December 10, 2010

Dr. Samuel Frimpong, Chair
Mining and Nuclear Engineering
226 McNutt Hall
Missouri University of Science and Technology
Rolla, MO 65409-0450

SUBJECT: EXAMINATION REPORT NO. 50-123/OL-11-01,
MISSOURI UNIVERSITY OF SCIENCE AND TECHNOLOGY

Dear Dr. Frimpong:

During the week of November 15, 2010, the U.S. Nuclear Regulatory Commission (NRC) administered operator licensing examinations at your Missouri University of Science and Technology Reactor. The examination was conducted according to NUREG-1478, "Operator Licensing Examiner Standards for Research and Test Reactors," Revision 2. Examination questions and preliminary findings were discussed at the conclusion of the examination with those members of your staff identified in the enclosed report.

In accordance with Title 10, Section 2.390 of the Code of Federal Regulations, 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 (PARS) 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 Public Electronic Reading Room). The NRC is forwarding the individual grades to you in a separate letter which will not be released publicly. If 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,

/TBlount for RA/

Johnny H. Eads, Jr., Chief
Research and Test Reactors Oversight Branch
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Docket No. 50-123

Enclosures:
1. Examination Report No. 50-123/OL-11-01
2. Written examination with facility comments

cc without enclosures: see next page

December 10, 2010

Dr. Samuel Frimpong, Chair
Mining and Nuclear Engineering
226 McNutt Hall
Missouri University of Science and Technology
Rolla, MO 65409-0450

SUBJECT: EXAMINATION REPORT NO. 50-123/OL-11-02,
MISSOURI UNIVERSITY OF SCIENCE AND TECHNOLOGY

Dear Dr. Frimpong:

During the week of November 15, 2010, the U.S. Nuclear Regulatory Commission (NRC) administered operator licensing examinations at your Missouri University of Science and Technology Reactor. The examination was conducted according to NUREG-1478, "Operator Licensing Examiner Standards for Research and Test Reactors," Revision 2. Examination questions and preliminary findings were discussed at the conclusion of the examination with those members of your staff identified in the enclosed report.

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Sincerely,

/TBlount for RA/
Johnny H. Eads, Jr., Chief
Research and Test Reactors Oversight Branch
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Docket No. 50-123

Enclosures:
1. Examination Report No. 50-123/OL-11-01
2. Written examination with facility comments

cc without enclosures: See next page
DISTRIBUTION w/ encls.:
PUBLIC PROB r/f JEads Facility File CRevelle (O07-F8)
ADAMS ACCESSION #: ML

OFFICE	PROB:CE		IOLB:LA		PROB:BC	
NAME	JNguyen		CRevelle		TBlount for JEads	
DATE	11/30/2010		12/10/2010		12/13/2010	

OFFICIAL RECORD COPY

cc:

William Bonzer, Reactor Manager
Missouri University of Science and Technology
Nuclear Reactor Facility
1870 Miner Circle
Rolla, MO 65409-0630

Homeland Security Coordinator
Missouri Office of Homeland Security
P.O. Box 749
Jefferson City, MO 65102

Planner, Dept of Health and Senior Services
Section for Environmental Public Health
930 Wildwood Drive, P.O. Box 570
Jefferson City, MO 65102-0570

Deputy Director for Policy
Department of Natural Resources
1101 Riverside Drive
Fourth Floor East
Jefferson City, MO 65101

A-95 Coordinator
Division of Planning
Office of Administration
P.O. Box 809
State Capitol Building
Jefferson City, MO 65101

Test, Research, and Training
Reactor Newsletter
University of Florida
202 Nuclear Sciences Center
Gainesville, FL 32611

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

REPORT NO.: 50-123/OL-11-01

FACILITY DOCKET NO.: 50-123

FACILITY LICENSE NO.: R-79

FACILITY: Missouri University of Science and Technology

SUBMITTED BY: **/RA/** 12/1/2010
John T. Nguyen, Chief Examiner Date

SUMMARY:

During the week of November 15, 2010, the NRC administered examinations to four Reactor Operator license candidates and one Senior Reactor Operator Instant license candidates. Two Reactor Operator license candidates failed the written examination (one candidate failed section A and C and the other failed section A). All other license candidates passed all applicable portions of their examinations.

REPORT DETAILS

1. Examiner: John T. Nguyen, Chief Examiner

2. Results:

	RO PASS/FAIL	SRO PASS/FAIL	TOTAL PASS/FAIL
Written	2/2	1/0	3/2
Operating Tests	4/0	1/0	5/0
Overall	2/2	1/0	3/2

3. Exit Meeting:

Bill Bonzer, Reactor Manager
John Nguyen, NRC, Examiner

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

ENCLOSURE 1

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

FACILITY: University of Science and Technology (Rolla)

REACTOR TYPE: MTR

DATE ADMINISTERED: 11/15/10

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
16.00	33.3	_____	_____	A. REACTOR THEORY, THERMODYNAMICS AND FACILITY OPERATING CHARACTERISTICS
16.00	33.3	_____	_____	B. NORMAL AND EMERGENCY OPERATING PROCEDURES AND RADIOLOGICAL CONTROLS
16.00	33.3	_____	_____	C. FACILITY AND RADIATION MONITORING SYSTEMS
48.00		_____ 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 ___

(***** 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 ___

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 ___

(***** 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 ___

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 ___

(***** 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

$\dot{Q} = \dot{m}\, c_p\, \Delta T$

$\dot{Q} = \dot{m}\, \Delta h$

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

$$SUR = \frac{26.06\ (\lambda_{eff}\rho)}{(\beta - \rho)}$$

$SUR = 26.06/\tau$

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

$P = P_0\ e^{(t/\tau)}$

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

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

$\rho = (Keff-1)/Keff$

$\rho = \Delta Keff/Keff$

$\bar{\beta} = 0.007$

$DR_1D_1^2 = DR_2D_2^2$

$Cp\ (H20) = 0.146\ \frac{kw}{gpm \cdot {}^\circ F}$

$\lambda_{eff} = 0.1/sec$

$SCR = S/(1-Keff)$

$CR_1\ (1-Keff)_1 = CR_2\ (1-Keff)_2$

$$M = \frac{(1-Keff)_0}{(1-Keff)_1}$$

$M = 1/(1-Keff) = CR_1/CR_0$

$SDM = (1-Keff)/Keff$

$I = I_o\ e^{-ux}$

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

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

$R = 6\ C\ E\ n$

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

$DR = DR_o e^{-\lambda t}$

$P = S / (1 - Keff)$

---

1 Curie = 3.7×10^{10} dps

1 hp = 2.54×10^3 BTU/hr

1 BTU = 778 ft-lbf

931 Mev = 1 amu

1 kg = 2.21 lbm

1 Mw = 3.41×10^6 BTU/hr

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

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

QUESTION **A.1** [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 target nucleus mass increases

d. decreases as target nucleus mass increases

QUESTION **A.2** [1.0 point]

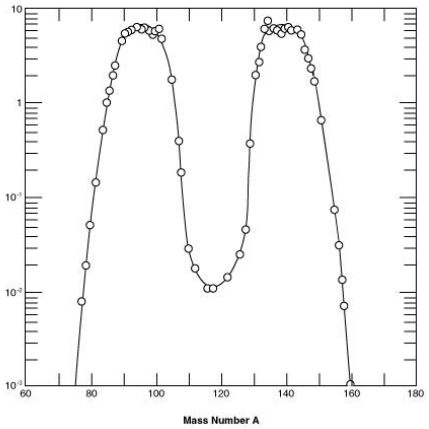
The following graph for U-235 depicts……

a. neutron energy distribution in the moderator

b. axial flux distribution in the core

c. radial flux distribution in the core

d. fission product yield distribution



QUESTION **A.3** [1.0 point]

Which ONE of the following is the MAJOR source of energy released during SHUTDOWN?

a. Energy of prompt gamma rays.

b. Energy of the decayed fission fragments.

c. Kinetic energy of the fission neutrons.

d. Kinetic energy of the fission fragments.

Section A Rx Theory, Thermo & Fac. Operating Characteristics

QUESTION **A.4** [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 2 compared to Reactor 1?

a. The resulting power level will be lower.

b. The resulting power level will be higher.

c. The resulting period will be longer.

d. The resulting period will be shorter.

QUESTION **A.5** [1.0 point]
What is β_{eff}?

a. The time required for the reactor to change by a power of e

b. The fraction of all fission neutrons that are born as delayed neutrons

c. The fraction of all delayed neutrons which reach thermal energy

d. The fractional change in neutron population per generation

QUESTION **A.6** [1.0 point]

With a 30 second period, power would double in approximately:

a. 15 seconds

b. 21 seconds

c. 32 seconds

d. 60 seconds

Section A Rx Theory, Thermo & Fac. Operating Characteristics

Question **A.7** [1.0 point]

Which of the following types of neutrons has a mean neutron generation lifetime of 12.5 seconds?

a. Prompt

b. Fast

c. Delayed

d. Thermal

Question **A.8** [1.0 point]

Which of the following statements is true about Xenon following a reactor scram?

a. The concentration of ^{135}Xe will decrease due to reduced nuclear flux

b. The concentration of ^{135}Xe will decrease by natural decay into ^{135}I

c. The concentration of ^{135}Xe will increase due to the decay of the ^{135}I inventory.

d. The concentration of ^{135}Xe will remain constant until it is removed via neutron burnout during the subsequent reactor startup.

QUESTION **A.9** [1.0 point]

Which **ONE** of the following conditions will **INCREASE** the shutdown margin of a reactor?

a. Lowering moderator temperature (Assume negative temperature coefficient).

b. Insertion of a positive reactivity worth experiment.

c. Burnout of a burnable poison.

d. Fuel depletion.

Section A Rx Theory, Thermo & Fac. Operating Characteristics

QUESTION **A.10** [1.0 point]

Which ONE of the following is the correct amount of reactivity added if the multiplication factor, k, is increased from 0.800 to 0.950?

a. 0.150

b. 0.158

c. 0.188

d. 0.197

QUESTION **A.11** [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

Section A Rx Theory, Thermo & Fac. Operating Characteristics

QUESTION **A.12** [1.0 point] Change made during administration of the examination.

Given the following Core Reactivity Data:

Control Rod	Total Worth (%dk/k)	Worth Removed (%dk/k)
Safety Rod 1	2.70	1.68
Safety Rod 2	3.20	2.60
Safety Rod 3	2.60	1.52
Regulating Rod	0.40	0.40

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

a. 2.70

b. 3.00

c. 5.70

d. 6.20

QUESTION **A.13** [1.0 point]

You enter the control room and note that all nuclear instrumentation show a steady neutron level, and no rods are in motion. Which ONE of the following conditions CANNOT be true?

a. The reactor is critical.

b. The reactor is subcritical.

c. The reactor is supercritical.

d. The neutron source has been removed from the core.

QUESTION **A.14** [1.0 point]

Inelastic scattering can be described as a process whereby a neutron collides with a nucleus and:

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

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

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

d. recoils with a higher kinetic energy, with the nucleus absorbing a gamma ray.

QUESTION **A.15** [1.0 point]

In a just critical reactor, adding one dollar worth of reactivity will cause:

a. A sudden drop in neutron flux.

b. The reactor period to be equal to $(\beta-\rho)/\lambda\rho$.

c. All prompt neutron term to become unimportant.

d. The resultant period to be a function of the prompt neutron lifetime.

QUESTION **A.16** [1.0 point]
An experiment to be placed in the central thimble 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

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

Section B Normal/Emergency Procedures and Radiological Controls

Question **B.1** [1.0 point]

The reactor is in a SHUTDOWN condition, as defined by MSTR Technical Specifications, when….

a. all rods are inserted and the reactor console is secured.

b. the reactor is subcritical by at least $1.00 in the reference core condition with the reactivity worth of all installed experiments included.

c. the reactor console is secured and no work is in progress involving core fuel, core structure, installed control rods, or control rod drives.

d. no experiments are being moved or serviced that have, on movement, a reactivity worth exceeding the maximum value allowed for a single experiment of $1.00.

Question **B.2** [1.0 point]

Two sheets of ¼ inch thick lead reduce a radiation beam from 200 mR/hr to 100 mR/hr at one foot. Which ONE of the following will be the radiation measurement at one foot if you add another two (for a total of 4) ¼ inch lead sheets?

a. 20 mR/hr.

b. 35 mR/hr.

c. 50 mR/hr.

d. 70 mR/hr.

Question **B.3** [1.0 point]

A room contains a source which, when exposed, results in a general area dose rate of 175 millirem per hour. This source is scheduled to be exposed continuously for 35 days. Select an acceptable method for controlling radiation exposure from the source within this room.

a. Lock the room to prevent inadvertent entry into the room.

b. Equip the room with a device to visually display the current dose rate within the room.

c. Equip the room with a motion detector that will alarm in the control room.

d. Post the area with the words "Danger-Radiation Area".

Section B Normal/Emergency Procedures and Radiological Controls

Question **B.4** [1.0 point]

The special unit for absorbed dose "Rem" is defined in 10 CFR Part 20 in terms of a dose equivalent. What does the term dose equivalent relate to?

a. It is derived by accounting for the amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in one year

b. It is equal to the absorbed dose (rad) multiplied by the quality factor (Q) of the radiation

c. It is equal to the absorbed dose (rad) divided by the quality factor (Q) of the radiation

d. It is the equivalent dose one would receive during the 50-year period following intake

Question **B.5** [1.0 point]

Which ONE of the listed radioisotopes produces the highest ionizing energy gamma?

a. H^{3}

b. N^{16}

c. Ar^{41}

d. U^{235}

Question **B.6** [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.

Section B Normal/Emergency Procedures and Radiological Controls

Question **B.7** [1.0 point]

Using a calibrated source of 5 curies of Co-60, what is the exposure rate at 6 feet from the source? Co-60 emits two gamma photons per decay with energies of 1.17 Mev and 1.33 Mev.

a. 750 mR/hr

b. 2.1 R/hr

c. 8.3 R/hr

d. 12.5 R/hr

Question **B.8** [1.0 point]

Which one of the following meets the definition of “Safety Limit”?

a. Setting for a an automatic protective device related to a variable having a significant safety function

b. Limits on important process variables to protect the fuel element cladding

c. Limits imposed on reactor core reactivity for a reference core condition

d. Constraints included in the Technical Specifications that are required for safe operation of the facility

Question **B.9** [1.0 point]

Which ONE of the following materials shall NOT be irradiated at MSTR?

a. A corrosive material.

b. A short half-life material.

c. 20 mg of explosive material.

d. Unsecured experiment of 0.50% $\Delta k/k$.

Section B Normal/Emergency Procedures and Radiological Controls

Question **B.10** [1.0 point]

What is the MINIMUM level of management who may authorize a key bypass of the control channel automatic function?

a. The Reactor Operator on Duty.

b. The Senior Reactor Operator on Duty.

c. The Reactor Manager.

d. The Reactor Director.

Question **B.11** [1.0 point]

An example of Byproduct Material would be….

a. Pu-239

b. U-233

c. U-235

d. Co-60

Question **B.12** [1.0 point]

“The reactor shall not be operated unless the pool water level is at least 16 feet above the core.” This is an example of a:

a. safety limit.

b. limiting safety system setting.

c. limiting condition for operation.

d. surveillance requirement.

Section B Normal/Emergency Procedures and Radiological Controls

Question **B.13** [1.0 point]

During Reactor operations, the Senior Reactor Operator (SRO) becomes ill and is taken to the hospital. Only the Reactor Operator (RO) and an experienced student remain in the facility. Reactor operations:

a. must be discontinued because both an RO and an SRO must be in the facility to satisfy Administrative Policy

b. must be discontinued because both an RO and an SRO must be in the facility to satisfy Technical Specifications

c. may continue until a replacement SRO can arrive at the facility within 60 minutes

d. may continue since the RO can monitor the console while the student can carry out prescribed written instructions and the RO shall call another SRO who is designated as the SRO-on call

Question **B.14** [1.0 point]

Before unloading of fuel elements from the core to the fuel storage rack, which ONE of the following tasks needs to be performed FIRST?

a. Calculate the shutdown margin.

b. Complete a startup checklist.

c. Turn off the Constant Air Monitor (CAM).

d. Withdraw Shim rods 1,2 and 3 to Shim range.

Question **B.15** [1.0 point]

Per MSTR Technical Specifications, which ONE of the following reactor periods will cause the reactor RUNDOWN?

a. 5 seconds.

b. 15 seconds.

c. 30 seconds.

d. 50 seconds.

Section B Normal/Emergency Procedures and Radiological Controls

Question **B.16** [1.0 point]

A release of airborne radioactive material where a person at the reactor site boundary is expected to receive a deep dose equivalent of 15 mrem over a 24 hour period is classified as:

a. Unusual Event

b. Alert

c. Site Area Emergency

d. General Emergency

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

Section C Facility and Radiation Monitoring Systems

Question **C.1** [1.0 point]

A signal of notification to the MST University Police Services is initiated by:

a. reactor pool water level low

b. HV safety channel off

c. primary water pump off

d. reactor fans off

Question **C.2** [1.0 point]

Nitrogen gas is used in the pneumatic transfer system instead of compressed air because:

a. it is more compressible

b. it does not retain moisture

c. it minimizes Ar-41 production

d. it minimizes N-16 production

Question **C.3** [1.0 point]

Normal evaporation for the MSTR pool is approximately:

a. 0.10 in per day

b. 0.5 in per day

c. 1.0 in per day

d. 2.0 in per day

Question **C.4** [1.0 point]

A signal for Rundown <15 sec period comes from the:

a. Startup channel

b. Log and Linear channel

c. Linear channel

d. Safety channel

Section C Facility and Radiation Monitoring Systems

Question **C.5** [1.0 point]

Which one of the following is a control rod interlock (RWP)?

a. CAM alarm

b. Ventilation off

c. Startup rate recorder off

d. Basement experimental area RAM alarm

Question **C.6** [1.0 point]

The MSTR is licensed to receive, possess and use …

a. up to 5.5 kg of U-235 enriched to less than 20 % in the form of reactor fuel.

b. up to 5.5 kg of U-235 enriched to less than 30 % in the form of reactor fuel.

c. up to 10 kg of U-235 enriched to less than 20 % in the form of reactor fuel.

d. up to 10 kg of U-235 enriched to less than 30 % in the form of reactor fuel.

Question **C.7** [1.0 point]

Which ONE of the following conditions does not allow the reactor operator from changing a steady-state mode to an AUTOMATIC mode during operations?

a. Two of shim rods are fully up.

b. Two of shim rods are fully down.

c. The regulating rod position indicates 6 inches of withdrawal.

d. The demand power sets at 125 kW, and the actual power indicates at 90 kW.

Section C Facility and Radiation Monitoring Systems

Question **C.8** [1.0 point]

Which ONE of the following is the actual design feature which prevents siphoning of pool water on a failure of the purification system?

a. A valve upstream of the primary pump will shut automatically.

b. A valve downstream of the primary pump will shut automatically.

c. The Emergency Fill system will automatically maintain pool level.

d. "Vacuum breaks" are located in the system which prevents draining the pool below about 16 feet above the core.

Question **C.9** [1.0 point]

Match each monitor and instrument (channel) listed in column A with a specific set point in column B. Items in column B is to be used only once.

	Column A		Column B
a.	Log & Linear Power Channel.	1.	2 cps
b.	Safety Channel.	2.	150% power
c.	Linear Channel	3.	5 sec period
d.	Start up Channel.	4.	Low HV 80%

Question **C.10** [1.0 point]

Which ONE of the following events will cause the audio/visual (BLUE) alarms?

a. Log N = 120%

b. Recorder off

c. Period < 30 sec

d. Safety channel = 150%

Section C Facility and Radiation Monitoring Systems

Question **C.11** [1.0 point]

The equations which describe the operation of the neutron source are:

a. Pu-239 -> alpha + U-235 B-10 + alpha -> N-13 + neutron

b. Pu-239 -> beta + Am-239 B-10 + beta -> Be-9 + neutron

c. Pu-239 -> alpha + U-235 Be-9 + alpha -> C-12 + neutron

d. Pu-239 -> beta + Am-239 Be-9 + beta -> Li-8 + neutron

Question **C.12** [1.0 point]

Which ONE of the following describes the operation of the building ventilation system exhaust duct and intake louvers?

a. The louvers automatically close when the ventilation fans are turned off.

b. The louvers automatically close when the building evacuation alarm sounds.

c. The louvers automatically close when any radiation area monitor alarms.

d. When the louvers reach their fully-closed position, the ventilation fans automatically turn off.

Question **C.13** [1.0 point]

Which ONE of the following is the Limiting Safety System Settings (LSSS) for the MSTR?

a. The cladding temperature must not exceed 510 °C.

b. The cladding temperature must not exceed 527 °C.

c. The thermal power shall not exceed 240 kW (120% of full power).

d. The thermal power shall not exceed 300 kW (150% of full power).

Section C Facility and Radiation Monitoring Systems

Question **C.14** [1.0 point]

Which part of the shim/safety rod assembly is responsible for ensuring that the rod receives more torque for inserting the rod than for withdrawing the rod?

a. Dashpot Assembly

b. Slip Clutch Assembly

c. Magnet Assembly

d. Linear Actuator

Question **C.15** [1.0 point]

Following a loss of building electrical power:

a. power to reactor instrumentation will not be lost due to a fast transfer (less than 50 msec) to the reserve supply.

b. power to reactor instrumentation will be restored following a 5 second time delay as transfer to the reserve supply occurs.

c. power will be lost to reactor instrumentation but will be automatically restored when building power returns.

d. power will be lost to reactor instrumentation and will not return until building power returns and the power supplies are manually reset.

Question **C.16** [1.0 point]

The ion exchanger resin has an upper limit for operation. This temperature is …

a. 46 °C (115 °F)

b. 57 °C (135 °F)

c. 78 °C (172 °F)

d. 90 °C (194 °F)

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

Section A Rx Theory, Thermo & Fac. Operating Characteristics

A.1
Answer: b
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, §

A.2
Answer: d
Reference: DOE Manual Vol. 1, pg. 57

A.3
Answer: b
Reference: Introduction to Nuclear Operation, Reed Burn, 1988, Sec 3.2, page 3-5

A.4
Answer: d
Reference: Equation Sheet. $\tau = (\ell^*/\rho) + [(\beta-\rho)/\lambda_{eff}\rho]$

A.5
Answer: ~~b~~ c Corrected typographical error
Reference: DOE Handbook, Vol. 2, Section 2.0

A.6
Answer: b
Reference: $P=P_o e^{t/\tau}$ or $t/T= \ln (P/P_o)$. $t=30*\ln(2)$; $t= 21$ sec

A.7
Answer: c
Reference: DOE Handbook Vol. 1 Section 3.0

A.8
Answer: c
Reference: Following a reactor shutdown, xenon-135 concentration will increase due to the decay of the iodine inventory of the core.
DOE Handbook, Vol. 2, Section 4

A.9
Answer: d
Reference: Standard NRC question

A.10
Answer: d
Reference:
Burn, R., *Introduction to Nuclear Reactor Operations,* © 1982, Sec 3.3.3, page 3-21.
In order to solve the question A.08, the applicant can use one of the following methods:
At k=0.8; $\rho = \Delta Keff/Keff$ or $\rho = Keff-1/Keff = -0.2/0.8 = -0.25$. At k=0.95, $\rho = -0.05/0.95$
$\rho = -0.053$. The difference between ρ is the answer ,i.e. $-0.053-(-0.25)=0.197$
$\Delta \rho = \rho 1 - \rho 2$ where $\rho 1 = Keff1-1/Keff1$ and $\rho 2 = Keff2-1/Keff2$. Substitute ρ1 and ρ2 with Keff1 and Keff2 into the equation above, the result is $\Delta\rho = keff1-keff2/(keff1 \times keff2)$

Section A Rx Theory, Thermo & Fac. Operating Characteristics

A.11
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.12
Answer: b
Reference:
SDM = $\sum$(B) - Max. (A) = 6.20%dk/k – 3.20%dk/k = 3.00 %dk/k

A.13
Answer: c
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1988,

A.14
Answer: a
Reference: DOE Handbook Vol I, pg. 45

A.15
Answer: d
Reference: Introduction to Nuclear Operation, Reed Burn, 1988, Sec 4.2, page 4-4

A.16
Answer: a
Reference: NRC Standard Question.

Section B Normal/Emergency Procedures and Radiological Controls

B.1
Answer: b
Reference: TS 1.2

B.2
Answer: c
Reference: A ½ thickness is 2 sheets. Add another 2 sheets, a radiation level will reduce by another ½, or 50 mR/hr

B.3
Answer: a
Reference: 10CFR20.1601(a)(3)

B.4
Answer: b
Reference: 10CFR20.1003 and NRC Training Material

B.5
Answer: b.
Reference: Chart of the Nuclides

B.6
Answer: b
Reference: NRC standard question

B.7
Answer: b
Reference: $R/hr = 6CE/r^2 = 6 \times 5 \times 1*(1.17+1.33)/ 6^2 = 2.08$ R/hr

B.8
Answer: b
Reference: TS 1.2

B.9
Answer: d
Reference: TS 3.7

B.10
Answer: b
Reference: SOP 101.B.9

B.11
Answer: d
Reference: Byproduct material is radioactive material made radioactive by the process of using special nuclear material; 10 CFR Part 20.1003

B.12
Answer: c
Reference: TS 3.3.1

Section B Normal/Emergency Procedures and Radiological Controls

B.13
Answer: d
Reference: TS 6.1.3

B.14
Answer: b
Reference: SOP 207

B.15
Answer: b
Reference: TS 3.1

B.16
Answer: a
Reference: EP Table I, page 10

Section C Facility and Radiation Monitoring Systems

C.01
Answer: a
Reference: Facility walkthrough

C.02
Answer: c
Reference: SAR 10.2

C.03
Answer: a
Reference: SOP 309, Sec B

C.04
Answer: b
Reference: SAR 7.1, Table 7.1

C.05
Answer: c
Reference: SAR 7.2

C.06
Answer: a
Reference: SAR 9.5

C.07
Answer: d
Reference: SAR 7.2.2.6 page 7-8, the servo system interlock (>2% of set point)

C.08
Answer: d
Reference: SOP 309 *Response to a Coolant System Leak*

C.09
Answer: a(3) b(2) c(4) d(1)
Reference: SAR 7.2

C.10
Answer: ~~c~~ a Corrected typographical error
Reference: SAR 7.2.2

C.11
Answer: c
Reference: SOP-653

C.12
Answer: a
Reference: SAR 9.1

C.13
Answer: d
Reference: TS 2.2

Section C Facility and Radiation Monitoring Systems

C.14
Answer: b
Reference: SAR 3.2

C.15
Answer: d
Reference: SOP-308

C.16
Answer: b
Reference: SAR 5.2