements. (1.00)

(***** CATEGORY K CONTINUED ON NEXT PAGE *****)

QUESTION K.05 (2.00)

Assume a core configuration is designated C-5-3. According to Standing Order #3, "Core Loading Identification," which of the C-5-3 designation characters change if:

a. two fuel elements are exchanged?

b. the fuel configuration is changed?

c. a new graphite element is added in place of a radiation basket?

d. a fuel element is replaced with a new element?

QUESTION K.06 (2.00)

In accordance with Standing Order #12:

a. If a new fuel element is added in place of an old element, at what value of change in excess reactivity will it be necessary to perform a control blade worth calibration? (0.50)

b. What information is needed in order to calculate the excess reactivity for an altered core loading? (1.00)

c. What is the maximum number of replacements of old fuel with new fuel allowed before a control blade worth calculation is required regardless of the change in excess reactivity? (0.50)

QUESTION K.07 (1.50)

In accordance with R.O.1, "Critical Experiment," what THREE personnel are required to be present during a critical experiment?

QUESTION K.08 (2.00)

In accordance with R.O.1, "Critical Experiment," what are the TWO acceptable methods for graphite element placement during initial loading?

QUESTION K.09 (1.00)

a. In accordance with R.O.11, "Handling of Irradiated Fuel," how many irradiated fuel elements may be out of the core or storage at the same time?

b. In accordance with R.O.10, "Receipt and Storage of New Fuel Elements," what is the maximum number of new fuel elements that may be out of a mechanically controlled geometry at any one time?

QUESTION K.10 (1.00)

A sample worth 1.5% DeltaK/K is to be removed from a fixed experiment in the core. The Reactor Operator proposes to remove the sample during a reactor start-up while the reactor is still shutdown by 2%. He cites R.O.4, "Adding or Removal of Samples from the Core," which states:

"Any sample having or expected to have a worth of +/- 0.1% DeltaK/K or greater will only be added to or removed from the core if the reactor remains subcritical after the insertion or removal."

The RO points out that the reactor will remain subcritical by 0.5% DeltaK/K and asks for your permission to perform the sample removal. Should you allow it? Explain your answer.

QUESTION K.11 (1.00)

What TWO solid decay products are most likely to be seen quickly by the 3rd floor CAM if a fuel cladding failure occurs?

QUESTION K.12 (1.50)

a. Assuming the ULR water reflected core has a critical mass of 3.3 Kg, how many fully loaded fuel elements would be required to reach criticality with no graphite reflectors? State all assumptions. Show all work. (1.00)

b. How many fully loaded elements are required for criticality in a graphite reflected core at the ULR? (0.50)

(***** END OF CATEGORY K *****)

QUESTION L.01 (1.50)

In accordance with Technical Specifications:

a. When is an operator or senior operator required to be present at the controls?

b. How many persons are required to be present whenever the reactor is in operation?

c. Within what physical bounds must the Senior Reactor Operator be when the reactor is in operation?

QUESTION L.02 (2.00)

Match the required approving body listed in Column B with the performance request in Column A. Each request listed in Column A has only one correct response from Column B. Column B responses may be used more than once.

Column A	Column B
a. Request to perform a procedure with a temporary change judged not to change the original intent.	1. The USNRC.
b. Request to perform a routine experiment.	2. The Reactor Safety Subcommittee.
c. Request to perform a non-routine experiment involving irradiation of liquid nitrogen.	3. The Reactor Supervisor.
d. Request to perform operations at less than 500 W with the source removed.	4. The Radiation Safety Officer.
	5. Both the Reactor Supervisor and the Radiation Safety Officer.
	6. The Senior Reactor Operator.
	7. The Console Operator.

QUESTION L.03 (2.00)

What are the FOUR interrelated variables associated with the core thermal and hydraulic performance on which Technical Specific tion Safety Limits fo the the forced convection mode of operation are based?

QUESTION L.04 (2.00)

What is the objuctive of the Limiting Safety System Settings for the:

a. FORCED convection mode of operation?

b. NATURAL convection mode of operation?

QUESTION L.05 (1.50)

TRUE or FALSE?

a. NRC approval is required prior to criticality following the recovery from an actual rod stuck condition?

b. The reactor (console) operator is responsible for the verification of completeness of all necessary approvals and authorizations prior to sample insertion into the reactor?

c. In accordance with Standing Order #4, "Sequence of Operations During Start-up and at Rated Power," if more than a 3% discrepancy exists between power indication on the two safety channels the reactor shall be shutdown immediately.

QUESTION L.06 (0.50)

If a setpoint listed in Standing Order #11, "Setpoints for Various Scrams and Alarms," needs to be adjusted to a value different from that noted in the standing order, whose permission is required?

(***** CATEGORY L CONTINUED ON NEXT PAGE *****)

QUESTION L.07 (1.00)

During operation at 1 MW, the console operator notices that inlet temperature is reading 111 F. What immediate action must the console operator take?

QUESTION L.08 (0.50)

What is the minimum time that a reactor operator or senior reactor operator must actively perform the functions of an operator during each calender quarter in order to maintain his/her operating license in an active status?

QUESTION L.09 (2.50)

a. In accordance with 10CFR55, under what conditions is an unlicensed person allowed to operate the reactor controls? (1.50)

b. In accordance with the ULR "Authority," paper, who must approve the operation of the reactor controls by an unlicensed individual? (0.50)

c. How does the console operator know which unlicensed individuals have been approved to operate the controls of the reactor? (0.50)

QUESTION L.10 (2.00)

In accordance with Technical Specifications, following a reactor scram caused by a process variable, what FOUR evaluations must be performed before resuming operation?

QUESTION L.11 (0.50)

TRUE or FALSE?

The reactor may continue to be operated if the main ventilation exhaust backup isolation valve is mechanically blocked in the open position provided that the primary isolation valve is verified operable by a stroke test.

QUESTION L.12 (0.50)

In Accordance with Technical Specifications, what special measurement is required in order to operate in the forced convection mode if an internal element is replaced by a radiation basket?

QUESTION L.13 (3.50)

In accordance with Technical Specification 3.4, "Radiation Monitoring Equipment:"

a. State the FIVE monitors which must be operable during reactor operation. (2.50)

b. State how long reactor operation may continue if one of the area monitors fails and is not replaced. (0.50)

c. State the limit on reactor power if a failed area radiation monitor is replaced by a temporary monitor.

(***** END OF CATEGORY L *****)
(********** END OF EXAMINATION **********)

ANSWER H.01 (3.00)

a. Americium 241 [0.50] decays by alpha emission [0.50].

Beryllium 9 absorbs the alpha [0.50] and decays immediately with the emission of a neutron [0.50].

OR

$^{241}Am \rightarrow {}^{237}Np$ + Alpha [1.00].

^{9}Be + Alpha $\rightarrow {}^{12}C$ + neutron [1.00]. (2.00)

b. 1. Gamma,n reactions (photoneutrons).

2. Spontaneous fission. (1.00)

REFERENCE

Introduction to Nuclear Reactor Operations, Burn, Section 5.2.

ANSWER H.02 (1.00)

a. TRUE

b. FALSE

REFERENCE

Introduction to Nuclear Reactor Operations, Burn, Section 5.3.

(***** CATEGORY H CONTINUED ON NEXT PAGE *****)

ANSWER H.03 (1.50)

Moving control blades from 0 to 12 inches adds 4.5% Delta K/K (+/-0.1). [0.25]

Moving the reg rod from 0 to 10 inches adds .09% Delta K/K (+/- .0025). [0.25]

Equation of interest is $CR_1 (1 - K_1) = CR_2 (1 - K_2)$.

and p = (1-K)/K or K = 1/(1-p) where p =rho (reactivity).

Therefore K_1 = 1/(1 + .09) = .917 (+/- .001) [0.25]

K_2 = 1/(1 -(-.09 + .045 +.0009)) = .958 (+/- .002) [0.25]

and CR_2 = 30 (1 - .917)/(1 - .958) = 59 counts per second (+/- 3).[0.50]

REFERENCE

Introduction to Nuclear Reactor Operations, Burn, Section 5.3.
Rod worth curves for core configuration C-7-3.

ANSWER H.04 (1.00)

The ratio of delayed to total core neutrons [0.50] once they have slowed down to thermal energies [0.50].

REFERENCE

Introduction to Nuclear Reactor Operations, Burn, Section 3.2.4.

ANSWER H.05 (1.50)

a. The prompt component.

b. After five minutes the power decrease is controlled by the decay of longest lived delayed neutron precursor (Br-87).

c. Subcritical multiplication (of core source neutrons) causes the power to stabilize.

REFERENCE

Introduction to Nuclear Reactor Operations, Burn, Section 4.6, 4.8 & 5.3.

ANSWER H.06 (0.50)

Because graphite has a significantly lower neutron absorption cross section.

REFERENCE

Introduction to Nuclear Reactor Operations, Burn, Section 2.8.10.

ANSWER H.07 (1.00)

From the equations sheet:

$$\dot{Q} = \dot{m} C_p (Temp_{out} - Temp_{in})$$

(1500 gal/min)(1 BTU/lbm/F)(91.4 F - 80 F)(8 lbm/gal) = 136,800 BTU/min

(136,800 BTU/min)(.00001758 MW/BTU/min) = 2.40 MW

(0.50 for the proper equation, 0.25 for the proper value of C_p, and 0.25 for the correct result).

(***** CATEGORY H CONTINUED ON NEXT PAGE *****)

REFERENCE

USAR, section 4.2.2.2.
Thermal-hydraulic Principles and Applications to the Pressurized Water Reactor, Chapter 5.

ANSWER H.08 (1.00)

d

REFERENCE

USAR, section 9.1.1.4.

ANSWER H.09 (1.00)

Because the end of the control blade [0.50] is moving through a region of higher flux [0.50] in the middle of its travel.

REFERENCE

Introduction to Nuclear Reactor Operations, Burn, Section 7.2 and 7.5.

(***** CATEGORY H CONTINUED ON NEXT PAGE *****)

ANSWER H.10 (3.00)

a. Because the transient effects of prompt neutrons are present only in the first seconds following the reactivity addition.

b. $T = t / Ln(n_1/n_0) = 35 \text{ sec} / Ln(4 \text{ kW}/2 \text{ kW}) = 50.5 +/-.5$ seconds.

OR, from an understanding of doubling time,

$T = t/Ln(2) = 35 \text{ sec} / .693 = 50.5 +/-.5$ seconds.

[0.75 for correct equation. 0.25 for correct result.]

c. To avoid heating of the primary coolant.

OR

To avoid the reactivity effects of the moderator temperature coefficient.

REFERENCE

Introduction to Nuclear Reactor Operations, Burn, Section 4.3, 4.4.1, 4.8, 4.11.8 and 7.2.

ANSWER H.11 (2.50)

a. 1. Fission.
   2. Iodine decay. (1.00)

b. 1. Radioactive decay.
   2. Burnup. (1.00)

c. 7 hours (+/- 1 hour) (0.50)

REFERENCE

Introduction to Nuclear Reactor Operations, Burn, Section 8.4.1.

(***** CATEGORY H CONTINUED ON NEXT PAGE *****)

ANSWER H.12 (2.00)

a. DECREASE

b. INCREASE

c. DECREASE

d. DECREASE

REFERENCE

Introduction to Nuclear Reactor Operations, Burn, Section 6.4.1.

(***** END OF CATEGORY H *****)

ANSWER I.01 (0.50)

To reduce the production of Ar-41.

REFERENCE

USAR, section 7.3.3.

ANSWER I.02 (0.50)

Loss of heat exchanger integrity.

REFERENCE

USAR, section 7.4.3.

ANSWER I.03 (0.50)

N-16.

REFERENCE

USAR, section 8.1.3.

ANSWER I.04 (1.00)

a.

REFERENCE

USAR, section 8.1.3.

(***** CATEGORY I CONTINUED ON NEXT PAGE *****)

ANSWER I.05 (1.50)

1. Particulate monitor.

   a. Scintillation detector [0.50].

   b. CAF, approximately 30,000 cpm OR 10 times MPC [0.25].

2. Gas detector.

   a. G M detector [0.50].

   b. CAF, approximately 15,000 cpm OR 10 times MPC [0.25].

REFERENCE

USAR, section 7.4.6(2) and Appendix 10.

ANSWER I.06 (1.50)

1. At the monitor (Locally).
2. In the control room.
3. In the Health Physics Laboratory.

REFERENCE

USAR, section 7.4.6.(1).d

ANSWER I.07 (1.00)

b.

(***** CATEGORY I CONTINUED ON NEXT PAGE *****)

REFERENCE

USAR, section 7.4.6.(1).e.

ANSWER I.08 (2.50)

a. 5(N-18) = 50 REM (0.25)

Total lifetime to date = 48 + 1 = 49 REM (0.25)

Total lifetime available = 50 - 49 = 1 REM (0.25)

Total this quarter available = 3 - 1 = 2 REM (0.25)

(Lifetime is more restrictive than quarterly limit)

0.85 REM/hr + (.03 rad/hr)(10 QF) = 1.15 REM/hr dose rate [0.25 for use of the conservative quality factor, 0.25 for appropriately considering both gamma and neutron dose] (0.50)

1.0 REM/1.15 REM/hr = 0.87 HR = 52 MIN (0.50)

b. 25 REM whole body one time exposure. (0.50)

REFERENCE

10CFR20.101(b)
E Plan, section 7.5.1.

ANSWER I.09 (0.50)

1000 mREM/hr.

REFERENCE

R.O.4, step 4.6.

ANSWER I.10 (0.50)

Na-24.

REFERENCE

USAR, section 8.1.1-2.

ANSWER I.11 (3.00)

a. A metal [0.50], lidded can [0.50], with a handle [0.50].

b. Must reduce dose to less than 10 mREM/hr at 1 foot [0.50].

$I = I_0 10^{-x/TVL}$ (from equation sheet)

I = 10 mREM/hr

I_0 = 25 mREM/hr

TVL = 2 inches

Therefore x = -2 inches X Log(10/25) = 0.80 inch +/- 0.1 inch.

[0.75 for proper equation, 0.25 for correct answer based on the candidates assumed level of reduction.]

REFERENCE

ULR, Standing Order #6, "Sample Handling Procedures".

ANSWER I.12 (2.50)

a. Access to the high radiation area may be controlled by:

1. A device lowering radiation upon entry [0.50] such that it is less than the high radiation limit [0.50].

2. A warning device that upon entry audibly [0.25] or visibly [0.25] alerts the person entering [0.25] and alerts the licensee or a supervisor [0.25].

b. By direct surveillance (to prevent unauthorized entry). (0.50)

REFERENCE

10CFR20.203.(c)

ANSWER I.13 (1.50)

1. Cover the spill with a moist absorbent material.

2. Call, do NOT go for help.

OR

Don't track contamination around the lab while seeking assistance.

3. Frisk when leaving the scene of the accident.

REFERENCE

ULR, R.O.4, "Adding or Removal of Samples to the Core," step 4.6.
ULR, Radiation Safety Guide, App. V, Sec. B.

ANSWER I.14 (1.00)

a. Finger rings.

b. After each removal or insertion operation.

(***** CATEGORY I CONTINUED ON NEXT PAGE *****)

REFERENCE

ULR, Standing Order #8, "Installation or Removal of Flux Wires or Foils".

ANSWER I.15 (0.50)

Make a cursory inspection of the reactor building for personnel.

REFERENCE

ULR, E.O.1, "Radiation Emergency".

(***** END OF CATEGORY I *****)

ANSWER J.01 (1.00)

Primary coolant high temperature.

REFERENCE

USAR, section 4.4.15.

ANSWER J.02 (1.50)

a. No motion.

b. Infinity.

c. Stable (or SLOWLY increasing).

REFERENCE

Introduction to Nuclear Reactor Operations, Burn, Table 4.4 and section 5.3.

ANSWER J.03 (1.00)

The sketch should show power starting at .5 MW, increasing to some power above this level but less than .6 MW [0.50] and then decreasing back to .5 MW [0.50]. Some slight damped harmonic oscillation about .5 MW is allowed.

REFERENCE

ULR, RO-5, "Routine Start-up".
USAR, section 4.4.12.

ANSWER J.04 (1.50)

Regulating rod worth curve [0.50] and the rod positions for the same power level [0.50] before and after the insertion of the sample [0.50].

(***** CATEGORY J CONTINUED ON NEXT PAGE *****)

REFERENCE

ULR R.0.4, "Adding or Removal of Samples to the Core," step 4.7.

ANSWER J.05 (3.00)

a. INCREASE

b. NO CHANGE

c. INCREASE

d. INCREASE

REFERENCE

USAR, section 4.
ULR R.0.6, "Operation at Power and Adjustments in Power Level," step 6.2.

ANSWER J.06 (1.00)

The indication will read low off-scale (and then slowly return to an on-scale reading).

OR

Lower than it would normally read.

REFERENCE

CAF

(***** CATEGORY J CONTINUED ON NEXT PAGE *****)

ANSWER J.07 (3.00)

Any four of the following:

1. Low source count rate - 3 cps.

2. High flux - 110%.

3. Short Period - 15 seconds.

4. Low flux - 5%.

5. Time delay block after "reactor startup" - 10 seconds.

(0.50 for each interlock and 0.25 for each setpoint)

REFERENCE

USAR, section 4.4.9 and table 4.4.
R.0.9 "Reactor and Control System Checkout Procedures".

ANSWER J.08 (1.00)

The regulating blade is fully withdrawn.

REFERENCE

USAR, tables 4.2 & 4.3.

ANSWER J.09 (1.00)

The primary flow is proportional to the square root of the transmitter output.

REFERENCE

USAR, table 4.5.

(***** CATEGORY J CONTINUED ON NEXT PAGE *****)

ANSWER J.10 (3.00)

a. Any five of the following at 0.50 point each:

1. Primary low flow.

2. Reactor core low flow.

3. Core inlet high temperature.

4. Core outlet high temperature.

5. Coolant gates open. (Riser and downcomer).

6. Coolant gate open. (Riser).

7. Primary piping alignment established.

b. Picoammeter switch set at greater than 100 kW range. (0.50)

REFERENCE

ULR Technical Specifications, section 3.3.
R.O.9 "Reactor and Control System Checkout Procedures", 9.2.2.(d).

ANSWER J.11 (3.00)

a. 1. SHUT

2. SHUT

b. 1. OPEN

2. SHUT

REFERENCE

USAR, section 3.4.2.2.

(***** CATEGORY J CONTINUED ON NEXT PAGE *****)

ANSWER J.12 (1.50)

Opening the valve activates an attached microswitch [0.50] which in turn opens a relay in the safety scram chain [0.50]. Opening of the relay in the safety scram chain results in the opening of a relay in the control blade magnet circuit [0.50] thus removing power to the magnets.

REFERENCE

ULR SP-23, "Scram Function Test Procedure".
USAR, Figure 4.20.

ANSWER J.13 (1.00)

Containment pressure would be higher than usual.

REFERENCE

USAR, section 3.3.

(***** END OF CATEGORY J *****)

ANSWER K.01 (2.00)

a. 5

b. 4

c. 3

d. 2

REFERENCE

USAR, section 4.5.8.

ANSWER K.02 (3.00)

Any three of the following at 1.00 point each:

1. The minimum number of control rods are inserted.

2. The console key is in the off position [0.50] and the key is removed [0.50].

3. No work in progress involving ore fuel [0.20], core structure [0.20], installed control rods [0.20], or control rod drives [0.20] unless the drives are physically decoupled [0.20].

4. No experiments in or near the reactor are being moved or serviced [0.50] that have a reactivity worth exceeding .5% DeltaK/k [0.50].

REFERENCE

ULR Technical Specifications 1.18.

ANSWER K.03 (0.50)

0.1% Delta K/K.

(***** CATEGORY K CONTINUED ON NEXT PAGE *****)

REFERENCE

Technical Specifications 3.1.

ANSWER K.04 (2.50)

See attached diagram A-1.

(0.50 points each for correct location in a,b and c. For d, 0.50 points for the correct number of fuel elements and 0.50 for the correct envelope).

REFERENCE

USAR, figure 4.1

ANSWER K.05 (2.00)

a. The 5 would change.

b. The C would change.

c. The 3 would change.

d. The 5 would change.

REFERENCE

ULR, Standing Order #3, "Core Loading Identification".

ANSWER K.06 (2.00)

a. 0.25% DeltaK/K. (0.50)

b. Need critical rod position for the new core loading [0.50] and rod worth curves from the previous core loading [0.50].

c. 3. (0.50)

(***** CATEGORY K CONTINUED ON NEXT PAGE *****)

REFERENCE

ULR, Standing Order #12.

ANSWER K.07 (1.50)

1. The Reactor Supervisor or other competent Senior Reactor Operator appointed by the Reactor Supervisor.
2. One additional licensed operator.
3. One other technically qualified scientific person (to act as an independent observer).

REFERENCE

ULR, R.O.1, "Critical Experiment".

ANSWER K.08 (2.00)

1. Load the graphite elements into grid positions appropriate to enclose (or ring) [0.50] each incremental loading of fuel [0.50].
2. Load the graphite elements into grid positions appropriate to enclose (or ring) [0.50] the expected final core configuration [0.50].

REFERENCE

ULR, R.O.1, "Critical Experiment," Step 1.2.14.

ANSWER K.09 (1.00)

a. 1

b. 4

(***** CATEGORY K CONTINUED ON NEXT PAGE *****)

REFERENCE

ULR, R.O.11, "Handling of Irradiated Fuel".
ULR, R.O.10, "Receipt and Storage of New Fuel Elements".

ANSWER K.10 (1.00)

No. Performance of experimental changes of this magnitude are limited [0.50] (by R.O.3) to subcritical conditions of at least the full worth of the most effective control blade (3.52%) [0.50].
[No is proper answer but credit is given only for correct explanation.]

REFERENCE

ULR, R.O.3, "Changes Which Can Affect Reactivity Other Than Movement of Fuel".

ANSWER K.11 (1.00)

1. Rb (88)

2. Cs (138)

REFERENCE

USAR, section 7.4.6.(1).c.

ANSWER K.12 (1.50)

a. 3.3 kG/.135 kG per element = 24.4 elements, therfore need 25 fully loaded elements.

(0.50 for equation setup, 0.50 for correct answer.)

b. 21 (0.50)

(***** CATEGORY K CONTINUED ON NEXT PAGE *****)

REFERENCE

USAR, section 1.2.2.
Start Up Report, section 1.

(***** END OF CATEGORY K *****)

ANSWER L.01 (1.50)

a. Whenever the reactor is not secured.

b. One (SRO).

c. Within the Pinanski Building (including the reactor containment)

OR

Within the facility boundary (as defined in the emergency plan).

REFERENCE

ULR Technical Specifications 6.1.4 & 5.
ULR Emergency Plan, section 2.2.

ANSWER L.02 (2.00)

a. 3

b. 5

c. 1

d. 6

REFERENCE

ULR Technical Specifications 3.6 and 6.8.
ULR, R.O.5, "Routine Startup," final NOTE.
10CFR50.59

(***** CATEGORY L CONTINUED ON NEXT PAGE *****)

ANSWER L.03 (2.00)

1. Reactor thermal power.

2. Reactor coolant flow rate.

3. Reactor coolant inlet temperature.

4. Height of water above the center line of the core.

REFERENCE

Technical Specifications 2.0.

ANSWER L.04 (2.00)

a. To ensure that automatic protective action is initiated [0.50] in order to prevent a Safety Limit from being exceeded [0.50].

b. To ensure that automatic protective action is initiated [0.50] in order to prevent undesirable radiation levels [0.25] on the surface of the pool [0.25].

REFERENCE

Technical Specifications 2.0.

ANSWER L.05 (1.50)

a. TRUE

b. TRUE

c. FALSE

(***** CATEGORY L CONTINUED ON NEXT PAGE *****)

REFERENCE

a. ULR E.0.7, "Stuck Rod or Safety Blade".
b. ULR Standing Order #6, "Sample Handling Procedures".
c. ULR Standing Order #4, "Sequence of Operations During Start-up and at Rated Power".

ANSWER L.06 (0.50)

The Reactor Supervisor.

REFERENCE

ULR Standing Order #11, "Setpoints for Various Scrams and Alarms".

ANSWER L.07 (1.00)

The console operator must immediately shutdown the reactor.

REFERENCE

ULR Technical Specifications, section 6.5.

ANSWER L.08 (0.50)

4 hours.

REFERENCE

10CFR55.53(e).

(***** CATEGORY L CONTINUED ON NEXT PAGE *****)

ANSWER L.09 (2.50)

a. When the unlicensed individual is under the direction [0.50] and in the presence of a licensed operator (RO or SRO) [0.50] and the operation is part of the individuals training (to qualify for a license or as a student) [0.50].

b. Reactor Supervisor. (0.50)

c. Written approvals are required and are available to the console operator. (0.50)

REFERENCE

10CFR55.13.
ULR Authority paper, section 7.

ANSWER L.10 (2.00)

An evaluation to determine:

1. if a safety limit was violated.

2. the cause of the scram.

3. the effects of operation to the scram point.

4. the appropriate action to be taken.

REFERENCE

ULR Technical Specifications 4.6.

ANSWER L.11 (0.50)

FALSE

(***** CATEGORY L CONTINUED ON NEXT PAGE *****)

REFERENCE

ULR Technical Specifications 3.5.

ANSWER L.12 (0.50)

Flux measurement.

REFERENCE

ULR Technical Specifications 5.2.

ANSWER L.13 (3.50)

a. 1. Gaseous stack monitor.
   2. Particulate stack monitor.
   3. 3rd floor (reactor level) CAM.
   4. Experimental level area radiation monitor.
   5. Over pool area radiation monitor.

b. 15 minutes.

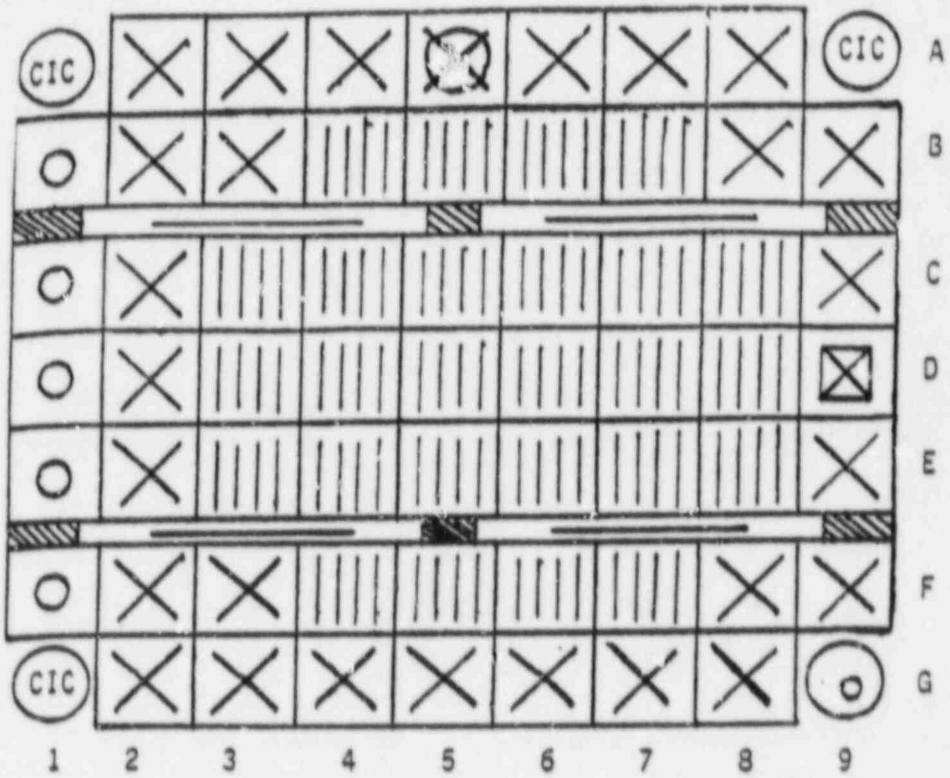
c. Limited to steady state operation.

REFERENCE

ULR Technical Specifications 3.4.

(***** END OF CATEGORY L *****)
(********** END OF EXAMINATION **********)

Figure A-1



Proportional Counter

Startup Source

Graphite Reflector Element

Fuel Element

Servo Control Element

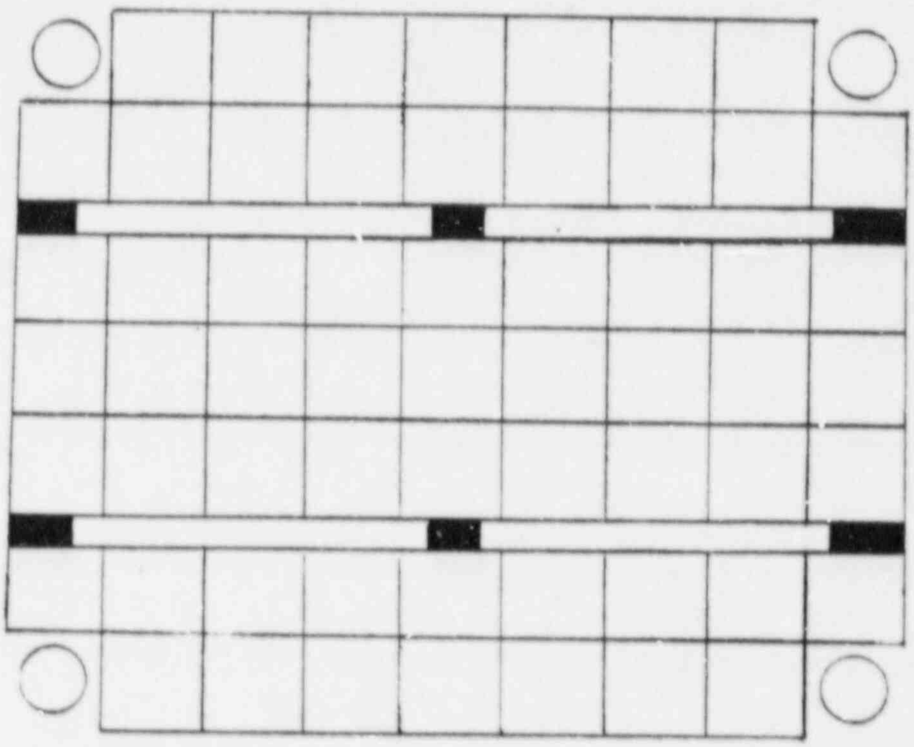
Radiation Basket

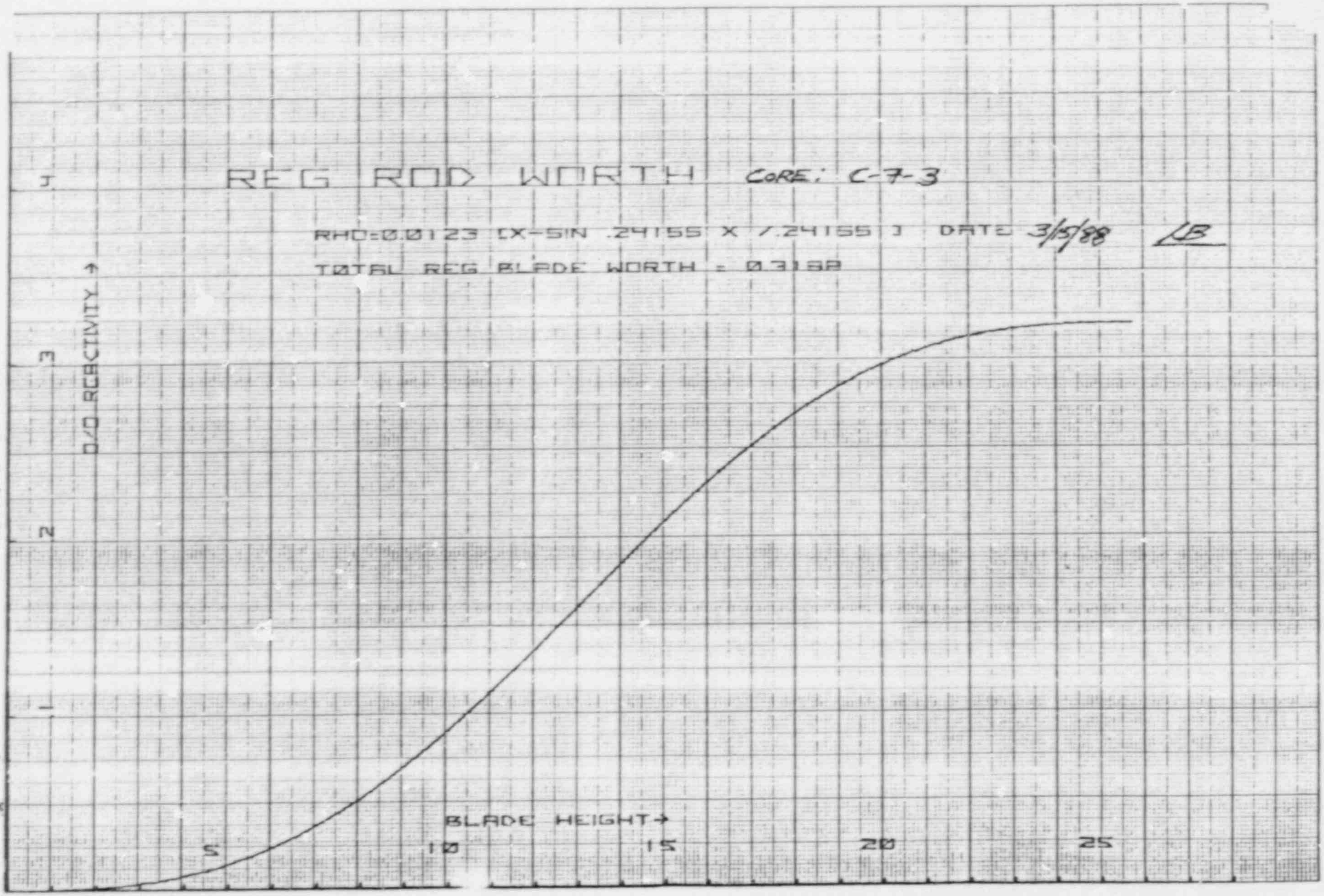
Compensated Ionization Chamber

Control Elements

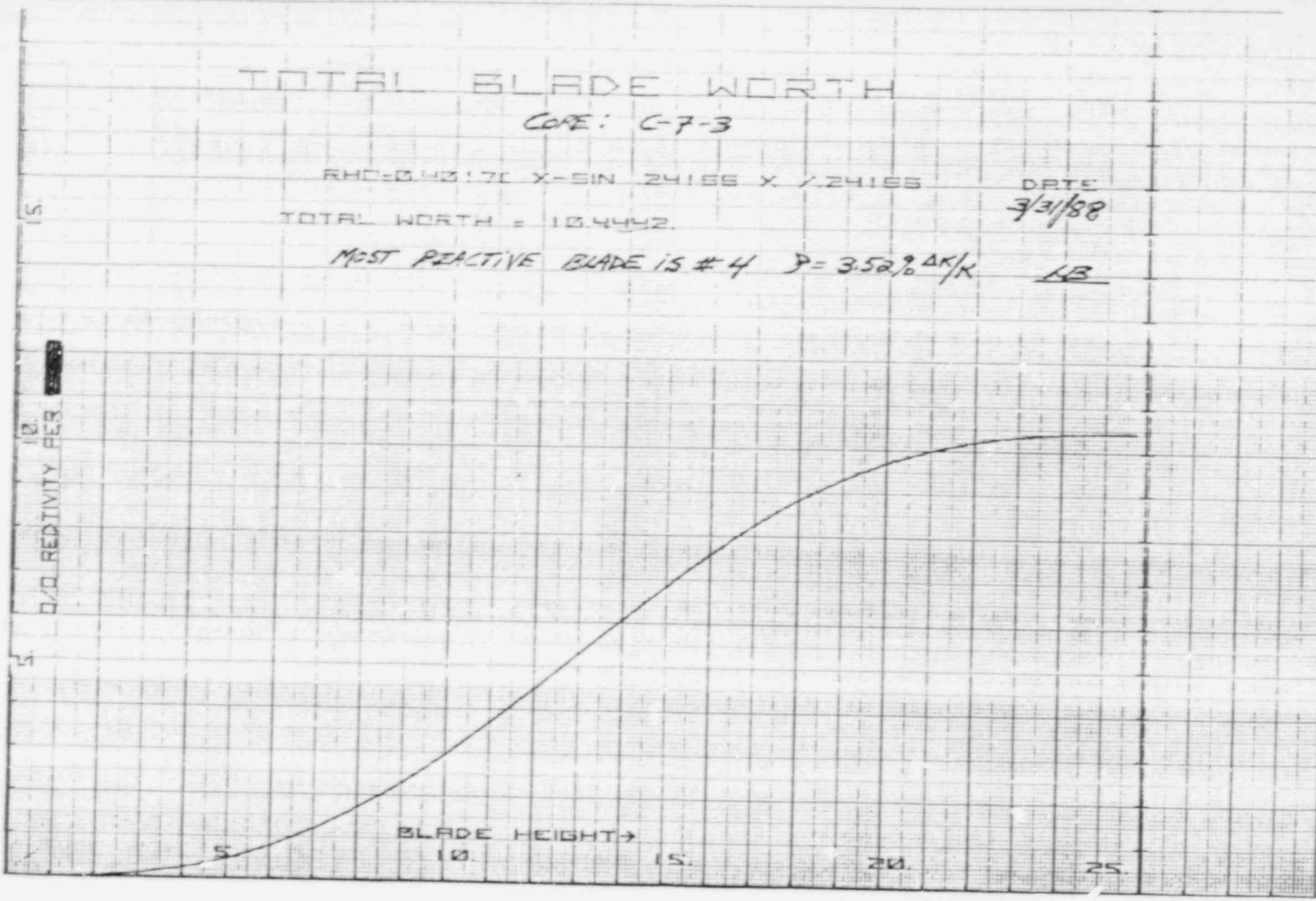
Figure 4.1. Core Arrangement

Figure Q-1





REG ROD WORTH
CoRE: C-7-3
RHO=0.0123 [X-SIN .24155 X /.24155] DATE 3/15/88
LB
TOTAL REG BLADE WORTH = 0.3188
D/O REACTIVITY →
BLADE HEIGHT→
1
2
3
5
10
15
20
25


TOTAL BLADE WORTH
CORE: C-7-3
RHO=0.43!7C X-SIN 24!55 X /.24!55
DATE
3/31/88
TOTAL WORTH = 10.4442
MOST REACTIVE BLADE IS #4 ρ= 3.52% ΔK/K
LB
D/D REDTIVITY PER [redacted]
15.
10.
5.
BLADE HEIGHT→
5.
10.
15.
20.
25.

EQUATION SHEET

$f = ma$

$w = mg$

$E = mC^2$

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

$PE = mgh$

$W = v\Delta P$

$\Delta E = 931\Delta m$

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

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

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

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

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

$SUR = 26.06/T$

$T = 1.44\ DT$

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

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

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

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

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

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

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

$\Sigma = N\sigma$

$v = s/t$

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

$a = (v_f - v_o)/t$

$v_f = v_o + at$

$\omega = \theta/t$

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

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

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

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

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

$I = I_o e^{-ux}$

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

$TVL = 1.3/u$

$HVL = 0.693/u$

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

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

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

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

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

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

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

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

$I_1 d_1 = I_2 d_2$

$I_1 d_1^2 = I_2 d_2^2$

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

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

WATER PARAMETERS

1 gal. = 8.345 lbm

1 gal. = 3.78 liters

1 ft^3 = 7.48 gal.

Density = 62.4 lbm/ft^3

Density = 1 gm/cm^3

Heat of vaporization = 970 Btu/lbm

Heat of fusion = 144 Btu/lbm

1 Atm = 14.7 psi = 29.9 in. Hg.

1 ft. H_2O = 0.4335 lbf/in^2

MISCELLANEOUS CONVERSIONS

1 Curie = 3.7×10^{10} dps

1 kg = 2.21 lbm

1 hp = 2.54×10^3 BTU/hr

1 Mw = 3.41×10^6 Btu/hr

1 Btu = 778 ft-lbf

1 inch = 2.54 cm

$^\circ F = 9/5\,^\circ C + 32$

$^\circ C = 5/9\,(^\circ F - 32)$

ATTACHMENT 3

FACILITY COMMENTS AND NRC RESOLUTION FOR
REACTOR OPERATOR AND SENIOR REACTOR OPERATOR
EXAMS ADMINISTERED ON AUGUST 3, 1988

Question A.02c/H.11c

Facility Comments: Since operating cycles for the ULR are fairly short, Xe buildup is unappreciable and is not a factor during operation. Operators have received generic training which has included the ranges specified in the training materials.

NRC Resolution: Because Xe effects are unappreciable at the ULR due to the short operating cycles, the generic ranges specified in the training material will be accepted. However, more representative values should be used in future operator training.

Question C.06

Facility Comment: "Convection, radiation, and conduction" should be accepted as descriptive terms for the heat transfer mechanism.

NRC Resolution: The question has been deleted from the examination. The question is not precise enough to elicit the required response.

Question C.10c/J.05c:

Facility Comment: Although secondary flow can be controlled by a throttle valve receiving a signal from primary temperature, in reality, the cooling tower louvers are controlled by a secondary coolant temperature sensor which will regulate the air flow through the cooling tower. In this mode, as is actually used, secondary flow will remain steady or decreasing is an accurate response.

NRC Response: The question has been deleted from the examination. The actual manner in which the secondary system temperature is controlled results in unacceptable question ambiguity.

Question D.11

Facility Comment: This question should be deleted from the test because it has never been addressed in training, nor does any facility staff member know the answer.

NRC Resolution: The question has been deleted from the examination because the answer is not known by ULR staff.

Question E.01/J.10

Facility Comment: Answers 5 and 6 are similar in that only one of these can be operative at one time depending on whether the downcomer or crosstall mode of cooling is being used. In addition, sub trips such as Bridge Position should be accepted as correct.

NRC Resolution: Comment noted, Bridge Position will also be accepted.

Question E.06

Facility Comment: Diagram 5.2 of the FSAR shows a rating of 75 kw, the FSAR description states a rating of 70 kw. Either answer should be accepted.

NRC Resolution: Since the difference between the two ratings is small, either will be accepted. However, the precise rating should be used in operator training materials.

Question E.08

Facility Comment: "Trip" is not the facility term for a scram. This terminology may prompt the candidate to include the startup inhibit of 3 cps in the answer and not to include the hi voltage scram. The answer depends on how the candidate interprets the word trip.

NRC Response: Comment noted, Control Blade Withdrawal Inhibit will also be accepted.

Question G.09

Facility Comment: The HP Lab and the Reactor Supervisor's offi . are the same.

NRC Resolution: Comment noted. HP Lab will be accepted in place of the Reactor Supervisor's office.