August 18, 2011

Dr. Sastry Sreepada, Director
Department of Mechanical, Aerospace
And Nuclear Engineering
Building JEC – Room2032
Rensselaer Polytechnic Institute
110 8th Street
Troy, NY 12180-3590

SUBJECT: INITIAL EXAMINATION REPORT NO. 50-225/OL-11-01, RENSSELAER POLYTECHNIC INSTITUTE

Dear Dr. Sreepada:

During the week of June 6, 2011, the U.S. Nuclear Regulatory Commission (NRC) administered operator licensing examination at your Rensselaer Polytechnic Institute reactor. The examination was conducted according to NUREG-1478, "Operator Licensing Examiner Standards for Research and Test Reactors," Revision 2, published in June 2007. 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 Patrick Isaac at 301-415-1019 or via email at patrick.isaac@nrc.gov.

Sincerely,

/RA/

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

Docket No. 50-225

Enclosures: 1. Examination Report No. 50-225/OL-11-01
2. Corrected Written Examination

cc w/enclosures: Mr. Jason Thompson, Rensselaer Polytechnic Institute

cc w/o enclosures: See next page

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DISTRIBUTION w/ enclosures.:
PUBLIC PROB r/f JEads Facility File (CRevelle)

ADAMS ACCESSION #: ML112160392

OFFICE	**PROB:CE**		**IOLB:LA**		**PROB:BC**	
NAME	**PIsaac**		**CRevelle**		**JEads**	
DATE	**8/4/11**		**8/9/11**		**8/18/11**	

OFFICIAL RECORD COPY

cc:

Mayor of the City of Schenectady
Schenectady, NY 12305

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Radioactive Waste Policy and Nuclear Coordination
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Albany, NY 12203-6399

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

EXAMINATION REPORT NO: 50-225/OL-11-01

FACILITY: Rensselaer Polytechnic Institute

FACILITY DOCKET NO.: 50-225

FACILITY LICENSE NO.: CX-22

SUBMITTED BY: /RA/ 8/01/2011
Patrick J. Isaac, Chief Examiner Date

SUMMARY:

During the week of June 6, 2011, the NRC administered a retake of the written operator licensing examination to two Senior Reactor Operator (SRO) candidates. Both candidates failed the examinations.

REPORT DETAILS

1. Examiner: Patrick J. Isaac, Chief Examiner

2. Results:

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

3. Exit Meeting:

Jason Thompson, Rensselaer Polytechnic Institute
Patrick Isaac, NRC, Examiner

The NRC Examiner agreed to make the following changes to the written examination:

Question A.11 - Delete due to confusion in the response.

Question B. 2 - Accept both “C” and “D” as correct answers

Question B.8 - Delete due to 3 out of 4 correct answers

Question C.15 - Delete the question as the equipment in question is no longer in use

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

FACILITY: RPI

REACTOR TYPE: Critical Experimental

DATE ADMINISTERED: 06/06/2011

CANDIDATE:

INSTRUCTIONS TO CANDIDATE:
Answers are to be written on the answer sheet provided. Attach the answer sheets to the examination. Points for each question are indicated in parentheses for each question. A 70% in each section 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
19.00	36.5	___________	____	A. REACTOR THEORY, THERMODYNAMICS AND FACILITY OPERATING CHARACTERISTICS
16.00	30.8	___________	____	B. NORMAL AND EMERGENCY OPERATING PROCEDURES AND RADIOLOGICAL CONTROLS
17.00	32.7	___________	____	C. FACILITY AND RADIATION MONITORING SYSTEMS
52.00		___________ FINAL GRADE	____%	TOTALS

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

Candidate's Signature

Section A – Theory & Fac. Operating Characteristics

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.

MULTIPLE CHOICE

001 a b c d ___

002 a b c d ___

003 a b c d ___

004 a b c d ___

005 a b c d ___

006 a b c d ___

007 a b c d ___

008 a b c d ___

009 a b c d ___

010 a b c d ___

011 a b c d ___

012 a b c d ___

013 a b c d ___

014 a b c d ___

015 a b c d ___

016 a b c d ___

017 a b c d ___

018 a b c d ___

019 a b c d ___

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

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.

001 a b c d ___

002 a b c d ___

003 a b c d ___

004 a b c d ___

005 a b c d ___

006 a ___ b ___ c ___ d ___

007 a b c d ___

008 a b c d ___

009 a b c d ___

010 a ___ b ___ c ___ d ___

011 a b c d ___

012 a b c d ___

013 a b c d ___

014 a b c d ___

015 a b c d ___

016 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.

001 a b c d ___

002 a b c d ___

003 a ___ b ___ c ___ d ___

004 a b c d ___

005 a b c d ___

006 a b c d ___

007 a b c d ___

008 a b c d ___

009 a b c d ___

010 a b c d ___

011 a b c d ___

012 a b c d ___

013 a b c d ___

014 a b c d ___

015 a b c d ___

016 a b c d ___

017 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

$Q = m\, c_p\, \Delta T$

$CR_1\,(1\text{-}K_{eff})_1 = CR_2\,(1\text{-}K_{eff})_2$

$SUR = 26.06/\tau$

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

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

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

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

$DR_1 D_1^2 = DR_2 D_2^2$

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

$DR = 6CiE/D^2$

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

1 eV = 1.6×10^{-19} watt-sec.

1 Curie = 3.7×10^{10} dps

1 gallon water = 8.34 pounds

1 Btu = 778 ft-lbf

°F = 9/5°C + 32

1 Mw = 3.41×10^{6} BTU/hr

°C = 5/9 (°F - 32)

Question: A.1 [1.0 point]

U-235 delayed neutron fraction (β_i) is listed as being 0.0065Δρ in most nuclear text books. Most research reactors however have an effective delayed neutron fraction ($\beta_{effective}$) of 0.0070 Δρ. Which one of the following is the reason for this difference?

a. Delayed neutrons are born at higher energies than prompt neutrons resulting in a greater worth for the neutrons.

b. The fuel includes U^{238} which has a relatively large β for fast fission.

c. Delayed neutrons are born at lower energies than prompt neutrons resulting in a greater worth for the neutrons.

d. The fuel includes U^{238} which via neutron absorption becomes Pu^{239} which has a larger β for fission.

Question: A.2 [1.0 point]

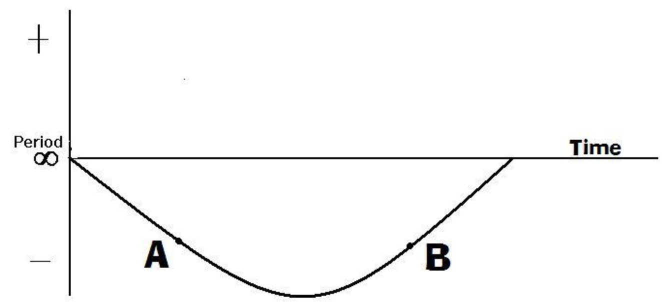
The figure depicts a plot of reactor period as a function of time. What best describes the behavior of **REACTOR POWER** between points A and B:

a. Constant

b. Continually decreasing

c. Decreasing then increasing

d. Continually increasing



Question: A.3 [1.0 point]

Given a high power scram set at 110%, and a scram delay time of 0.5 sec, if the reactor is operating at 100% power prior to the scram, approximately how high will reactor power get with a positive 20 second period?

a. 113%

b. 116%

c. 124%

d. 225%

Question: A.4 [1.0 point]

Which ONE of the following isotopes has the largest microscopic cross-section for absorption for thermal neutrons?

a. Sm^{149}

b. Xe^{135}

c. U^{235}

d. B^{10}

Question: A.5 [1.0 point]

Which one of the following is the MAJOR source of energy recovered from the fission process?

a. Kinetic energy of the fission neutrons

b. Kinetic energy of the fission fragments

c. Decay of the fission fragments

d. Prompt gamma rays

Question: A.6 [1.0 point]

Which factors of the six factor formula are affected by a **DECREASE** in core temperature and how are they affected?

a. $\uparrow\varepsilon$, $\uparrow P_{FNL}$, $\downarrow P_{TNL}$, $\uparrow p$, $\downarrow\eta$

b. $\uparrow P_{FNL}$, $\uparrow P_{TNL}$, $\uparrow\varepsilon$, $\downarrow f$, $\uparrow p$

c. $\uparrow\varepsilon$, $\downarrow P_{FNL}$, $\downarrow P_{TNL}$ $\downarrow p$, $\uparrow f$

d. $\uparrow\varepsilon$, $\uparrow P_{FNL}$ $\downarrow P_{TNL}$ $\uparrow p$, $\downarrow\eta$, $\downarrow f$

Question: A.7 [1.0 point]

K-effective differs from K-infinite in that K-effective takes into account:

a. leakage from the core

b. neutrons from fast fission

c. the effect of poisons

d. delayed neutrons

Question: A.8 [1.0 point]

The following shows a decay chain for the radioactive element Radon (Rn). This decay chain is a good example of ___ decay.

$$^{222}_{86}Rn \xrightarrow{3.8\text{ d}} {}^{218}_{84}Po$$

a. Alpha

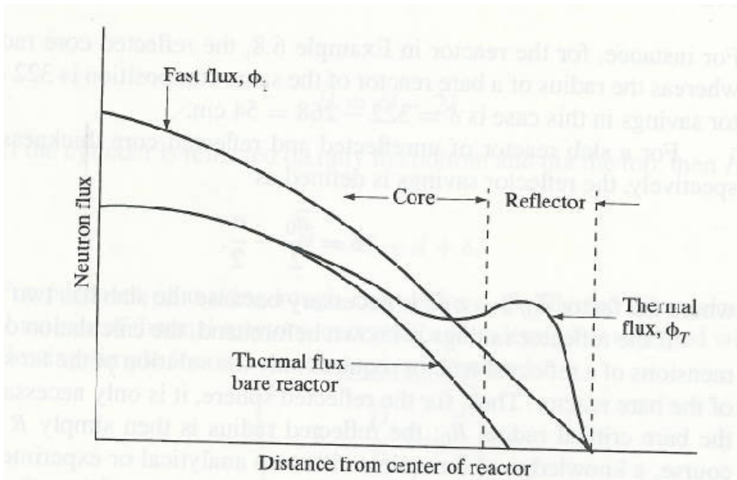
b. Beta

c. Gamma

d. Neutron

Question: A.9 [1.0 point]

The following figure shows fast and thermal fluxes in a reflected and non-reflected thermal reactor. Which of the following statements is true regarding a typical reflector?



a. A reflector has a high cross section for absorption which **increases** the peak power to average power ratio.

b. A reflector has a high cross section for scattering, which **increases** the peak to average power ratio

c. Thermal neutrons tend to accumulate in the reflector until they leak back into the core, escape, or become absorbed, which **reduces** the peak to average power ratio.

d. Fast neutrons become absorbed in the reflector fuel, which raises the thermal flux and **reduces** the peak to average power ratio.

Question: A.10 [1.0 point]

Which of the following statements is the predominant factor for the change in Xenon concentration following a reactor scram?

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

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

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

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

Question: A.11 [1.0 point] **DELETED**

You perform two initial startups a week apart. Each of the startups has the same starting conditions, (core burnup, pool and fuel temperature, and count rate are the same). The only difference between the two startups is that during the **SECOND** one you stop for 10 minutes to answer the phone. For the second startup compare the critical rod height and count rate to the first startup.

	Rod Height	Count Rate
a.	Higher	Same
b.	Lower	Same
c.	Same	Lower
d.	Same	Higher

Question: A.12 [1.0 point]

You enter the control room and observe that the neutron instrumentation indicates a steady neutron level with no rods in motion. Which ONE condition below CANNOT be true?

a. The reactor is critical.

b. The reactor is subcritical.

c. The reactor is supercritical.

d. The neutron source is in the core.

Question: A.13 [1.0 point]

Which ONE of the following is the reason for the -80 second period following a reactor scram?

a. The negative reactivity added during a scram is greater than Keffective

b. The half-life of the longest-lived group of delayed neutron precursors is approximately 55 seconds

c. The fuel temperature coefficient adds positive reactivity as the fuel cools down, thus retarding the rate at which power drops

d. The amount of negative reactivity added is greater than the Shutdown Margin

Question: A.14 [1.0 point]

Which ONE of the following describes the term prompt jump?

a. The instantaneous change in power level due to withdrawing a control rod.

b. A reactor which has attained criticality on prompt neutrons alone.

c. A reactor which is critical using both prompt and delayed neutrons.

d. A positive reactivity insertion which is less than β_{eff}.

Question: A.15 [1.0 point]

Which ONE of the following describes the difference between reflectors and moderators?

a. Reflectors decrease core leakage while moderators thermalize neutrons

b. Reflectors shield against neutrons while moderators decrease core leakage

c. Reflectors decrease thermal leakage while moderators decrease fast leakage

d. Reflectors thermalize neutrons while moderators decrease core leakage

Question: A.16 [1.0 point]

Which ONE of the following statements describes the difference between Differential (DRW) and Integral (IRW) rod worth curves?

a. DRW relates the worth of the rod per increment of movement to rod position. IRW relates the total reactivity added by the rod to the rod position.

b. DRW relates the time rate of reactivity change to rod position. IRW relates the total reactivity in the core to the time rate of reactivity change.

c. IRW relates the worth of the rod per increment of movement to rod position. DRW relates the total reactivity added by the rod to the rod position.

d. IRW is the slope of the DRW at a given rod position

Question: A.17 [1.0 point]

With the reactor on a constant period, which transient requires the LONGEST time to occur?

A reactor power change of:

a. 5% power going from 1% to 6% power

b. 10% power going from 10% to 20% power

c. 15% power going from 20% to 35% power

d. 20% power going from 40% to 60% power

Question: A.18 [1.0 point]

Which one of the following is NOT a reason for or benefit of operating with a flat neutron flux profile?

a. A higher average power density is possible.

b. More even burn up of fuel results.

c. Moderator temperature is equalized throughout the core.

d. Control rod worth is made more uniform.

Question: A.19 [1.0 point]

Of the approximately 200 Mev of energy released per fission event, the largest amount appears in the form of:

a. beta and gamma radiation

b. prompt and delayed neutrons

c. fission fragments

d. alpha radiation

Question: A.20 [1.0 point]

Which ONE of the following describes "Excess Reactivity"?

a. Extra reactivity into the core due to the presence of the source neutrons.

b. A measure of the resultant reactivity if all of the control rods and other poisons were removed.

c. The combined reactivity worth of control rods and other poison needed to keep the reactor shutdown.

d. The maximum reactivity insertion with the reactor shutdown with control rods fully inserted under peak Xenon conditions.

(*** End of Section A ***)

Question: B.1 [1.0 point]

In order to ensure the health and safety of the public, in an emergency, 10CFR50 allows the operator to deviate from Technical Specifications. What is the minimum level of authorization needed to deviate from Tech. Specs?

a. USNRC

b. Reactor Supervisor

c. Licensed Senior Reactor Operator.

d. Licensed Reactor Operator.

Question: B.2 [1.0 point]

In accordance to technical specification, the safety limit set for the fuel pellet temperature resulting from normal operation or transient effects is limited to _________

a. 300 ^{o}C

b. 500 ^{o}C

c. 1000 ^{o}C

d. 1700 ^{o}C

Question: B.3 [1.0 point]

Which one of the following statements defines the Technical Specifications term "Channel Test?"

a. The adjustment of a channel such that its output corresponds with acceptable accuracy to known values of the parameter which the channel measures

b. The qualitative verification of acceptable performance by observation of channel behavior

c. The introduction of a simulated signal into the instrument primary sensor for verification of proper instrument response alarm and/or initiating action.

d. The combination of sensors, electronic circuits and output devices connected to measure and display the value of a parameter

Question: B.4 [1.0 point]

According to the RPI Technical Specifications what are the requirements for the Licensed Senior Reactor Operator (LSO) to be *Readily Available on Call* while on duty?

a. Whenever the reactor is not shutdown, the LSO on duty is not required to be in the control room, but must be at the facility,

b. Whenever the reactor is not shutdown, the LSO on duty shall remain within a 10 mile radius

c. Whenever the reactor is not shutdown, the LSO on duty shall remain within 15 minutes of the facility or within a 20 mile radius, whichever is closer

d. Whenever the reactor is not shutdown, the LSO on duty shall remain within 30 minutes of the facility or a 15 mile radius, whichever is closer.

Question: B.5 [2.0 points, 0.5 each]

Assuming that no channels are bypassed, the safety system channels which are required by the Technical Specifications to be operating in all modes of operation are:

a. log N power level, reactor period, pool water level

b. linear power level, manual scram, criticality detector

c. reactor period, water dump valve scram, manual scram

d. log N power level, reactor door scram, manual scram

Question: B.6 [2.0 points, 0.5 each]

Match the radiation reading from column A with its corresponding radiation area classification (per 10 CFR 20) listed in column B.

Column A	Column B
a. 10 mRem/hr	1. Unrestricted Area
b. 150 mRem/hr	2. Radiation Area
c. 10 Rem/hr	3. High Radiation Area
d. 550 Rem/hr	4. Very High Radiation Area

Question: B.7 [1.0 point]

A radioactive source generates a dose of 100 mr/hr at a distance of 10 feet. Using a two inch thick sheet of lead for shielding the reading drops to 50 mr/hr at a distance of 10 feet. What is the minimum number of sheets of the same lead shielding needed to drop the reading to less than 5 mr/hr at a distance of 10 ft?

a. 1

b. 3

c. 5

d. 7

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

All of the following are interlocks that prevent control rod withdrawal during reactor operations EXCEPT:

a. failure of line voltage to recorders.

b. water level in reactor tank 12 inches above core top grid.

c. neutron flux = 60 counts per minute.

d. fill pump running

Question: B.9 [1.0 point]

In the event of a suspected fuel leak from a SPERT fuel element, which of the following nuclides would most likely be found in an **Air Particulate** Sample?

a. Rn-226

b. Xe-133

c. Cs-138

d. Co-60

Question: B.10 [2.0 points, 0.5 each]

Match the requirements (10 CFR 55) for maintaining an active operator license in column A with the correct time period from column B.

Column A	Column B
a. Renewal of license	1. 4 months
b. Medical examination	2. 1 year
c. Console manipulation evaluation	3. 2 years
d. Requalification exam (written)	4. 6 years

Question: B.11 [1.0 point]

Which one of the following at the RPI Critical Facility **DOES NOT** require the presence of a Senior Reactor Operator (SRO)?

a. The manipulation of reactor console controls by a student in training

b. The relocation of an in-core experiment with worth equivalent to $1.00

c. Removal of the control rods for maintenance

d. The rearrangement of two fuel assemblies

Question: B.12 [1.0 point]

According to the Emergency Plan, how frequently the emergency signal of the critical facility is checked?

a. Bi-annually

b. Annually

c. Quarterly

d. Semi-annually.

Question: B.13 [1.0 point]

According to the Emergency Plan, the decision to perform preliminary decontamination on site will be made by

a. By the individual

b. Senior Operator

c. The radiation Safety Officer

d. The radiation treatment team at the hospital.

Question: B.14 [1.0 point]

Which one of the following does NOT require NRC approval for changes?

a. Facility License

b. Requalification plan

c. Emergency Implementation Procedures

d. Emergency Plan

Question: B.15 [1.0 point]

Which ONE of the following actions is required for a spill involving material that contains 15 microcuries of beta gamma emitters:

a. confine the spill immediately.

b. vacate and secure the affected room.

c. right the container of spilled material.

d. drop absorbent paper on the liquid spill.

Question: B.16 [1.0 point]

For a known core arrangement, the addition, movement, or removal of fuel will be limited to…..

a. ½ the difference between the current number of fuel pins and the linearly extrapolated critical number from the 1/M plot or 50 fuel pins, whichever is smaller

b. $0.10 of reactivity or 4 fuel pins, whichever is greater

c. $0.20 of reactivity or 4 fuel pins, whichever is smaller

d. $0.30 of reactivity or 2 fuel pins, whichever is smaller

Question: B.17 [1.0 point]

It is April 1, 2011. You have stood watch for the following hours during the last quarter:

Jan. 11, 2011	0.5 hours
Feb. 24, 2011	1.5 hours
Mar. 16, 2011	1.0 hours

What requirements must you meet in order to stand an RO watch today?

a. None. You've met the minimum requirements of 10 CFR 55.

b. You must perform 4 hours of shift functions under the direction of a licensed operator or licensed senior operator as appropriate.

c. You must perform 6 hours of shift functions under the direction of a licensed operator or licensed senior operator as appropriate.

d. You must submit a new application form to the NRC requesting a waiver to reactivate your license.

(*** End of Section B ***)

Question: C.1 [1.0 point]

A linear power channel (LP1 or LP2) uses a (an):

a. uncompensated ion chamber

b. compensated ion chamber

c. fission chamber

d. boron-trifluoride detector

Question: C.2 [1.0 point]

Period information is supplied from the:

a. BF_3 detector.

b. Linear Channel 1.

c. Linear Channel 2.

d. Log Amplifier.

Question: C.3 [1.0 point]

Match the alarm setpoint on area gamma (radiation) monitors with location

a. Control room	1. 20mr/hr
b. Equipment hallway	2. 10mr/hr
c. Reactor room	3. 100mr/hr
d. Reactor deck	4. 40mr/hr

Question: C.4 [1.0 point]

Which ONE of the following describes the ventilation system for the reactor room?

a. It uses natural circulation with a single vent to the outside stack.

b. It uses natural circulation sharing a vent with the control room that is isolated on measured HIGH Ar-41.

c. It shares a forced fan vent with the control room with back draft dampers to prevent cross-contamination.

d. It uses a single vent with natural circulation during normal operation with a forced fan starting on measured HIGH Ar-41.

Question: C.5 [1.0 point]

Fuel pellet expansion in the SPERT fuel pins is most likely accommodated by __________.

a. the stainless steel cladding

b. the He fill gas around the fuel pellets

c. the small dowel on the lower end cap which inserts into the lower grid plate

d. the chromium nickel spring in the upper plenum region

Question: C.6 [1.0 point]

The Dump Valve Bypass control:

a. allows air to be admitted to the dump valve operator regardless of the scram condition

b. bleeds air from the dump valve operator to ensure that the valve opens on a scram

c. recloses the dump valve once it has opened if no scram conditions exist

d. locks air onto the dump valve operator if an automatic scram occurs but still allows response to manual scrams

Question: C.7 [1.0 point]

The structure within the core that forms the base of the three-tiered core-support structure is the:

a. carrier plate.

b. plastic spacer plate.

c. fuel pin lattice plate.

d. unistrut support plate.

Question: C.8 [1.0 point]

Maximum control rod motion is limited to:

a. 22 inches, the length of the active absorber in the control rod.

b. 42 inches, the nominal length of a fuel pin.

c. 36 inches, the effective height of the core.

d. 64 inches, the height of water in the tank.

Question: C.9 [1.0 point]

The area gamma monitoring system has detectors located in the control room, in the reactor room:

a. on the reactor deck and outside the reactor room window.

b. in the counting room and outside the reactor room window.

c. on the reactor deck and in the fuel storage vault.

d. in the counting room and in the fuel storage vault.

Question: C.10 [1.0 point]

The water dump valve operation may be by-passed by:

a. locking closed the water dump valve operator locally.

b. depressing the bypass pushbutton on the main control panel.

c. placing key switch located on CP-2 to the "By-pass" position.

d. disconnecting the DC current output at the Solenoid Interrupt Circuit module.

Question: C.11 [1.0 point]

What is the Most Severe Hypothetical Accident at the RPI CRF?

a. Insertion of excess reactivity

b. Loss of Normal Electric Power

c. Loss of coolant flow

d. The loss of coolant from the reactor tank and leaking outside of confinement space

Question: C.12 [1.0 point]

The startup channel detector provides indication of neutron flux by using:

a. current which is triggered by a neutron fission event occurring in the detector.

b. current which is proportional to the number of neutron interactions in the detector.

c. pulses which are triggered by a neutron absorption event occurring in the detector.

d. pulses which are inversely proportional to the input energy of the neutron interaction in the detector.

Question: C.13 [1.0 point]

Which ONE of the following describes the device used for calibrating the logarithmic power channel?

a. Gold-foil neutron flux pin.

b. Boron-impregnated neutron flux pin.

c. Stochastic thermal power temperature recorder.

d. Local gamma-flux power radiation level recorder.

Question: C.14 [1.0 point]

Which ONE of the following describes the warning output of the criticality detector system (area monitor)?

a. An audible alarm is provided in the control room and a visual alarm is provided outside the facility.

b. An audible and visual alarm is provided in the control room.

c. Audible alarm is provided in the reactor room and a visual alarm is provided in the control room.

d. An audible and visual alarm is provided in the reactor room.

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

The reactor is operating at 100% power when the 400 cycle MG set fails. As a result:

a. control rods cannot be moved.

b. the dump valve automatically opens.

c. the reactor scrams.

d. control rods cannot be withdrawn.

Question: C.16 [1.0 point]

When there is a loss of power, the reactor tank pump suction valve:

a. fails OPEN, and the discharge valve fails CLOSED.

a. fails OPEN, and the discharge valve fails OPEN.

b. fails CLOSED, and the discharge valve fails CLOSED.

c. fails CLOSED, while the discharge valve fails OPEN.

Question: C.17 [1.0 point]

The reactor will scram if one of the following interlocks is not satisfied:

a. Reactor Period > 15 sec

b. Reactor Console keys(2) on

c. Line voltage to records > 110V

d. Moderator-Reflector water fill 'off'

Question: C.18 [1.0 point]

If smoke or fire is detected, the operator must immediately:

a. stop all rod withdrawal and notify the Senior Reactor Operator.

b. determine the location, and close down all fans.

c. notify the Operations Supervisor.

d. shutdown and secure the reactor.

(*** End of Examination ***)

A.1 c
REF: Standard NRC Reactor Theory Question

A.2 b

REF: From point A to B, reactor period is negative, and since $Pf=Poe^{\frac{t}{T}}$, power will continue to decrease.
DOE Manual Vol. 1, Section 2

A.3 a
REF: $P = P_0 e^{t/\tau}$ $P_o = 110\%$ $\tau = 20$ sec. $t = 0.5$ $P = 110 e^{0.5/20} = 112.78\%$

A.4 b
Sm^{149} (41,000 b); U^{235} (687 b); Xe^{135} (2.65 x 10^6 b); B^{10} (3840 b)
REF: Lamarsh, J. "Introduction to Nuclear Engineering" p. 738

A.5 b
REF: Standard NRC Reactor Theory Question

A.6 b
REF:

As reactor core temperature increases, the moderator to fuel ratio will decrease due to the decrease in density of the water. Therefore, due to this fact:

↑*Lf (Fast Non-Leakage Factor):* is the probability that neutrons will not leak out while still fast. Therefore, with more moderator in the core, the probability that they will not leak out increases.

↑p*(Resonance Escape Probability)*: is the probability that a neutron will be reduced to thermal energy levels without being absorbed by U-238. Due to the decrease in temperature and Doppler Broadening effects, the probability of escape increase.

↓***f*** *(Thermal Utilization Factor)*: is the ratio of absorption in fuel to the amount absorbed in the core (e.g., fuel, moderator, control rods, etc.). When the temperature decreases, the water moderator contracts, and a significant amount of it will accumulate in the reactor core. This means that N_m, the number of moderator atoms per cm^3, will be increased, making it more likely for a neutron to be absorbed by a moderator atom. This increase in N_m results in an decrease in thermal utilization as moderator temperature decrease because a neutron now has a better chance of hitting a moderator atom.

DOE Manual Vol 2, Section 1.0

Additionally,

Starting with a very hard spectrum (the extreme left of figure 3), softening the neutron spectrum as a result of an increase in H/U will impact the six-factor formula as follows.

1. Changes in thermal η will be negligible.
2. Changes in the thermal utilization factor are dependent on the product of the fuel and moderator microscopic cross sections and their number densities (or, their

macroscopic cross section). As H/U increases the number density of fuel is lowered and the number density of moderator is increased. Both the fuel and moderator microscopic absorption cross sections will increase as the system thermalizes. Therefore, the thermal utilization factor will always decrease.

3. The resonance escape probability will increase with decreasing fuel number density because of the corresponding reduction in the resonance absorber, ^{238}U.
4. The fast fission factor will decrease because fewer fast neutrons will impact the fuel.
5. The thermal non-leakage probability will increase because of the decrease in thermal diffusion length.
6. The fast non-leakage probability will increase because fast neutron age is lowered with increased moderation.

RPI Reactor Critical Facility *A Manual of Experiments,* MANE-4440: Critical Reactor Laboratory dated 2010, p.25

A.7 a
REF: Lamarsh, Introduction to Nuclear Engineering, 3rd Edition, Section 6.5, page 290.

A.8 a
REF: Nuclides and Isotopes: Chart of the Nuclides. Lockheed Martin 16th Ed.

A.9 c
REF: The thermalized neutrons are not absorbed as quickly in the reflector as neutrons thermalized in the core since the reflector, being unfueled, has a much smaller absorption cross-section. The thermal neutrons tend to accumulate in the reflector until they leak back into the core, escape from the outer surface of the reflector, or are absorbed.
Lamarsh, J. 2001. Introduction to Nuclear Engineering 3rd Ed.. p. 305.

A.10 b
REF: 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 and NEEP 234 “Reactor Physics I” pg. 9

A.11 d **DELETED**
REF: Burn, R. Introduction to Nuclear Reactor Operations, 1982, Sect. 5.7

A.12 c
REF: A supercritical reactor cannot indicate a steady neutron level.

A.13 b
REF: Introduction to Nuclear Reactor Operations, Reed Robert Burn, Section 3.2.2, Delayed Neutrons.

A.14 a
REF: Lamarsh, Introduction to Nuclear Engineering, 2nd Edition, page 287.

A.15 a
REF: Introduction to Nuclear Reactor Operations, Reed Robert Burn, Section 5.4, Inverse Multiplication, p. 5-14.

A.16 a
REF: Laboratory 4 Experiment.

A.17 a
REF: Introduction to Nuclear Reactor Operations, Reed Robert Burn, Section 4.3, Reactor Period and Reactor Power

A.18 c
REF: MIT Reactor Physics Notes; Reactivity Feedback

A.19 c
REF:
Duderstadt and Hamilton, Nuclear Reactor Analysis, page 65.

A.20 b
REF: Glasstone, S. and Sesonske, A, *Nuclear Reactor Engineering,* Kreiger Publishing, Malabar, Florida, 1991, § 5.198, p. 300.

B.1 c
REF: 10CFR50.54(y)

B.2 c, d
REF: Technical Specification (2.1 specifications)

B.3 c
REF: TS 1.0

B.4 d
REF: RPI TS 1.0, September 2004

B.5 d
REF: Technical Specifications, Table 1.

B.6 a, 2; b, 3; c, 3; d, 4
REF: 10 CFR 20.1003, Definitions

B.7 c
REF: Two inches = one-half thickness ($T_{½}$). Using 5 half-thickness will drop the dose by a factor of $(½)^5$ = 1/32 ⇒ 100/32 = 3.13

B.8 b **DELETED**
REF: RPI Technical Specifications, section 3.2(Table 2)

B.9 c
Reference: Emergency Preparedness Plan for the Maryland University Training Reactor, dated 12/99 p. 4-2 and MUTR SAR

B.10 a 4 b 3 c 2 d 3
REF: 10CFR55

B.11 a
Reference: Under 10 CFR Part 55, The regulations in this part do not require a license for an individual who- "Under the direction and in the presence of a licensed operator or senior operator, manipulates the controls of a research or training reactor as part of the individual's training as a student"
10 CFR Part 55.13

B.12 b
REF: Emergency Procedure

B.13 c
REF: Emergency Plan, page 8, Decontamination

B.14 c
REF: 10 CFR 50.54q; 10 CFR 50.59; 10 CFR 55.59

B.15 b
REF: Emergency Procedures, 7.3.2.

B.16 c
REF: RCF Operating Procedures, G “Fuel Handling”, Version 2.1, September 2006

B.17 c
REF: 10CFR55.53e & f

(*** End of Section B ***)

C.1 a
REF: Laboratory 1.

C.2 d
REF: SAR, Figure 7.1

C.3 a 2; b 4; c1; d 3
REF: SAR page 7-7.

C.4 a
REF: SAR, Section 9.1.

C.5 b
REF: RPI SAR, Section 4.2, November 2002

C.6 a
REF: Prestart Procedures.

C.7 a
REF: SAR page 4-14

C.8 c
REF: SAR, Section 4.2.2.

C.9 a
REF: SAR page 7-7

C.10 c
REF: Prestart Procedures.

C.11 a
Safety Analysis Report, 13.1.1

C.12 c
REF: Laboratory 1.

C.13 a
REF: Surveillance Procedure “Power Calibration.”

C.14 b
REF: Emergency Procedures, page 3

C.15 d **DELETED**
REF: SAR, Figure 7.2.

C.16 a
REF: SAR Figure 5.1.

C.17 b
REF: Technical Specification (3.2) Table 2 (interlock)

C.18 d
REF: RPI Emergency Plan, Section 6.2.

(*** End of Section C ***)
(***** End of Examination *****)