UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

April 18, 2018

Mr. Al Queirolo, Director of Reactor Operations
Massachusetts Institute of Technology
138 Albany Street
Cambridge, MA 02139

SUBJECT: EXAMINATION REPORT NO. 50-020/OL-18-01, MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Dear Mr. Queirolo:

During the week of February 5, 2018, 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 internet e-mail John.Nguyen@nrc.gov.

Sincerely,

/RA/

Anthony Mendiola, Chief
Research and Test Reactors Oversight Branch
Division of Licensing Projects
Office of Nuclear Reactor Regulation

Docket No. 50-020

Enclosures:
1. Examination Report No. 50-020/OL-18-01
2. Written examination

cc: w/o encl: See next page

SUBJECT: EXAMINATION REPORT NO. 50-020/OL-18-01, MASSACHUSETTS INSTITUTE OF TECHNOLOGY DATED APRIL 18, 2018

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Date	04/03/2018	04/10/2018	04/18/2018

OFFICIAL RECORD COPY

cc:

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

REPORT NO.: 50-020/OL-18-01

FACILITY DOCKET NO.: 50-020

FACILITY LICENSE NO.: R-37

FACILITY: MITR-II

EXAMINATION DATES: February 6 - 7, 2017

SUBMITTED BY: ***/RA/*** **04/03/2018**
John T. Nguyen, Chief Examiner Date

SUMMARY:
During the week of February 5, 2018 the NRC administered operator licensing examinations to one Senior Reactor Operator Instant and one Senior Reactor Operator Update candidates. 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	N/A	1/0	1/0
Operating Tests	N/A	2/0	2/0
Overall	N/A	2/0	1/0

3. Exit Meeting:
John T. Nguyen, Chief Examiner, NRC
Al Queirolo, Director of Reactor Operations, MIT
Keith Honeycutt, Training Supervisor, MIT
Frank Warmsley, Senior Reactor Operator, MIT

The NRC examiner thanked the facility for their support in the administration of the examinations. The examiner discussed the generic weaknesses observed during the operating test to include the 10 CFR 50.59 process.

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

FACILITY:	Massachusetts Institute of Technology
REACTOR TYPE:	MITR II Research
DATE ADMINISTERED:	2/7/2018
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 2

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 ___

B03 a b c d ___

B04 a b c d ___

B05 a b c d ___

B06 a ___ b ___ c ___ d ___ (0.5 each)

B07 a b c d ___

B08 a b c d ___

B09 a b c d ___

B10 a ___ b ___ c ___ d ___ (0.25 each)

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 ___

(***** 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 ___ (0.25 each)

C07 a b c d ___

C08 a ___ b ___ c ___ d ___

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

C09 a b c d ___

C10 a b c d ___

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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]
Which ONE of the following factors of the Six Factor formula is most affected by changing the core materials?

a. Thermal Utilization Factor (f)

b. Resonance Escape Probability (p)

c. Fast Fission Factor (ε)

d. Fast Non-Leakage Factor (L_f)

QUESTION A.02 [1.0 point]
Given the following Core Reactivity Data (not at MITR):

Control Rod	Total Worth (beta)	Core excess (beta) at 100 watts)	
Blade 1	1.60	Full out (0.0)	
Blade 2	3.50	2.50	
Blade 3	2.70	0.70	
Blade 4	2.30	1.50	
Blade 5	1.20	0.80	

Which one of the following is the calculated shutdown margin that would satisfy the Technical Specification Minimum Shutdown Margin? Assume that all blades are scrammable.

a. 2.3 beta

b. 3.5 beta

c. 5.5 beta

d. 5.8 beta

QUESTION A.03 [1.0 point]
The reactor is critical at 100 watts. A blade is withdrawn to insert a positive reactivity of 0.126 %Δ k/k. Which ONE of the following will be the stable reactor period as a result of this reactivity insertion? Given beta effective = 0.0078

a. 9.3 seconds

b. 46 seconds

c. 52 seconds

d. 80 seconds

QUESTION A.04 [1.0 point]
The reactor is operating at 100 W with a fuel temperature of 50 °F. When a control rod with an average rod worth of 0.2% delta k/k/inch is withdrawn 5 inches, reactor power increases and becomes stable at a higher level. What is the final fuel temperature? Given the fuel temperature coefficient of reactivity of -1.25 E-4 Δ k/k/ °F and ignoring any other temperature effects.

a. -80 °F

b. 30 °F.

c. 80 °F

d. 130 °F

QUESTION A.05 [1.0 point]
A reactor is critical at 18.1 inches on a controlling blade. The controlling blade is withdrawn to 18.5 inches. The reactivity inserted is 0.1 % Δ k/k. What is the differential rod worth?

a. 0.10 %Δ k/k/inch at 18.1 inches.

b. 0.20 %Δ k/k/inch at 18.2 inches.

c. 0.25 %Δ k/k/inch at 18.3 inches.

d. 0.30 %Δ k/k/inch at 18.4 inches.

QUESTION A.06 [1.0 point]
Two critical reactors at low power are identical except that Reactor 1 has a beta fraction of 0.0072 and Reactor 2 has a beta fraction of 0.0060. An equal amount of positive reactivity is inserted into both reactors. Which ONE of the following will be the response of Reactor 1 compared to Reactor 2?

a. The final power level will be lower.

b. The final power level will be higher.

c. The resulting period will be longer.

d. The resulting period will be shorter.

QUESTION A.07 [1.0 point]
The reactor is shutdown. A reactor operator makes a mistake by inserting a sample worth of 1 beta into the reactor core. Which ONE of the following best describes the reactor kinetic?

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

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

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

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

QUESTION A.08 [1.0 point]
The neutron microscopic cross-section for absorption σ_a generally:

a. increases as neutron energy increases

b. decreases as neutron energy increases

c. increases as neutron velocity increases

d. decreases as target nucleus mass increases

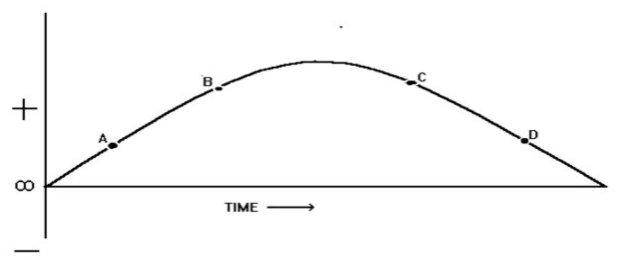
QUESTION A.09 [1.0 point]
Shown below is a trace of reactor period as a function of time. Between points C and D reactor power is:

a. constant.

b. continually decreasing.

c. continually increasing.

d. increasing, then constant.



QUESTION A.10 [1.0 point]
Given the thermal neutron flux (Ø) is 1.0×10^{13} neutrons/cm^2/second, and the macroscopic cross-section (Σ_f) for fission is 0.1 cm^{-1}. The fission rate is:

a. 1.0×10^{12} fissions/cm/second

b. 1.0×10^{14} fissions /cm/second

c. 1.0×10^{12} fissions/cm^3/second

d. 1.0×10^{14} fissions /cm^3 / second

QUESTION A.11 [1.0 point]
If the multiplication factor, k, is increased from 0.800 to 0.950, the amount of reactivity added is:

a. 0.150 $\Delta k/k$

b. 0.197 $\Delta k/k$

c. 0.250 $\Delta k/k$

d. 0.297 $\Delta k/k$

QUESTION A.12 [1.0 point]
Reactor power is rising on a 20 second period. Approximately how long will it take for power to double?

a. 14 seconds

b. 29 seconds

c. 40 seconds

d. 80 seconds

QUESTION A.13 [1.0 point]
A reactor is slightly supercritical with the thermal utilization factor = 0.800. 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. 0.798

b. 0.800

c. 0.802

d. 0.804

QUESTION A.14 [1.0 point]
Delayed neutrons are considered to cause “fission” easier than prompt neutrons because delayed neutrons have a:

a. higher energies than prompt fission neutrons.

b. higher fast non-leakage probability.

c. lower reproduction factor.

d. lower thermal utilization factor.

QUESTION A.15 [1.0 point]
Which ONE of the following conditions will require the control rod withdrawal to maintain constant power level following the change?

a. Insertion of an experiment containing cadmium.

b. Adding of a fuel experiment such as U-235 into the core.

c. Pool water temperature decrease.

d. Burnout of Xenon in the core.

QUESTION A.16 [1.0 point]
Which ONE of the following statements correctly describes the concentration of Xenon in the core following a scram from extended operation of 5 Megawatts? Xenon concentration …

a. initially decreases due to the loss of Iodine production, then increases to maximum concentration.

b. eventually decreases to zero in approximately 10 to 15 hours.

c. increases to maximum in approximately 7 to 10 hours due to I-135 decay.

d. increases to maximum in approximately 7 to 10 hours due to Cs-135 decay.

QUESTION A.17 [1.0 point]
Which ONE of the following is the stable reactor period which will result in a power rise from 50% to 100% power in 30 seconds?

a. 13 seconds

b. 21 seconds

c. 43 seconds

d. negative (-) 43 seconds

QUESTION A.18 [1.0 point, 0.25 each]
Replace "X" with the type of decay necessary (Alpha, Beta, Gamma or Neutron emission) to produce the following reactions. Choices may be used once, more than once, or not at all.

a. $_{92}U^{238} \rightarrow {}_{90}Th^{234} + X$

b. $_{83}Bi^{203} \rightarrow {}_{82}Pb^{203} + X$

c. $_{2}He^{4} + {}_{4}Be^{9} \rightarrow {}_{6}C^{12} + X$

d. $_{84}Po^{210} \rightarrow {}_{82}Pb^{206} + X$

QUESTION A.19 [1.0 point]
Which ONE of the following statement best defines the reactor excess reactivity? The reactor excess reactivity is:

a. a measure of the additional fuel loaded to overcome fission product poisoning.

b. a measure of remaining control rod worth when the reactor is exactly critical.

c. the combined control rod negative reactivity worth required to keep the reactor shutdown.

d. the maximum reactivity by which the reactor can be shutdown with one control rod fully withdrawn.

QUESTION A.20 [1.0 point]
If $(1 - ß_{eff})*K_{eff} = 1$, the reactor is:

a. subcritical.

b. critical.

c. supercritical.

d. prompt critical

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

Category B: Normal/Emergency Procedures and Radiological Controls

QUESTION B.01 [1.0 point]
Per MITR Technical Specifications, the Building ∆P - Reactor Start interlock for the containment building ventilation system shall be calibrated:

a. Quarterly

b. Semi-annually

c. Annually

d. Biennially

QUESTION B.02 [1.0 point]
How long will it take a 10 Curie source, with a half-life of 5 years, to decay to 1 Curie?

a. 6.0 Years

b. 11.5 Years

c. 16.6 Years

d. 23.0 Years

QUESTION B.03 [1.0 point]
The conductivity of the primary coolant, averaged over 24 hours, shall be kept:

a. below 10 μS/cm at 20°C.

b. higher than 10 μS/cm at 20°C.

c. below 100 μS/cm at 20°C.

d. higher than 100 μS/cm at 20°C.

QUESTION B.04 [1.0 point]
Per MITR Technical Specifications, what is a minimum level of authority to approve minor changes to the EXPERIMENTS, that modification does not significantly change the effectiveness or the intent of the procedure?

a. The MIT Reactor Safeguards Committee (MITRSC) and the Director of Reactor Operations

b. 1 Reactor Operator, 1 Senior Reactor Operator, and the Superintendent

c. 2 Senior Reactor Operators and the Director of Reactor Operations

d. 1 Reactor Operator, 2 Senior Reactor Operators

QUESTION B.05 [1.0 point]
Which ONE of the following is NOT a responsibility of the Emergency Director?

a. Determining the class of the emergency.

b. Updating of emergency plans and procedures.

c. Terminating an emergency and initiating recovery actions.

d. Authorization for emergency exposures in excess of occupational limits during rescue and recovery activities.

QUESTION B.06 [2.0 points, 0.5 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.	Modification reflector piping system (This change requires an amendment)	1. Class A
b.	Change the Basis in TS 3.2.2, Reactivity Insertion Rate and Automatic control	2. Class B
c.	Modification of Administrative Procedure, PM 1.4	3. Class C
d.	Replace Shim blade with identical one	

QUESTION B.07 [1.0 point]
Per Administration Procedure, PM 1.3, which ONE of the following is **NOT** a duty for the shift supervisor?

a. Verifying the completeness and accuracy of the log book entries on the shift.

b. Present at the reactor room whenever the Console Relief/Turnover is conducted.

c. Informing the Operations Superintendent of unusual occurrences on the shift

d. Authorizing and witnessing both startups and increases in reactor power of greater than 10%.

QUESTION B.08 [1.0 point]
If the measured dose at the site boundary reads between 5 to 10 mRem/hr, this emergency event will be classified as:

a. Site Area Emergency

b. Alert

c. Notification of Unusual Events

d. AOP 5.6.2

QUESTION B.09 [1.0 point]
The dose rate from a mixed beta-gamma point source is 100 mrem/hour at a distance of one (1) foot, and is 0.1 mrem/hour at a distance of twenty (20) feet. What percentage of the source consists of beta radiation?

a. 20%

b. 40%

c. 60%

d. 80%

QUESTION B.10 [1.0 points, 0.25 each]
Match the 10 CFR Part 55 requirements listed in Column A for an actively licensed operator with the correct time period from Column B. Column B answers may be used once, more than once, or not at all.

	Column A		Column B
a.	License Expiration	1.	1 year
b.	Medical Examination	2.	2 years
c.	Requalification Written Examination	3.	4 years
d.	Requalification Operating Test	4.	6 years

QUESTION B.11 [1.0 point]
An irradiated sample with a half-life of 60 minutes provides a dose rate of 1 rem/hr at 1 ft. Approximately how far from the sample must a Radiation Area sign be posted?

a. 6 ft.

b. 9 ft.

c. 14 ft.

d. 30 ft.

QUESTION B.12 [1.0 point]
In accordance with 10CFR20.1301, individual members of the public are limited to a TEDE in one year of:

a. 10 mrem.

b. 100 mrem.

c. 500 mrem.

d. 1250 mrem.

QUESTION B.13 [1.0 point]
Which ONE of the following statements is true regarding the Technical Specification Shutdown Margin requirements?

a. The reflector dump time must be at least twice the initial measured value.

b. The shutdown margin is the amount of reactivity that would exist if all reactivity control devices were moved to the maximum reactive condition from the point where the reactor is exactly critical at reference core conditions.

c. With the most reactive shim blade fully withdrawn, the reactor will remain subcritical without further operator action.

d. With the most reactive blade and regulating rod fully withdrawn, the reactor can be made at least 1% $\Delta K/K$ subcritical from the most restrictive operating conditions (cold, Xenon free, including experiment worth).

QUESTION B.14 [1.0 point]
In order to ensure the health and safety of the public, 10CFR50 allows the operator to deviate from Technical Specifications. What is the minimum level of authorization needed to deviate from Tech. Specs?

a. Director of Reactor Operations

b. MITRSC

c. Licensed Senior Reactor Operator.

d. Licensed Reactor Operator.

QUESTION B.15 [1.0 point]
For MITR Radiation Area Monitor alarms, the Reactor Floor #1 trip is set at:

a. 5 mR/hr

b. 15 mR/hr

c. 25 mR/hr

d. 35 mR/hr

QUESTION B.16 [1.0 point]
How is the emergency core cooling system (ECCS) prepared in case the system needs to be activated to prevent further tank level degradation? The ECCS needs to have its water supply connected to the _________.

a. Heat exchanger outlet lines.

b. Primary coolant reactor inlet lines.

c. Primary coolant storage tank.

d. City water lines.

QUESTION B.17 [1.0 point]
All applicants for an RO or SRO license must submit Form 396 and 398 to the U.S. NRC before taking the examinations. This requirement is specified in 10 CFR:

a. Part 19

b. Part 20

c. Part 50

d. Part 55

QUESTION B.18 [1.0 points]
A radiation survey of an area reveals a general radiation reading of 1 mrem/hr. There is, however, a small pipe which reads 20 mrem/hr at one (1) meter. Which ONE of the following defines the posting requirements for the area in accordance with 10CFR20?

a. Control Access Area.

b. Caution, Radiation Area.

c. Caution, High Radiation Area.

d. Grave Danger, Very High Radiation Area.

QUESTION B.19 [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. Increase power to verify whether it alarms at the setpoint.

b. Continue an operation because the temperature is within TS limit.

c. Continue operation, but immediately report the result to the supervisor because of exceeding abnormal setpoint.

d Shutdown the reactor; immediately report the result to the supervisor for the TS violation.

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

QUESTION C.01 [1.0 point]
Which ONE of the following statements correctly describes the limitations imposed on the D_2 concentration and recombiner operation?

a. The D_2 concentration in the helium blanket shall not exceed 6% by volume. The temperature of the middle of the recombiner shall be greater than 50 ˚C during operation above 100 kW. The flow rate shall be between 1.5 and 8 cfm prior to reactor startup if the reactor has been shutdown for more than 24 hours.

b. The D_2 concentration in the helium blanket shall not exceed 10% by volume. The temperature of the middle of the recombiner shall be greater than 50 ˚C during operation above 100 kW. The flow rate shall be between 1.5 and 8 cfm prior to reactor startup if the reactor has been shutdown for more than 24 hours.

c. The D_2 concentration in the helium blanket shall not exceed 6% by volume. The temperature of the middle of the recombiner shall be greater than 30 ˚C during operation above 100 kW. The flow rate shall be between 1.5 and 8 cfm prior to reactor startup if the reactor has been shutdown for more than 24 hours.

.

d. The D_2 concentration in the helium blanket shall not exceed 6% by volume. The temperature of the middle of the recombiner shall be greater than 50 ˚C during operation above 100 kW. The flow rate shall be greater than 1.5 cfm prior to reactor startup if the reactor has been shutdown for more than 24 hours.

QUESTION C.02 [1.0 point]
Which ONE of the following information is **NOT** required for the independent Estimated Critical Position (ECP) calculation?

a. ΔK due to xenon

b. ΔK due to sample loading

c. ΔK due to temperature change

d. ΔK due to Δ primary coolant flow rate

QUESTION C.03 [1.0 point]
If a presence of ____ is found in the secondary side of the reflector heat exchanger, a possible leak occurs from the D_2O system to the secondary system.

a. Tritium

b. Na-24

c. Ar-41

d. Al-28

QUESTION C.04 [1.0 point]
A “Low Pressure Personnel Lock” and a “Main Personnel Airlock Gaskets Deflated” alarm in the control room. This could be caused by:

a. A check valve fails; causing the Utility Room (UR) air compressor stops supplying air to door gaskets; but directly vented air to the Nuclear Engineering Building (NEB) air compressor.

b. A check valve fails; causing both the UR and the NEB air compressors provide a pressure air to door gaskets.

c. All air compressors supplied to door gaskets are inoperable.

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

QUESTION C.05 [1.0 point]
When a shield flow decreases to _______, the reactor will have _______.

a. 55 gpm / an automatic scram

b. 65 gpm / an automatic scram

c. 55 gpm / an Interlock

d. 65 gpm / a Rod Run Down

QUESTION C.06 [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 = 720 psig	1. Normal
b. Reg rod reaches near-in limit position and no operator action for 30 sec	2. Interlock
c. Pneumatic blower stops when exhaust fan stops	3. Rod Run down
d. Low Voltage chamber power supply = 200 V	4. Scram

QUESTION C.07 [1.0 point]
Which ONE of the following tables correctly provide a minimum number of required radiation monitors?

Channels	Table 1 (Minimum Number)	Table 2 (Minimum Number)	Table 3 (Minimum Number)	Table 4 (Minimum Number)
Area	1	1	1	1
Sewer	0	1	1	1
Secondary Coolant	1	1	0	1
Stack	1	1	1	1
Plenum	1	1	1	1
Building Airborne Reactivity	1	0	1	1
Primary Coolant	1	1	1	0

a. Table 1

b. Table 2

c. Table 3

d. Table 4

Category C: Facility and Radiation Monitoring Systems

QUESTION C.08 [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 can 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.09 [1.0 point]
Which ONE of the following best describes on how a signal of the Channel 3 (Log N Period) is fed to a logarithmic amplifier in the control room? A signal of the Channel 3 comes from:

a. (n,β) reaction with a voltage signal output.

b. (n,α) reaction with a current signal output

c. fission fragment with a pulse output

d. (n,p) reaction with a current signal output.

QUESTION C.10 [1.0 points]
The reactor operator could not switch from manual to auto control mode if the deviation between the power-set and the actual power exceeds 1.5%.   Where is the interlock coming from?

a. Period Channel (Channel 1)

b. Level Channel (Channel 4)

c. Linear Flux Channel (Channel 7)

d. Automatic Control Channel (Channel 9)

QUESTION C.11 [1.0 point]
The primary function of the discriminator in the Channel 1 (Startup Channel) 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.

QUESTION C.12 [1.0 point]
Per Technical Specifications, a minimum of the primary coolant flow rate is:

a. 1000 gpm

b. 1300 gpm

c. 1800 gpm

d. 2300 gpm

QUESTION C.13 [1.0 point]
If the radiation monitor in the off-gas system detects abnormal radiation levels, the pool ventilation will be automatically secured. Protection from overpressure of the coolant system in this condition is provided by:

a. a relief valve on the off-gas discharge piping which relieves to the main ventilation exhaust plenum.

b. the sample line connections between the isolation valves.

c. a vacuum breaker on suction side of the off-gas blower.

d. a blowout patch on the primary storage tank.

QUESTION C.14 [1.0 point]
Which ONE of the following is NOT a purpose of the shield coolant system?

a. Cool spectrometer magnets if spectrometers are operational.

b. Remove heat deposited by gamma rays from the shield.

c. Remove heat from the H_2O shutter tank.

d. Cool 3GV facility samples.

QUESTION C.15 [1.0 point]
The MAIN purpose of using CO_2 purge to blanket the graphite reflector is to:

a. reduce the production of Ar-41.

b. cool the empty space in the thermal column.

c. minimize the fast neutron flux in the thermal column.

d. maximize the thermal neutron flux in the thermal column.

QUESTION C.16 [1.0 point]
Which ONE of the following conditions prevents changing the reactor operation from a steady-state mode to an automatic mode?

a. All shim blades are above the subcritical interlock position.

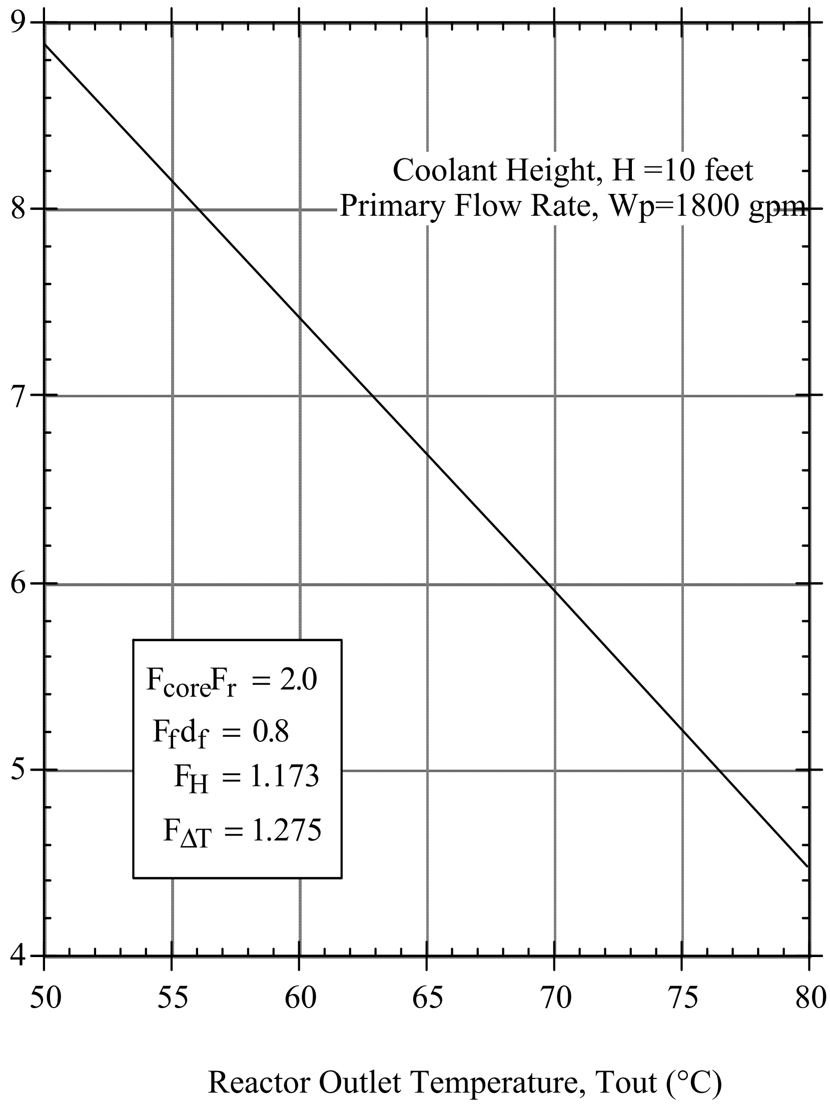
b. The regulating rod control switch is in the neutral position.

c. The regulating rod position indicates 6.00 inches of withdrawal.

d. The demand power sets at 215 μA, and the actual power indicates at 200 μA.

Category C: Facility and Radiation Monitoring Systems

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



a. Safety Limit for forced convection operations.

b. Limiting Conditions for Operations in all modes.

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

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

Category C: Facility and Radiation Monitoring Systems

QUESTION C.18 [1.0 point]
Which ONE of the following statements would consider a TS violation for the pH primary coolant?

a. The pH is between 6.0 and 7.0

b. The minimum pH is greater than 5.0.

c. The maximum pH is greater than 8.0

d. The maximum pH is less than 8.0

QUESTION C.19 [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.

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

Category A: Theory, Thermo & Fac. Operating Characteristics

A.01
Answer: a
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Sec 3.3.1

A.02
Answer: a
Reference: Shutdown = Total rod worth – core excess
11.3 beta – 5.5 beta = 5.8 beta
Minimum SDM = Shut down – highest worth of control rod
5.8 beta - 3.5 beta (blade number 2) = 2.3 beta

A.03
Answer: c
Reference: Reactivity added = 0.126 % Δk/k = 0.00126 Δ k/k

$$\tau = (\beta-\rho)/\lambda_{eff}\rho = \frac{0.0078 - 0.00126}{(0.1)(0.00126)} = 51.9 \text{ seconds}$$

A.04
Answer: d
Reference: Reactivity added by control rod = +(0.002 Δk/k/inch)((5 inches) = 0.01 Δ k/k
Fuel temperature change = - reactivity of rod/fuel temp. coeff.
(- 0.01 Δ k/k)/(- 1.25E-4 Δ k/k/°F) = 80 °F
Final Fuel temperature = 50 °F +80 °F = 130 °F

A.05
Answer: c
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Sec 7.3
Differential position is mid-point of 18.1 and 18.5 = 18.3
Differential blade worth (Δk/k/in) = (Δk/k) / (change in blade position)
= 0.1 (%Δ k/k) /0.4 in = 0.25 % Δk/k/in

A.06
Answer: c
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Sec 4.9

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

A.07
Answer: c
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Sec 4.2
Note: reactor is shutdown. When the insertion of 1 beta, Keff is less than 1.

A.08
Answer: b
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Sec 2.5

A.09
Answer: c
Reference: Reactor is continually increasing, since a reactor period is still positive.

A.10
Answer: c
Reference: Fission rate = thermal flux (Ø) x macroscopic cross-section. (Σ_f) = 1.0 x 10^{13} neutrons/cm^2/second x 0.1 cm^{-1} = 1.0 × 10^{12} neutrons/cm^3/second
Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Sec 2.6.2

A.11
Answer: b
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1982, Sec 3.3.3, page 3-21.
$\Delta\rho$ = keff1-keff2/(keff1 x keff2) = 0.95-0.8 /(0.8*0.95)=0.197

A.12
Answer: a
Reference: $P = P_0 e^{t/T}$ —> ln(2) = time ÷ 20 seconds –> time = ln (2) x 20 sec. 0.693 x 20 ≈ 13.8 sec.

A.13
Answer: a
Reference: Burn, R., Introduction of Nuclear Reactor Operations, © 1988, Sec 3.3.1

A.14
Answer: b
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Sec 3.3.1

A.15
Answer: a
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Sec 3.3.1

A.16
Answer: c
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Sec 8.2

A.17
Answer: c
Reference: P = P0 et/T —> T= t/Ln(P/ P0)
T= 30/Ln(100/50); T = 43 sec.

A.18
Answer: a, alpha   b, $_{+1}\beta^0$ c, neutron   d, alpha

A.19
Answer: b
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988, Sec 6.2

A.20
Answer: d
Reference: Burn, R., Introduction of Nuclear Reactor Operations, © 1988, Sec 4.2

Category B: Normal/Emergency Procedures and Radiological Controls

Category B: Normal/Emergency Procedures and Radiological Controls

B.01
Answer: c
Reference: TS 4.5.3

B.02
Answer: c
Reference: $A = A_\circ * e^{-\lambda t}$
$1Ci = 10\ Ci * e^{-\lambda(t)}$
$\lambda = \ln(2) / t$ - half-life
$\ln(1/10) = -\ln2/5\ yr*(t)$ --> -2.30/-0.138
solve for t: 16.6 years

B.03
Answer: a
Reference: TS 3.3.6

B.04
Answer: c
Reference: TS 7.5.2.2

B.05
Answer: b
Reference: EP 4.3.2.1 and 4.3.2.2

B.06
Answer: a(A) b(A) c(B) d(C) (0.5 each)
Reference: PM 1.4

B.07
Answer: b
Reference: TS 6.1.3

B.08
Answer: c
Reference: PM 4.4.4.14

B.09
Answer: c
Reference: 10CFR20 - At 20 feet, there is no beta radiation. Gamma at 20 feet = 0.1 mrem/hour, gamma at 1 foot = 40 mrem/hour. Therefore beta at 1 foot = 60 mrem/hour = 60%.

B.10
Answer: a,4 b,2 c,2 d,1 (0.25 each)
Reference: 10CFR55

B.11
Answer: b
Reference: DR1D12 = DR2D22 ;
Radiation area > 5 mrem/hour.
1000 mrem (1) 2 = 5 mrem (d) 2
D = 14.1 ft

B.12
Answer: b
Reference: 10CFR20

B.13
Answer: d
Reference: TS 1.3.43

B.14
Answer: c
Reference: 10CFR50.54(y)

B.15
Answer: d
Reference: PM 3.1.1.1 Page 4 of 15

B.16
Answer: d
Reference: PM 5.2.3

B.17
Answer: d
Reference: 10CFR55

B.18
Answer: c
Reference: $DR_1D_1^2 = DR_2D_2^2$;
20 mrem/hr at one meter (100 cm.)
results in 222.2 mrem/hr at 30 cm.

B.19
Answer: c
Reference: RSM 3.2.2

Category C: Facility and Radiation Monitoring Systems

C.01
Answer: a
Reference: T.S. 3.3.3

C.02
Answer: d
Reference: PM 3.1.5

C.03
Answer: a
Reference: RSM 7.4.1

C.04
Answer: c
Reference: RSM 8.2.1

C.05
Answer: a
Reference: RSM 6.5.7

C.06
Answer: a(1) b(3) c(2) d(4) (0.25 each)
Reference: RSM 9.3, 9.4

C.07
Answer: d
Reference: TS, Table 3.7.1-1

C.08
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.09
Answer: b
Reference: SAR 7.4.1

C.10
Answer: d
Reference: SAR 7.3.1 and Figure 7-1

C.11
Answer: b
Reference: RSM 5.2.1

C.12
Answer: c
Reference: TS, Table 3.2.3-1

C.13
Answer: d
Reference: RSM 3.2.5

C.14
Answer: c
Reference: SAR 5.4.1.2

C.15
Answer: a
Reference: RSM 3.7.2

C.16
Answer: d
Reference: RSM 4.3
It exceeds 1.5% limit.

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

C.18
Answer: c
Reference: TS 3.3.6

C.19
Answer: d
Reference: RSM 3.7.1