February 11, 2011

Dr. Donald Wall, Director
Nuclear Radiation Center
Washington State University
Pullman, WA 99164-1300

SUBJECT: INITIAL EXAMINATION REPORT NO. 50-027/OL-11-01, WASHINGTON STATE UNIVERSITY TRIGA REACTOR

Dear Dr. Wall:

During the week of January 17, 2011, the NRC administered an operator licensing examination at your Washington State University TRIGA Reactor. The examination was conducted according to NUREG-1478, "Operator Licensing Examiner Standards for Research and Test Reactors," Revision 2.

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 paul.doyle@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. 50-027

Enclosure 1: Initial Examination Report No. 50-027/OL-11-01
Enclosure 2: Facility Comments with NRC Resolutions
Enclosure 3: Corrected NRC Written Examination

cc without enclosure: See next page

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RidsNRRDPRPRTB Facility File (CRevelle) O-7F8

ADAMS ACCESSION #: ML110250168 **TEMPLATE #:NRR-074**

OFFICE	PRTB:CE		IOLB:LA	E	PRTB:SC	
NAME	PDoyle		CRevelle		JEads	
DATE	2/11/11		2/9/11		2/11/11	

OFFICIAL RECORD COPY

cc:

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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.: 50-027/OL-11-01

FACILITY DOCKET NO.: 50-027

FACILITY LICENSE NO.: R-76

FACILITY: Washington State University TRIGA

EXAMINATION DATES: January 19, 2010

SUBMITTED BY: **/RA/** 1/21/2011
Paul V. Doyle Jr., Chief Examiner Date

SUMMARY:

During the week of January 17, 2011, the NRC administered operator licensing examinations to two reactor operator (RO) license applicants at the Washington State University TRIGA reactor. Both license candidates passed all portions of their respective examination.

REPORT DETAILS

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

2. Results:

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

3. Exit Meeting: Paul V. Doyle Jr., NRC, Chief Examiner
Corey Hines, Nuclear Radiation Center, Supervisor

The chief examiner (CE) thanked the facility for their support in administering the examinations. The facility provided comments on the written examination which have been incorporated into the examination included with this report. No generic weaknesses were noted during the operating tests.

Washington State University Comments on NRC Written Examination

NRC Operator Exam for the WSU Reactor

1-19-11

Facility Comment:
Question B.02 We recommend this question be thrown out. The correct answer is Pullman Regional Hospital.

NRC Resolution:
Agree in part. The examiner asked the candidates to answer the question as written. The hospital is the same, but changed its name a few years ago. The NRC has changed the name of the hospital in the examination question bank for Washington State University.

Facility Comment:
Question B.09 We recommend that the correct answer be changed to 25 rem on the exam. Answer b. Per the emergency plan, the whole body dose for lifesaving purposes is 25 rems when no lower dose is practicable, and > 25 rems on a voluntary basis only.

NRC Resolution:
Agree. The answer key has been changed.

Facility Comment:
Question C.11 We recommend changing C.11c to Linear Channel, changing C.11d to Pulse Channel with 5 as the answer, and part C.11.e be thrown out.

NRC Resolution:
Agree. This question was modified during administration. Both candidates were made aware of the changes, the body and answer key for this question have been modified.

Facility Comment:
Question C.16 We recommend this question be thrown out. This is no longer done for the operability check per out SOPs. A different procedure is used entirely.

NRC Resolution:
Agree. Further discussion with the facility revealed that the radiation monitoring equipment stipulated in the question was replaced with radiation monitoring equipment without the option to insert a test signal internally.

U.S. Nuclear Regulatory Commission

Research and Test Reactors
Operator Licensing Examination

WITH ANSWER KEY

Washington State University TRIGA Reactor
Week of January 17, 2011

Enclosure 3

Question A.01 [1.0 point]
Which **ONE** of the four factors listed below is the **MOST** affected by an increase in poison level in the reactor?

a. Fast Fission Factor (ε)

b. Fast Non-Leakage Probability ($\mathcal{L}_f$)

c. Thermal Utilization Factor (f)

d. Reproduction Factor (η)

Question A.02 [1.0 point]
A **FAST** neutron will lose the **MOST** energy per collision when interacting with the nucleus of which ONE of the following elements?

a. H^1

b. H^2

c. C^{12}

d. U^{238}

Question A.03 [1.0 point]
β for U^{235} is 0.0065. $\beta_{effective}$ for the Washington State Univ. reactor is 0.007. Why is $\beta_{effective}$ larger?

a. The reactor contains U^{238} which has a larger β for fast fission than U^{235}.

b. The reactor contains Pu^{239} which has a larger β for thermal fission than U^{235}.

c. Delayed neutrons are born at a higher average energy than fission neutrons resulting in a greater amount of fast fissioning.

d. Delayed neutrons are born at a lower average energy than fission neutrons resulting in fewer being lost to fast leakage.

Question A.04 [1.0 point]
Immediately after a pulse [approximately 1 millisecond] where is the HOTTEST part of a fuel element?

a. in the fuel cladding itself

b. at the edge of the fuel elements adjacent to the cladding

c. at the thermocouples, midway between the fuel axial centerline and the fuel edge.

d. the center of the fuel elements

Question A.05 [1.0 point]
During a reactor startup, the Reactor Operator notes that the source is not in. After inserting the neutron source you note reactor power is increasing **LINEARLY**. What was the condition of the reactor just prior to inserting the source?

a. Substantially subcritical

b. Slightly subcritical

c. Exactly critical

d. Slightly supercritical

Question A.06 [1.0 point]
A reactor startup is in progress. Each control rod withdrawal is inserting exactly **EQUAL** amounts of reactivity. Select the **EXPECTED** neutron population and count rate response as "K_{eff}" approaches 1.0. The change in neutron population per reactivity insertion is:

a. **SMALLER**, and it takes **LESS** time to reach a new equilibrium count rate

b. **LARGER**, and it takes **LESS** time to reach a new equilibrium count rate.

c. **SMALLER**, and it takes **MORE** time to reach a new equilibrium count rate.

d. **LARGER**, and it takes **MORE** time to reach a new equilibrium count rate.

Question A.07 [1.0 point]
The difference between a moderator and a reflector is that a reflector …

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

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

c. increases the neutron production factor, and a moderator decreases the thermal utilization factor.

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

Question A.08 [1.0 point]
During a startup you increase reactor power from 100 watts to 195 watts in a minute. Which ONE of the following is reactor period?

a. 30 seconds.

b. 60 seconds.

c. 90 seconds.

d. 120 seconds.

Question A.09 [1.0 point]
The Fast Fission Factor (ε) is defined as "The ratio of the number of neutrons produced by …

a. fast fission to the number produced by thermal fission.

b. thermal fission to the number produced by fast fission.

c. fast and thermal fission to the number produced by thermal fission.

d. fast fission to the number produced by fast and thermal fission.

Question A.10 [1.0 point]
When performing rod calibrations, many facilities pull the rod out a given increment, then measure the time for reactor power to double (doubling time), then calculate the reactor period. If the doubling time is 42 seconds, what is the reactor period?

a. 29 sec

b. 42 sec

c. 61 sec

d. 84 sec

Question A.11 [1.0 point]
Which one of the following conditions would **INCREASE** the shutdown margin of a reactor?

a. Inserting an experiment adding positive reactivity.

b. Lowering moderator temperature if the moderator temperature coefficient is negative.

c. Depletion of a burnable poison.

d. Depletion of uranium fuel.

Question A.12 [1.0 point]
Which one of the following factors is the most significant in determining the differential worth of a control rod?

a. The rod speed.

b. Reactor power.

c. The flux shape.

d. The amount of fuel in the core.

Question A.13 [1.0 point]
Which one of the following statements concerning reactivity values of equilibrium (at power) xenon and peak (after shutdown) xenon is correct? Equilibrium xenon is _________ of power level; peak xenon is _______ of power level.

a. **INDEPENDENT INDEPENDENT**

b. **INDEPENDENT DEPENDENT**

c. **DEPENDENT INDEPENDENT**

d. **DEPENDENT DEPENDENT**

Question A.14 [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.

Question A.15 [1.0 point]
Which one of the following statements describes why installed neutron sources are used in reactor cores?

a. To increase the count rate by an amount equal to the source contribution.

b. To increase the count rate by 1/M (M = Subcritical Multiplication Factor).

c. To provide neutrons to initiate the chain reaction.

d. To provide a neutron level high enough to be monitored by instrumentation.

Question A.16 [1.0 point]
Several processes occur during the neutron cycle which increase or decrease the number of neutrons. Which ONE of the following describes a process which **INCREASES** the number of neutrons?

a. Fast Non-Leakage probability ($\mathcal{L}_f$)

b. Resonance Escape Probability (p)

c. Thermal Utilization Factor (f)

d. Reproduction Factor (η)

Question A.17 [1.0 point]
INELASTIC 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. is absorbed, with the nucleus emitting a gamma ray, and the neutron with a lower kinetic energy.

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.18 [1.0 point]
A reactor is exactly critical. What is the resultant K_{eff} if all delayed neutrons were instantaneously removed from the reactor?

a. 1.007

b. 1.000

c. 0.993

d. 0.0000

Question A.19 [1.0 point]
An initial count rate of 100 is doubled five times during startup. Assuming an initial K_{eff}=0.950, what is the new K_{eff}?

a. 0.957

b. 0.979

c. 0.988

d. 0.998

Question A.20 [1.0 point]
K_{eff} is K_{∞} times …

a. the fast fission factor (ε)

b. the total non-leakage probability ($\mathfrak{L}_f \times \mathfrak{L}_{th}$)

c. the reproduction factor (η)

d. the resonance escape probability (p)

Question B.01 [2.0 points, ½ each]
Match the requirements 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 year
b.	Medical Examination	2 years
c.	Requalification Written examination	4 years
d.	Requalification Operating Test	6 years

Question B.02 [1.0 point] This question will be modified as shown below. It was NOT modified for the examination. The candidates were asked to answer what the answer was from the old emergency plan.

An experimenter fell while carrying an irradiated sample. He broke his arm, and is bleeding. In addition, the sample container broke and the experimenter is contaminated by radioactive powder. Where would you send the experimenter for treatment?

a. Moscow Clinic

b. ~~Memorial Hospital~~ Pullman Regional Hospital

c. Whitman Hospital

d. St. Joseph Regional Medical Center

Question B.03 [1.0 point]
Identify the lowest level of management who may authorize a substantive change to the Technical Specifications:

a. Any Reactor Operator

b. Any Senior Reactor Operator

c. The Facility Director

d. The NRC

Question B.04 [1.0 point]
Your annual dose received to date is 900 mRem. You are performing maintenance on the reactor, in an area with an average dose rate of 300 mRem/hr. Which of the following is the longest you may work without **EXCEEDING** a 10 CFR 20 deep dose limit?

a. 1 hour

b. 7 hours

c. 13 hours

d. 24 hours

Question B.05 [1.0 point]

Total Effective Dose Equivalent (TEDE) is defined as the sum of the deep dose equivalent and the committed effective dose equivalent. The deep dose equivalent is related to the …

a. dose to organs or tissues.

b. external exposure to the skin or an extremity.

c. external exposure to the lens to the eyes.

d. external whole-body exposure

Question B.06 [1.0 point]

Limiting Safety System Settings (LSSS) are …

a. limits on very important process variables which are found to be necessary to reasonably protect the integrity of certain physical barriers which guard against the uncontrolled release of radioactivity.

b. settings for automatic protective devices related to those variable having significant safety functions.

c. combinations of sensors, interconnecting cables of lines, amplifiers and output devices which are connected for the purpose of measuring the value of a variable.

d. the lowest functional capability of performance levels of equipment required for safe operation of the facility.

Question B.07 [1.0 point]

Which ONE of the following conditions does not meet the requirements of an **IRRADIATION**?

a. Dose equivalent rate of 5 Rem/hr at 1 foot upon removal from the reactor shielding.

b. Irradiation resides in the reactor for 12 days.

c. Reactivity worth is $0.45

d. The sample contains natural uranium.

Question B.08 [1.0 point]

Which one of the following can authorize reentry to the WSU NRC facilities after an evacuation due to an emergency?

a. Nuclear Regulatory Commission.

b. The Radiation Safety Officer.

c. The Emergency Director.

d. The State of Washington Department of Social and Health Services, Radiation Control Section.

Question B.09 [1.0 point]
Which one of the following is the maximum whole body dose allowed to save a life in accordance with the WSU NRC Emergency Preparedness Plan?

a. 12 rems.

b. 25 rems.

c. 100 rems.

d. 500 rems.

Question B.10 [1.0 point]
Which one of the following is the **MINIMUM** level of staff to authorize maintenance that is not described or outlined in any SOP or Administrative Procedure, and determine the need for a specific written procedure?

a. The WSU NRC Director.

b. The Reactor Supervisor.

c. A Senior Reactor Operator.

d. A Reactor Operator.

Question B.11 [1.0 point]
Which one of the following is the dose rate at one foot above which operations involving the sample must be directly supervised by the Reactor Supervisor, Radiation Safety Evaluator or a designated assistant?

a. 100 mRem/Hr.

b. 500 mRem/Hr.

c. 1 Rem/Hr.

d. 10 Rem/Hr.

Question B.12 [1.0 point]
Which one of the following is the **MINIMUM** shutdown margin specified for administrative purposes by the SOPs?

a. $0.10

b. $0.25

c. $0.50

d. $1.00

Question B.13 [1.0 point]
You've been asked to retrieve a sample. There is some concern that the experimenter made a math error and the sample may have a stronger radiation field than anticipated. You expect the sample to emit both a beta and a gamma radiation. The person removing the sample stops the withdrawal at 3 feet below the surface. Given the HVL for 1 Mev gamma radiation in water is about 8 inches, is this a realistic level to stop to detect a radiation problem and why?

a. Yes, three feet of water is not a very good at shielding either beta or gamma radiation.

b. No, three feet of water is an excellent shield for betas, you will however get an accurate reading for gammas.

c. No, three feet of water is an excellent shield for gammas, you will however get an accurate reading for betas.

d. No, three feet of water is an excellent shield for betas and the reading for gammas will be off by a factor of about 30.

Question B.14 [1.0 point]
The reactor scrams due to loss of power (electrical storms). Prior to restarting the reactor you must get permission from (as a minimum)

a. An NRC licensed Reactor Operator

b. An NRC licensed Senior Operator

c. The Reactor Supervisor

d. The Reactor Manager

Question B.15 [2.0 points, ½ each]
Identify each of the following as either a Safety Limit (SL), Limiting Safety System Setting (LSSS) or a Limiting Condition for Operation (LCO).

a. The reactor power shall not exceed 1.3 MW under any condition of operation.

b. 500°C as measured in an instrumented fuel rod located in the central region of the core.

c. The maximum temperature in a 30/20 LEU-type TRIGA fuel rod shall not exceed 1150°C under any condition of operation.

d. All fuel elements shall be stored in a geometrical array where the K_{eff} is less than 0.8 for all conditions of moderation.

Question B.16 [1.0 point]
Which **ONE** of the following locations is the normal (no evacuation required) Emergency Support Center per the Emergency Plan?

a. Reactor Control Room

b. Reactor Shop

c. Sidewalk in front of the Nuclear Radiation Center Main Office.

d. Nuclear Radiation Center Main Office.

Question B.17 [1.0 point]
The Quality Factor is used to convert …

a. dose in rads to dose equivalent in rems.

b. dose in rems to dose equivalent in rads.

c. contamination in rads to contamination equivalent in rems

d. contamination in rems to contamination equivalent in rads.

Question B.18 [1.0 point, ¼ each]
Match the Federal Regulation chapter in column A with the requirements covered in column B.

	Column A		Column B
a.	10 CFR 20	1.	Operator Licenses
b.	10 CFR 50	2.	Facility Licenses
c.	10 CFR 55	3.	Radiation Protection
d.	10 CFR 73	4.	Special Nuclear Material

Question C.01 [1.0 point]
Which of the following components is primarily responsible for maintenance of pool water pH?

a. Water Filter

b. Mixed Bed Ion Exchanger

c. Skimmer

d. Chemical addition pot

Question C.02 [1.0 point]
How is radioactive effluent discharged using the dilution method?

a. The Dump/recirc pump supplies water to the eductor, which in turn provides motive force for the raw water.

b. The Dump/recirc pump supplies water to the vacuum break, which in turn provides motive force for the raw water.

c. The raw water flow through the eductor provides motive force for the radioactive effluent from the sample tank.

d. The raw water flow through the vacuum break provides motive force for the radioactive effluent from the sample tank.

Question C.03 [1.0 point]
A pipe breaks just downstream of the primary coolant pump. What design feature of the system prevents draining of the pool?

a. Signal from a pool float which shuts a valve in the pump suction line.

b. Signal from a pool float which shuts off the primary pump.

c. Level in the pool drops below a minimum required to supply suction pressure to the pump. (Net Positive Suction Head)

d. Level in the pool drops below siphon break holes in the suction pipe.

Question C.04 [1.0 point]
Which ONE of the following is the neutron source use for reactor startup?

a. ^{241}Am–^{9}Be (Americium Beryllium)

b. ^{239}Pu–^{9}Be (Plutonium Beryllium)

c. ^{210}Po–^{9}Be (Polonium Beryllium)

d. ^{123}Sb–^{9}Be (Antimony Beryllium)

Question C.05 [2.0 points, ½ each]
Match the purification system functions in column A with the purification component listed in column B

Column A	Column B
a. remove floating dust, bug larvae, etc.	1. Demineralizer (Ion Exchanger)
b. remove dissolved impurities	2. Skimmer
c. remove suspended solids	3. Filter (strainer)
d. maintain pH	

Question C.06 [1.0 point]
Which ONE of the choices correctly identifies the radiation detector signal which if it trips will realign the ventilation system to dilute mode?

a. Continuous Air Monitor WARN alarm

b. Continuous Air Monitor HIGH alarm

c. Exhaust Gas Monitor WARN alarm

d. Exhaust Gas Monitor HIGH alarm.

Question C.07 [1.0 point]
Following a reactor power calibration if necessary power reading on the Nuclear Instruments is adjusted by

a. adjusting the physical position (up or down) of the detector.

b. adjusting the high voltage signal to the detector.

c. adjusting the gain of the preamplifier circuit.

d. adjusting the meter face.

Question C.08 [1.0 point]
During a reactor scram, damage to electrically operated control rods is prevented by …

a. A small spring located at the bottom of the rod.

b. A piston attached to the upper end of the safety rod enters a special damping cylinder as the rod approaches the full insert position.

c. An electrical-mechanical brake energizes when the rod down limit switch is energized.

d. A dashpot which is positioned at the end of the shaft travel which decelerates the rod for the last five inches of fall.

Question C.09 [1.0 point]
Which ONE of the following parameters is NOT measured in the Primary Cooling Loop?

a. Temperature

b. Pressure

c. Conductivity

d. pH

Question C.10 [1.0 point]
Which ONE of the following is the method used to detect a slow leak in the primary/secondary coolant heat exchanger?

a. Lowering pool level.

b. Positive gross β-γ sample of secondary water.

c. Increasing conductivity in primary water.

d. Increasing amount of make-up water in secondary.

Question C.11 [2.0 points, ~~0.4~~ 0.5 each] **The candidates were made aware of this change during the exam.**
Match the instrument channel in column A with the appropriate detector listed in column B.

a. Start-up Channel	1. Compensated Boron Lined Ion Chamber
b. Log Count Rate Channel	2. Fission Chamber
c. Wide Range Linear Channel	3. Geiger Tube
d. ~~Safety Channel 1~~ Pulse Channel	4. Ion Chamber (No lining)
~~e. Safety Channel 2~~	~~5. Uncompensated Boron Lined Ion Chamber~~

Question C.12 [1.0 point]
During operations at high power (950 kWatt) you lose compensating voltage for a compensated on chamber. Which ONE of the following would be the resulting change in indicated power?

a. Small decrease in indicated power

b. Large decrease in indicated power (Scram, due to loss of compensating voltage.)

c. Small increase in indicated power.

d. Large increase in indicated power

Question C.13 [1.0 point]

Which ONE of the following is the method used to control the buildup of salt (dissolved solids) in the secondary system?

a. Secondary makeup system uses deionized water.

b. A demineralizer (ion exchanger)

c. Periodic draining of sump (blowdown of system).

d. Activated charcoal filter.

Question C.14 [1.0 point]

How is the signal supplying the control element continuous position indication generated?

a. A series of limit switches located every ½ inch of control element length open and close as the magnet passes generating a signal proportional to control element position.

b. A servo generator chain driven by the drive motor generates a signal proportional to control element position.

c. A lead screw at the top of the control element moves in and out of an induction coil generating a signal proportional to the control element position.

d. A servo generator located in the control panel, is energized by auxiliary contacts in the in-out switch generating a signal proportional to the control element position.

Question C.15 [1.0 point]

Which ONE of the following neutron absorbing materials is NOT used in any of the control elements?

a. Borated Graphite

b. Boron-Aluminum Alloy (Boral)

c. Hafnium

d. Stainless Steel

Question C.16 [1.0 point] **This question was deleted per facility comment.**

~~The operability check for the ARMs requires you to depress a lighted green button on the face of the monitor. Depressing the green button …~~

~~a. grounds the meter output, so that you may check the zero position on the meter.~~

~~b. exposes the detector to a test source so that you may check operability.~~

~~c. inserts an electrical test signal into the circuitry to test operability.~~

~~d. checks the operability of the battery backup for the detector.~~

Question C.17 [1.0 point]
You've been asked to retrieve a sample. There is some concern that the experimenter made a math error and the sample may have a stronger radiation field than anticipated. Which ONE of the following detectors would you use as you approach the sample?

a. Geiger-Müller

b. GeLi

c. Scintillation

d. Ion Chamber

Question C.18 [1.0 point]
The purpose of the graphite slugs located at the top and bottom of each fuel rod is …

a. absorb neutrons, thereby reducing neutron embrittlement of the upper and lower guide plates.

b. absorb neutrons, thereby reducing neutron leakage from the core.

c. reflect neutrons, thereby reducing neutron leakage from the core.

d. couple neutrons from the core to the nuclear instrumentation, decreasing shadowing effects.

A.01 c
REF: WSU RO Training Manual, Unit 5, p. 119. Exam 1

A.02 a
REF: WSU RO Training Manual, Unit 5, p. 76. Exam 1

A.03 d
REF: WSU RO Training Manual, Unit 6, § 2.2 Delayed Neutrons. Exam 1

A.04 b
REF: WSU, Reactor Operator Training Manual, Figure 6.21, p. 6-51. Exam 1

A.05 c
REF: RO Training Manual, Unit 6, pages 6-21, & 6-22. Exam 1

A.06 d
REF: Reactor Training Manual - *Introduction To Nuclear Physics*. Exam 1, Exam 4, Exam 6

A.07 a
Ref: Reactor Training Manual - *Reflector* and *Moderation*. Exam 6

A.08 c
Ref: $P = P_0 e^{t/\tau}$ —> $\tau = t/\ln(P/P_0)$ $\tau = 60/\ln(195/100) = 60/\ln(1.95) = 89.84 \approx 90$ sec. Exam 6

A.09 c
Ref: Reactor Training Manual - *Neutron Life Cycle*. Exam 6

A.10 c
Ref: $\ln(2) = -\text{time}/\tau$ $\tau = \text{time}/(\ln(2)) = 60.59 \approx 61$ seconds. Exam 6

A.11 d
Ref: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 6.2.3, p. 6-4. Exam 7

A.12 c
Ref: Lamarsh, J.R., *Introduction to Nuclear Engineering,*1983. § 7.2, p. 303.
Burn, R., *Introduction to Nuclear Reactor Operations,* © 1982, § 7.2 & 7.3, pp. 7-1 — 7-9. Exam 7

A.13 d
Ref: Lamarsh, J.R., *Introduction to Nuclear Engineering,* - 1983. § 7.4, pp. 316 — 322.
Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, §§ 8.1 —8.4, pp. 8-3 — 8-14. Exam 7

A.14 a
Ref: T.S. Definition 1.8, Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 6.2.1, pp. 6-2. Exam 7

A.15 d
Ref: Standard NRC QuestionBurn, R., © 1982, §5.2, p. 5-1. Exam 7

A.16 d
Ref: Glasstone, S. And Sesonske, A, *Nuclear Reactor Engineering,* Kreiger Publishing, Malabar, Florida, 1991, § 3.154, p. 188. Exam 7

A.17 b
Ref: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, §. Exam 7

A.18 c
Ref: WSU RO Training Manual, Unit 5. Exam 1, Exam 4

A.19 d
Ref: WSU RO Training Manual, Unit 5, §IV.A Approach to Critial p. 174. Exam 1 $CR_1/CR_2 = (1 - K_{eff2})/(1 - K_{eff1})$
$1/32\ (1 - 0.95) = 1 - K_{eff2}$ $1 - 0.05/32 = K_{eff2}$ $K_{eff2} = 0.9984$

A.20 b
Ref: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory.

B.01 a, 6; b, 2; c, 2; d, 1
Ref: 10 CFR 55 Exam 1. Exam 1

B.02 b
Ref: WSU Emergency Plan, § 3.1.12, p. 13. Exam 1

B.03 d
Ref: 10 CFR 50.90. Exam 1

B.04 c
Ref: Stay time = (can get - got) divided by dose. Can get is the 10 CFR 50 limit = 5.0 Rem.
(5.0 - 0.9) ÷ 0.3 = (4.1)/3 = 13⅔. 13 is less than 13⅔. Exam 1

B.05 d
Ref: 10 CFR 20.1201. Exam 1

B.06 b
Ref: Technical Specifications § 1.4 *Reactor Instrumentation.* Exam 1

B.07 c
Ref: SOP-2, § A, second paragraph, 1–4, pages 1 and 2, and SOP-1, § B.1 a–d, page 2. Exam 1

B.08 c
Ref: WSU NRC Emergency Preparedness Plan Section 3.4. Exam 1a

B.09 ~~c~~ b answer changed per facility comment.
Ref: WSU NRC Emergency Preparedness Plan Section 3.5. Exam 1a

B.10 c
Ref: WSU NRC Administrative Procedure, "Performance of Maintenance Activities," Page 1 Section C. Exam 1a

B.11 a
Ref: WSU NRC SOP #1, Page 13, Section M. Exam 1a

B.12 c
Ref: WSU NRC SOP #5, Page 10, Section II.M. Exam 1a

B.13 d
Ref: Standard NRC Question

B.14 b
Ref: SOP 4 § A.3.c. Exam 2

B.15 a, LCO; b, LSSS; c, SL; d, LCO
Ref: T.S. a: § 3.1.a; b: § 2.2.a; c: § 2.1.b; d § 3.8.d. Exam 2

B.16 d
Ref: Emergency Plan, § 8.1. Exam 2

B.17 a
Ref: 10CFR20.1004. Exam 2

B.18 a, 3; b, 2; c, 1; d, 4
Ref: Facility License and 10 CFR Parts 20, 50, 55 and 73

C.01 b
Ref: WSU SAR, figure 4.10. Exam 1

C.02 c
Ref: WSU, SAR, Figure 3.4-1, p. 3-13, and WSU SOP #11, Standard Procedure for Liquid Waste Samples, § D Dilution System, pp. 6 – 8. Exam 1

C.03 d
Ref: WSU SAR figure 4.9. Exam 1, Exam 4, Exam 8

C.04 d
Ref: Unit 11, Table: WSU TRIGA Reactor Characteristics. Exam 1

C.05 a, 2; b, 1; c, 3; d, 1
Ref: SAR § 4.10, figure 4.10-1. Exam 2

C.06 b
Ref: SOP 19 § C.2.d.2.a.2. p. 5. Exam 2

C.07 a
Ref: Old NRC question from Examination Question bank, also SOP 13, p. 5. Exam 2

C.08 d
Ref: SAR § 4.7, p. 4-19, 1st ¶. Exam 2

C.09 d
Ref: SAR § 4,9. Exam 2

C.10 c
Ref: SAR

C.11 a, 2; b, 2; c, 1; d, ~~1~~ 5; ~~e, 5~~ Question modified per facility comment.
Ref: SAR

C.12 c
Ref: Reactor Operator Training Manual, Unit 7, § 2.2.2, Compensated Ion Chambers ¶ #2. Exam 1

C.13 c
Ref: SAR

C.14 b
Ref: WSU SOP #8, Standard Procedure for Control Element Maintenance, Removal and Replacement, CAUTION on page 4. Exam 1, Exam 2, Exam 4, Exam 7

C.15 c
Ref: WSU SAR, §§ 4.5 & 4.6, pp. 4-9 – 4-16. Exam 1, Exam 2, Exam 4, Exam 7.

~~C.16 b~~ Question deleted per facility comment.
~~Ref: SOP-17, § B.1 p. 1. Exam 1, Exam 7~~

C.17 d
Ref: Standard NRC question, also NRC Examination Question Bank. Exam 2, Exam 4, Exam 8, Exam 11

C.18 c
Ref: SAR § Figure on page 4-10. Exam 2, Exam 7

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

FACILITY: Washington State University

REACTOR TYPE: TRIGA

DATE ADMINISTERED: 01/ /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 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. Reactor Theory, Thermodynamics and Facility Operating Characteristics
20.00	33.3	_______	______	B. Normal and Emergency Operating Procedures and Radiological Controls
20.00	33.3	_______	______	C. Facility and Radiation Monitoring Systems
60.00	TOTALS	_______	______	FINAL GRADE

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 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.
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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$DR_1 d_1^2 = DR_2 d_2^2$$

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

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

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

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

1 Horsepower = 2.54 x 10^3 BTU/hr

1 BTU = 778 ft-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.01	a b c d ___	A.11	a b c d ___
A.02	a b c d ___	A.12	a b c d ___
A.03	a b c d ___	A.13	a b c d ___
A.04	a b c d ___	A.14	a b c d ___
A.05	a b c d ___	A.15	a b c d ___
A.06	a b c d ___	A.16	a b c d ___
A.07	a b c d ___	A.17	a b c d ___
A.08	a b c d ___	A.18	a b c d ___
A.09	a b c d ___	A.19	a b c d ___
A.10	a b c d ___	A.20	a b c d ___

B.01a 1 2 3 6 ___

B.01b 1 2 3 6 ___

B.01c 1 2 3 6 ___

B.01d 1 2 3 6 ___

B.02 a b c d ___

B.03 a b c d ___

B.04 a b c d ___

B.05 a b c d ___

B.06 a b c d ___

B.07 a b c d ___

B.08 a b c d ___

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.15a SL LSSS LCO ___

B.15b SL LSSS LCO ___

B.15c SL LSSS LCO ___

B.15d SL LSSS LCO ___

B.16 a b c d ___

B.17 a b c d ___

B.18a 1 2 3 4 ___

B.18b 1 2 3 4 ___

B.18c 1 2 3 4 ___

B.18d 1 2 3 4 ___

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