April 7, 2008

Mr. Robert J. Agasie
Reactor Director
Nuclear Reactor Laboratory
1513 University Avenue, Room 141ME
University of Wisconsin
Madison, WI 53706-1687

SUBJECT: INITIAL EXAMINATION REPORT NO. 50-156/OL-08-01, UNIVERSITY OF WISCONSIN TRIGA REACTOR

Dear Mr. Agasie:

During the week of March 17, 2008, the NRC administered an operator licensing examination at your University of Wisconsin TRIGA 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 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 (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 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. Paul V. Doyle Jr. at (301) 415-1058 or via internet e-mail pvd@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. 50-156

Enclosures: 1. Initial Examination Report No. 50-156/OL-08-01
2. Written examination with facility comments incorporated

cc without enclosures: See next page

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OFFICE	PRTB:CE		IOLB:LA	E	PRTB:SC	
NAME	PDoyle pvd		CHart cah		JEads jhe	
DATE	4/4/08		4/1/08		4/7/08	

OFFICIAL RECORD COPY

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

REPORT NO.: 50-156/OL-08-01

FACILITY DOCKET NO.: 50-156

FACILITY LICENSE NO.: R-74

FACILITY: University of Wisconsin TRIGA Reactor

EXAMINATION DATES: March 17 – 20, 2008

SUBMITTED BY: /RA/ 4/1/08
Paul V. Doyle Jr., Chief Examiner Date

SUMMARY:

During the week of March 17, 2008, the NRC administered licensing examinations to four reactor operator and one senior reactor operator (upgrade) candidates. All five candidates passed all portions of their examinations.

REPORT DETAILS

1. Examiners:
   Paul V. Doyle Jr., Chief Examiner

2. Results:

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

3. Exit Meeting:
   Paul V. Doyle Jr., NRC, Examiner
   Robert Agasie, University of Wisconsin, Reactor Director
   Michele Blanchard, University of Wisconsin, Reactor Supervisor

The NRC examiner thanked the facility management for their support in the administration of the examinations. The facility pointed out a few comments on the written examination question B.01 had two correct answers, b or a, and question B.06 part b also had two correct answers 2 or 3. Also question C.03 is no longer valid due to installation of a new ventilation system, and has been deleted. The examination included with this report has been updated for all comments.

OPERATOR LICENSING EXAMINATION

With Answer Key

UNITED STATES NUCLEAR REGULATORY COMMISSION

UNIVERSITY OF WISCONSIN

March 17, 2008

Enclosure 2

QUESTION A.01 [2.0 points, 0.5 each]

Using the drawing of the Integral Rod Worth Curve provided, identify each of the following reactivity worths.

	Column A		Column B
a.	Total Rod Worth	1.	B - A
b.	Actual Shutdown Margin	2.	C - A
c.	Technical Specification Shutdown Margin Limit	3.	C - B
d.	Excess Reactivity	4.	D - C
		5.	E - C
		6.	E - D
		7.	E - A

QUESTION A.02 [1.0 point]

Reactor power is rising on a 30 second period. Approximately how long will it take for power to double?

a. 35 seconds

b. 50 seconds

c. 70 seconds

d. 100 seconds

QUESTION A.03 [2 points, ½ each]

Match the description of plant conditions in column A with resulting xenon conditions in column B.

	Column A		Column B
a.	4 hours after a power increase	1.	Xenon concentration is increasing to a peak
b.	2 hours after a power decrease	2.	Xenon concentration is decreasing to a trough
c.	16 hours after a “clean” startup	3.	Xenon concentration is approximately zero (reactor is “clean”)
d.	72 hours after a shutdown	4.	Xenon concentration is “relatively” steady at a “non-zero” value

QUESTION A.04 [1.0 point]

The number of neutrons passing through a one square centimeter of target material per second is the definition of which one of the following?

a. Neutron Population (np)

b. Neutron Impact Potential (nip)

c. Neutron Flux (nv)

d. Neutron Density (nd)

QUESTION A.05 [1.0 point]
The neutron microscopic cross-section for absorption (σ_a) of an isotope 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.06 [1.0 point]
A reactor contains three safety rods and a control rod. Which one of the following would result in a determination of the excess reactivity of this reactor?

a. The reactor is critical at a low power level, with all safety rods full out and the control rod at some position. The reactivity remaining in the control rod (i.e. its rod worth from its present position to full out) is the excess reactivity.

b. The reactor is shutdown. Two safety rods are withdrawn until the reactor becomes critical. The total rod worth withdrawn is the excess reactivity.

c. The reactor is at full power. The total worth of all rods withdrawn is the excess reactivity.

d. The reactor is at full power. The total worth remaining in all the safety rods and the control rod (i.e. their worth from their present positions to full out) is the excess reactivity. page 50.

QUESTION A.07 [1.0 point]
The first of two pulses had a reactivity worth $2.00 and a peak power of 1050 Mw. If the second pulse had a reactivity worth $1.50, what was the peak power of the second?

a. 263 Mw

b. 653 Mw

c. 525 Mw

d. 1485 Mw

QUESTION A.08 [1.0 point]
With the reactor on a constant period, which of the following changes in reactor power would take the **LONGEST** time?

a. 5% — from 1% to 6%

b. 15% — from 20% to 35%

c. 20% — from 40% to 60%

d. 25% — from 75% to 100%

QUESTION A.09 [1.0 point]
You are assigned to check the operation of a new nuclear instrumentation channel. You know that the reactor will stabilize with a - 80 second period shortly after shutdown. To check the channel you measure the time for power to decrease by a factor of 10. This time should be approximately…

a. 45 seconds (¾ minute)

b. 90 seconds (1-½ minutes)

c. 135 seconds (2-¼ minutes)

d. 180 seconds (3 minutes)

QUESTION A.10 [1.0 point]
Which one of the following statements best describes the difference between a moderator and a reflector. A reflector …

a. increases the neutron production factor and a moderator increases the fast fission factor.

b. increases the neutron production factor and a moderator decreases the fast fission factor.

c. increases the fast non-leakage factor and a moderator increases the thermal utilization factor.

d. decreases the fast non-leakage factor and a moderator increases the thermal utilization factor.

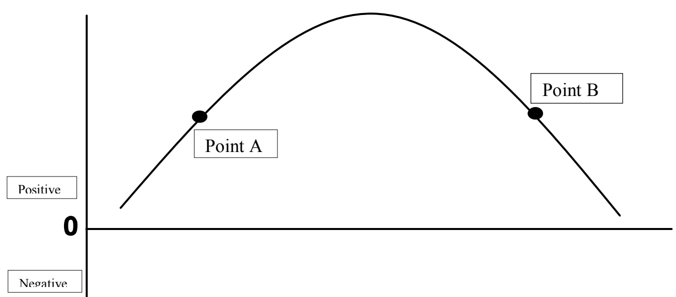
QUESTION A.11 [1.0 point]
Shown below is a trace of reactor period as a function of time. Between points A and B reactor power is:

a. continually increasing.

b. continually decreasing.

c. increasing, then decreasing.

d. constant.



QUESTION A.12 [1.0 point]
A thin foil target of 10% copper and 90% aluminum is in a thermal neutron beam. Given $\sigma_{a\ Cu}$ = 3.79 barns, $\sigma_{a\ Al}$ = 0.23 barns, $\sigma_{s\ Cu}$ = 7.90 barns, and $\sigma_{s\ Al}$ =1.49 barns, which ONE of the following reactions has the highest probability of occurring? A neutron ...

a. scattering reaction with aluminum

b. scattering reaction with copper

c. absorption in aluminum

d. absorption in copper

QUESTION A.13 [1.0 point]
Which ONE of the reactions below is an example of a **PHOTONEUTRON** source?

a. ${}_1H^2 + {}_0\gamma^0 \rightarrow {}_1H^1 + {}_0n^1$

b. ${}_{92}U^{238} \rightarrow {}_{35}Br^{87} + {}_{57}La^{148} + 3{}_0n^1 + {}_0\gamma^0$

c. ${}_{51}Sb^{123} + {}_0n^1 \rightarrow {}_1H^1 + {}_0\gamma^0$

d. ${}_4Be^9 + {}_2\alpha^4 \rightarrow {}_6C^{12} + {}_0n^1$

QUESTION A.14 [1.0 point]
ELASTIC SCATTERING is the process by which a neutron collides with a nucleus and …

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

b. recoils with less kinetic energy than it had prior to the collision with the nucleus emitting a gamma ray.

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

d. recoils with a higher kinetic energy than it had prior to the collision with the nucleus emitting a gamma ray.

QUESTION A.15 [1.0 point]
Which one of the following statements details the effect of fuel temperature on core operating characteristics? As fuel temperature …

a. increases, Doppler peaks will become higher.

b. decreases, resonance escape probability will increase.

c. decreases, U^{238} and Erbium will absorb more neutrons.

d. increases, the fast non-leakage probability will decrease.

QUESTION A.16 [1.0 point]
You enter the control room and note that all nuclear instrumentation channels 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.17 [1.0 point]

When compared to β, β_{eff} is:

a. smaller, because delayed neutrons are born at lower energies than prompt neutrons.

b. larger, because delayed neutrons are born at lower energies than prompt neutrons.

c. smaller, because delayed neutrons are born at higher energies than prompt neutrons.

d. larger, because delayed neutrons are born at higher energies than prompt neutrons.

QUESTION A.18 [1.0 point]

Xenon is produced in the reactor by two methods. One is directly from fission; the other is from the following decay chain Tellurium-_________-Xenon. Which **ONE** of the following is the isotope that goes in the blank?

a. Barium

b. Gadolinium

c. Iodine

d. Promethium

QUESTION B.01 [1.0 point]
Which ONE of the following situations would illustrate a time when the reactor is secured?

a. One of the control rod drives is removed for inspection; the rod is decoupled and is fully inserted into the core, all other rods are fully inserted and the console key is in the ‘off’ position and removed.

b. All control rods are fully inserted; the console key is in the ‘off’ position and removed, while fuel is being rearranged in the fuel storage racks.

c. The control rods are withdrawn to a subcritical position, the core is subcritical by 0.02% ΔK/K.

d. An experiment having a reactivity of 0.07% ΔK/K is being installed in the reactor with all control rods fully inserted and the key removed.

QUESTION B.02 [2.0 points, 0.5 each]
Match the type of radiation in column A with its associated Quality Factor (10CFR20) from column B.

	Column A	Column B
a.	alpha	1
b.	beta	2
c.	gamma	5
d.	neutron (unknown energy)	10
		20

QUESTION B.03 [2.0 points, 0.5 each]
Match the terms in column A with their respective definitions in column B.

	Column A		Column B
a.	Radioactivity	1.	The thickness of a material which will reduce a gamma flux by a factor of two.
b.	Contamination	2.	An impurity which pollutes or adulterates another substance. In radiological safety, contamination refers to the radioactive materials which are the sources of ionizing radiations.
c.	Dose	3.	The quantity of radiation absorbed per unit mass by the body or by any portion of the body.
e.	Half-thickness	4.	That property of a substance which causes it to emit ionizing radiation. This property is the spontaneous transmutation of the atoms of the substance.

QUESTION B.04 [2.0 points, ⅔ each]
Match each of the Technical Specification Limits in Column A with its corresponding value in Column B. (Each limit has only one answer, values in Column B may be used once, more than once or not at all.)

	Column A	Column B
a.	Each Unsecured Experiment	0.2% ΔK/K
b.	Each Secured Experiment	0.7% ΔK/K
c.	Minimum Shutdown Margin	1.4% ΔK/K
		2.0% ΔK/K

QUESTION B.05 [1.0 point]
Many research reactors use different methods to reduce the dose due to N^{16} at the pool top. If the method used keeps the N^{16} ten (10) feet below the surface of the water, and a half-thickness for the N^{16} gamma(s) is one foot for water, then the dose due to N^{16} is reduced (approximately) by a factor of … (Note: Neglect any reduction in dose rate due to half-life.)

a. 20

b. 100

c. 200

d. 1000

QUESTION B.06 [2.0 points, ½ each]
Match type of radiation (a thru d) with the proper penetrating power (1 thru 4)

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.07 [1.0 point]
Based on the Requalification Plan for licensed personnel, each licensed operator must complete a minimum of ______ significant reactivity change(s) during each quarter.

a. 1

b. 4

c. 7

d. 10

QUESTION B.08 [1.0 point, ¼ each]
Identify the PRIMARY source (irradiation of air, irradiation of water, or fission product) of EACH of the radioisotopes listed.

a. ${}_{1}H^{3}$

b. ${}_{18}Ar^{41}$

c. ${}_{7}N^{16}$

d. ${}_{54}Xe^{135}$

QUESTION B.09 [1.0 point]
“The reactor power level shall not exceed 1500 kW under any conditions of operation.” This is an example of a:

a. safety limit.

b. limiting safety system setting.

c. limiting condition for operation.

d. surveillance requirement.

QUESTION B.10 [1.0 point]
The **CURIE** content of a radioactive source is a measure of …

a. the number of radioactive atoms in the source.

b. the amount of energy emitted per unit time by the source

c. the amount of damage to soft body tissue per unit time.

d. the number of nuclear disintegrations per unit time.

QUESTION B.11 [1.0 point]
According to the Emergency Plan, the Emergency Planning Zone (EPZ) is

a. Room 130 (Reactor Laboratory).

b. that portion of the center and east wings of the Mechanical Engineering Building south of the lobby, plus the portion of Engineering Drive south of the designated areas of the building.

c. the area within a 500 foot radius from the centerline of the reactor laboratory ventilation exhaust.

d. Mechanical Engineering Building and the adjacent Fenced Area.

QUESTION B.12 [1.0 point]
Which ONE of the following statements correctly describes the relationship between the Safety Limit (SL) and the Limiting Safety System Setting (LSSS)?

a. The SL is a maximum operationally limiting value that prevents exceeding the LSSS during normal operations.

b. The SL is a parameter that assures the integrity of the fuel cladding. The LSSS initiates protective actions to preclude reading the SL.

c. The LSSS is a parameter that assures the integrity of the fuel cladding. The SL initiates protective action to preclude reaching the LSSS.

d. The SL is a maximum setpoint for instrumentation response. The LSSS is the minimum number of channels required to be operable.

QUESTION B.13 [1.0 point]
Which ONE of the following is the **LOWEST** level of management who may approve substantive written operating procedure changes?

a. the Reactor Director

b. the Reactor Safety Committee

c. a Senior Reactor Operator

d. the Reactor Supervisor

QUESTION B.14 [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."* 10CFR50.54(y) states that the minimum level of management which may authorize this action is …

a. any Reactor Operator licensed at facility.

b. any Senior Reactor Operator licensed at facility.

c. Facility Manager (or equivalent at facility).

d. NRC Project Manager.

QUESTION B.15 [1.0 point]
The CURIE content of a source is a measure of:

a. the number of radioactive atoms in the source.

b. the amount of energy emitted per second by the source.

c. the capability of the source to cause damage to the body.

d. the number of disintegrations of source nuclei each second.

QUESTION B.16 [1.0 point]

You initially remove a sample from the pool reading 1 R/hr at 30 cm from the source. You then replace the sample in the pool. An hour later you remove the sample and the reading is now 390 mR/hr at 30 cm. You again replace the sample back in the pool. Which one of the following is the minimum amount of time you should wait to be able to bring out the sample without generating a high radiation area?

a. ½ hour

b. 1 hour

c. 1½ hours

d. 2 hours

QUESTION C.01 [2.0 points, ½ each]
Match the purification system conditions listed in column A with their respective causes listed in column B. Each choice is used only once.

Column A	Column B
a. High Radiation Level at demineralizer.	1. Channeling in demineralizer.
b. High Radiation Level downstream of demineralizer.	2. Fuel element failure.
c. High flow rate through demineralizer.	3. High temperature in demineralizer system
d. High pressure upstream of demineralizer.	4. Clogged demineralizer

QUESTION C.02 [1.0 point]
WHICH ONE of the following detectors is used primarily to measure Ar^{41} released to the environment?

a. NONE, Ar^{41} has too short a half-life to require environmental monitoring.

b. Stack Gas Monitor

c. Stack Particulate Monitor

d. Area Radiation Monitor above pool

QUESTION C.03 [1.0 point] **This question deleted per facility comment, due to new ventilation system.**
Which ONE of the following describes how the ventilation system responds on receipt of an evacuation alarm?

a. Room exhaust fan continues to operate, emergency exhaust fan must be started manually

b. Room exhaust fan continues to operate, emergency exhaust fan starts automatically

c. Room exhaust fan must be secured, emergency exhaust fan must be started manually

d. Room exhaust fan must be secured, emergency exhaust fan starts automatically

QUESTION C.04 [1.0 point]
Which ONE of the following is the main function performed by the **DISCRIMINATOR** circuit in the Startup Channel?

a. To generate a current signal equal and of opposite polarity as the signal due to gammas generated within the Startup Channel Detector.

b. To filter out small pulses due to gamma interactions, passing only pulses due to neutron events within the Startup Channel Detector.

c. To convert the linear output of the Startup Channel Detector to a logarithmic signal for metering purposes.

d. To convert the logarithmic output of the metering circuit to a δt (delta time) output for period metering purposes.

QUESTION C.05 [1.0 point]
During reactor operation, a leak develops in the primary to intermediate heat exchanger. Which ***ONE*** of the following conditions correctly describes how the system will react? Pool level will …

a. increase, the automatic level control will Pool maintain level within an 1 and ½ inches of normal.

b. increase, an alarm will occur at the Security and Police Headquarters two inches above normal

c. decrease, the reactor will scram if level decreases by two inches.

d. decrease, the intermediate loop pump will trip due to low pressure.

QUESTION C.06 [1.0 point]
For a safety blade, the “out” limit light is ON, the “in” limit light is OFF, and “magnet engaged” light is OFF. What is the configuration of the system?

a. the drive is full out and the blade is full in.

b. the blade is full out and the drive is full in.

c. the blade and drive are both full out.

d. the blade and drive are both full in.

QUESTION C.07 [1.0 point]
The normal rods use electric drive motors for positioning. The transient rod is moved by

a. pneumatics (air)

b. pneumatics (Nitrogen)

c. hydraulics (Water)

d. hydraulics (Oil)

QUESTION C.08 [1.0 point]
WHICH ONE of the following is the purpose of the diffuser pump?

a. increase heat transfer rate due to increased mixing within the core

b. decrease the activation rate of O^{16} to N^{16} due to reduced time in core

c. increase transport time for N^{16} to reach surface of pool

d. break up of O^{16} bubbles in pool, thereby decreasing production of N^{16}

QUESTION C.09 [1.0 point]
Which **ONE** of the following will cause an Annunciator Alarm?

a. pneumatic tube blower off.

b. air particulate activity less than 1×10^{-14} ci/ml.

c. 12 second reactor period.

d. core inlet temperature at 128°F.

QUESTION C.10 [2.0 points, ½ each]
Match the reactor power instrumentation listed in column A with its corresponding detector type from column B. (Choices from column B may be used more than once or not at all.)

	Column A	Column B
a.	Log Count Rate	1. Gamma Ionization Chamber
b.	Log N	2. Boron Lined Compensated Ionization Chamber
c.	Picoammeter	3. Fission Chamber
d.	Pulse Channel	4. Kanne Ionization Chamber

QUESTION C.11 [1.0 point]
The neutron source in use in the core is made of …

a. americium-beryllium

b. californium

c. plutonium-beryllium

d. radium-beryllium

QUESTION C.12 [1.0 point]
Which of the following scrams is **NOT** available in PULSE MODE?

a. High fuel temperature.

b. High Voltage (Loss to Nuclear Instrumentation).

c. Power Level (pA 1 & 2)

d. Pool Level

QUESTION C.13 [1.0 point]
Which ONE of the following is the main reason for pressurizing the intermediate loop water?

a. To prevent water from the primary loop leaking into the intermediate loop.

b. To increase heat transfer through the heat exchangers.

c. To attenuate radiation from primary loop water in the primary heat exchanger floor area.

d. To prevent intermediate pump cavitations.

QUESTION C.14 [1.0 point]
When the Bridge Area Radiation Monitor reads 50 mrem/hour, which **ONE** of following actions occurs?

a. an alarm sounds

b. the reactor scrams

c. the building exhaust fans are turned off

d. Emergency Venting Mode initiates

QUESTION C.15 [1.0 point]
When the “Experimental Facility Radiation Level High” annunciator alarms:

a. an evacuation alarm sounds after 20 seconds.

b. the reactor scrams.

c. the emergency exhaust fan is started.

d. no automatic actions occur.

QUESTION C.16 [1.0 point]
The Safety Channels (picoammeters):

a. supply a period signal for use in the Automatic mode.

b. provide a 1 kW inhibit for the pulse or square wave modes.

c. provide a zero output, fail safe, trip signal to scram the reactor.

d. provide a insertion inhibit signal to the fission counter drive circuit

QUESTION C.17 [2.0 points, ½ each]
Match the system listed in column A with the proper piping color code listed in Column B.

Column A		Column B	
a.	City water	1.	Red
b.	Air	2.	Blue
c.	Contaminated water	3.	Green
d.	Softened water	4.	Black

A.01 a, 7; b, 2; c, 1; d, 5
REF: Standard NRC Question

A.02 c
REF: $P = P_0 e^{t/T}$ —> ln(2) = time ÷ 100 seconds –> time = ln (2) x 100 sec. 0.693 x 100 ≈ 0.7 x 100 ≈ 70 sec.

A.03 a, 2; b, 1; c, 4; d, 3
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, Volume 3, Enabling Objectives 4.3 through 4.7.

A.04 c
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, Volume 2, Enabling Objective 2.1b.

A.05 b
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, Volume 2, Enabling Objective 2.3.

A.06 a
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, Volume 3, Control Rod Effectiveness

A.07: a
REF: Peak power is proportional to $\Delta\$_{prompt}^2$ $P_1/\rho_2^2 = P_2/\rho_1^2$ $1050/0.5^2 = P_2/1^2$ $(1050/4) * 1 = P_2$ $62.5 = P_2$, NEEP 234, *Reactor Pulsing* p. 144.

A.08 a.
REF: $P = P_0 e^{t/\tau}$ $\ln(P/P_0) = t/\tau$ Since you are looking for which would take the longest time it is obvious to the most casual of observers that the ratio P/P_0 must be the largest. Also DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, Volume 2, Enabling Objective 2.6.

A.09 d
REF: $P/P_0 = e^{-T/\tau}$ ln(0.1) = - T(time)/τ(-80sec) Time = ln (0.1) × -80 sec = 184 seconds ≈ 3 minutes. Also DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, Volume 2, Enabling Objective 2.6.

A.10 c
REF: NEEP 234, p. 87. Facility Supplied Examination Bank.

A.11 a
REF: Standard NRC Question[1]

A.12 a $0.1 \times 3.79 = 0.379$ $0.9 \times 0.23 = 0.207$ $0.1 \times 7.9 = 0.79$ $0.9 \times 1.49 = 1.34$
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, Volume 2, Enabling Objective 2.7.

A.13 a
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, Volume 2, Enabling Objective 1.3.

A.14 a
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, Volume 1, Enabling Objective 5.2.

A.15 b
REF: NEEP 234, p.A.15 Also facility supplied Examination Bank A question 222.

A.16 c
REF: Standard NRC question

A.17 b
REF: (NRC99) UWNR OTM, Reactor Physics II. Facility supplied Examination Bank A, question 215.

A.18 c
REF: UWNR OTM, Reactor Physics I. Rewrite of facility supplied examination question bank A, question 202.

B.01 b or a 2nd correct answer added per facility comment
REF: Technical Specifications § 1 *Definitions*.

B.02 a, 20; b, 1; c, 1; d, 10
REF: 10CFR20.100x

B.03 a, 4; b, 2; c, 3; d, 1
REF: Standard NRC question

B.04 a, 0.7%; b, 1.4%; c, 0.2%
REF: (NRC2001) Technical Specifications, §§ 3.1, 3.6, (a) and (b)

B.05 d
REF: Basic Radiological Controls knowledge: "Half-Thickness and Tenth-Thickness". $2^{10} = 1024$

B.06 a, 4; b, 2 or 3; c, 1; d, 3 2nd correct answer for part b added per facility comment. Using a light material will result in less Bremsstrahlung radiation.
REF: Standard NRC Health Physics Question

B.07 a
REF: *UNWR 004 Reactor Operator Proficiency Maintenance Program* § B 3rd ¶.

B.08 a, Water; b, Air; c, Water; d, Fission
REF: Standard NRC question.

B.09 a
REF: (NRC2000) Technical Specifications, Section 2.1 (SAR, p.14-7).

B.10 d
REF: Standard Health Physics Definition.

B.11 a
REF: UNWR 006 Emergency Plan § 8.0 *Facilities and Equipment*

B.12 b
REF:

B.13 b
REF: Technical Specifications, Section 6.4 (SAR, p.14-36)

B.14 b
REF: 10CFR50.54(y)

B.15 d
REF: (NRC99) UWNR OTM, Health Physics I & II, Section I, "Definitions," letter a, "Radioactivity"

B.16 c
REF: $I_t = I_0 e^{-\lambda t}$ 390 mR/hr ÷ 1000 mR/hr = $e^{-\lambda 1hr}$ ln(0.39) = -λ * 1 hr. λ = 0.9416 $hour^{-1}$
SOLVING for additional time: $If = I_t e^{-\lambda t}$ 100mR/hr = 390 mR/hr $e^{-0.9416\,(time)}$ ln (0.25) = -0.9163 * time
time = 1.4454

C.01 a, 2; b, 3; c, 1; d, 4
Ref: Standard NRC cleanup loop question.

C.02 b
REF: SAR § 2.5.9, pages 2-54, 2-55.

~~C.03 a~~ Question deleted per facility comment, new ventilation system
~~REF: (NRC99, NRC2001) UWNR 155; SAR, Section 9.1 Facility supplied examination bank.~~

C.04 b
REF: NEEP 234, Controls & Instrumentation II, Nuclear Instrumentation, *Discriminator,* page 4 of 13.

C.05 b
REF: UWNR Reactor Cooling System Description (from addendum to 2003-2004 Annual Report); UWNR SAR2000 Section 7.6 Control Console and Display Instruments

C.06 a
REF: (NRC95) SAR, Section 7.3, p.7-7

C.07 a
REF: UWNR Safety Analysis Report Rev.1, 8/2004

C.08 c
REF: (NRC99) SAR, Section 4.4, p.4-25; SAR, Section 5.6, p.5-5.

C.09 d
REF: Facility supplied examination bank. a: SAR, Section 10.2, p.10-6; b: UWNR OTM, Health Physics I & II, UWNR OTM, Controls & Instrumentation VI, "Particulate Activity Monitor"; SAR, Section 11.1.1.1; c: UWNR OTM, Controls & Instrumentation I & II, "Log N Channel Alarms and Interlocks"; d: UWNR OTM, Controls & Instrumentation VII, "Temperature Measurements", SAR, Section 7.6, p.7-12 (no "preset level" given)

C.10 a, 3; b, 2; c, 2; d, 1
REF: NEEP 234 pages 160 - 177, page 181 and 2000 SAR, § 7.2.3

C.11 d
REF: 2000 SAR Chapter 4, § 4.2.4, page 4-16

C.12 c
REF: Control & Instrumentation IV, Table of Technical Specification Required Scrams and Setpoints vs. Mode.

C.13 a
REF: Facility supplied question bank C, question # 53

C.14 a
REF: UWNR OTM, Controls & Instrumentation VI, "Area Radiation Monitor System," "System: Area Radiation Monitors - Auto Actions at Alarm Point"

C.15 d
REF: (NRC2000) UWNR OTM, Controls & Instrumentation VI, "Area Radiation Monitor System"C.16, also facility supplied question

C.16 c
REF: NEEP 234, Controls and Instrumentation I & II figure 29 page 177.

C.17 a, 3; b, 4; c, 1; d, 2
REF: (NRC99) UWNR OTM, Reactor Water Systems III, "Demineralizer"; posted on wall near demineralizer

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

FACILITY: University of Wisconsin

REACTOR TYPE: TRIGA

DATE ADMINISTERED: 03/17/2008

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 brackets 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.

% of Category Value	% of Total	Candidates Score	Category Value	Category
20.00	33.3	______	____	A. ℞ Theory, Thermodynamics and Facility Operating Characteristics
20.00	33.3	______	____	B. Normal, Emergency and Radiological Controls Procedures
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

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.
13. When you have completed and turned in you examination, leave the examination area. If you are observed in this area while the examination is still in progress, your license may be denied or revoked.

EQUATION SHEET

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

1 Horsepower = 2.54 x 10^3 BTU/hr

1 BTU = 778 ft-lbf

1 gal (H_2O) ≈ 8 lbm

c_P = 1.0 BTU/hr/lbm/°F

1 kg = 2.21 lbm

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

A.01a 1 2 3 4 5 6 7 ___	A.07 a b c d ___
A.01b 1 2 3 4 5 6 7 ___	A.08 a b c d ___
A.01c 1 2 3 4 5 6 7 ___	A.09 a b c d ___
A.01d 1 2 3 4 5 6 7 ___	A.10 a b c d ___
A.02 a b c d ___	A.11 a b c d ___
A.03a 1 2 3 4 ___	A.12 a b c d ___
A.03b 1 2 3 4 ___	A.13 a b c d ___
A.03c 1 2 3 4 ___	A.14 a b c d ___
A.03d 1 2 3 4 ___	A.15 a b c d ___
A.04 a b c d ___	A.16 a b c d ___
A.05 a b c d ___	A.17 a b c d ___
A.06 a b c d ___	A.18 a b c d ___

B.01 a b c d ___

B.02a 1 2 5 10 20 ___

B.02b 1 2 5 10 20 ___

B.02c 1 2 5 10 20 ___

B.02d 1 2 5 10 20 ___

B.03a 1 2 3 4 ___

B.03b 1 2 3 4 ___

B.03c 1 2 3 4 ___

B.03d 1 2 3 4 ___

B.04a 0.2% 0.7% 1.4% 2.0% ___

B.04b 0.2% 0.7% 1.4% 2.0% ___

B.04c 0.2% 0.7% 1.4% 2.0% ___

B.05 a b c d ___

B.06a 1 2 3 4 ___

B.06b 1 2 3 4 ___

B.06c 1 2 3 4 ___

B.06d 1 2 3 4 ___

B.07 a b c d ___

B.08a Air Water Fission ___

B.08b Air Water Fission ___

B.08c Air Water Fission ___

B.08d Air Water Fission ___

B.09 a b c d ___

B.10 a b c d ___

B.11 a b c d ___

B.12 a b c d ___

B.13 a b c d ___

B.14 a b c d ___

B.15 a b c d ___

B.16 a b c d ___

C.01a 1 2 3 4 ___

C.01b 1 2 3 4 ___

C.01c 1 2 3 4 ___

C.01d 1 2 3 4 ___

C.02 a b c d ___

C.03 a b c d ___

C.04 a b c d ___

C.05 a b c d ___

C.06 a b c d ___

C.07 a b c d ___

C.08 a b c d ___

C.09 a b c d ___

C.10a 1 2 3 4 ___

C.10b 1 2 3 4 ___

C.10c 1 2 3 4 ___

C.10d 1 2 3 4 ___

C.11 a b c d ___

C.12 a b c d ___

C.13 a b c d ___

C.14 a b c d ___

C.15 a b c d ___

C.16 a b c d ___

C.17a 1 2 3 4 ___

C.17b 1 2 3 4 ___

C.17c 1 2 3 4 ___

C.17d 1 2 3 4 ___

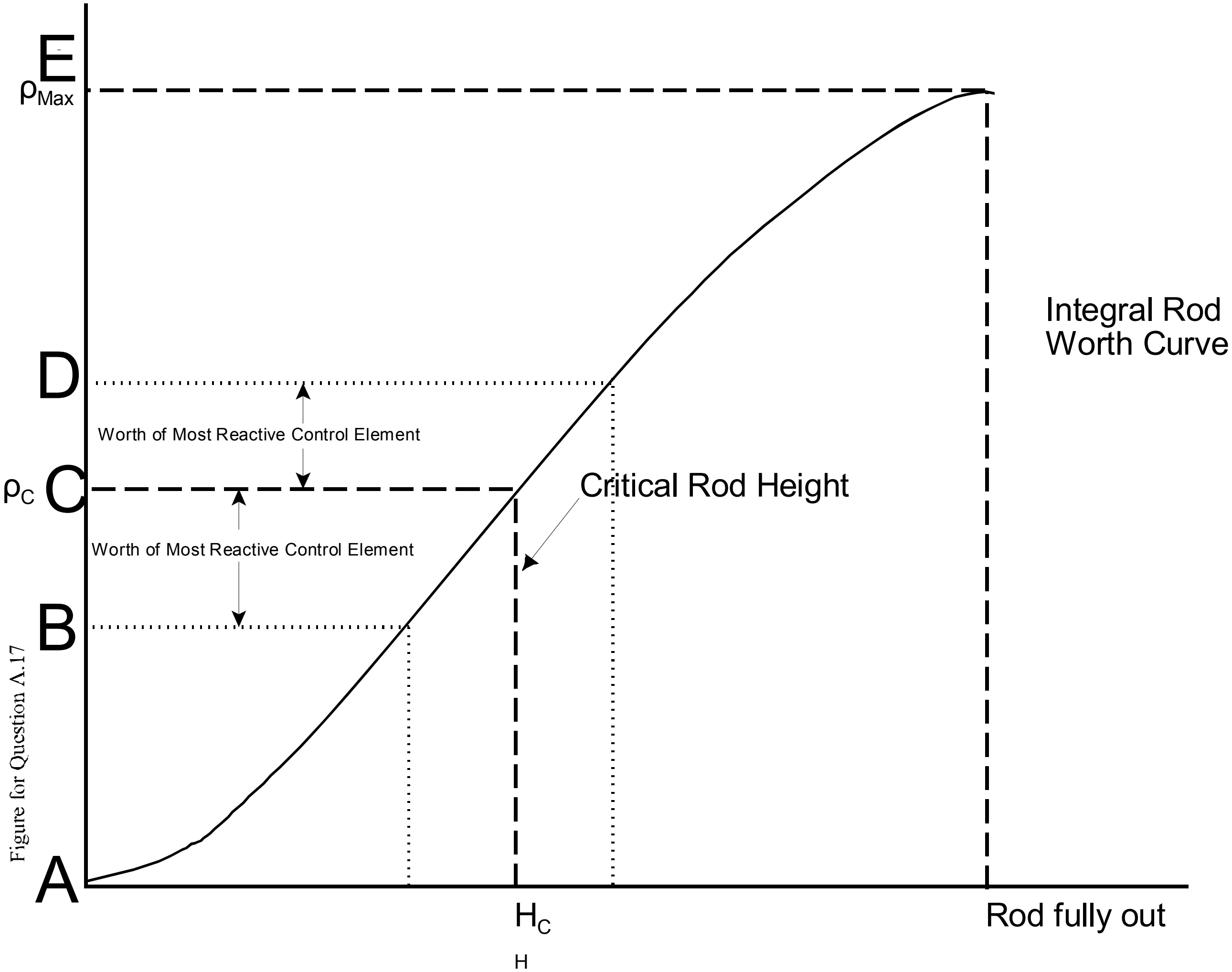


Figure for Question A.17