

August 14, 2007

Mr. David Adams
Department of Biology and Biotechnology
Worcester Polytechnic Institute
100 Institute Road
Worcester, MA 01609-2280

SUBJECT: INITIAL EXAMINATION REPORT NO. 50-134/OL-07-01, WORCESTER
POLYTECHNIC INSTITUTE

Dear Mr. Adams:

During the week of August 6, 2007, the NRC administered an operator licensing examination at your Worcester 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.

In accordance with Title 10, Section 2.790 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. Should you have any questions concerning this examination, please contact Patrick Isaac at 301-415-1019 or via email at pxi@nrc.gov.

Sincerely,

/RA/

Johnny Eads, Chief
Research and Test Reactors Branch B
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Docket No. 50-134

Enclosures: 1. Examination Report No. 50-134/OL-07-01
2. Examination and answer key

cc w/encls:
Please see next page

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cc:

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Framingham, MA 01702-5399

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

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

FACILITY: Worcester Polytechnic Institute

REACTOR TYPE: Pool

DATE ADMINISTERED: 8/7/2007

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% overall is required to pass the examination. Examinations will be picked up three (3) hours after the examination starts.

<u>CATEGORY VALUE</u>	<u>% OF TOTAL</u>	<u>CANDIDATE'S SCORE</u>	<u>% OF CATEGORY VALUE</u>	<u>CATEGORY</u>
<u>18.00</u>	<u>53.0</u>	_____	_____	B. NORMAL AND EMERGENCY OPERATING PROCEDURES AND RADIOLOGICAL CONTROLS
<u>16.00</u>	<u>47.0</u>	_____	_____	C. PLANT AND RADIATION MONITORING SYSTEMS
FINAL GRADE	_____	_____	% TOTALS	

ALL THE WORK DONE ON THIS EXAMINATION IS MY OWN. I HAVE NEITHER GIVEN NOR RECEIVED AID.

CANDIDATE'S SIGNATURE

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 ____

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

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 ____

(***** 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 not received or 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.
6. Fill in the date on the cover sheet of the examination (if necessary).
7. Print your name in the upper right-hand corner of the first page of each section of your answer sheets.
8. The point value for each question is indicated in parentheses after the question.
9. Partial credit will NOT be given.
10. If the intent of a question is unclear, ask questions of the examiner only.
11. When you are done and have turned in your examination, leave the examination area as defined by the examiner.

EQUATION SHEET

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

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

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

$$SCR = S/(1-K_{eff})$$

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

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

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

$$SUR = 26.06/\tau$$

$$M = 1/(1-K_{eff}) = CR_1/CR_0$$

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

$$SDM = (1-K_{eff})/K_{eff}$$

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

$$\dot{Pwr} = \dot{W}_f m$$

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

$$\ell^* = 1 \times 10^{-5} \text{ seconds}$$

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

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

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

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

$$\rho = \Delta K_{eff}/K_{eff}$$

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

$$DR_1 D_1^2 = DR_2 D_2^2$$

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

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

$$1 \text{ Curie} = 3.7 \times 10^{10} \text{ dps}$$

$$1 \text{ kg} = 2.21 \text{ lbm}$$

$$1 \text{ hp} = 2.54 \times 10^3 \text{ BTU/hr}$$

$$1 \text{ Mw} = 3.41 \times 10^6 \text{ BTU/hr}$$

$$1 \text{ BTU} = 778 \text{ ft-lbf}$$

$$^{\circ}\text{F} = 9/5 ^{\circ}\text{C} + 32$$

$$1 \text{ gal H}_2\text{O} \approx 8 \text{ lbm}$$

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

QUESTION B.1 [1.0 point]

An accessible area within the facility has general radiation levels of 325 mrem/hour. What would be the EXPECTED posting for this area?

- a. "Caution, Very High Radiation Area"
- b. "Danger, Airborne Radioactivity Area"
- c. "Danger, High Radiation Area"
- d. "Caution, Radiation Area"

QUESTION B.2 [1.0 point]

While working on an experiment, you receive the following radiation doses: 100 mrem (β), 25 mrem (γ), and 5 mrem (thermal neutrons). Which ONE of the following is your total dose?

- a. 175 mrem
- b. 155 mrem
- c. 145 mrem
- d. 130 mrem

QUESTION B.3 [1.0 point, ¼ each]

Match type of radiation (1 thru 4) with the proper penetrating power (a thru d)

- | | |
|------------|------------------------------------|
| a. Gamma | 1. Stopped by thin sheet of paper |
| b. Beta | 2. Stopped by thin sheet of metal |
| c. Alpha | 3. Best shielded by light material |
| d. Neutron | 4. Best shielded by dense material |

QUESTION B.4 [1.0 point]

10CFR50.54(x) states: *"A licensee may take reasonable action that departs from a license condition or a technical specification (contained in a license issued under this part) in an emergency when this action is immediately needed to protect the public health and safety and no action consistent with license conditions and technical specifications that can provide adequate or equivalent protection is immediately apparent."* Per 10CFR50.54(y), which one of the following is the minimum level of authorization for this action?

- a. Reactor Operator licensed at the facility.
- b. Senior Reactor Operator licensed at the facility.
- c. Facility Manager (or equivalent at facility).
- d. The U.S. Nuclear Regulatory Commission Project Manager

QUESTION B.5 [1.0 point]

In order to maintain an active reactor or senior reactor operator license, the license-holder must perform the functions of his/her position for at least:

- a. four hours per calendar quarter.
- b. six hours per calendar quarter.
- c. one hour per month.
- d. sixteen hours per year.

QUESTION B.6 [1.0 point]

As permitted by 10 CFR 50.59, the WPI reactor facility may:

- a. Modify systems and change the Technical Specifications (TS) if the NRC is notified afterwards.
- b. Perform new and little understood experiments when they are for research.
- c. Determine the affects of modifications and their impact on TS.
- d. Redefine the boundaries of accidents previously analyzed in the Safety Analysis Report (SAR).

QUESTION B.7 [1.0 point]

Which ONE of the following is the 10 CFR 20 definition of **TOTAL EFFECTIVE DOSE EQUIVALENT (TEDE)**?

- a. The sum of the deep does equivalent and the committed effective dose equivalent.
- b. The dose that your whole body receives from sources outside the body.
- c. The sum of the external deep dose and the organ dose.
- d. The dose to a specific organ or tissue resulting from an intake of radioactive material.

QUESTION B.8 [1.0 point]

Which ONE of the following activities may be performed by a licensed operator without the permission or supervision of a senior licensed operator?

- a. Temporary changes to a procedure.
- b. Movement of fuel from the core to a fuel rack.
- c. Placing the pool water level safety switch in the BYPASS position.
- d. Measurement of rod drop times.

QUESTION B.9 [1.0 point]

A small radioactive source is to be stored in an accessible area of the reactor building. The source reads 2 R/hr at 1 foot. Assuming no shielding is to be used, a Radiation Area barrier would have to be erected from the source at least a distance of approximately:

- a. 400 feet
- b. 40 feet
- c. 20 feet
- d. 10 feet

QUESTION B.10 [1.0 point]

In accordance with the WPI Technical Specifications, the term "Shutdown Margin" describes:

- a. the time required for the rods to fully insert
- b. the departure from $K\text{-effective} = 1.00$
- c. the amount of subcriticality, considering the worth of all rods
- d. the amount of subcriticality with the most reactive rod fully withdrawn

QUESTION B.11 [1.0 point]

Which ONE of the following would be classified as a Reportable Occurrence?

- a. A reactor pool low level alarm
- b. Release of fission products from a fuel element
- c. Unanticipated reactivity change greater than $0.1\% \Delta k/k$
- d. Reactor scram

QUESTION B.12 [1.0 point]

The reactor is deemed to be in the shutdown condition when the number of fuel elements on the grid plate is less than ...

- a. 12
- b. 16
- c. 20
- d. 25

QUESTION B.13 [1.0 point]

Which one of the following areas is always considered a restricted area as defined in 10 CFR 20?

- a. The second floor of Washburn Laboratories, directly above the reactor control drives.
- b. The second and third floors of Washburn Laboratories.
- c. The reactor room and the areas above the reactor.
- d. The reactor room.

QUESTION B.14 [1.0 point]

In the event of an area evacuation, personnel should proceed to the emergency assembly area, located:

- a. in the operations boundary.
- b. at Freeman Plaza entrance area to Salisbury Laboratories.
- c. at the Campus Police building.
- d. in Stratton Hall.

QUESTION B.15 [1.0 point]

You have not performed the functions of an RO or SRO in the past 6 months. Per the Regulations, prior to resuming activities authorized by your license, how many hours must you complete in that function under the direction of an RO or SRO as appropriate?

- a. 4
- b. 6
- c. 12
- d. 40

QUESTION B.16 [1.0 point]

An Emergency Action Level is:

- a. a condition which calls for immediate action, beyond the scope of normal operating procedures, to avoid an accident or to mitigate the consequences of one.
- b. a class of accidents for which predetermined emergency measures should be taken or considered.
- c. a procedure that details the implementation actions and methods required to achieve the objectives of the Emergency Plan.
- d. a specific instrument reading or observation which may be used as a threshold for initiating appropriate emergency procedures.

QUESTION B.17 [1.0 point, ¼ 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. 3 years
d. Requalification Operating Test	4. 6 years

QUESTION B.18 [1.0 point]

Which one of the following terms is identical with the "Operations Boundary" ?

- a. Emergency Planning Zone (EPZ).
- b. Site Boundary.
- c. On-Site.
- d. Site Geographical Area.

QUESTION C.1 [1.0 point]

Which ONE condition below will result in an alarm?

- a. Reactor period = 20 seconds.
- b. Beam Tube monitor reading of 30 mrem/hr.
- c. Pool level 4 inches below overflow pipe.
- d. Overflow tank high level.

QUESTION C.2 [1.0 point]

A portable radiation monitor may temporarily replace one of the fixed area radiation monitors provided that:

- a. the required alarms are operational.
- b. The portable monitor is capable of measuring neutron dose rates.
- c. The portable monitor is used for a maximum time of one (1) week.
- d. The portable monitor is calibrated (not a source check) before each startup

QUESTION C.3 [1.0 point]

The Beam Port design protects personnel against radiation from the port by:

- a. a shutter and concrete shield plugs.
- b. portable shielding around the beamport.
- c. alternately stacked graphite logs and a stepped closure door.
- d. graphite filler plugs.

QUESTION C.4 [1.0 point]

The limit for minimum water level above the core is based on providing:

- a. adequate neutron shielding during operation.
- b. the proper amount of core cooling.
- c. sufficient suction head for the purification pump.
- d. adequate gamma radiation shielding during operation.

QUESTION C.5 [1.0 point]

The shrouds which surround each safety blade have small holes at the bottom. The purpose of these holes is to:

- a. minimize the effect of viscous damping on scram times.
- b. provide a cooling water path through the shrouds.
- c. provide points where a shroud lifting tool can be attached.
- d. smooth out the thermal neutron flux distribution at the bottom of the core.

QUESTION C.6 [1.0 point]

Pool water purity is measured by a resistivity probe located at:

- a. the outlet of the demineralizer.
- b. the inlet to the demineralizer.
- c. the outlet of the purification pump.
- d. the outlet of the reactor pool.

QUESTION C.7 [1.0 point]

Which ONE of the following is the approximate rate at which the ventilation system is designed to completely change the reactor compartment air?

- a. 1 change per hour.
- b. >2 changes per hour.
- c. >3 changes per hour.
- d. >4 changes per hour.

QUESTION C.8 [1.0 point]

In case of a radioactive spill, the ventilation system:

- a. exhaust duct must be closed.
- b. supply and exhaust ducts must be closed.
- c. fans must be tripped.
- d. remains operating.

QUESTION C.9 [1.0 point]

Which ONE of the following demineralizer regeneration processes will remove radioactive particulates from the resin bed?

- a. Resin mixing.
- b. Caustic soda treatment.
- c. Acid solution treatment.
- d. Backwash.

QUESTION C.10 [1.0 point]

Which alarm(s) provide indication of abnormal conditions at Campus Security Headquarters?

- a. Area radiation monitors only.
- b. Area radiation monitors and Reactor Pool low water level.
- c. Area radiation monitors and Argon-41.
- d. Reactor Pool low water level and Argon-41.

QUESTION C.11 [1.0 point]

Which ONE of the following will cause a building evacuation alarm?

- a. Loss of electrical power.
- b. High pool temperature.
- c. High radiation level at fuel storage container surface.
- d. Pool water level 9" below overflow pipe

QUESTION C.12 [1.0 point]

Reactor fuel consists of:

- a. 20% enriched alloy with aluminum cladding.
- b. 20% enriched alloy with stainless steel cladding.
- c. 93% enriched alloy with aluminum cladding.
- d. 93% enriched alloy with stainless steel cladding.

QUESTION C.13 [1.0 point]

Which ONE of the following is the normal flow rate for the cleanup system circulation pump?

- a. 5 gpm.
- b. 10 gpm.
- c. 15 gpm.
- d. 20 gpm.

QUESTION C.14 [1.0 point]

Which ONE of the following systems does NOT receive emergency power from the battery backup system following a loss of normal power?

- a. Area radiation monitoring system.
- b. Evacuation alarms.
- c. Emergency lighting system.
- d. Safety instrumentation system.

QUESTION C.15 [1.0 point]

The evacuation alarm setpoints for the area radiation monitors are:

- a. Pool - 50 mrem/hr Beam Tube - 50 mrem/hr Thermal Column - 20 mrem/hr
- b. Pool - 50 mrem/hr Beam Tube - 20 mrem/hr Thermal Column - 20 mrem/hr
- c. Pool - 20 mrem/hr Beam Tube - 20 mrem/hr Thermal Column - 50 mrem/hr
- d. Pool - 20 mrem/hr Beam Tube - 50 mrem/hr Thermal Column - 50 mrem/hr

QUESTION C.16 [1.0 point]

An abnormal condition is indicated by the lighting of a box on the annunciator panel and the sounding of an alarm horn. Pressing the “Acknowledge” on the annunciator panel or control console will always:

- a. silence the horn and extinguish the light.
- b. silence the horn only if the condition has returned to normal.
- c. silence the horn.
- d. extinguish the light.

(***** END OF EXAMINATION *****)

Answer Key

B.1 c

REF: 10CFR20

B.2 d

REF: Reactor Training Manual - *Ionizing Radiation*

B.3 a, 4 b, 2 c, 1d, 3

REF: Reactor Training Manual - *Health Physics*

B.4 b

REF: 10CFR50.54(y).

B.5 a

REF: WPI Requalification Program

B.6 c

REF: 10 CFR 50.59

B.7 a

REF: 10 CFR 20.1003 *Definitions*

B.8 d

REF: SP-03, Rod Drop-Time Measurement

B.9 c

REF:

$$\frac{DR_1}{X_2^2} = \frac{DR_2}{X_1^2} \quad X_2^2 = \frac{DR_1}{DR_2} X_1^2 \quad X^2 = \frac{2000}{5} \times 1^2 = 400 \text{ ft}^2 \quad X = 20 \text{ ft}$$

B.10 d

REF: Technical Specifications, Section 2.1

B.11 b

REF: Technical Specifications, Section 1.0

B.12 a

REF: Technical Specifications, Section 1.0

B.13 d

REF: Technical Specifications, Section 4.2

B.14 b

REF: Emergency Plan, Section 7.5

B.15 b

REF: 10CFR55.53(f)(2))

Answer Key

B.16 d

REF: WPI Emergency Preparedness Plan, Section 2.0.

B.17 a, 4 b, 2 c, 2d, 1.

REF: WPI Requalification Plan

B.18 a

REF: WPI Emergency Plan, Section 2.0

Answer Key

C. 1 b

REF: WPI Setpoint Summary

C. 2 a

REF: WPI Technical Specifications, Section 3.3

C. 3 a

REF: WPI SAR, Section 10.2

C. 4 d

REF: WPI SAR, Section 4.4

C. 5 a

REF: WPI SAR, Section 4.2.2.1

C. 6 a

REF: MP-01

C. 7 b

REF: WPI SAR, Section 9.1

C. 8 d

REF: SAR, Section 9.1

C. 9 d

REF: Demineralizer Regeneration Procedure

C. 10 b

REF: Emergency Plan, Section 7.1

C. 11 d

REF: WPI Setpoint Summary

C. 12 a

REF: SAR, Section 4.2.1

C. 13 b

REF: WPI SAR, Section 5.3

C. 14 d

REF: WPI SAR, Section 8.2

C. 15 b

REF: WPI Setpoint Summary

C. 16 c

REF: WPI SAR, Section 7.3