U.S. NUCLEAR REGULATORY COMMISSION

REGION III

Report No. 50-150/OLS-87-01(DRS)

Docket No. 50-150 License No. R-75

Licensee: Ohio State University
Nuclear Reactor Laboratory
1298 Kinnear Road
Columbus, OH 43212

Facility Name: Nuclear Reactor Laboratory, UTR-10

Examination Administered At: Ohio State University, Columbus, Ohio

Examination Conducted: October 7-8, 1987

Examiner: Elizabeth A. Hare Elizabeth A Hare 10/22/87
Date

Approved By: Thomas M. Burdick, Chief
Operating Licensing Section 10/22/87
Date

Examination Summary

Examination administered on October 7-8, 1987 (Report No. 50-150/OLS-87-01(DRS)) to two reactor operator candidates.
Results: Both candidates passed.

REPORT DETAILS

1. Examiners

E. A. Hare, Chief Examiner

2. Exit Meeting

On October 8, 1987 at the conclusion of the examination, a meeting was held to discuss generic findings made during the course of the examination. The following personnel attended the meeting:

Facility Representative

R. Myser, Plant Supervisor

NRC Representatives

E. A. Hare, Chief Examiner
T. M. Burdick, Chief, Operating Licensing Section

The items discussed during this meeting are listed in the following paragraphs.

a. Three instances were observed where facility personnel placed their ungloved hands into the reactor pool. The examiner noted that placing one's hand into the reactor pool without a glove was not a good radiation practice since the water is potentially contaminated. This practice should be observed and revised as appropriate.

b. The OSURR training material did not contain substantial information on the normal A.C. power system, action to be taken on loss of A.C. power or backup power supply. This should be reviewed and revised as necessary.

c. The procedures used at OSURR do not clearly state what is the responsibility of the RO/SRO. This should be clearly defined in each procedure or in a "conduct of operations" procedure.

3. Examination Review

Refer to the Attachment.

ATTACHMENT

A.02 c.

Facility Comment: Incorrect answer is given in answer key (0.736 delta K/K)

$$\frac{K-1}{K} = \frac{1.0795-1}{1.0795} = 0.0736 \text{ delta K/K}$$

is the correct answer.

NRC Response: Agree with comment answer key will be change to 0.0736 delta K/K.

A.04 a.b.

Facility Comment: This question is not appropriate for an R.O. exam. I recommend that it be deleted. It tests knowledge and understanding of 1/V behavior that an R.O. does not need. The intent of assigning this material to our R.O. candidates to read was for them to gain a general understanding of fuel and moderator coefficients of reactivity. This question from Section 5.81 of Nuclear Reactor Operations, p. 259, is too specific.

NRC Response: Disagree with comment. The answer did not require knowledge of 1/V behavior for credit. The question only required basic knowledge of moderator temperature coefficient not specific knowledge such as 1/V. The answer key will not be changed.

B.01

Facility Comment: This question is too vague even though you told the examinees which section (6.0) of the Technical Specifications to consider in their answer. Also, the expected answer lists items that an SRO reviews as a part of approval of a request form (see procedure AP-4 II). An R.O. does not choose or approve experiment location. I would recommend that this question be weighted less (perhaps 1.5 points instead of 3).

NRC Response: Disagree with comment. It is unclear from reading AP-4 II, what is the responsibility of the RO or SRO. It is not clearly stated. A RO should be cognizant of experiment in and around the core, and how they could effect reactor operations. The answer key and question value will not be changed.

C.03

Facility Comment: Since this question does not specify to exclude poison section differences, the following answers are also correct:

		R.R.	Shim Safety (SS)
1.	Different Lengths	24"	26"
2.	Different Reactivities	1/4 of S.S.	4 x R.R.
3.	Grooved vs. Smooth	Smooth	Grooved Surface
4.	Boron vs. Stainless Steel	Stainless	1.5% Natural Boron

Ref. Question and Answer from 1985 equal exam B7.

Also Sections 1.8.1 and 1.8.2 of the HSR indicate the following:

		R.R.	Shim Safety (SS)
1.	Solid vs. Hollow	Hollow	Solid

NRC Response: Agree with comment. Answer key will be change to reflect all possible answers.

C.05

Facility Comment: During training, we discussed and/or demonstrated what happens if:

1. Blower motor is turned off at the switch away from the Rabbit control panel - rabbit stays in.

2. Fuse is removed from the Rabbit control panel - wind gates are reversed so the rabbit is returned to the receiving terminal.

3. Rabbit permit off in the control room - rabbit cannot be sent.

4. Although it was not covered in training, if the rabbit permit is turned off while the rabbit is in, the rabbit is returned. I would recommend credit for either answer 2 or 4 above.

NRC Response: Disagree with comment. No reference material was sent to substantiate facility comment. The question dealt with operation of the solenoids. Answer key will not be changed.

D.05 a.

Facility Comment: Since we do not use the fission chamber (start-up channel) as ar absolute power level monitor, a better indication of its range is simply the recorder and/or meter scales which go from 1 - 10,000 cps. I recommend this as an acceptable answer.

NRC Response: Agree with comment. Will accept either answer for full credit. Answer key will be changed.

E.01

Facility Comment: A revised answer for fast vs. slow scram was sent just prior to the exam. This same information is enclosed again.

NRC Response: Agree with comment. The answer key will be changed to the revised answer.

E.07

Facility Comment: A revised scram list was included in information sent just prior to the exam. It is enclosed again. Please grade using new information.

NRC Response: Agree with comment. Answer key will be changed to the revised answer.

F.07 b.

Facility Comment: There is now a key bypass as described in Section 1.7.7 of the revised information in the HSR. It is enclosed again for review. Please grade according to latest information.

NRC Response: Agree with comment. Answer key will be changed to the revised answer.

G.03

Facility Comment: This seems to be an administrative question more appropriate for an SRO. Also, the reference for the answer is incorrect. It should be 20.101, not 20.201. I would recommend that this question be weighted less (1.5 points instead of 3).

NRC Response: Disagree with comment. This question is appropriate for RO and SRO level of knowledge. The answer key will not be changed. The reference will be changed to be 10 CFR 20.101.

G.06

Facility Comment: The correct answer is 75 mr, not 75 mr/hr.

$$\frac{45 \text{ min.}}{60 \text{ min./hr.}} \times 100 \text{ mr/hr.} = 75 \text{ mr}$$

NRC Response: Agree with comment. The answer key will be changed to 75 mr.

MASTER COPY

U. S. NUCLEAR REGULATORY COMMISSION
REACTOR OPERATOR LICENSE EXAMINATION

FACILITY: OHIO STATE UNIVERSITY

REACTOR TYPE: POOL-MTR

DATE ADMINSTERED: 87/10/07

EXAMINER: HARE, E. A.

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
14.25	14.21	_____	_____	A. PRINCIPLES OF REACTOR OPERATION
14.00	13.97	_____	_____	B. FEATURES OF FACILITY DESIGN
14.00	13.97	_____	_____	C. GENERAL OPERATING CHARACTERISTICS
13.50	13.47	_____	_____	D. INSTRUMENTS AND CONTROLS
15.00	14.96	_____	_____	E. SAFETY AND EMERGENCY SYSTEMS
14.75	14.71	_____	_____	F. STANDARD AND EMERGENCY OPERATING PROCEDURES
14.75	14.71	_____	_____	G. RADIATION CONTROL AND SAFETY
100.2		_____ Final Grade	_____%	Totals

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

_____
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 A.01 (2.00)

Briefly EXPLAIN the difference between:

a. Fast and prompt neutrons. (1.0)

b. Slow and delayed neutrons. (1.0)

QUESTION A.02 (2.00)

a. Explain the difference between K-infinite and K-effective. (1.0)

b. K-effective of a reactor is given as 1.0795 delta k/k. What K-excess does the reactor have? (0.5)

c. What reactivity is associated with this K-effective? (0.5)

QUESTION A.03 (2.00)

a. Define reactor period. (1.0)

b. Explain the term prompt critical. (1.0)

QUESTION A.04 (2.00)

a. How does highly enriched uranium fuel (U-235) effect the moderator temperature coefficient over lifetime of fuel? (1.0)

b. How will this change if low enriched fuel is used in future core loads? (1.0)

QUESTION A.05 (1.50)

a. What is the purpose of the "moderator" in the reactor? (1.0)

b. Indicate which one of the following is considered an important aspect of a good moderator. (0.5)

1. Low mass number
2. Large absorption cross section
3. Small scattering cross section

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

QUESTION A.06 (1.00)

Reactor power is 100 watts and increasing on a 30 second period. How long will it take for the reactor power to reach 10 kilowatts? (Neglect heating effects) Show your work. (1.0)

QUESTION A.07 (0.75)

How much excess reactivity is permitted by the OSU Technical Specifications? (.75)

QUESTION A.08 (1.00)

DEFINE the term Shutdown Margin. (1.0)

QUESTION A.09 (2.00)

a. A step insertion of a small amount of positive reactivity is made to a reactor while critical in the very low power range. Describe the changes in neutron flux and why the changes occur after the reactivity addition. (Neglect heating effects.) (1.0)

b. Describe the changes in neutron flux and why the changes occur following a reactor scram from full power operation. (1.0)

(***** END OF CATEGORY A *****)

QUESTION B.01 (3.00)

When an experiment is being installed in the reactor, in accordance with OSURR Technical Specifications, there are THREE (3) considerations the operator must keep in mind when choosing a location. STATE the THREE considerations.

Section 6.0

QUESTION B.02 (3.00)

From Figure 1, OSU Reactor Core Layout, LIST the components that are marked 1 through 8.

QUESTION B.03 (1.50)

What is the determining factor of fuel element lifetime and what is it dependent upon?

QUESTION B.04 (1.50)

Fill in the blanks of the following statements.

1. The control system shall have a shutdown margin of at least _____% in reactivity.

2. The regulating rod shall be worth less than _____% in reactivity.

3. The reactor shall be subcritical by a minimum margin of _____% in reactivity when the maximum worth shim-safety rod and the regulating rod are fully withdrawn from the core.

QUESTION B.05 (3.00)

From Figure 14, Flow diagram for the water process system , LIST the components that are marked 1 through 10.

QUESTION B.06 (2.00)

STATE the primary and secondary functions of the water process system.

(***** END OF CATEGORY B *****)

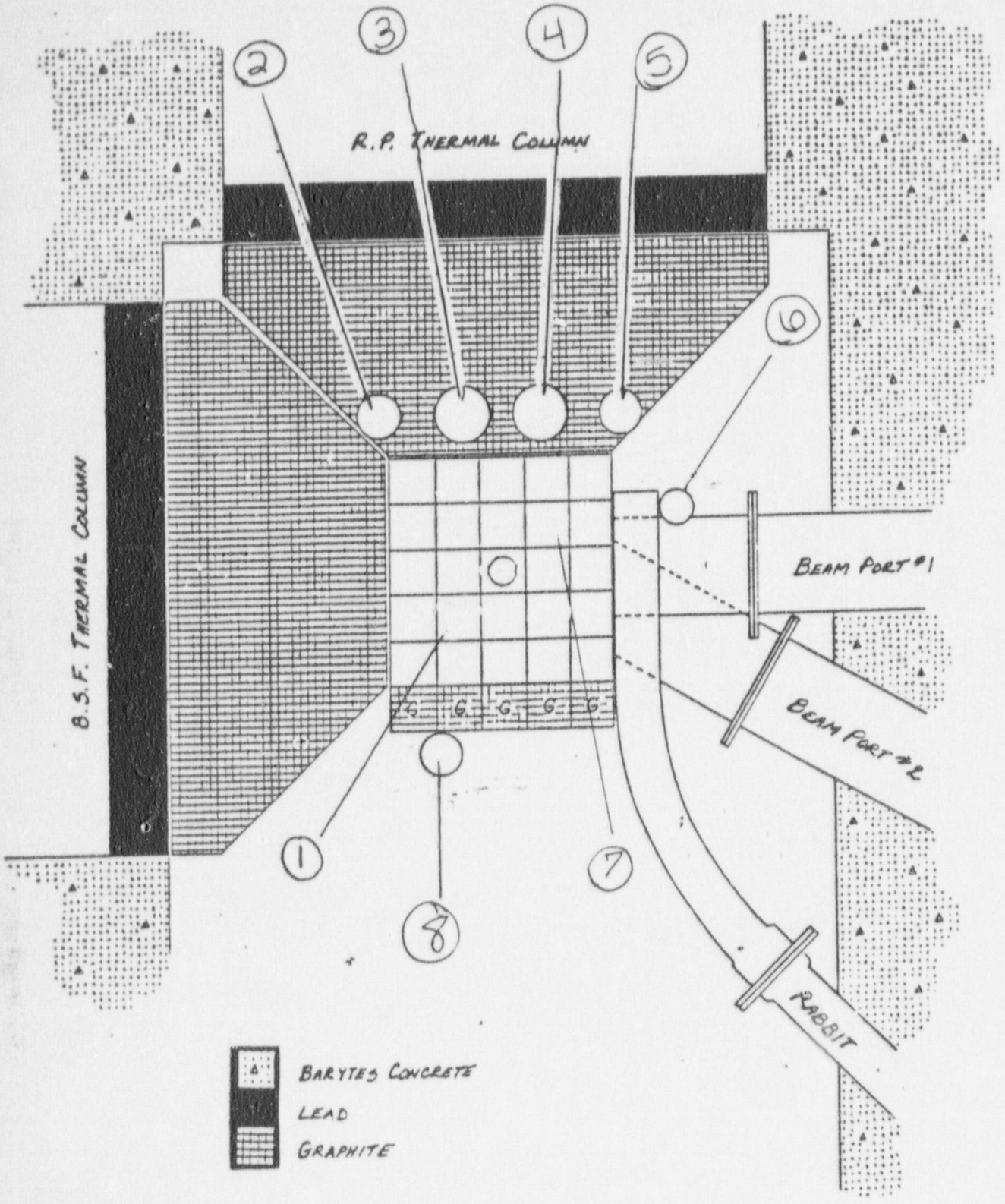

FIGURE 1. OSU Reactor Core Layout - Top View

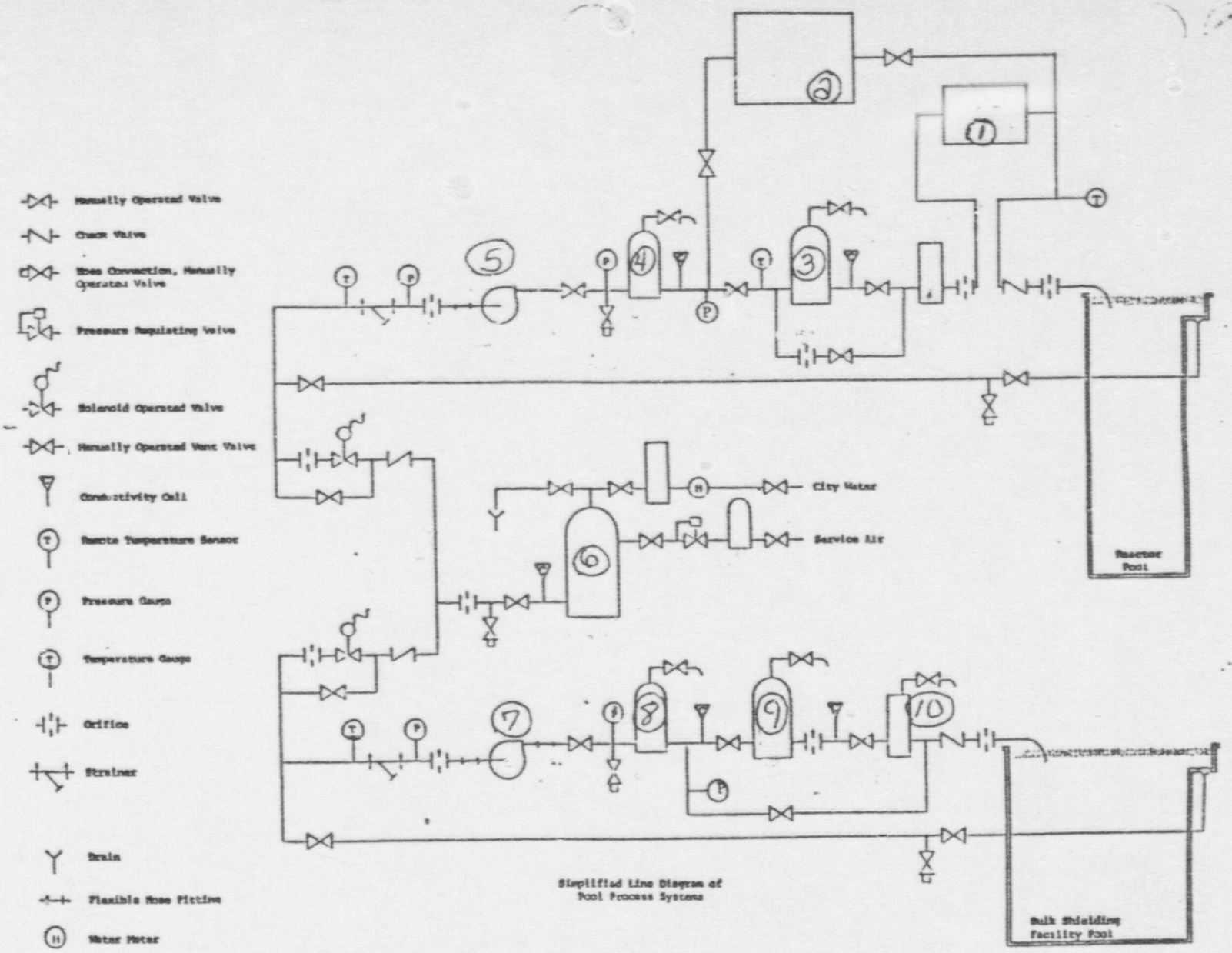

Figure 14

Flow Diagram of the Water Processing System

QUESTION C.01 (1.00)

The biological shield at OSURR consists of light water and concrete. What are the radiation levels at 1 m above the pool surface and outer lateral surface when operating at 10 Kw?

QUESTION C.02 (2.00)

For the following items, STATE the nominal values for each:

a. Recirculating Flow Rate

b. Conductivity

c. Heat Exchanger (Chiller) Cooling rate

d. Pool Water Heater heating rate

QUESTION C.03 (3.00)

The regulating rod is identical to the shim-safety rods with the exception of THREE features. LIST TWO of the three features.

QUESTION C.04 (1.50)

a. How often is conductivity monitored? (0.5)

b. How and where is it monitored? (1.0)

QUESTION C.05 (1.00)

LIST TWO (2) ways to operate the solenoids that return the rabbit to the receiving terminal.

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

QUESTION C.06 (2.50)

a. Explain why reactor startup cannot be accomplished without the Pu-Be source. (1.0)

b. How is the source position indicated? (1.5)

QUESTION C.07 (3.00)

a. What is the difference between the standard fuel elements and the control rod fuel elements? (2.0)

b. What is the reason for having the special fuel elements? Consider all types. (1.0)

(***** END OF CATEGORY C *****)

QUESTION D.01 (2.00)

What is the difference between an uncompensated and a compensated ion chamber?

QUESTION D.02 (2.50)

LIST the FOUR (4) monitored locations in the area radiation monitoring system and STATE their trip level.

QUESTION D.03 (2.00)

a. How many shim-safety rods can be withdrawn at a time (upward movement)? (0.5)

b. What position does the manual drive toggle switch end up in when released? (0.5)

c. Choose correct answer.

A (LOWER/RAISE) signal to any shim-safety control rod overrides a (LOWER/RAISE) signal to any other shim-safety rod. (1.0)

QUESTION D.04 (1.00)

a. When is the building exhaust air monitored? (0.5)

b. What type of detector is it? (0.5)

QUESTION D.05 (3.00)

For the following instrumentation, STATE what type of detector it is and its range.

a. Startup Channel (Log Count Rate) (1.0)

b. Level Safety (1.0)

c. Period Safety (1.0)

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

QUESTION D.06 (2.00)

With respect to shim-safety control rod assembly:

a. Where is the dash pot cylinder located and what is the purpose of this cylinder. (1.5)

b. What is contained in the poison section of these rods? (0.5)

QUESTION D.07 (1.00)

Concerning the startup channel; Briefly discuss how neutrons are distinguished from alpha, beta, and gamma radiation. (1.0)

(***** END OF CATEGORY D *****)

QUESTION E.01 (2.00)

EXPLAIN the difference between a fast scram and a slow scram.

QUESTION E.02 (1.00)

WHICH TWO (2) interlocks prevent the operator from obtaining magnet current if they are not satisfied?

QUESTION E.03 (3.00)

For the following lights provided for each shim safety rod, STATE what each one indicates and its lamp color.

1. Jam
2. Down
3. Engage

QUESTION E.04 (1.50)

Concerning Emergency Power, answer the following:

a. Upon loss of building power, what emergency power is supplied? (0.5)

b. What TWO (2) ways can you confirm the rods were on the bottom and the reactor safety shut down if building power is lost? (1.0)

QUESTION E.05 (2.00)

LIST TWO (2) ways the evacuation alarm can be sounded.

QUESTION E.06 (1.50)

What are the Safety System design criteria for the possibility of single electrical fault disabling a scram function? (1.5)

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

QUESTION E.07 (3.00)

LIST 15 items or conditions that will cause a scram.

QUESTION E.08 (1.00)

Which TWO (2) control room recorders do not have scram functions associated with their operation? (1.0)

(***** END OF CATEGORY E *****)

QUESTION F.01 (2.50)

LIST FIVE (5) of the six special considerations an SRO should be made aware of and initial per OM-08, Reactor Operation Logbook Records.

QUESTION F.02 (1.50)

LIST the THREE (3) times or conditions, a complete set of readings shall be made.

QUESTION F.03 (1.00)

When a stable reactor period has been reached in a reactor startup, WHAT TWO (2) pieces of information shall be noted in the logbook?

QUESTION F.04 (3.00)

LIST the minimum staffing requirements for the following operational conditions:

a. Normal reactor operation (1.0)

b. First startup of the day (1.0)

c. Fuel handling (1.0)

QUESTION F.05 (1.75)

LIST the reactor operator's responsibilities when a nuclear emergency is declared.

QUESTION F.06 (2.00)

Section 9.0, Surveillance Requirements of the OSURR Technical Specifications, states that a reactor check-out shall be performed prior to each day's operation (unless the operation is for more than one full day).

STATE the minimum check-out requirements.

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

QUESTION F.07 (3.00)

a. When would an operator want to bypass a low level source scram? (1.5)

b. How is this accomplished (i.e., bypassed)? (1.5)

(***** END OF CATEGORY F *****)

QUESTION G.01 (1.00)

Fill in the blanks of the following questions.

a. If storing a sample that has greater than _____ mr/hr contact dose rate, place the sample in a lead pig prior to storage.

b. Radiation levels outside of a radioactive materials storage facility should not exceed _____ mr/hr.

QUESTION G.02 (1.50)

A material decays at a rate of 40 percent per day. What is its half-life?

QUESTION G.03 (3.00)

According to 10 CFR 20, an individual in a restricted area may be allowed to receive a whole body dose of radiation greater than 1.25 rem per quarter when THREE conditions are met. What are these conditions? (Assume non-emergency conditions.)

QUESTION G.04 (2.25)

During reactor operations, Argon 41 is produced.

a. What is its source, half-life, and decay mode? (1.5)

b. Where is it produced? (.75)

QUESTION G.05 (2.00)

Does the biological effect of 100 rem depend on whether it is a neutron or gamma dose? EXPLAIN.

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

QUESTION G.06 (1.50)

While working in an area marked "Caution, Radiation Area," an operator discovers his dosimeter is off scale and leaves the area. Assuming he had been working in the area for 45 minutes, what is the maximum dose he would have received? (Show all work and state any assumptions you have made.)

QUESTION G.07 (2.00)

a. STATE the quarterly occupational dose limit for whole body, hands and feet, and skin of whole body. (1.5)

b. What is the dose limit for individuals under the age of 18? (.5)

QUESTION G.08 (1.50)

If the dose rate from a radiation source is 100 mrem/hr at 1 meter, what is the dose rate at 25 cm? Show work. (1.5)

(***** END OF CATEGORY G *****)
(********** END OF EXAMINATION **********)

EQUATION SHEET

$f = ma$

$w = mg$

$E = mc^2$

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

$PE = mgh$

$V_f = V_0 + at$

$W = \sqrt{\Delta P}$

$v = s/t$

$s = V_0 t + \frac{1}{2} at^2$

$a = (V_f - V_0)/t$

$w = \theta/t$

$\Delta E = 931\ \Delta m$

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

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

$Pwr = W_f \Delta h$

$P = P_0 10^{sur(t)}$

$P = P_0 e^{t/T}$

$SUR = 26.06/T$

$SUR = 26\rho/\ell^* + (\beta - \rho)T$

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

$T = \ell/(\rho - \beta)$

$T = (\beta - \rho)/(\lambda\rho)$

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

$\rho = [(\ell/(T K_{eff})] + [\bar{\beta}_{eff}/(1 + \bar{\lambda}T)]$

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

$\Sigma = \sigma N$

Cycle efficiency = (Network out)/(Energy in)

$A = \lambda N \qquad A = A_0 e^{-\lambda t}$

$\lambda = \ell n 2/t_{\frac{1}{2}} = 0.693/t_{\frac{1}{2}}$

$t_{\frac{1}{2}} eff = \dfrac{[(t_{\frac{1}{2}})\ (t_b)]}{[(t_{\frac{1}{2}}) + (t_b)]}$

$I = I_0 e^{-\Sigma x}$

$I = I_0 e^{-\mu x}$

$I = I_0\ 10^{-x/TVL}$

$TVL = 1.3/\mu$

$HVL = -0.693/\mu$

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

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

$CR_1 (1 - K_{eff1}) = CR_2 (1 - k_{eff2})$

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

$M = (1 - K_{eff0})/(1 - K_{eff1})$

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

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

$\bar{\lambda} = 0.1$ 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
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 = 0.433 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 in = 2.54 cm
°F = 9/5°C + 32
°C = 5/9 (°F-32)
1 BTU = 778 ft-lbf

ANSWER A.01 (2.00)

a. Fast neutrons are of high energy levels and prompt neutrons are those released at the time of fission. (1.0)

b. Slow neutrons are of low energy levels and delayed neutrons appear at some time after the fission event due to fission fragments. (1.0)

REFERENCE

Nuclear Reactor Engineering, pgs. 11, 90

ANSWER A.02 (2.00)

a. K-infinite is the multiplication constant for a theoretical reactor with no leakage. K-effective takes into account neutrons lost due to slow and fast leakage (K-eff = K-inf * slow and fast non-leakage probability). (1.0)

b. K-excess = K-effective -1 = 1.0795 -1 = .0795 delta k (0.5)

c. Reactivity = (K-effective -1)/K-effective
= (1.0795 -1)/1.0795 = ~~0.738~~ 0.0736 delta k/k (0.5)

REFERENCE

Nuclear Reactor Engineering, pgs. 152, 234

ANSWER A.03 (2.00)

a. The time required for the neutron density (or flux) to change by a factor e. (1.0)

b. When a reactor is critical on prompt neutrons alone (i.e., a reactor became prompt critical when the reactivity is equal to the fraction of delay neutrons. (1.0)

REFERENCE

Nuclear Reactor Engineering, pgs. 236 and 248

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

ANSWER A.04 (2.00)

a. By using highly enriched U-235, sufficient U-235 will be present to prevent the moderator temperature coefficient from becoming positive. (1.0)

b. With slightly enriched fuel (both U-235 and U-238) Pu-239 is produced, having a positive reactivity effect. This can allow the moderator temperature coefficient to become positive after a period of operation. (1.0)

REFERENCE

Nuclear Reactor Operations, pg. 259

ANSWER A.05 (1.50)

a. Neutrons of low energy have the highest probability of causing fission in the fuel. Most neutrons are born at high energy levels. The moderator reduces the neutron energy level. (1.0)

b. 1. Low mass number (0.5)

REFERENCE

Nuclear Reactor Operations, pgs. 438, 445

ANSWER A.06 (1.00)

$P = Po*\exp(t/T)$
$10,000 = 100*\exp(t/30)$
$\ln 100 = t/30$
$t = 30*4.6 = 138$ seconds
$= 2.3$ minutes (1.0)

REFERENCE

OSURR Requal Test 1985 Question A.2

ANSWER A.07 (0.75)

1.5% delta k/k (.75)

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

REFERENCE

OSURR Technical Specification 4.1.3

ANSWER A.08 (1.00)

Shutdown margin is the amount of negative reactivity inserted below the minimum critical height.

REFERENCE

OSURR Requal Exam 1985, Question 3.a.

ANSWER A.09 (2.00)

a. There is a "prompt jump" increase in neutron flux due to the immediate effects of prompt neutrons. (0.5) Power then increases on a stable period the value of which is determined by the amount of reactivity inserted and the delayed neutron generation time. (0.5)

b. Following a scram there is a prompt drop in neutron flux as prompt neutron generation is stopped. (0.5) Flux then gradually decreases as delayed neutrons continue to be generated from the decay of the precursor groups. (0.5)

REFERENCE

Nuclear Reactor Engineering, pgs. 90-93

(***** END OF CATEGORY A *****)

ANSWER B.01 (3.00)

No experiment shall be installed in the reactor in such a manner that:

1. It could shadow the nuclear instrumentation system monitors.
2. Failure of the experiment could interfere with the insertion of a control rod.
3. Failure of the experiment could credibly result in fuel element damage.

(3 @ 1.0 pt each = 3.0)

REFERENCE

OSURR Technical Specifications, pg. 5
Section 6

ANSWER B.02 (3.00)

1. Regulating Rod
2. Uncompensated ion chamber
3. Compensated ion chamber (#2)
4. Compensated ion chamber (#1)
5. Uncompensated ion chamber
6. Fission chamber
7. Shim Safety Control Rod (#2)
8. Neutron source (Pu-Be)

(8 @ .375 pts each = 3.0)

REFERENCE

OSURR Reactor Description and Hazard Summary Section 1.2

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

ANSWER B.03 (1.50)

Corrosion of cladding is the limiting factor [0.75]. It is dependent on water purity [0.75].

REFERENCE

OSURR Reactor Description and Hazard Summary Section 1.3.1

ANSWER B.04 (1.50)

1. 6%
2. 0.7%
3. 1%

(3 @ 0.5 pts each = 1.5)

REFERENCE

OSURR Technical Specifications 4.2.3

ANSWER B.05 (3.00)

1. Chiller
2. Water Heater
3. Ion Exchanger
4. Cuno Filter
5. Centrifugal Pump
6. Mixed Bed Resin Exchanger
7. Centrifugal Pump
8. Cuno Filter
9. Ion Exchanger
10. Flow Meter

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

REFERENCE

Figure 14 of OSURR Reactor Description and Hazards Summary

ANSWER B.06 (2.00)

The primary purpose is water purification [1.0] (to retard fuel cladding corrosion) and secondary function is cooling and/or heating [1.0].

REFERENCE

OSURR Reactor Description and Hazards Summary, Section 1.9

(***** END OF CATEGORY B *****)

ANSWER C.01 (1.00)

Pool Surface: < 5 mrem/hr @ 1 m (0.5)
Outer Lateral Surface: < 0.25 mrem/hr (0.5)

REFERENCE

OSURR Reactor Description and Hazards Summary Section 1.4

ANSWER C.02 (2.00)

a. 10 gpm +/- 1 gpm

b. 0.1 - 1.5 mhos/cm + .2 mhos/cm

c. 0.5 degrees F/hr +/- .1

d. 3-4 degrees F/hr

(4 @ 0.5 pts each = 2.0)

REFERENCE

OSURR Reactor Description and Hazards Summary Section 1.1

ANSWER C.03 (3.00)

1. The poison section is attached directly to the drive screw without a magnet and hence does not fall into the core when magnet current is cut off or reduced.

2. There is no magnet engaged indicating light associated with this control rod since there is no magnet.

3. There is a 10-turn potentiometer included in the drive train to provide a signal to the servo control system..

(2 of 8 required @ 1.5 pts each = 3.0)

4. Different lengths (RR = 24" SS = 26")

5. Different reactivities RR = 1/4 of SS SS = 4 x RR

REFERENCE

OSURR Reactor Description and Hazards Summary Section 1.8.2

6. RR is smooth, SS is grooved.

7. RR is stainless steel, SS is 1.5% Nat'l Boron

8. RR is hollow, SS is solid

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

ANSWER C.04 (1.50)

a. Monitored each operating day. (0.5)

b. By using a remote-reading conductivity probe [0.5] located in the water process system piping [0.5]. (1.0)

REFERENCE

OSURR Reactor Description and Hazards Summary Section 1.9.2

ANSWER C.05 (1.00)

1. Manual pushbutton (0.5)

2. Automatic mechanism actuated by a timer. (0.5)

REFERENCE

OSURR Reactor Description and Hazards Summary, Section 1.5.5

ANSWER C.06 (2.50)

a. The reactor cannot be started up due to the low source level scram. (1.0)

b. At the control console on a single dial indicator [0.75] and upper and lower limit lights [0.75]. (1.5)

REFERENCE

OSURR Reactor Description and Hazards Summary, Section 1.7.10

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

ANSWER C.07 (3.00)

a. Standard fuel elements consist of 10 fuel plates (and each contains a nominal 140 grams of U-235). (1.0)

Control rod fuel elements are modified standard fuel elements with the central four fuel plates removed. The central two fuel plates are absent to provide a channel through which the poison section moves. The adjacent fuel plate position on each side is fitting with an aluminimum plate which acts as a constraining guide for the poison section. (Each element contains a nominal 84 grams of U-235 distributed equally among the remaining six fuel plates.) (1.0)

b. Four partial fuel elements were originally planned for the reactor to provide reactivity and/or flux shimming for the core. (0.5)

Excess reactivity for experiments could be obtained only if a more heavily loaded element was acquired. (A ten-plate element containing a nominal 178 grams of U-235 is used.) (0.5)

REFERENCE

OSURR Reactor Description and Hazards Summary Section 1.3

(***** END OF CATEGORY C *****)

ANSWER D.01 (2.00)

An uncompensated ion chamber detects gamma rays as well as neutrons. A compensated ion chamber is constructed so that gamma ray induced currents are automatically subtracted from the total current reading; thus the resulting net current represents only neutron interaction. (2.0)

REFERENCE

Nuclear Reactor Engineering, pg. 313

ANSWER D.02 (2.50)

1. Pool Top
2. Thermal Column
3. Beam Port Area
4. Process System

(4 @ 0.5 pts each = 2.0)

Trip Level: 10 mr/hr (0.5)

REFERENCE

OSURR Reactor Description and Hazards Summary Section 1.7.9

ANSWER D.03 (2.00)

a. One (0.5)

b. Neutral (0.5)

c. Lower (0.5)
Raise (0.5)

REFERENCE

OSURR Reactor Description and Hazards Summary, Section 1.8

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

ANSWER D.04 (1.00)

a. Whenever reactor is in operation. (0.5)

b. GM detector. (0.5)

REFERENCE

OSURR Reactor Description and Hazards Summary, Section 1.7.11

ANSWER D.05 (3.00)

a. Fission Chamber (0.5)

Shutdown approximately 1 mw with startup source in place and fission chamber @ lower limit to nominal 10 Kw with fission chamber raised approximately 72 cm. (0.5)

b. Uncompensated Ion Chamber (0.5) → OR 0-10,000 cps

Shutdown to 150% of full power (0.5)

c. Compensated Ion Chamber (0.5)

Infinity to +1 sec over full power range (0.5)

REFERENCE

OSURR Reactor Description and Hazards Summary, Section 1.1

ANSWER D.06 (2.00)

a. Located at the base of the guide tube. (0.5)

The purpose is to slow down speed of rod after a scram as it reaches its lower limit. (1.0)

b. Boron-stainless steel (0.5)

REFERENCE

OSU Reactor Description and Hazards Summary, Section 1.8.1 and Figure 1.3

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

ANSWER D.07 (1.00)

The pulses generated from ionizations caused by fission fragments are much larger than those of alphas, betas, and gammas. Therefore, by setting disc. only pulses above alpha cutoff are detected. (1.0)

REFERENCE

OSURR Requal 1985, Question 2.a., Section D

(***** END OF CATEGORY D *****)

ANSWER E.01 (2.00)

The safety amplifier electronically trips and applies
~~A~~ fast scram ~~signals~~ ~~reduces~~ magnet control amplifiers ~~through the sigma bus~~ causing
~~to drop~~ the shim-safety control rods to drop
due to loss of current (< 2 mA)
A slow scram removes power from the magnet ~~power supplies.~~ by means
of a relay in the voltage path of the coil

REFERENCE

OSU Reactor Description and Hazards Summary, Section 1.7.6

ANSWER E.02 (1.00)

1. Control and Instrument Power

2. Key Switch

(2 @ 0.5 pts each = 1.0)

REFERENCE

OSU Reactor Description and Hazard Summary, Section 1.7.6

ANSWER E.03 (3.00)

1. Indicates control rod malfunction [0.75]
   Lamp Color: Red [0.25]

2. Indicates control rod lead screw at lower limit of travel [0.75]
   Lamp Color: Green [0.25]

3. Indicates control rod engaged to the electromagnet assembly [0.75]
   Lamp Color: White [0.25]

REFERENCE

OSURR Reactor Description and Hazards Summary Section 1.8.1

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

ANSWER E.04 (1.50)

a. (None to control room instrumentation); only emergency lamps and security system have backup batteries. (0.5)

b. Either by sound or by visual if a flashlight is available to observe that the rods have dropped (when up, control rod and connection to connecting rod are visible. When down, connecting rod and connection top surface only are visible). (1.0)

REFERENCE

OSURR Requal Exam 1985, Question E.2.

ANSWER E.05 (2.00)

1. Can be operated from the control console by a manual switch. (1.0)

2. Will sound automatically if the annunciator acknowledge button is not pushed within 12 seconds after trouble signal is received. (1.0)

REFERENCE

OSURR Reactor Description and Hazards Summary, Section 1.7.8

ANSWER E.06 (1.50)

The safety system shall be designed such that no single electrical fault which partially or completely disables the automatic scram function, can, if any manner, impair or disable the manual scram function, and vice versa. (1.5)

REFERENCE

OSURR Technical Specification 5.2

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

ANSWER E.07 (3.00)

Safety System Continuity

Bulk Shielding Facility Area Manual Switch

Control Rod Area Manual Switch

Thermal Column Area Manual Switch

Rabbit Area Manual Switch

Control Console Manual Pushbutton

CIC Power Supply #1, Loss of High Voltage Relay

CIC Power Supply #2, Loss of High Voltage Relay

Servo System Error Relay (> +/- 8% of setpoint)

Period Recorder Microswitch, 5 Second Period

Linear Level Recorder Microswitch, 120% on 150% Scale

~~Safety Trouble (malfunction in safety amplifiers)~~
Low Offset Voltage, Level Safety amplifier #1 or #2
~~2 Phone Jacks for Incorporation in Experiments~~
Low Offset Voltage, Period Safety Amplifier #3

Low Source Level (the LCR recorder must be indicating greater than two counts per second)

Startup Channel Use Switch (must be in the "use" position)

Log-N-Period Operate Switch (must be in the "operate" position)

Power to Linear Recorder

Power to Period Recorder

Power to LCR Recorder

~~Excess Current on Any Two Magnets~~

HV Failure from Safety Power Supply

Period Generator Off Switch (must be in the "off" position)

~~Safety Amp Fault~~

A short period signal

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

A high power level

(15 required @ 0.2 pts each = 3.0)

REFERENCE

OSURR Reactor Description and Hazards Summary, Section 1.7.6

ANSWER E.08 (1.00)

Log-N
Effluent

(2 @ 0.5 pts each = 1.0)

REFERENCE

OSURR Requal Exam 1985, Question E.6

(***** END OF CATEGORY E *****)

ANSWER F.01 (2.50)

1. Any unplanned scram
2. S.E. after loss of building power
3. Adjustment of compensation voltage
4. Using the low source bypass
5. Installing and removing the RY-4 jumper
6. Using less than a nominal 30 second period

(Any 5 of the above @ 0.5 pts each = 2.5)

REFERENCE

OM-08, Reactor Operation Logbook Records, pg. 5

ANSWER F.02 (1.50)

1. Every hour
2. Every operator change
3. Every power change if the reactor is then leveled

REFERENCE

OM-08 Reactor Operation Logbook Records, pg. 1

ANSWER F.03 (1.00)

1. Control rod positions
2. Period produced

(2 @ 0.5 pts each = 1.0)

REFERENCE

OM-1, Reactor Power Changes, pg. 3

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

ANSWER F.04 (3.00)

a. Two or more personnel, at least one of which is a licensed reactor operator, shall be in the building at the time of reactor operation.

b. First startup of the day - 2 persons shall be in the building, one of which shall be a licensed senior reactor operator.

c. A minimum of three staff shall be present during fuel handling. One must be a licensed senior reactor operator, and one must be a licensed reactor operator.

REFERENCE

OSU AP-13, Personnel Required for Reactor Operations, pgs. 1 and 2

ANSWER F.05 (1.75)

The Reactor Operator is responsible for performing the following:

a. Depress the manual scram button on the Control Console [0.25], announce over the intercom that the building is to be evacuated [0.25], and assure that the building evacuation horn is sounded [0.25].

b. Turn off the building fans as he/she leaves the Control Room. (0.25)

c. Pick up both a neutron-sensitive and gamma-sensitive survey instrument [0.25], as well as the NRL sign-in logbook [0.25], and proceed to the Van de Graff Laboratory [0.25].

REFERENCE

OSU, EP-01, pg. 2

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

ANSWER F.06 (2.00)

The check-out shall include, as a minimum, the following:

a. A visual inspection of the core and experimental facilities. (0.5)

b. A functional check on pool water temperature and conductivity devices. (0.5)

c. A functional check on operation of the annunciator system. (0.5)

d. A front panel calibration of the instrumentation and area radiation monitoring systems. (0.5)

REFERENCE

OSU IM-03, OSURR Pre-Start Checkout, pg. 1, OSURR Technical Specification Section 9.0

ANSWER F.07 (3.00)

a. This is used only during a core unload - loading operation when conducting approach to criticality tests. (1.5)

b. This is accomplished by ~~jumpering the contact between the pins ("3" and "4") of [illegible] in the safety monitor. (The jumper is installed on the back of the slow scram console.)~~ inserting a key into its designated bypass keylock on the front panel of the slow scram module (1.5)

REFERENCE

OSU IM-6, Use of Low Level Source Bypass, pg. 1

(***** END OF CATEGORY F *****)

ANSWER G.01 (1.00)

a. 100
b. 5

REFERENCE

Labelling and Storage of Radioactive Materials, RS 1, pg. 1

ANSWER G.02 (1.50)

N=Noe [- lambda *t] (0.5)
(100-40)/100 = e [- lambda *1)
ln 0.6 = lambda
.51 = lambda

T 1/2 = ln 2/lambda (0.5)
T 1/2 = 0.693/.51
= 1.36 days (0.5)

REFERENCE

Nuclear Reactor Engineering, Glasstone and Sesonske, pgs. 31 and 32

ANSWER G.03 (3.00)

1. Does not exceed 3 Rem/quarter.

2. Radiation history is known and recorded on NRC Form 4.

3. The dose rate received when added to his radiation history does not exceed 5(N-18).

(3 @ 1.0 pts each = 3.0)

REFERENCE

10 CFR 20.201

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

ANSWER G.04 (2.25)

a. Ar-40 (n, gamma) Ar-41;
Half-life 1.83 hrs.;
Decay by beta emission (1.5)

(Half-life must be within 20%)

b. It is produced in air in the experimental facilities. (.75)

REFERENCE

OSURR Reactor Description and Hazards Summary Report, Section 1.5.5

ANSWER G.05 (2.00)

No [0.5]. The unit rem already considers the different effects. Rem is a biological unit, thus different radiation causing the same dose in rem should have the same effect [1.5].

REFERENCE

10 CFR 20

ANSWER G.06 (1.50)

A radiation area is > 5 mr/hr.

A high radiation area is > 100 mr/hr.

The maximum dose rate in a properly marked radiation area is 100 mr/hr.

The maximum dose is calculated as follows:

45/60 x 100 = 75 mr~~/hr~~ (1.5)

REFERENCE

10 CFR 20

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

ANSWER G.07 (2.00)

a. Whole Body - 1.25 rem/quarter

Hands and feet 18.75 rem/quarter

Skin 7.50 rem/quarter

b. 10 percent of the above limits.

REFERENCE

10 CFR 20.101, 104

ANSWER G.08 (1.50)

I1D12 = I2D22
(100 mrem/hr (1 m)2 = I2 (.25 m)2
1600 mrem/hr = I2 (1.5)

REFERENCE

OSURR Requal Exam 1985, Question G.1

(***** END OF CATEGORY G *****)
(********** END OF EXAMINATION **********)