December 1, 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-16-01, MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Dear Dr. Moncton:

During the week of October 19, 2016, the U.S. Nuclear Regulatory Commission (NRC) administered an operator licensing examination at your Massachusetts Institute of Technology reactor. The written examination and operating test 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 e-mail John.Nguyen@nrc.gov.

Sincerely,

/RA/

Anthony Mendiola, 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-16-01
2. Facility comments on written examination with NRC resolution
3. Written examination with facility comments incorporated

cc: w/o encl: See next page

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DISTRIBUTION w/ encls.:
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ADAMS ACCESSION NO.: ML 15322A221

OFFICE	NRR/DPR/PROB	NRR/DPR/PROB	NRR/DPR/PROB
NAME	JNguyen	CRevelle	AMendiola
DATE	11/03/2015	11/18 /2015	12/01/2015

OFFICIAL RECORD COPY

cc:

City Manager
City Hall
Cambridge, MA 02139

Department of Environmental Protection
One Winter Street
Boston, MA 02108

Mr. Jack Priest, Director
Radiation Control Program
Department of Public Health
529 Main Street
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Charlestown, MA 02129

Mr. John Giarrusso, Planning and Preparedness Division Chief
Massachusetts Emergency Management Agency
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Test, Research and Training
Reactor Newsletter
P.O. Box 118300
University of Florida
Gainesville, FL 32611-8300

Ms. Sarah M. Don, (Interim) Superintendent
Massachusetts Institute of Technology
Nuclear Reactor Laboratory
Research Reactor
138 Albany Street, MS NW12-116A
Cambridge, MA 02139

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

REPORT NO.: 50-020/OL-16-01

FACILITY DOCKET NO.: 50-020

FACILITY LICENSE NO.: R-37

FACILITY: MITR-II

EXAMINATION DATES: October 19-20, 2015

SUBMITTED BY: _____ _____
John T. Nguyen, Chief Examiner Date

SUMMARY:
During the week of October 19, 2015, the NRC administered operator licensing examinations to two Senior Reactor Operator-Instant. The candidates passed all applicable portions of the examinations.

REPORT DETAILS

1. Examiners: John T. Nguyen, Chief Examiner, NRC

2. Results:

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

3. Exit Meeting:

John Foster, Interim Director of Reactor Operations, MIT
Sarah Don, Interim Superintendent of Reactor Operations, MIT
Frank Warmsley, Training Supervisor, MIT
John T. Nguyen, Chief Examiner, NRC

The NRC examiner thanked the facility for their support in the administration of the examinations.

ENCLOSURE 1

FACILITY COMMENTS WITH NRC RESOLUTION

FACILITY COMMENT QUESTION B.06 part a
The answer key lists “a(3)” as a correct answer. However, the correct answer is “a(2)” per PM 1.4.1, Administrative Procedure. We request “a(2)” as a correct answer.

NRC RESPONSE
Facility comment accepted.

FACILITY COMMENT QUESTION B.08
The answer key lists “b” as a correct answer. However, the correct answer is “c” for 15 months instead of 14.5 months. We request “c” as a correct answer.

NRC RESPONSE
Facility comment accepted.

FACILITY COMMENT QUESTION C.12
The answer key lists “c” as a correct answer. However, the correct answer is “d” per RSM 3.2.5. We request “d” as a correct answer.

NRC RESPONSE
Facility comment accepted.

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

FACILITY:	Massachusetts Institute of Technology
REACTOR TYPE:	MITR II Research
DATE ADMINISTERED:	10/19/2015
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 ___ (0.33 each)

(***** 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 ___

B04 a ___ b ___ c ___ d ___ (0.25 each)

B05 a b c d ___

B06 a ___ b ___ c ___ d ___ (0.25 each)

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 ___ (0.33 each)

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 ___

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 ___

C11 a ___ b ___ c ___ d ___

e ___ f ___ g ___ h ___ (0.25 each)

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 only 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

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

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

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

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

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

$$\ell^* = 1\times10^{-4}\ \text{sec}$$

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

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

$$CR_1(-\rho_1) = CR_2(-\rho_2)$$

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

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

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

$$M = \frac{1-K_{eff_1}}{1-K_{eff\,2}}$$

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

$$\mathrm{T} = \frac{\ell^*}{\rho-\overline{\beta}}$$

$$\mathrm{T} = \frac{\ell^*}{\rho} + \left[\frac{\overline{\beta}-\rho}{\lambda_{eff}\rho+\dot{\rho}}\right]$$

$$T_{\frac{1}{2}} = \frac{0.693}{\lambda}$$

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

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

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

$$DR_1\,d_1^{\,2} = DR_2 d_2^{\,2}$$

$$DR = \frac{6\,Ci\,E(n)}{R^2}$$

$$\frac{(\rho_2-\beta)^2}{Peak_2} = \frac{(\rho_1-\beta)^2}{Peak_1}$$

DR – Rem, Ci – curies, E – Mev, R – feet

1 Curie = 3.7 x 10^{10} dis/sec

1 Horsepower = 2.54 x 10^{3} BTU/hr

1 BTU = 778 ft-lb

1 gal (H_2O) ≈ 8 lb

c_P = 1.0 BTU/hr/lb/°F

1 kg = 2.21 lb

1 Mw = 3.41 x 10^{6} BTU/hr

°F = 9/5 °C + 32

°C = 5/9 (°F - 32)

c_p = 1 cal/sec/gm/°C

QUESTION A.01 [1.0 point]
Most text books list β for a U^{235} fueled reactor as 0.0065. However, your SAR lists β_{eff} as 0.0078. The MAIN reason for obtaining larger β_{eff} than β is:

a. U^{235} in fuel burns out and generates more delayed neutrons during the fuel life cycle

b. some U^{238} in the core becomes Pu^{239} in which Pu^{239} contributes more delayed neutrons during fission

c. delayed neutrons are born at lower energies than prompt neutrons resulting in less loss due to leakage for these neutrons

d. delayed neutrons are born at higher energies than prompt neutrons resulting in a greater worth for these neutrons

QUESTION A.02 [1.0 point]
During a reactor scram from 5 MW, which ONE of the following best describes the values of K-effective and ρ?

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

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

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

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

QUESTION A.03 [1.0 point]
A mechanism by which a nucleus can gain stability by converting a neutron to a proton or vice versa is called:

a. gamma decay

b. beta decay

c. alpha decay

d. photoelectric effect

QUESTION A.04 [1.0 point]
A reactor is shutdown. Reactor operator accidentally inserts a fuel element worth of 1.8 %Δk/k into the core. With this insertion, a reactor will be:

a. subcritical

b. critical

c. supercritical

d. prompt critical

QUESTION A.05 [1.0 point]
Reactor #1 with a K_{eff} of 0.1 and reactor #2 with a K_{eff} of 0.9, a reactivity is added for both reactors until each K_{eff} is increasing by 0.1 (K_{eff1} = 0.2 and K_{eff2} = 1.0). Which ONE of the following is the amount of reactivity added in a reactor #1 in comparing with the amount of reactivity added in a reactor #2 for the same increment?

a. Same amount

b. Eighteen-times lesser

c. Eighteen-times higher

d. Forty-five-times higher

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

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

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

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

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

QUESTION A.07 [1.0 point]
A reactor is at 10 KW. A rod is pulled to insert a positive reactivity of 0.2 beta. Which ONE of the following will be the stable reactor period as a result of this reactivity insertion? Given beta-effective = 0.0078 and λ_{eff}= 0.1.

a. 20 seconds

b. 40 seconds

c. 55 seconds

d. 65 seconds

QUESTION A.08 [1.0 point]
Which ONE of the following types of neutrons has a mean neutron generation lifetime of 12.5 seconds?

a. Prompt

b. Delayed

c. Fast

d. Thermal

QUESTION A.09 [1.0 point]
The reactor is SHUTDOWN by 5% Δk/k with the count rate of 100 counts per second (cps). The control rods are withdrawn until the count rate is doubled. What is the value of K_{eff} at this point?

a. 0.952

b. 0.976

c. 0.998

d. 1.002

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	1.05
Fast non-leakage probability	0.80
Resonance escape probability	0.90
Thermal non-leakage probability	0.92
Thermal utilization factor	0.80
Reproduction factor	1.86

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. 0.743

d. 0.775

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]
During the time following a reactor scram, reactor power decreases on an 80 second period, which corresponds to the half-life of the longest-lived delayed neutron precursors, which is approximately:

a. 80 seconds

b. 55 seconds

c. 40 seconds

d. 20 seconds

QUESTION A.13 [1.0 point]
Which ONE of the following is the time period in which the MAXIMUM amount of Xe-135 will be present in the core?

a. 1 to 2 hours after a power increase from 50% to 100%

b. 7 to 11 hours after a scram from 50% power

c. 1 to 2 hours after a start up to 100%power

d. 7 to 11 hours after a scram from 100% power

QUESTION A.14 [1.0 point]
Inelastic scattering can be described as a process whereby a neutron collides with a nucleus and leaves the nucleus in an excited state. The nucleus later:

a. emits a gamma ray and a neutron with lower energy

b. emits a gamma ray and a neutron with higher energy

c. emits a beta particle and a neutron with lower energy

d. emits an alpha particle ONLY

QUESTION A.15 [1.0 point]
An experiment to be placed in the rabbit tube has been wrapped in cadmium. Which ONE of the following types of radiation will be most effectively blocked by the cadmium wrapping?

a. Thermal neutrons

b. Fast neutrons

c. Gamma rays

d. X-rays

QUESTION A.16 [1.0 point]
Which ONE of the following is the major source of energy (heat) generated after SHUTDOWN?

a. Prompt gamma ray

b. Fission product decay

c. Delayed neutrons

d. Hydrogen gas

QUESTION A.17 [1.0 point]
Which ONE of the following is the stable reactor period which will result in a power rise from 1% to 100% power in 120 seconds?

a. 10 seconds

b. 13 seconds

c. 26 seconds

d. 80 seconds

QUESTION A.18 [1.0 point]
The FAST FISSION FACTOR is defined as a ratio of:

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

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

c. the number of fast neutrons produced from U-238 over the number of thermal neutrons produced from U-235

d. the number of fast neutrons produced from all fission over the number of fast neutrons produced from thermal fission

QUESTION A.19 [1.0 point]
For the alpha decay of a nuclide, its atomic mass number will _____, and the number of protons will _____.

a. increase by 2 / increase by 1

b. decrease by 2 /decrease by 2

c. decrease by 4 / decrease by 2

d. increase by 4 / increase by 2

QUESTION A.20 [1.0 point, 0.33 each]
Match the term listed in Column A with its corresponding units listed in column B. Answer in Column B can be used once, more than once, or not at all.

	Column A	Column B
a.	Microscopic Cross Section	1. 1/cm
b.	Macroscopic Cross Section	2. 10^{-24} cm^2
c.	Neutron Flux	3. Neutrons / cm^2 /sec
.		4. Neutrons / cm^3 /sec
		5. 10^{-24} cm^3

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

Category B: Normal/Emergency Procedures and Radiological Controls

QUESTION B.01 [1.0 point]
The operation when the reactor is at 2 MW with one primary coolant pump and one primary heat exchanger ON is defined as:

a. Half-Power Operation

b. 100 KW Operation

c. Full-Power Operation

d. unattended condition

QUESTION B.02 [1.0 point, 0.25 each]
Match the following 10 CFR 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]
You receive a quarterly dosimetry report stating that you have received whole body occupational exposures of:
1 mrem of beta
1 mrem of alphas
1 mrem of neutrons of unknown energy
What would be the total effective dose equivalent?

a. 3 mrem

b. 12 mrem

c. 22 mrem

d. 31 mrem

QUESTION B.04 [1.0 point, 0.25 each]
Match type of radiation listed in column A with their quality factor listed in column B. Items in column B can be used once, more than once or not at all.

	Column A	Column B	
a.	X-ray	1.	1
b.	Gamma	2.	5
c.	Alpha particles	3.	10
d.	High-energy photons	4.	20

QUESTION B.05 [1.0 point]
A radioactive source reads 5 Rem/hr on contact. Five hours later, the same source reads 1.25 Rem/hr. How long is the time for the source to decay from a reading of 5 Rem/hr to 625 mRem/hr?

a. 6.5 hours

b. 7.5 hours

c. 8.5 hours

d. 9.5 hours

QUESTION B.06 [1.0 point, 0.25 each]
Match the change/modification 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.	Add more responsibilities to the Radiation Protection Officer listed in PM 1.1.3	1. Class A
b.	Delete BNCT Facility Beams listed in Technical Specifications	2. Class B
c.	Make change to Technical Specifications due to grammar errors	3. Class C
d.	Replace primary cooling pump	

QUESTION B.07 [1.0 point]
Given that the following emergency conditions occur at the MIT reactor facility:

(a) Low level coolant alarm
(b) Particulate monitor indicates 1500 kcpm/s
(c) Radiation levels at the site boundary indicate 110 mRem/hr sustained for one hour

Which ONE of the following is the appropriate Emergency Classification?

a. Notification of Unusual Event

b. Alert

c. Site Area Emergency

d. General Emergency

QUESTION B.08 [1.0 point]
An annual test of the nuclear instrument was performed. Which ONE of the following is the latest the test that must be performed again without violation of the Technical Specifications?

a. 13 months after

b. 14 months after

c. 15 months after

d. 16 months after

QUESTION B.09 [1.0 point]
A radioactive material is decayed at a rate of 30% per every two hours. Determine its half-life?

a. 2 hours

b. 3 hours

c. 4 hours

d. 5 hours

QUESTION B.10 [1.0 point]
During a reactor operation, the reactor operator observes that the core outlet temperature exceeds 54°C. For this temperature, which ONE of the following is the best action?

a. The operator can increase power to verify that it should alarm at the setpoint

b. The operator may continue an operation because the temperature is within TS limit

c. The operator shall shutdown the reactor; and then immediately report the result to NRC due to temperature being above TS limit

d. The operator may continue an operation, but immediately report the result to the supervisor since the reactor does not alarm at setpoint

QUESTION B.11 [1.0 point]
Which ONE of the following is the MINIMUM staffing requirement when the reactor is NOT SECURED?

a. 1 SRO in the control room + 1 HP on call

b. 1 RO in the control room + 1 HP on site

c. 1 SRO onsite + 1 RO in the control room + 1 HP on call

d. 1 SRO onsite +1 shift supervisor in the control room + 1 HP on site

QUESTION B.12 [1.0 point]
A two-curie source, emits 100% of a 2 Mev gamma, is to be stored in the reactor building. How far from the source should a HIGH RADIATION AREA sign be posted?

a. 7 feet

b. 8 feet

c. 11 feet

d. 16 feet

QUESTION B.13 [1.0 point]
The MAIN purpose of limiting 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.14 [1.0 point, 0.33 each]
Match each component of compressed air system in column A with its associated pressure in column B. Items in column B is to be used once, more than once or not at all.

Column A		Column B	
a.	Personnel locks seal	1.	40 psi
b.	Compressor supply air	2.	50 psig
c.	Low pressure air alarm	3.	100 psig
		4.	145 psi
		5.	200 psi
		6.	250 psi

QUESTION B.15 [1.0 point]
The individual authorized to downgrade the emergency and initiate recovery operation is the:

a. MITR Emergency Director

b. MITR Radiation Protection Officer

c. Nuclear Reactor Laboratory Director

d. MIT Campus Police Chief

QUESTION B.16 [1.0 point]
The control rod calibration shall be performed at least:

a. monthly

b. quarterly

c. semi-annually

d. annually

QUESTION B.17 [1.0 point]
The below items are listed as a reportable occurrence, EXCEPT:

a. A core outlet temperature exceeds 60 °C

b. An uncontrolled reactivity change of 1.5 %ΔK/K

c. Reactor operation at 90 KW without primary pump

d. Reactor operation at 5.0 MW with only primary pump

QUESTION B.18 [1.0 point]
The four parameters to be used for evaluating the safety limit are:

a. water tank level, thermal power, reflector flow, and primary flow

b. reactivity, thermal power, water tank level, and outlet temperature

c. reactor period, thermal power, outlet temperature, and primary flow

d. outlet temperature, thermal power, water tank level, and primary flow

QUESTION B.19 [1.0 point]
Which ONE of the following correctly describes the requirement of "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.20 [1.0 point]
Whenever the reactor is operating at power levels in excess of _____, the ventilation system shall be operating to provide at least _____ of exhaust ventilation flow through the containment building stack.

a. 100 KW / 10000 cfm

b. 150 kW / 8500 cfm

c. 250 KW / 7500 cfm

d. 500 kW / 5000 cfm

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

Category C: Facility and Radiation Monitoring Systems

QUESTION C.01 [1.0 point]
Which ONE of the following is the MOST correct reason why the reactor takes a long period of time to attain a thermal equilibrium?

a. The primary coolant has a large volume of water, so it creates a negative temperature feedback before attaining a thermal equilibrium

b. The primary coolant pumps require a long period of time to reach a constant speed; therefore it takes more time for distributing heat capacity

c. The heavy water has a large heat capacity; therefore it is slow to attain an equilibrium distribution

d. The graphite reflector has a large heat capacity; therefore it is slow to attain an equilibrium distribution

QUESTION C.02 [1.0 point]
After shutdown from a 6 MW operation, a leak occurs from the D_2O tank to the reflector heat exchanger of the secondary system. The MAIN reason in which the secondary water monitor cannot detect tritium is:

a. No tritium in the reflector heat exchanger when leak occurs

b. Tritium emits alpha particle, but the monitor is designed to sense gamma only

c. Tritium emits beta particle, but the monitor is designed to sense gamma only

d. Tritium emits neutrons, but the monitor is mostly sensitive to particulate radiation only

QUESTION C.03 [1.0 point]
To minimize radiation streaming from a reactor core to top shield lid, the sleeve and plug are:

a. made by lead and a beam port is blanketed by helium

b. made by aluminum and a gasket cover is bolted over the beam port's opening

c. stepped and gas seals are made by bolding a ring against the aluminum flange

d. made by polyethylene and a gasket cover is bolted over the beam port's opening

QUESTION C.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 shift supervisor must approve all reshims prior to performance

b. Reactor power is to be maintained within 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 C.05 [1.0 point]
On a startup within 16 hours of shutdown, you are required to check all of the listed below for Channel #1 operation, EXCEPT:

a. Amplifier ON

b. Count rate OK

c. Source is in place

d. Gain and discrimination settings

QUESTION C.06 [1.0 point]
During a 3 MW reactor operation, you discover that the temperature in the middle of the recombiner is 40 °C for fifteen minutes. Which ONE of the following is the MAXIMUM reactor power you must reduce to ensure you do not violate the Technical Specifications?

a. 119 kW

b. 109 kW

c. 99 kW

d. 89 kW

QUESTION C.07 [1.0 point]
During a NORMAL reactor startup, which ONE of the following contributes to NORMALLY defeating the subcritical interlock?

a. Having all shim blades at the subcritical position

b. Pulling and holding the ”subcritical-bypass” joystick

c. Waiting for the power level to reach a stable level

d. Withdrawing the regulating rod to reach a critical power level

QUESTION C.8 [1.0 point]
Which ONE of the following is an INCORRECT statement associated with the reactor grid-plate?

a. The hold-down grid-plate is locked permanently and never unlatched

b. The interlock provides a scram if the latching mechanism is unlatched

c. The hold-down grid-plate cannot be rotated unless the shim blades are fully inserted

d. The interlock prevents any coolant flow while the grid is rotated to latch position

QUESTION C.9 [1.0 point]
The Detector Signal Conditioner LED of an Area Radiation Monitor is indicated by all dashes (“-“). It means the detector is in:

a. the saturation mode

b. the calibration mode

c. the source test

d. the power failure

QUESTION C.10 [1.0 points]
Figure 8-1 depicts the MITR normal and emergency electrical distribution. In the event of a loss of off-site power, which ONE of the following will distribute AC power to the Panel 1 (Circuit 1-12)?

a. Panel 1 (Circuit 13 – 20)

b. 5-kW generator

c. Main power distribution (208/120V)

d. There are no systems that provide AC power to the Panel 1 (Circuit 1 -12) during a loss of off-site power

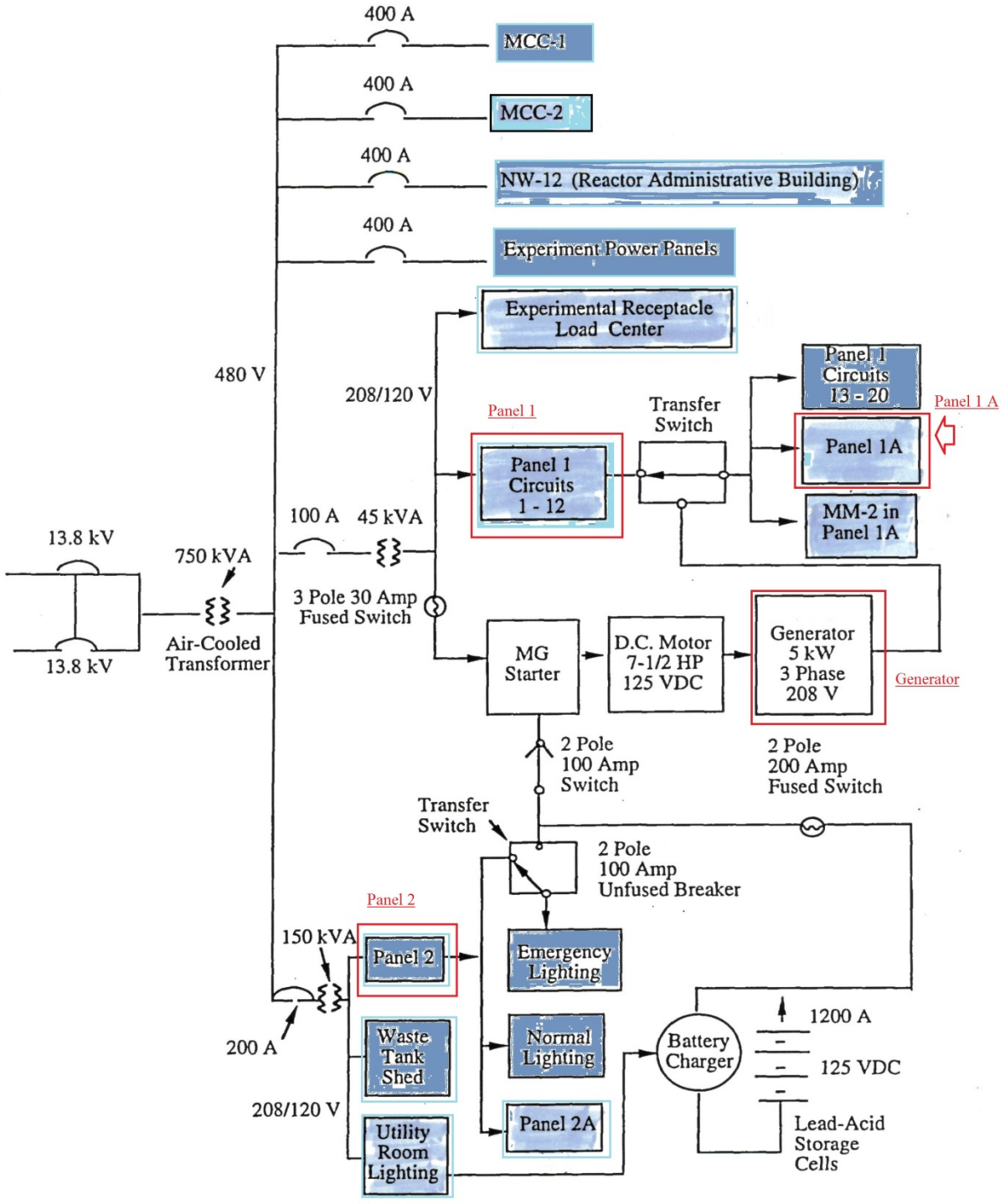


Figure 8-1

QUESTION C.11 [2.0 points, 0.25 each]

Category C: Facility and Radiation Monitoring Systems

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.	Stack Gas monitor	1.	Monitor radiation level in the reactor top
b.	Plenum Particulate monitor	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.	Log N Period (Chanel 3)	7.	Provide a high power level scram
h.	Power Level (Chanel 4)	8.	Provide indication of the reactor power level when all off-site electrical power has been lost

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 reactor power level shall be reduced to less than ____ and samples must be taken every _____ .

a. 500 kW / 0.5 hr

b. 300 kW / 1.0 hr

c. 200 kW/ 1.5 hrs

d. 100 kW / 2.0 hrs

Category C: Facility and Radiation Monitoring Systems

QUESTION C.13 [1.0 point]
All free surfaces of the thermal column gas box seal are blanketed with CO_2. The reason for using CO_2 purge to blanket the thermal column gas box seal is to:

a. cool the empty space in the thermal column

b. minimize the fast neutron flux in the thermal column

c. maximize the thermal neutron flux in the thermal column

d. prevent corrosion caused by nitrous oxide formation in air

QUESTION C.14 [1.0 point]
Which ONE of the following is considered a NORMAL range for the pH of the fuel storage pool?

a. 5.5 – 7.0

b. 7.0 – 8.5

c. 8.5 – 10.0

d. 10.0 – 11.5

QUESTION C.15 [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. Secondary power + Reflector power + Shield power

b. Primary power – Secondary power + Shield power

c. Secondary power + Reflector power - Shield power

d. Primary power + Reflector power + Shield power

QUESTION C.16 [1.0 point]
The weekend surveillance system is activated. An alarm on the center scram panel will cause an audible alarm at all of the below listed areas, EXCEPT:

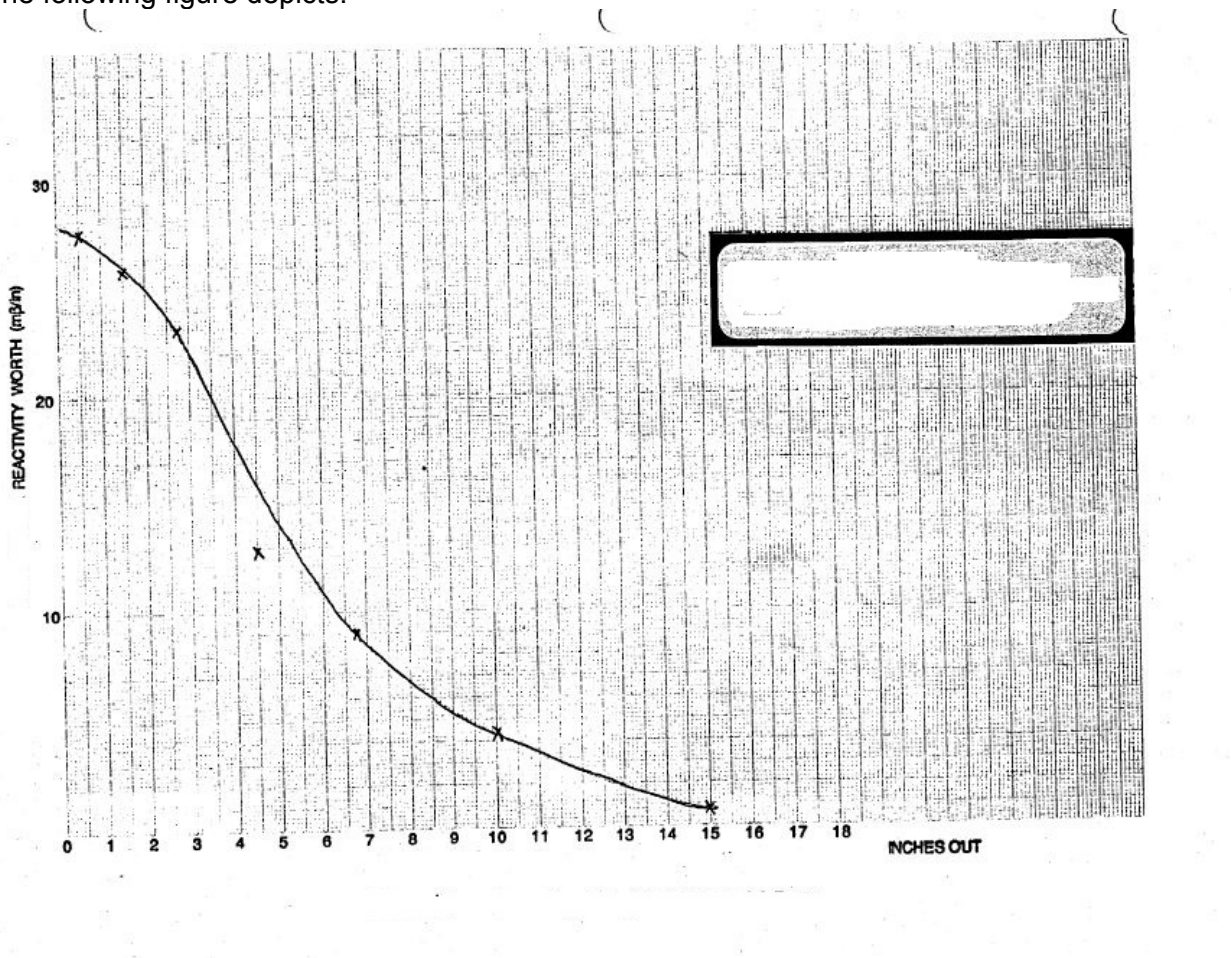
a. the Emergency Director office

b. the Utility room

c. the Reception desk

d. the Reactor floor

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



a. MITR Differential REG Rod Worth Curve

b. MITR Integral REG Rod Worth Curve

c. MITR REG Rod Drop Test

d. MITR REG Rod In-hour Curve

QUESTION C.18 [1.0 point]
Which ONE of following actions should the reactor operator perform immediately when the rabbit station radiation monitor alarms during rabbit irradiation?

a. Commence an unscheduled Shutdown and dump the reflector

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

c. Insist the rabbit operator immediately removes the sample into the lead pig

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.19 [1.0 point]
The Emergency Power Distribution System batteries have the capacity to supply power to selected instruments and pumps for a MAXIMUM period of _____ under a nominal battery load of 72 amps.

a. 1 hour

b. 3 hours

c. 8 hours

d. 10 hours

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

Category A: Theory, Thermo & Fac. Operating Characteristics

A.01
Answer: c
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1982, Sec 3.3

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

A.03
Answer: b
Reference: NRC Standard Question

A.04
Answer: a
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Sec 4.2

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 $\Delta k/k$
$\Delta\rho$ reactor B = $(Keff_1-Keff_2)/(Keff_1*Keff_2)$. (1-0.9)/(1.0*0.9) = 0.11 $\Delta k/k$
5/0.11 = 45

A.06
Answer: a
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Sec 3.3.1

A.07
Answer: b
Reference:
Reactivity added = 0.2 beta x .0078 = 0.00156 $\Delta k/k$
$\tau = (\beta-\rho)/\lambda_{eff}\rho$ = $\frac{0.0078 - 0.00156}{(0.1)(0.00156)}$ = 40 seconds

A.08
Answer: b
Reference: DOE Handbook Vol. 1 Module 2, Section 3.0

A.09
Answer: b
Reference:
Keff1=1/1- ρ1
Keff1 =1/(1-(-.05)) —>Keff1= 0.952,
Count1*(1-Keff1) = Count2*(1-Keff2)
Count1*(1-0.952) = Count2*(1-Keff2)
100*(1-0.952) = 200(1- Keff2); Keff2 = 0.976

A.10
Answer: d
Reference: K eff = 1.05*0.80*0.90*0.92*1.86*x
X= 1/1.294 = 0.773

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: b
Reference: Group 1 is the longest-lived delayed neutron precursor for thermal fission in U-235, with a half-life of 55.72 sec.
Lamarsh, J. "Introduction to Nuclear Engineering" p. 88

A.13
Answer: d
Reference: Burn, R., Introduction of Nuclear Reactor Operations, © 1982, Sec 8.4, page 8-9.

A.14
Answer: a
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Sec 2.4.5, page 2-29.

A.15
Answer: a
Reference: NRC Standard Question

A.16
Answer: b
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, Section 3.2.1

A.17
Answer: c
Reference: $P = P_0 e^{t/T}$ —> $T = t/\mathrm{Ln}(P/P_0)$
$T = 120/\mathrm{Ln}(100)$; T = 26 sec.

A.18
Answer: d
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1982, Sec 3.3.1, page 3-16.

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

A.20
Answer: a(2) b(1) c(3)
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, Sec 2.6

Category B: Normal/Emergency Procedures and Radiological Controls

B.01
Answer: a
Reference: PM 2.2.1.1

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

B.03
Answer: a
Reference: The report already provides a conversion in mrem, so you just add them up.

B.04
Answer: a(1) b(1) c(4) d(3)
Reference: 10 CFR 20

B.05
Answer: b
Reference: $DR = DR_{\circ} * e^{-\lambda t}$
$1.25 \text{ rem/hr} = 5 \text{ rem/hr} * e^{-\lambda(5hr)}$
$\ln(1.25/5) = -\lambda * 5 \rightarrow \lambda = 0.277$; solve for t: $\ln(.625/5) = -0.277 * t$
t=7.5 hours

B.06 Key answer change per facility comment
Answer: ~~a(3)~~ a(2) b(1) c(1) d(2)
Reference: PM 1.4

B.07
Answer: c
Reference: TS 7.1 Emergency Plan, Table 4.5.3-3

B.08 Key answer change per facility comment
Answer: ~~b~~ c
Reference: TS Definition, Frequency
Not exceed: 25% of 1 years + 1 years = ~~2.5 months~~ 3 months + 12 months = ~~14.5 months~~ 15 months

B.09
Answer: c
Reference: $DR = DR_{\circ} * e^{-\lambda t}$
30% is decayed, so 70% is still there $70\% = 100\% * e^{-\lambda(2hrs)}$
$\ln(70/100) = -\lambda * 2 \rightarrow \lambda = 0.1783$ $t_{1/2} = \ln(2)/\lambda \rightarrow .693/.1783$ t=3.89 hours

B.10
Answer: d
Reference: RSM 3.2.2 and TS Table 3.2.3

Category B: Normal/Emergency Procedures and Radiological Controls

B.11
Answer: c
Reference: TS 7.1.3

B.12
Answer: d
Reference: 6CEN = R/hr @ 1 ft. -> 6 x 2 x 2 x 1 = 24 R/hr at 1ft. $I_0D_0^2 = I*D^2$
24 R/hr*(1 ft)^2 = 0.1 R/hr *D^2
D= sqrt(24/0.1) = 15.5 ft.

B.13
Answer: b
Reference: TS 3.3.3

B.14
Answer: a(1) b(4) c(3)
Reference: RSM 8.6

B.15
Answer: a
Reference: Emergency Plan 4.3.3.1

B.16
Answer: d
Reference: TS 4.2

B.17
Answer: c
Reference: TS 1.3 and TS 2.2

B.18
Answer: d
Reference: TS 2.2

B.19
Answer: c
Reference: PM 1.14.3

B.20
Answer: c
Reference: TS 3.5.1

Category C: Facility and Radiation Monitoring Systems

C.01
Answer: d
Reference: RSM 6.3.4

C.02
Answer: c
Reference: RSM 7.4.1

C.03
Answer: b
Reference: RSM 2.3

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

C.05
Answer: c
Reference: PM 3.1.1.2

C.06
Answer: c
Reference: TS 3.3.3

C.07
Answer: a
Reference: RSM 4.2

C.08
Answer: a
Reference: RSM 1.4

C.09
Answer: a
Reference: RSM 7.2.1

C.10
Answer: d
Reference: RSM 8.8

C.11
Answer: a(3) b(2) c(8) d(4) e(5) f(1) g(6) h(7)
Reference: RSM 5-3 and TS 4.3

C.12 Key answer change per facility comment
Answer: ~~c~~ d
Reference: RSM 3.2.5

Category C: Facility and Radiation Monitoring Systems

C.13
Answer: d
Reference: RSM 3.7.2

C.14
Answer: a
Reference: TS 3.3.6

C.15
Answer: d
Reference: PM 2.4.2

C.16
Answer: a
Reference: RSM 9.5

C.17
Answer: a
Reference: SAR Figure 4.8

C.18
Answer: b
Reference: PM 1.10, step 4.14B

C.19
Answer: c
Reference: RSM 8.8.2