February 26, 2015

Dr. David E. Moncton, Director
of the Nuclear Reactor Laboratory
Massachusetts Institute of Technology
138 Albany Street
Mail Stop NW 12-208
Cambridge, MA 02139

SUBJECT: EXAMINATION REPORT NO. 50-020/OL-15-01, MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Dear Dr. Moncton:

During the week of February 2, 2015, the U.S. Nuclear Regulatory Commission (NRC) administered an operator licensing examination at your Massachusetts Institute of Technology reactor. The examinations were conducted according to NUREG-1478, "Operator Licensing Examiner Standards for Research and Test Reactors," Revision 2. Examination questions and preliminary findings were discussed with those members of your staff identified in the enclosed report at the conclusion of the examination.

In accordance with Title 10 of the *Code of Federal Regulations,* Section 2.390, a copy of this letter and the enclosures will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records component of NRC's Agencywide Documents Access and Management System (ADAMS). ADAMS is accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html. The NRC is forwarding the individual grades to you in a separate letter which will not be released publicly. Should you have any questions concerning this examination, please contact Mr. John T. Nguyen at (301) 415-4007 or via internet e-mail John.Nguyen@nrc.gov.

Sincerely,

/RA/

Kevin Hsueh, Chief
Research and Test Reactors Oversight Branch
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Docket No. 50-020

Enclosures:
1. Examination Report No. 50-020/OL-15-01
2. Facility Comments with NRC Resolution
3. Written Examination

cc: w/o encl: See next page

Dr. David E. Moncton, Director
of the Nuclear Reactor Laboratory
Massachusetts Institute of Technology
138 Albany Street
Mail Stop NW 12-208
Cambridge, MA 02139

February 26, 2015

SUBJECT: EXAMINATION REPORT NO. 50-020/OL-15-01, MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Dear Dr. Moncton:

During the week of February 2, 2015, the U.S. Nuclear Regulatory Commission (NRC) administered an operator licensing examination at your Massachusetts Institute of Technology reactor. The examinations were conducted according to NUREG-1478, "Operator Licensing Examiner Standards for Research and Test Reactors," Revision 2. Examination questions and preliminary findings were discussed with those members of your staff identified in the enclosed report at the conclusion of the examination.

In accordance with Title 10 of the *Code of Federal Regulations,* Section 2.390, a copy of this letter and the enclosures will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records component of NRC's Agencywide Documents Access and Management System (ADAMS). ADAMS is accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html. The NRC is forwarding the individual grades to you in a separate letter which will not be released publicly. Should you have any questions concerning this examination, please contact Mr. John T. Nguyen at (301) 415-4007 or via internet e-mail John.Nguyen@nrc.gov.

Sincerely,
/RA/

Kevin Hsueh, Chief
Research and Test Reactors Oversight Branch
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Docket No. 50-020

Enclosures:
1. Examination Report No. 50-020/OL-15-01
2. Facility Comments with NRC Resolution
3. Written Examination

cc: w/o encl: See next page

DISTRIBUTION w/ encls.:
PUBLIC RidsNRRDPRPRTA RidsNRRDPRPRTB Facility File (CRevelle) O-07 F-08

ADAMS ACCESSION NO.: ML15043A745

OFFICE	NRR/DPR/PROB	NRR/DPR/PROB	NRR/DPR/PROB
NAME	JNguyen	CRevelle	KHsueh
DATE	02/18/2015	02/24/2015	02/26/2015

OFFICIAL RECORD COPY

cc:

City Manager
City Hall
Cambridge, MA 02139

Department of Environmental Protection
One Winter Street
Boston, MA 02108

Beverly Anderson, Interim Director
Radiation Control Program
Department of Public Health
Schrafft Center, Suite 1M2A
529 Main Street
Charlestown, MA 02129

John Giarrusso, Planning and Preparedness Division Chief
Massachusetts Emergency Management Agency
400 Worcester Road
Framingham, MA 01702-5399

Test, Research and Training
Reactor Newsletter
P.O. Box 118300
University of Florida
Gainesville, FL 32611-8300

U. S. NUCLEAR REGULATORY COMMISSION
OPERATOR LICENSING INITIAL EXAMINATION REPORT

REPORT NO.: 50-020/OL-15-01

FACILITY DOCKET NO.: 50-020

FACILITY LICENSE NO.: R-37

FACILITY: MITR-II

EXAMINATION DATES: February 3 -4, 2015

SUBMITTED BY: ____________________________ __________
John T. Nguyen, Chief Examiner Date

SUMMARY:
During the week of February 2, 2015, the NRC administered operator licensing examinations to one Senior Reactor Operator-Instant, one Senior Reactor Operator-Upgrade, and one Reactor Operator-Retake candidates. The Reactor Operator-Retake candidate failed the Section A, Reactor Theory, Thermo-hydraulics and Facility Operating Characteristics, of the written examination. The other two candidates passed all applicable portions of the examinations.

REPORT DETAILS

1. Examiners: John T. Nguyen, Chief Examiner, NRC
Michele C. DeSouza, Examiner Trainee, NRC

2. Results:

	RO PASS/FAIL	SRO PASS/FAIL	TOTAL PASS/FAIL
Written	0/1	1/0	1/1
Operating Tests	0/0	2/0	2/0
Overall	0/1	2/0	2/1

3. Exit Meeting:
Kevin Hsueh, Chief, RTR, NRC
John T. Nguyen, Chief Examiner, NRC
Michele C. DeSouza, Examiner Trainee, NRC
Frank Warmsley, Asst. Superintendent and Training Supervisor, MIT
Edward Lau, Assistant Director of Operations, MIT
Susan Tucker, Quality Assurance Supervisor, MIT

Upon completion of the examinations, the NRC Examiners met with facility staff representatives to discuss the results. The facility licensee had various comments on the written examination that were incorporated in the examination report (see enclosure 2). At the conclusion of the meeting, the NRC examiners thanked the facility for their support in the administration of the examinations.

FACILITY COMMENTS ON THE WRITTEN EXAM WITH NRC RESOLUTION

QUESTION A.06 [1.0 point]
Which ONE of the following correctly describes the SIX- FACTOR FORMULA?

a. $K_\infty = K_{eff}$ * the utilization factor

b. $K_{eff} = K_\infty$ * the total leakage probability

c. $K_\infty = K_{eff}$ * the total leakage probability

d. $K_{eff} = K_\infty$ * the total non-leakage probability

Answer: d.
REF: Burn, R., Introduction of Nuclear Reactor Operations, © 1988, Sec 3.3

Facility Comments: The answer key has D as the correct answer, and it is. However when one of the candidates was receiving training on this very item, the notes that he was given by the instructor contained an error. This error was found and corrected after the training was completed for this candidate. However the correction was never passed along to the candidate. After the exam was taken, it was discovered that he was never informed of the correction in his notes and hence his knowledge.

Facility Recommendation: We ask if any consideration can be given for this particular candidate only in such that if the material that was later corrected, was in fact passed along to the candidate, we believe he would have correctly answered the question. This is evidenced by the other candidate who did take the later course with the corrected information choosing the correct answer.

Reference: None

NRC Resolution: The NRC does **NOT** accept the comment and accepts only d. as the correct answer.

QUESTION A.17 [1.0 point]
Which ONE of the following has the largest neutron capture cross section?

a. B-10

b. Sm-149

c. Xe-135

d. I-131

Answer: c
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, Sec 8.1

Facility Comments: The answer key has C. as the correct answer, however, both candidates answered A. They answered A because they know that the reactor uses Boron as the neutron absorbing substance in the shim blades and that in power reactors that insert a poison in the water, it is also boron used. Without a chart that shows the relative neutron absorption cross sections for the isotopes given, they chose the answer that they knew.

Facility Recommendation: We request that answer A be accepted as a correct answer for this test. If the question is used in future tests, that a chart be provided that can be used for identifying the cross sections for the various isotopes.

Reference: None

NRC Resolution: This is a standard NRC question and the NRC accepts only c as the correct answer.

U. S. NUCLEAR REGULATORY COMMISSION
NON-POWER REACTOR LICENSE EXAMINATION

FACILITY:	Massachusetts Institute of Technology
REACTOR TYPE:	MITR II Research
DATE ADMINISTERED:	2/4/2015
CANDIDATE:	______________________

INSTRUCTIONS TO CANDIDATE:
Answers are to be written on the Answer sheet provided. Attach all Answer sheets to the examination. Point values are indicated in parentheses for each question. A 70% in each category is required to pass the examination. Examinations will be picked up three (3) hours after the examination starts.

CATEGORY VALUE	**% OF TOTAL**	**CANDIDATE'S SCORE**	**% OF CATEGORY VALUE**	**CATEGORY**
20.00	**33.3**	________	_____	**A. REACTOR THEORY, THERMODYNAMICS AND FACILITY OPERATING CHARACTERISTICS**
20.00	**33.3**	________	_____	**B. NORMAL AND EMERGENCY OPERATING PROCEDURES AND RADIOLOGICAL CONTROLS**
20.00	**33.3**	________	_____	**C. FACILITY AND RADIATION MONITORING SYSTEMS**
60.00		________ **FINAL GRADE**	_____ %	**TOTALS**

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

____
Candidate's Signature

ENCLOSURE 3

A. RX THEORY, THERMO & FAC OP CHARS

A N S W E R   S H E E T

Multiple Choice (Circle or X your choice)
If you change your Answer, write your selection in the blank.

A01 a b c d ___

A02 a b c d ___

A03 a b c d ___

A04 a b c d ___

A05 a b c d ___

A06 a b c d ___

A07 a b c d ___

A08 a b c d ___

A09 a b c d ___

A10 a b c d ___

A11 a b c d ___

A12 a b c d ___

A13 a b c d ___

A14 a b c d ___

A15 a b c d ___

A16 a b c d ___

A17 a b c d ___

A18 a b c d ___

A19 a b c d ___

A20 a b c d ___

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

B. NORMAL/EMERG PROCEDURES & RAD CON

A N S W E R   S H E E T

Multiple Choice (Circle or X your choice)
If you change your Answer, write your selection in the blank.

B01 a b c d ___

B02 a ___ b ___ c ___ d ___ (0.25 each)

B03 a ___ b ___ c ___ d ___ (0.25 each)

B04 a b c d ___

B05 a b c d ___

B06 a b c d ___

B07 a b c d ___

B08 a b c d ___

B09 a b c d ___

B10 a b c d ___

B11 a b c d ___

B12 a b c d ___

B13 a b c d ___

B14 a b c d ___

B15 a b c d ___

B16 a b c d ___

B17 a b c d ___

B18 a b c d ___

B19 a b c d ___

B20 a b c d ___

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

C. PLANT AND RAD MONITORING SYSTEMS

A N S W E R   S H E E T

Multiple Choice (Circle or X your choice)
If you change your Answer, write your selection in the blank.

C01 a b c d ___

C02 a b c d ___

C03 a b c d ___

C04 a ___ b ___ c ___ d ___ (0.25 each)

C05 a b c d ___

C06 a b c d ___

C07 a b c d ___

C08 a b c d ___

C09 a b c d ___

C10 a ___ b ___ c ___ d ___ (0.25 each)
e ___ f ___ g ___ h ___

C11 a b c d ___

C12 a b c d ___

C13 a b c d ___

C14 a b c d ___

C15 a b c d ___

C16 a b c d ___

C17 a b c d ___

C18 a b c d ___

C19 a b c d ___

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

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. After the examination has been completed, you must sign the statement on the cover sheet indicating that the work is your own and you have neither received nor given assistance in completing the examination. This must be done after you complete the examination.

3. 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.

4. Use black ink or dark pencil <u>only</u> to facilitate legible reproductions.

5. Print your name in the blank provided in the upper right-hand corner of the examination cover sheet and each Answer sheet.

6. Mark your Answers on the Answer sheet provided. USE ONLY THE PAPER PROVIDED AND DO NOT WRITE ON THE BACK SIDE OF THE PAGE.

7. The point value for each question is indicated in [brackets] after the question.

8. If the intent of a question is unclear, ask questions of the examiner only.

9. When turning in your examination, assemble the completed examination with examination questions, examination aids and Answer sheets. In addition turn in all scrap paper.

10. Ensure all information you wish to have evaluated as part of your Answer is on your Answer sheet. Scrap paper will be disposed of immediately following the examination.

11. To pass the examination you must achieve a grade of 70 percent or greater in each category.

12. There is a time limit of three (3) hours for completion of the examination.

EQUATION SHEET

$$\dot{Q} = \dot{m} c_p \Delta T = \dot{m} \Delta H = UA \Delta T$$

$$P_{\max} = \frac{(\rho - \beta)^2}{2\alpha(k)\ell}$$

$$\ell^* = 1 \times 10^{-4} \text{ seconds}$$

$$SCR = \frac{S}{1 - K_{eff}}$$

$$CR_1(1 - K_{eff_1}) = CR_2(1 - K_{eff_2})$$

$$\lambda_{eff} = 0.1 \sec^{-1}$$

$$SUR = 26.06\left[\frac{\lambda_{eff}\,\rho}{\beta - \rho}\right]$$

$$M = \frac{1 - K_{eff_0}}{1 - K_{eff_1}}$$

$$M = \frac{1}{1 - K_{eff}} = \frac{CR_1}{CR_2}$$

$$P = P_0\,10^{SUR(t)}$$

$$P = P_0\,e^{\frac{t}{\tau}}$$

$$P = \frac{\beta(1 - \rho)}{\beta - \rho} P_0$$

$$SDM = \frac{(1 - K_{eff})}{K_{eff}}$$

$$\tau = \frac{\ell^*}{\rho - \bar{\beta}}$$

$$\tau = \frac{\ell^*}{\rho} + \left[\frac{\bar{\beta} - \rho}{\lambda_{eff}\,\rho}\right]$$

$$\Delta\rho = \frac{K_{eff_2} - K_{eff_1}}{k_{eff_1} \times K_{eff_2}}$$

$$T_{‰} = \frac{0.693}{\lambda}$$

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

$$DR = DR_0\,e^{-\lambda t}$$

$$\lambda_{eff} = 0.1/\sec$$

$$DR = \frac{6CiE(n)}{R^2}$$

$$DR_1 d_1^2 = DR_2 d_2^2$$

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	°F = 9/5°C + 32
931 Mev = 1 amu	°C = 5/9 (°F - 32)

Section A ℞ Theory, Thermo & Fac. Operating Characteristics

QUESTION A.01 [1.0 point]
Elastic Scattering is the process whereby a neutron collides with a nucleus and:

a. recoils with the same kinetic energy it had prior to the collision.

b. recoils with the lower kinetic energy, with the nucleus emitting a gamma ray.

c. is absorbed by the nucleus, with the nucleus emitting a gamma ray.

d. recoils with the higher kinetic energy, with the nucleus emitting a beta particle.

QUESTION A.02 [1.0 point]
Reactor is increasing power from 10 W to 1 MW when the reactor operator accidently inserted a sample worth of 1.0 % ΔK/K into the reactor core. Which ONE of the following best describes the values of Keff and ρ during the power increment?

a. $K_{eff} = 1$ and $0 < \rho < 1$

b. $K_{eff} > 1$ and $0 < \rho < \beta\text{-eff}$

c. $K_{eff} > 1$ and $\beta\text{-eff} < \rho < 1$

d. $K_{eff} > 1$ and $1 < \rho <$ infinity (∞)

QUESTION A.03 [1.0 point]
Few minutes following a reactor scram, the reactor period has stabilized and the power level is decreasing at a **CONSTANT** rate. What is the reactor power one minute later from 50 kW?

a. 106 kW

b. 5 kW

c. 24 kW

d. 38 kW

QUESTION A.04 [1.0 point]
Which ONE of the following elements will slow down fast neutron LEAST quickly, produces the smallest energy loss per collision?

a. Hydrogen-1

b. Boron-10

c. Oxygen-16

d. Uranium-238

QUESTION A.05 [1.0 point]
Reactor A with a K_{eff} of 0.1 and reactor B with a K_{eff} of 0.6, K_{eff} is increased by 0.1 for each reactor. The amount of reactivity added in reactor A is ______ in reactor B for the same increment.

a. less than

b. same

c. six times

d. twenty-one times

QUESTION A.06 [1.0 point]
Which ONE of the following correctly describes the SIX- FACTOR FORMULA?

a. $K_\infty = K_{eff}$ * the utilization factor

b. $K_{eff} = K_\infty$ * the total leakage probability

c. $K_\infty = K_{eff}$ * the total leakage probability

d. $K_{eff} = K_\infty$ * the total non-leakage probability

QUESTION A.07 [1.0 point]
Which ONE of the following describes the term **PROMPT JUMP**?

a. A reactor is increasing power at a constant rate of +80 second period

b. The instantaneous change in power level due to inserting control rods

c. The instantaneous change in power level due to inserting negative worth, - 0.3 %Δk/k, of experiment

d. The instantaneous change in power level due to removing negative worth,- 0.3 %Δk/k, of experiment

QUESTION A.08 [1.0 point]
Given the associated graph, which of the following answers best describe the neutron behavior within Region III?

a. The neutron cross section is inversely proportional to the neutron velocity (1/V)

b. The neutron cross section decreases steadily with increasing neutron energy (1/E)

c. Neutrons in this region have more likely to be fissionable than neutrons in region II

d. Neutrons in this region are more likely to be absorbed than neutrons in region I

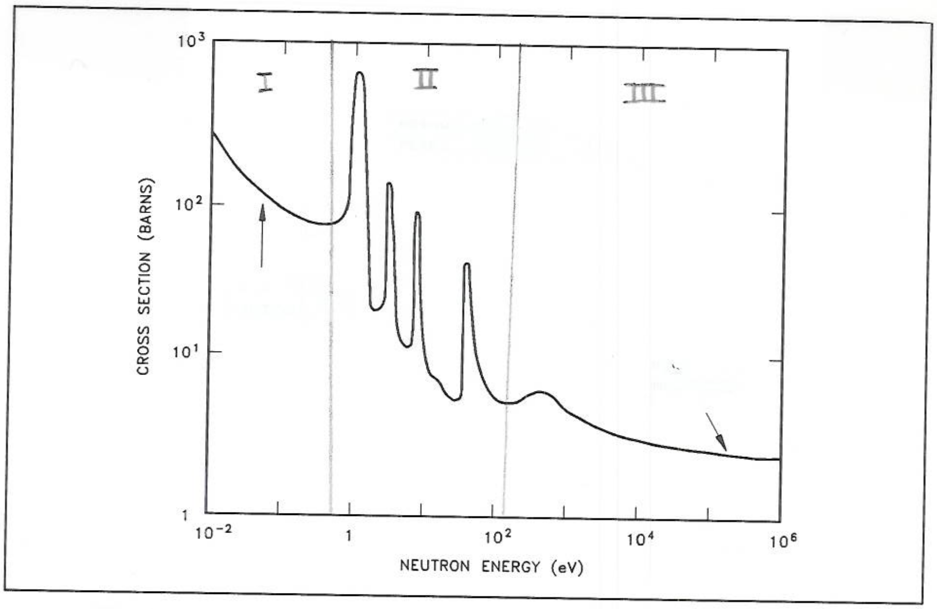


Figure 1 Typical Neutron Absorption Cross Section vs. Neutron Energy

Section A ℞ Theory, Thermo & Fac. Operating Characteristics

QUESTION A.09 [1.0 point]
Which ONE of the following is a number of neutrons in the Uranium-235 nucleus ($_{92}U^{235}$)?

a. 92

b. 143

c. 235

d. The U-235 doesn't have a constant number of neutrons, it fluctuates between 95 and 140.

QUESTION A.10 [1.0 point]
A reactor is slightly supercritical with the following values for each of the factors in the six-factor formula:

Fast fission factor	1.03
Fast non-leakage probability	0.84
Resonance escape probability	0.96
Thermal non-leakage probability	0.88
Thermal utilization factor	0.70
Reproduction factor	1.96

A control rod is inserted to bring the reactor back to critical. Assuming all other factors remain unchanged, the new value for the thermal utilization factor is:

a. 0.698

b. 0.702

c. 0.074

d. 0.076

QUESTION A.11 [1.0 point]
The reactor is on a **CONSTANT** positive period. Which ONE of the following power changes will take the **longest time** to complete?

a. 5%, from 95% to 100%

b. 10%, from 80% to 90%

c. 15%, from 15% to 30%

d. 20%, from 60% to 80%

QUESTION A.12 [1.0 point]
Delayed neutrons are produced by:

a. decay of gamma

b. Photoelectric Effect

c. decay of fission fragments

d. directly from the fission process

QUESTION A.13 [1.0 point]
Which ONE of the following is the MAIN reason for operating reactor with thermal neutrons instead of fast neutrons?

a. The fission cross section of the fuel is much higher for fast neutrons than thermal energy neutrons. Since fast neutrons are easier to cause fission, a reactor cannot control with fast neutrons.

b. The neutron lifetime of thermal neutrons is longer than fast neutrons, so the fuel has enough time to capture thermal neutrons.

c. The fission cross section of the fuel is much higher for thermal energy neutrons than fast neutrons, so thermal neutrons are easier to cause fission.

d. The atomic weight of thermal neutrons is larger than fast neutrons, so thermal neutrons are easily to slow down and be captured by the fuel.

QUESTION A.14 [1.0 point]
A reactor is subcritical with K_{eff} of 0.955. Which ONE of the following is the MINIMUM reactivity (ρK/K) that must be added to produce a PROMPT criticality? Given βeff=0.0078

a. 0.0450

b. 0.0078

c. 0.0548

d. 0.1000

QUESTION A.15 [1.0 point]
Following a positive reactivity addition to a shutdown reactor, the neutron power will increase even though k-effective is less than 1. The MAIN reason is due to:

a. Subcritical multiplication process

b. Neutron moderation in the fuel

c. Production of fast neutrons

d. Void temperature coefficient in the moderator

QUESTION A.16 [1.0 point]
The RESONANCE ESCAPE PROBABILITY is defined as a ratio of:

a. the number of thermal neutrons absorbed in fuel over the number of thermal neutrons absorbed in fuel and core materials.

b. the number of fast neutrons produced by fission in a generation over the number of total neutrons produced by fission in the previous generation.

c. the number of fast neutrons produced by U-238 over the number of thermal neutrons absorbed in fuel.

d. the number of neutrons that reach thermal energy over the number of fast neutrons that start to slow down.

QUESTION A.17 [1.0 point]
Which ONE of the following has the largest neutron capture cross section?

a. B-10

b. Sm-149

c. Xe-135

d. I-131

QUESTION A.18 [1.0 point]
Reactor is at 100 % power. The following graph shows the reactor time behavior following a reactor scram. Which ONE of the following best describes the transition of power between point C and D after the initial insertion? .

a. An **immediate** decrease in the **prompt neutron fraction** due to leakage, absorption, and a reduction in the fission rate

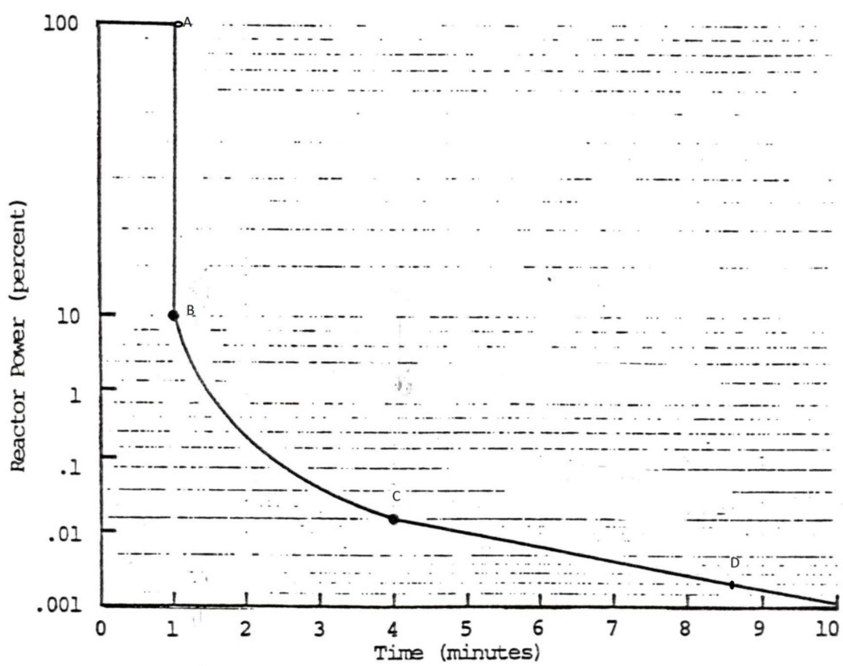
b. Fission product gases such as xenon begin to buildup causing the expansion of fuel density

c. The **longest** lived delayed neutron precursor begins to effect

d. The **short** lived delayed neutron precursors begin to effect

INTRODUCTION TO NUCLEAR REACTOR OPERATIONS
Reactor Kinetics
Reed Robert Burn
December 1988

Figure 4.3 Reactor Time Behavior Following a Reactor Scram



QUESTION A.19 [1.0 point]
Which ONE of the following best describes the alpha decay of a nuclide?

a. The atomic mass number increases by 2, and the number of protons increase by 1

b. The atomic mass number decreases by 2, and the number of protons decrease by 2

c. The atomic mass number decreases by 4, and the number of protons decrease by 2

d. The atomic mass number increases by 4, and the number of protons increase by 2

QUESTION A.20 [1.0 point]
As primary coolant temperature increases, a control blade worth:

a. increases due to the increase in thermal diffusion length

b. decreases due to higher neutron adsorption in the moderator

c. decreases due to a water density in the primary tank increases

d. remains the same due to same amount of poison in the control blade

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

Section B Facility and Radiation Monitoring Systems

QUESTION B.01 [1.0 point]
Per MITR Technical Specifications, which ONE of the following statements is NOT true for reactor operations?

a. Reactor Operator at the console has the authority and duty to shutdown the reactor at any time if he feels it necessary.

b. Whenever the reactor is NOT secured, two persons shall be onsite, one of whom shall be a licensed senior reactor operator.

c. The Radiation Protection Officer shall be onsite at all time when the reactor is NOT shutdown.

d. The shift supervisor shall be present in the control room during the startups and increase in power of greater than 10%.

QUESTION B.02 [1.0 points, 0.25 each]
Match the following 10CFR parts:

	Column A	Column B
a.	Operator's Licenses	1. Part 19
b.	Standards for Protection against Radiation	2. Part 20
c.	Notices, Instructions, and Reports to Workers	3. Part 50
d.	Domestic Licensing of Production and Utilization Facilities	4. Part 55

QUESTION B.03 [1.0 point, 0.25 each]
Match the Plans and Procedures listed in Column A with its corresponding Classifications listed in column B. Answer in Column B can be used once, more than once, or not at all.

	Column A	Column B
a.	Emergency Plan	1. Class A
b.	Abnormal Operating Procedure	2. Class B
c.	Technical Specification Tests	3. Class C
d.	Scram Tests	

Section B Facility and Radiation Monitoring Systems

QUESTION B.04 [1.0 point]
During continuous power operation with the automatic control system, it may be necessary for the operator to reshim the control blades to maintain the regulating rod within its useful range.

Which ONE of the following describes the requirements associated with this reshim of control blades?

a. The duty supervisor must approve all reshims prior to performance.

b. Reactor power is to be maintained within 2.5% of the desired level while reshimming.

c. All shim blades must be maintained within 2.5 inches of each other during the reshim and within 1.0 inch following the reshim.

d. The first motion of any control absorber during a reshim should be inward so as to lower reactor power.

QUESTION B.05 [1.0 point]
Per MITR Technical Specification, Shim blade and Regulating rod drive shall be inspected ________ for proper operation.

a. Monthly

b. Quarterly

c. Semi-annually

d. Annually

QUESTION B.06 [1.0 point]
Assume an individual has received whole body occupational exposures of:
10 mrads of beta
10 mrads of alpha
10 mrads of gamma

What would be the cumulative dose equivalent (H_T) in **mrem** for this individual?

a. 30 mrem

b. 220 mrem

c. 260 mrem

d. 310 mrem

Section B Facility and Radiation Monitoring Systems

QUESTION B.07 [1.0 point]
Per MITR Technical Specifications, which ONE of the following will violate the Limiting Safety System Settings with ONE pump operation?

a. Primary Coolant Flow = 1800 gpm

b. Core Outlet Water Temperature = 65 °C

c. Steady State Power = 3.0 MW

d. Coolant height of 11 feet above top of fuel plates

QUESTION B.08 [1.0 point]
A biennial test of the nuclear instrument was performed. Per MITR Technical Specifications, which ONE of the following is the latest the test that must be performed again without overdue?

a. 7.5 months after

b. 26 months after

c. 29 months after

d. 31 months after

QUESTION B.09 [1.0 point]
Per MITR Technical Specifications, the MINIMUM number of radiation area monitors required during reactor operations is:

a. One

b. Two

c. Three

d. No requirement

Section B Facility and Radiation Monitoring Systems

QUESTION B.10 [1.0 point]
What class of emergency would be declared, If 100 mrem/hour for 1-hour whole body or 500 mrem thyroid dose at the site boundary?

a. Unusual Event

b. Alert

c. Site Area

d. General

QUESTION B.11 [1.0 point]
The individual authorized to terminate or downgrade the emergency and to initiate recovery operation is the:

a. Emergency Coordinator

b. Radiation Protection Officer

c. MIT Campus Police Chief

d. Emergency Director

QUESTION B.12 [1.0 point]
A one-curie source, emitted 100% of 1 Mev gamma, is to be stored in the reactor building. How far from the source should a HIGH RADIATION AREA sign be posted?

a. 5 feet

b. 8 feet

c. 11 feet

d. 16 feet

QUESTION B.13 [1.0 point]
A 20-ml sample of primary water is brought to the spectrum analyzer for nuclide identification. What is the dominant nuclide you would expect in that sample, assuming it is a routine (normal) operation (no fuel leak)?

a. Na-24

b. N-16

c. Xe-135

d. I-131

QUESTION B.14 [1.0 point]
Which ONE of the following is the definition of Total Effective Dose Equivalent (TEDE) specified in 10 CFR Part 20?

a. The sum of thyroid dose and external dose

b. The sum of the external deep dose and the organ dose

c. The sum of the deep dose equivalent and the committed effective dose equivalent

d. The dose that your whole body is received from the source, but excluded from the deep dose

QUESTION B.15 [1.0 point]
The MAIN purpose of limit deuterium concentration in the helium blanket is to prevent:

a. pressure build up in the helium blanket

b. flammability of deuterium in the helium blanket

c. high level of deuterium hazards in the reactor bay

d. fuel cladding damage due to deuterium interacting with aluminum

QUESTION B.16 [1.0 point]
Select the list that gives the order of types of radiation from the **LEAST** penetrating to the **MOST** penetrating (i.e. travels the further in air).

a. neutron, gamma, beta, alpha

b. alpha, beta, neutron, gamma

c. beta, alpha, gamma, neutron

d. alpha, neutron, beta, gamma

QUESTION B.17 [1.0 point]
The MITR shall notify the U.S. NRC within 30 days when the licensed operator or senior operator terminates his or her license. This requirement can be found in:

a. 10 CFR Part 19

b. 10 CFR Part 20

c. 10 CFR Part 50

d. 10 CFR Part 55

QUESTION B.18 [1.0 point]
Which ONE of the following statements describes the requirement that must be observed when "locking out" facility equipment after permission is granted?

a. SRO witness lockout; SRO will verify safe system condition; Superintendent must be notified; the system must be tagged out and a notation as to the system being locked out shall be made on the status board.

b. RO will witness lockout; RO will verify safe system condition; SRO must be notified; the system must be tagged out and a notation as to the system being locked out shall be made on the status board.

c. SRO will witness lockout; person performing the work will perform lockout; person performing the work will retain the key on their person; the system must be tagged out and a notation as to the system being locked out shall be made on the status board.

d. SRO will verify safe system condition; any member of the Radiation Protection Office Staff will witness lockout; person performing the work will perform lockout; the person performing the work will retain the key on their person and the system must be tagged out.

QUESTION B.19 [1.0 point]
Corrosive materials that could affect or react with another material present in the reactor system shall be:

a. limited to 1 millicurie

b. limited to 1 milligram

c. limited to 1 milliliter

d. doubly encapsulated

QUESTION B.20 [1.0 point]
How long will it take a 50 curie source, with a half-life of 5.27 years, to decay to 2 Curie?

a. 10 Years

b. 15 Years

c. 25 Years

d. 35 Years

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

Section C Facility and Radiation Monitoring Systems

QUESTION C.01 [1.0 point]
Auto control system will prevent reactor switching to auto control mode when:

a. The regulating rod is at 2-in position

b. Period channel exceeds 60 second period

c. One of the SHIM blades is at 8-in position

d. The deviation between the power-set and the actual power exceeds 1.5%

QUESTION C.02 [1.0 point]
Which ONE of the following is the correct operation for the reactor MAIN exhaust damper of the ventilation system?

a. Air to open/spring to close/butterfly valves

b. Spring to open/Air to close/ ball valves

c. hydraulic to open/spring to close/ ball valves

d. hydraulic to open/hydraulic to close/ butterfly valves

QUESTION C.03 [1.0 point]
The MAIN function of the fixed, absorber plates on the absorber spider assembly is to

a. MINIMIZE neutron flux in the lower half of the core and MAXIMIZE power peaking at the top of the core.

b. MINIMIZE the fuel burn-up in the lower half of the core and MINIMIZE Nitrogen-16 peaking at the top of the core.

c. MAXIMIZE neutron flux in the lower half of the core and MINIMIZE power peaking at the top of the core.

d. MINIMIZE the fuel burn-up in the lower half of the core and MAXIMIZE power peaking at the top of the core.

Section C Facility and Radiation Monitoring Systems

QUESTION C.04 [1.0 point, 0.25 each]
Reactor is at full power. Match the input signals listed in column A with their AUTOMATIC responses listed in column B. (Items in column B can be used once, more than once or not at all.)

	Column A		Column B
a.	Intake damper oil pressure = 680 psig	1.	Normal
b.	Reg rod reaches near-in limit position and no operator action for 30 sec	2.	Interlock
c.	Voltage Chamber power supply = 0 V	3.	Rod Run down
d.	Temperature Reactor Outlet = 40 °C	4.	Scram

QUESTION C.05 [1.0 point]
Which ONE of the following is the correct reason for the "Main Personnel Airlock Gaskets Deflated" alarm and reactor scram?

a. The Utility Room (UR) air compressor supplied air to door gaskets exceeds 40 psig.

b. Both the UR and the Nuclear Engineering Building (NEB) air compressors are inoperable. No air is supplied to door gaskets.

c. The UR air compressor is NOT operable, only the Nuclear Engineering Building air compressor is supplied air to door gaskets.

d. A check valve fails; causing the UR air compressor stops supplying air to door gaskets; but directly vented air to the NEB air compressor.

QUESTION C.06 [1.0 point]
Which ONE of the following reasons could cause a “High Temperature HE-1 Primary Outlet” alarm?

a. A temperature detector located at the outlet of the main primary heat exchanged exceeds its setpoint.

b. A temperature detector located at the inlet of the main primary heat exchanged exceeds its setpoint.

c. Shutdown the auxiliary pump MM-2, so no surge volume is available to compensate for volume changes due to heatup and cooldown.

d. A temperature detector located at the outlet of the cooling tower is disconnected.

QUESTION C.07 [1.0 point]
Which ONE of following actions should the reactor operator perform immediately when the rabbit station radiation monitor alarms during rabbit irradiation (AUTO Transfer 1PH1 ←> NW13)?

a. Commence an unscheduled Shutdown and dump the reflector

b. Eject the sample into hot cell using the “Abort Auto Transfer” pushbutton

c. Eject the sample into hot cell using the “OPERATE RESET” pushbutton

d. Immediately shutdown the reactor. When radiation levels are less than the permissible limit, push the 1PH1 “Eject” pushbutton to remove the sample.

QUESTION C.8 [1.0 point]
The primary concern associated with the pressure relief system when charcoal filters becoming submersed during a large leak of primary coolant is:

a. loss of efficiency in moving particulates.

b. possible spontaneous combustion during dryout.

c. reduction in relief flow capability to relieve pressure.

d. possible spread of contaminants previously trapped in the charcoal.

QUESTION C.9 [1.0 point]
In the event of a loss of building power, the emergency battery will DIRECTLY provide

a. 120V-AC power to the Emergency Lightning Panel

b. 120V-DC power to the Emergency Lightning Panel

c. 120V-DC power to the reactor control room light and medical facility room light

d. There are no systems directly received a 120V-DC power from the emergency battery

QUESTION C.10 [2.0 points, 0.25 each]
Match each monitor and instrument (channel) listed in column A with a specific purpose in column B. Items in column B is to be used only once.

	Column A		Column B
a.	Channel 3.	1.	Monitor radiation level in the reactor top.
b.	Channel 4.	2.	Detect radioisotopes released due to fuel failure.
c.	High Level Emergency Power Channel (HLEPC)	3.	Determine the effluent of Ar-41.
d.	Portable monitor.	4.	Survey of laboratory.
e	Log Count-Rate channel.	5.	Monitor neutron level during the reactor startup.
f.	Area radiation monitor.	6.	Provide a period scram.
g.	Stack Gas monitor.	7.	Provide a high power level scram.
h.	Plenum Particulate monitor.	8.	Provide indication of the reactor power level when all off-site electrical power has been lost.

QUESTION C.11 [1.0 point]
When the core tank and the reflector tank simultaneously ruptured, which ONE of the following is the proper procedure to add the city water to the reactor core?

a. Manually connect the quick-connect hoses to a pair of valves (MV-67 and 68), then open MV-69 and MV-70.

b. Turn the MM-1 ON, open the reflector valve (DV-1), and thus providing city water to the core with pressure.

c. Low pool water level automatically opens check valves, thus providing city water to the core.

d. There is no way for city water to be sent directly to the reactor core; the only source is the makeup water tank.

QUESTION C.12 [1.0 point]
When the off-gas system is isolated and H_2 concentration exceeds 1% in the air space above the primary water pool system, the MAXIMUM reactor power level shall be less than:

a. 1000 kW

b. 300 kW

c. 200 kW

d. 100kW

QUESTION C.13 [1.0 point]
Which ONE of the following is the correct formula for calculating the thermal power hourly on the reactor operating data log?

a. Primary power + Reflector power + Shield power

b. Primary power – Secondary power + Reflector power + Shield power

c. Primary power + Secondary power + Reflector power + Shield power

d. (Primary power + Secondary power)/2 + Reflector power + Shield power

Section C Facility and Radiation Monitoring Systems

QUESTION C.14 [1.0 point]
Which ONE of the following is considered a NORMAL range of the pH primary coolant?

a. 6.0 – 7.0

b. 7.0 – 8.0

c. 8.0 – 9.0

d. 9.0 – 10.0

QUESTION C.15 [1.0 point]
All free surfaces of the D_2O in the reflector system are blanketed with helium. Which ONE of the following is NOT the intent of this system? The intent of this system is NOT to:

a. Provide an inert, non-radioactive vehicle to circulate the disassociated D_2 and O_2 from the reflector tank to the re-combiner.

b. Prevent the corrosion that would be caused by nitrous-oxide formation from air in the presence of high radiation fields.

c. Prevent air with entrained H_2O moisture from entering the system, coming in contact with the D_2O, and degrading it.

d. Prevent O_2 in air coming in contact with N_{16}, and could cause flammability.

QUESTION C.16 [1.0 point]
The primary function of the discriminator in the Channel 1 is to:

a. amplify pulses produced by alpha particles resulting from the natural decay of fission fragment.

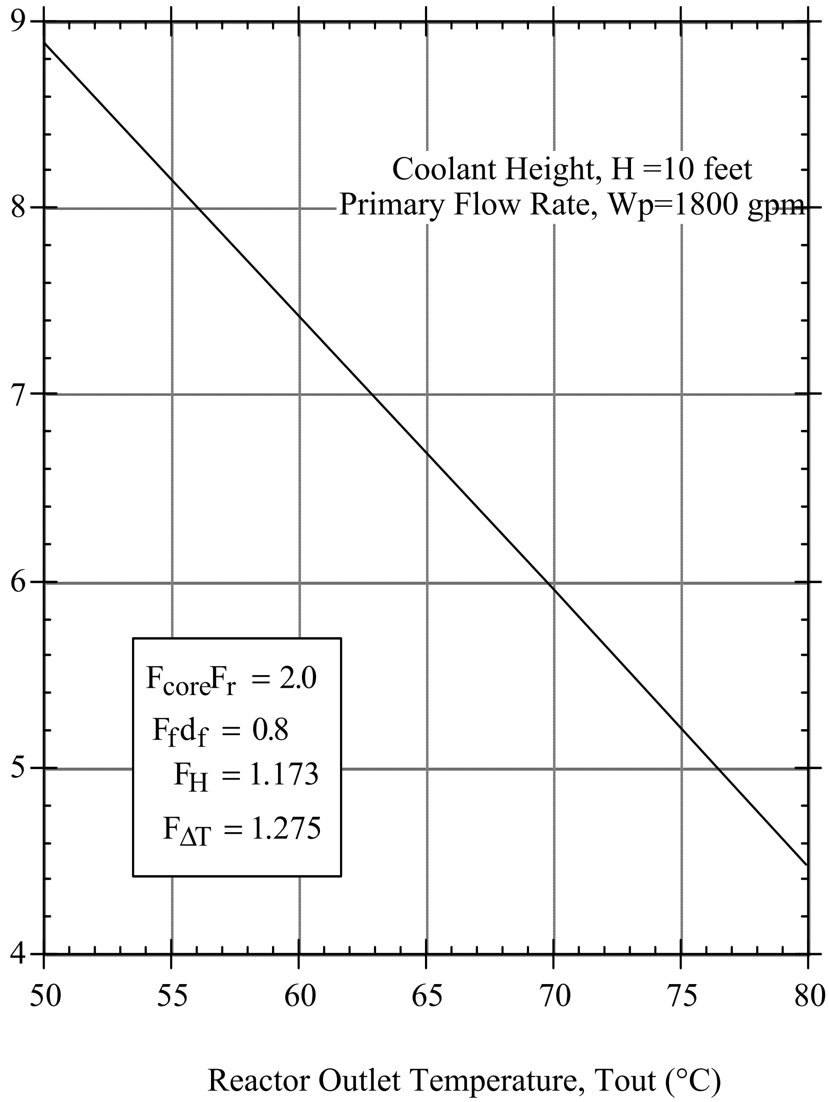
b. distinguish the pulses created by neutron-induced fissions from pulses produced by the gamma rays for the true signal.

c. convert pulses created by neutron-induced fissions into a d.c. current

d. filter out ALL pulses created by neutron-induced fissions and select ONLY pulses produced by the gamma rays for the true signal.

<u>Section C Facility and Radiation Monitoring Systems</u>

QUESTION C.17 [1.0 point]
The following figure depicts:



a. MITR Limiting Safety System Settings for forced convection operation with two pumps

b. MITR Limiting Safety System Settings for forced convection operation with one pump

c. MITR Limiting Safety System Settings for natural convection operation with no pump

d. MITR Safety Limit for forced convection operation

Section C Facility and Radiation Monitoring Systems

QUESTION C.18 [1.0 point]
Figure 8-1 depicts the MIT normal and emergency electrical distribution. In the event of a loss of off-site power, which ONE of the following will distribute power to the Panel 2A?

a. Panel 2 Circuits

b. 5-kW generator

c. Main power distribution

d. There are no systems that provide power to the Panel 2A during a loss of off-site power

Section C Facility and Radiation Monitoring Systems

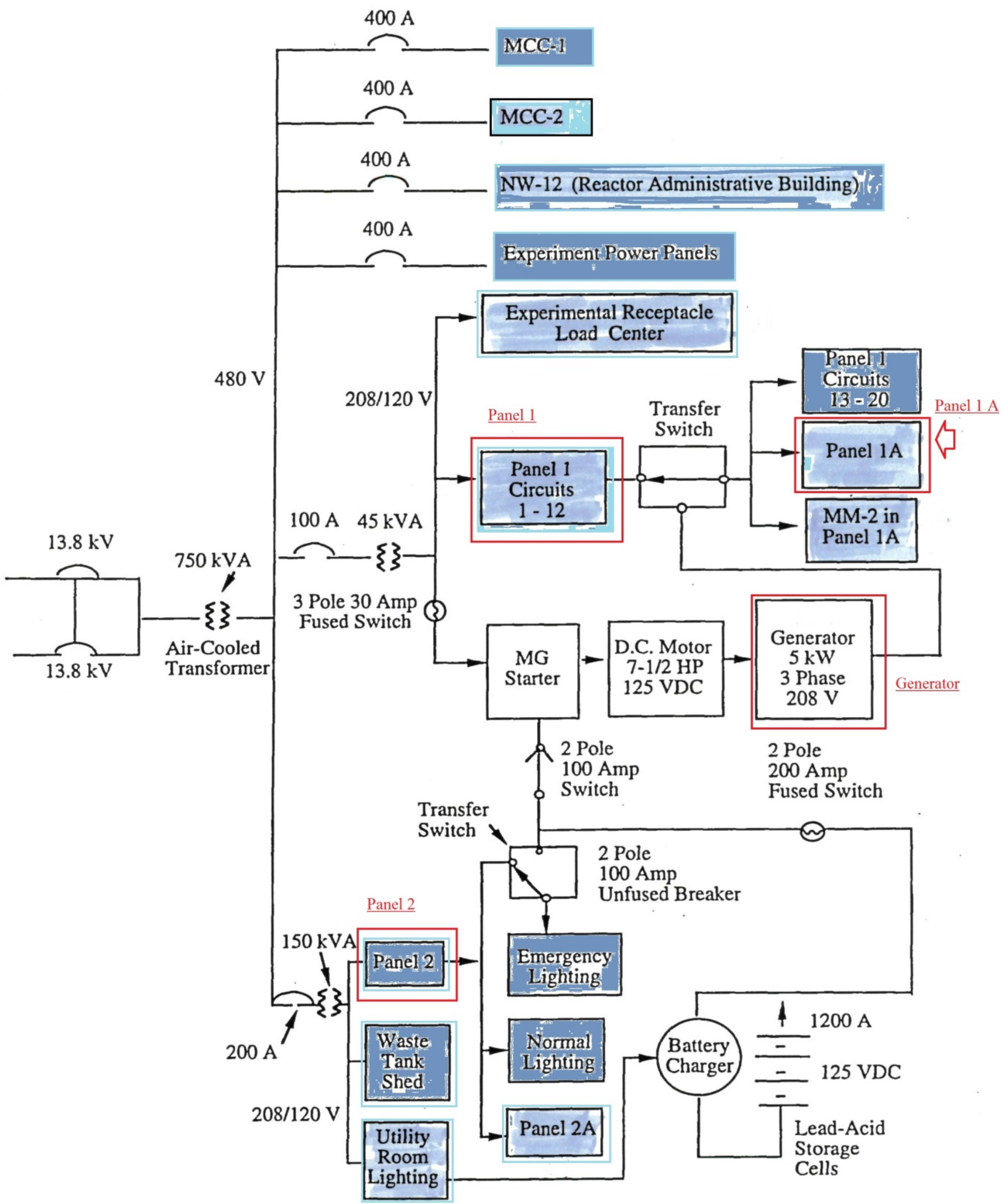


Figure 8-1

Section C Facility and Radiation Monitoring Systems

QUESTION C.19 [1.0 points]
Which ONE of the following figures best describes the operation of the inlet plenum siphon break when a rupture occurs in the inlet piping?

a. Figure 1

b. Figure 2

c. Figure 3

d. Figure 4

Section C Facility and Radiation Monitoring Systems

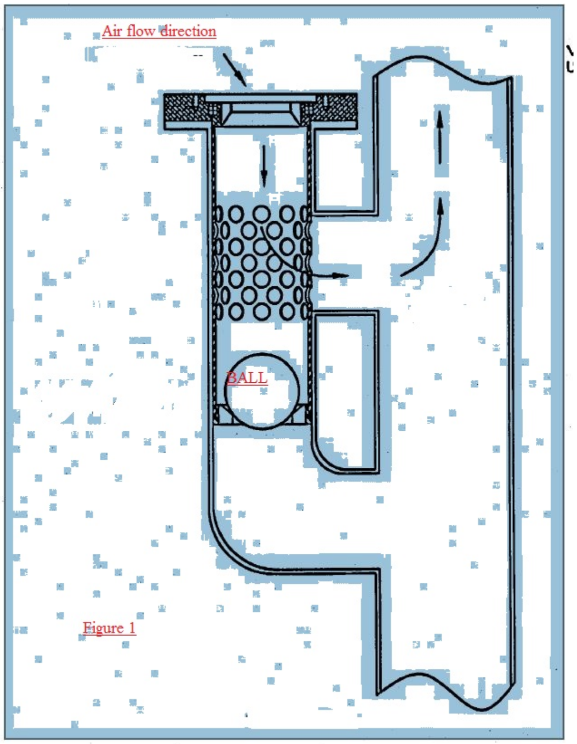


Figure 1

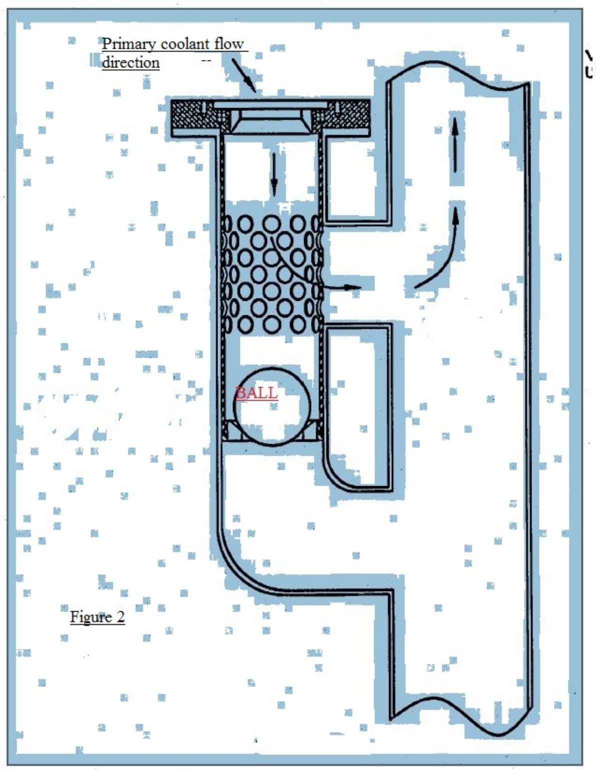


Figure 2

Section C Facility and Radiation Monitoring Systems

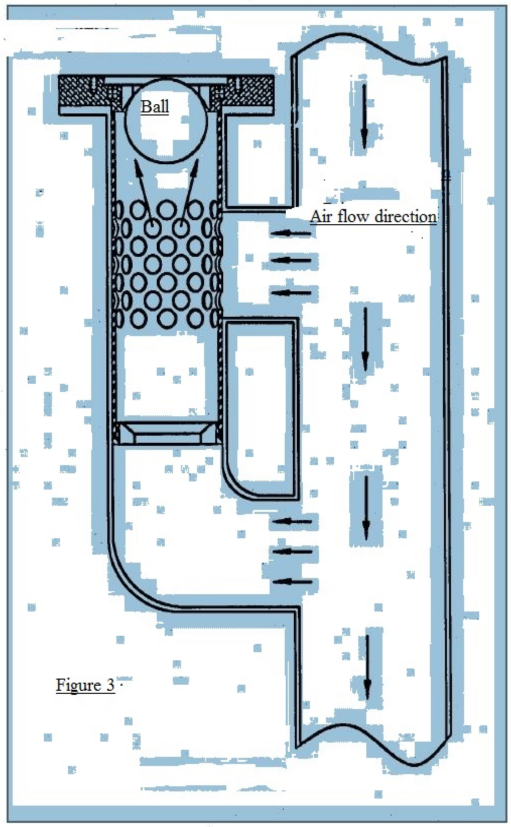
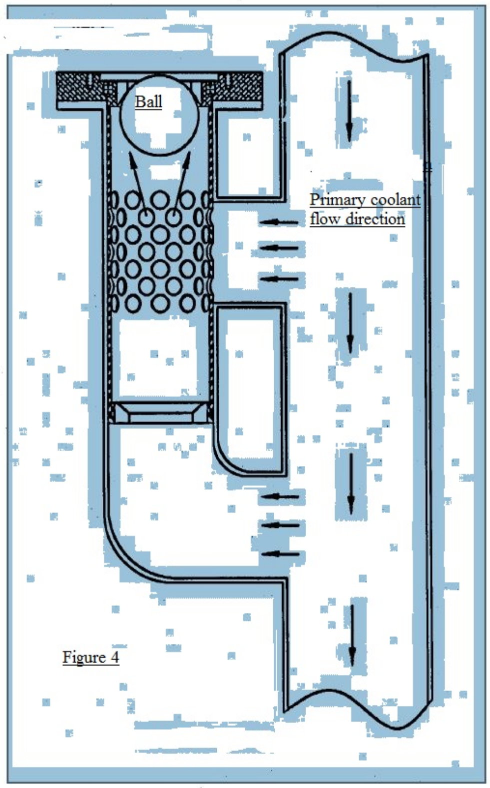


Figure 3

Section C Facility and Radiation Monitoring Systems



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

Section A ℞ Theory, Thermo & Fac. Operating Characteristics

A.01
Answer a
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, Sec 2.4.5, page 2-29.

A.02
Answer: c
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Sec 4.2

A.03
Answer: c
Reference: $P = P_0\ e^{t/T}$ = 50 kW | $e^{(60sec/-80sec)}$ = 50 kW * $e^{-0.75}$ = 0.472 | 50 kW = 23.6 kW

A.04
Answer: d
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, Sec 2.5.3, page 2-45.

A.05
Answer: d
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1982, Sec 3.3.3, page 3-21.
$\Delta\rho$ reactor A = $(Keff_1-Keff_2)/(Keff_1*Keff_2)$. (0.2-0.1)/(0.2*0.1) = 5 Δk/k
$\Delta\rho$ reactor B = $(Keff_1-Keff_2)/(Keff_1*Keff_2)$. (0.7-0.6)/(0.7*0.6) = 0.2381 Δk/k
5/0.2381 = 21

A.06
Answer: d
Reference: Burn, R., Introduction of Nuclear Reactor Operations, © 1988, Sec 3.3

A.07
Answer: d
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1982, Page 4-21.

A.08
Answer b
Reference: DOE Fundamentals Handbook Nuclear Physics and Reactor Theory Vol. 2

A.09
Answer: b
Reference: Nuclides and Isotopes
N = A – Z 235-92 = 143

A.10
Answer: a
K eff = 1.03*0.84*0.96*0.88*1.96*x
X= 1/1.4326 = 0.698
Reference: Burn, R., Introduction of Nuclear Reactor Operations, © 1988, Sec 3.3

A.11
Answer: c
Reference: Time is related to ratio of final power to initial power. 2:1 is the largest ratio.

A.12
Answer: c
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1982, Sec 3.2.

A.13
Answer: c
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1982, Figure 2.6, page 2-39

A.14
Answer: c
Reference: from k=0.955 to criticality (k=1), ρρ = (k-1)/k = -0.047 ρk/k or ρρ = 0.047 ρk/k needed to reach criticality. From criticality to JUST prompt, ρk/k = β_{eff} required, so minimum reactivity added to produce prompt criticality will be: 0.047+0.0078= 0.0548

A.15
Answer: a
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, subcritical Multiplication process.

A.16
Answer: d
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1982, Sec 3.3.1

A.17
Answer c
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, Sec 8.1

A.18
Answer: c
Reference: Burn, R., Introduction to Nuclear Reactor Operations, ©4.5, 1988

A.19
Answer: c
Reference: Chart of the Nuclides

A.20
Answer: a
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1982, Sec 7.6

Section B Facility and Radiation Monitoring Systems

B.01
Answer: c
Reference: PM 1.3 and TS 7.1

B.02
Answer: a (4), b (2), c (1), d (3)
Reference: 10 CFR

B.03
Answer: a(1) b(2) c(2) d(3)
Reference: PM 1.4

B.04
Answer: d
Reference: PM 2.4, Step 3(a)

B.05
Answer: d
Reference: TS 4.2.9

B.06
Answer: b
Qualify factor(Q) - adjusts absorbed dose to dose equivalent
Q = 1 for x, gamma or beta
Q = 20 for alphas and other heavy particles
Q = 10 for neutrons of unknown energy; table 1004(b).2. is for known energies
Q = 10 for high-energy protons

Reference: 10 CFR 20

B.07
Answer: b
Reference: TS 2.2

B.08
Answer: c
Reference: TS Definition, Frequency
Not exceed: 25% of 2 years + 2 years = 6 months + 24 months = 30 months

B.09
Answer: a
Reference: TS 3.7.1

B.10
Answer: c
Reference: EP 4.4.1.3

Section B Facility and Radiation Monitoring Systems

B.11
Answer: d
Reference: Emergency Plan 4.3.2.1

B.12
Answer: b
Reference: 6CEN = R/hr @ 1 ft. -> 6 x 1 x 1 x 1 = 6 R/hr at 1ft. I0D02 = I*D2
6 R/hr*(1 ft) 2 = 0.1 R/hr *D 2
D= sqrt(6/0.1) = 7.7 ft.

B.13
Answer: a
Reference: NRC Standard Questions

B.14
Answer: c
Reference: 10 CFR 20.1003

B.15
Answer: b
Reference: TS 3.3.3

B.16
Answer: b
Reference: NRC standard question

B.17
Answer: c
Reference: 10 CFR 50.74

B.18
Answer: c
Reference: PM 1.14.3

B.19
Answer: d
Reference: TS 6.3

B.20
Answer: c
Reference: T $A = A_{\circ} * e^{-\lambda t}$
$2Ci = 50Ci * e^{-\lambda(t)}$
Ln(2/50) = -ln2/5.27 yr*(t) --> -3.2189/-0.1315 → solve for t: 24.47 years

Section C Facility and Radiation Monitoring Systems

C.01
Answer: d
Reference: RSM 4.3

C.02
Answer: d
Reference: RSM 8.3.6

C.03
Answer: c
Reference: RSM 1.2

C.04
Answer: a(2) b(3) c(4) d(1)
Reference: RSM 9.3, 9.4

C.05
Answer: b
Reference: RSM 8.2.1

C.06
Answer: a
Reference: RSM 3.4.2

C.07
Answer: b
Reference: RSM 1.10, step 4.14B

C.08
Answer: b
Reference: PM 5.2.14, Follow-up Action

C.9
Answer: b
Reference: RSM, Figure 8.14, Emergency Power system Block Diagram

C.10
Answer: a(6) b(7) c(8) d(4) e(5) f(1) g(3) h(2) (0.25 each)
Reference: RSM 5-3 and TS 4.3

C.11
Answer: a
Reference: SAR 6-4, page 6-4 and SAR, page 5-18

C.12
Answer: c
Reference: RSM 3.2.5

Section C Facility and Radiation Monitoring Systems

C.13
Answer: a
Reference: PM 2.4.2

C.14
Answer: a
Reference: TS 3.3.6

C.15
Answer: d
Reference: RSM 3.7.1

C.16
Answer: b
Reference: RSM 5.2.1

C.17
Answer: a
Reference: TS 2.2, Figure 2.2-1

C.18
Answer: d
Reference: RSM, Emergency Power

C.19
Answer: a
Reference: RSM, Coolant Systems