September 27, 2007

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

SUBJECT: INITIAL EXAMINATION REPORT NO. 50-027/OL-07-02, WASHINGTON STATE UNIVERSITY

Dear Dr. Wall:

During the week of August 6, 2007, the NRC administered an initial operator licensing examinations at your Washington State University Reactor. The examinations were conducted according to NUREG-1478, "Non-Power Reactor Operator Licensing Examiner Standards ," Revision 1. 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 10 CFR 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 (the Public Electronic Reading Room) 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. 50-027

Enclosures: 1. Initial Examination Report No. 50-027/OL-07-02
2. Examination with NRC resolution of Facility comments included

cc w/enclosures:
Please see next page

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ADAMS ACCESSION #: ML072420395 **TEMPLATE #:NRR-074**

OFFICE	PRTB:CE	IOLB:LA	PRTB:SC
NAME	PDoyle pvd	CHart cah	JEads jhe
DATE	9/19/2007	09/27/2007	9/27/2007

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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-07-02

FACILITY DOCKET NO.: 50-027

FACILITY LICENSE NO.: R-76

FACILITY: Washington State University

EXAMINATION DATES: August 07-08, 2007

SUBMITTED BY: /RA/ 9/19/07
Paul V. Doyle Jr., Chief Examiner Date

SUMMARY:

During the week of August 6, 2007, the NRC administered operator licensing examinations to one Senior Reactor Operator (Upgrade), and 2 Reactor Operator license candidates. One Reactor Operator failed section A of the written examination only. The other two candidates passed all portions of their administered examinations.

REPORT DETAILS

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

2. Results:

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

3. Exit Meeting:
   Paul V. Doyle Jr., NRC, Examiner
   John Nguyen, NRC, Project Manager
   Eric Corwin, Washington State University TRIGA, Reactor Supervisor
   David King, Washington State University TRIGA, SRO

   The NRC examiner thanked the facility staff for their support in the administration of the examinations. The facility had four comments on the written examination which have been incorporated into the version included with this report. The NRC project manager, also thanked the facility for their support of his getting acquainted with the WSU TRIGA reactor.

ENCLOSURE 1

OPERATOR LICENSING EXAMINATION
With Answer Key

UNITED STATES NUCLEAR REGULATORY COMMISSION

WASHINGTON STATE UNIVERSITY
August 07, 2007

ENCLOSURE 2

QUESTION A.01 [1.0 point]
Which alteration or change to the core will most strongly affect the thermal utilization factor.

a. Build up of fission products in fuel.

b. Removal of moderator.

c. Addition of U^{238}

d. Removal of a control rod.

QUESTION A.02 [1.0 point]
Following a significant reactor power increase, the moderator temperature coefficient becomes increasingly more negative. This is because:

a. as moderator density decreases, less thermal neutrons are absorbed by the moderator than by the fuel.

b. the change in the thermal utilization factor dominates the change in the resonance escape probability.

c. a greater density change per degree F occurs at higher reactor coolant temperatures.

d. the core transitions from an under-moderated condition to an over-moderated condition.

QUESTION A.03 [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.04 [1.0 point]
The term "***Prompt Critical***" refers to:

a. the instantaneous jump in power due to a rod withdrawal

b. a reactor which is supercritical using only prompt neutrons

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

d. a reactivity insertion which is less than $ß_{eff}$

QUESTION A.05 [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.06 [2.0 points. ½ each]
Match each term in column A with the correct definition in column B.

	Column A	Column B
a.	Prompt Neutron	1. A neutron in equilibrium with its surroundings.
b.	Fast Neutron	2. A neutron born directly from fission.
c.	Thermal Neutron	3. A neutron born due to decay of a fission product.
d.	Delayed Neutron	4. A neutron at an energy level greater than its surroundings.

QUESTION A.07 [1.0 point]
A reactor is subcritical with a shutdown margin of 0.0526 ΔK/K. The addition of a reactor experiment increases the indicated count rate from 10 cps to 20 cps. Which one of the following is the new K_{eff} of the reactor?

a. 0.53

b. 0.90

c. 0.975

d. 1.02

QUESTION A.08 [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.09 [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.10 [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.11 [1.0 point]
Which ONE of the following describes the MAJOR contributor to the production and depletion of Xenon respectively in a STEADY-STATE OPERATING reactor?

	Production	Depletion
a.	Radioactive decay of Iodine	Radioactive Decay
b.	Radioactive decay of Iodine	Neutron Absorption
c.	Directly from fission	Radioactive Decay
d.	Directly from fission	Neutron Absorption

QUESTION A.12 [1.0 point]
In a reactor at full power, the thermal neutron flux (φ) is 2.5 x 10^{12} neutrons/cm^2/sec. and the macroscopic fission cross-section Σ_f is 0.1 cm^{-1}. The fission reaction rate is:

a. 2.5 x 10^{11} fissions/sec.

b. 2.5 x 10^{13} fissions/sec.

c. 2.5 x 10^{11} fissions/cm^3/sec.

d. 2.5 x 10^{13} fissions/cm^3/sec.

QUESTION A.13 [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.14 [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 K_{eff}

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.15 [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.16 [1.0 point] ✔

Regulating rod worth for a reactor is 0.001 ΔK/K/inch. The moderator temperature coefficient (α_{Tmod}) for the same reactor is 0.0005 ΔK/K/°F. If moderator temperature increases by 9°F. By how much, and in which direction must the regulating rod move to compensate?

a. 4½ inches, outward

b. 9 inches, outward

c. 4½ inches, inward

d. 9 inches, inward

QUESTION A.17 [1.0 point]
You just shutdown the reactor. Reactor period has stabilized at -80 sec and reactor power is at 1000 cpm. What would you expect reactor power to read three minutes later.

a. 500 cpm

b. 333 cpm

c. 100 cpm

d. 10 cpm

QUESTION A.18 [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.19 [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 B.01 [1.0 point]
Based on the Requalification Plan for operators, each licensed operator must complete a minimum of ______ reactivity manipulations during each 2 year cycle.

a. 4

b. 10

c. 20

d. 28

QUESTION B.02 [1.0 point]
What is the best type of shielding material to protect personnel from a thermal neutron beam?

a. Lead

b. Heavy clothing

c. Rubber

d. $Boron^{10}$

QUESTION B.03 [1.0 point]
Which one of the following is the definition of Committed Dose Equivalent?

a. The sum of the deep dose equivalent and the committed effective dose equivalent.

b. The dose equivalent that the whole body receives from sources outside the body.

c. The sum of the external deep dose equivalent and the organ dose equivalent.

d. The 50 year dose equivalent to an organ or tissue resulting from an intake of radioactive material.

QUESTION B.04 [2.0 points, ½ each]
Identify each of the actions listed below as either a Channel ***CHECK***, Channel ***TEST***, or Channel ***CAL***ibration.

a. Verifying overlap between Nuclear Instrumentation meters.

b. Replacing an RTD with a precision resistance decade box, to verify proper channel output for a given resistance.

c. Performing a calorimetric (heat balance) calculation on the primary system, then adjusting Nuclear Instrumentation to agree.

d. During shutdown you verify that the period meter reads -80 seconds.

QUESTION B.05 [1.0 point]
WSU uses three classifications of accidents. Choose the item below which correctly lists the three classifications in least to most significant order.

a. alert, safety event, unusual event

b. unusual event, alert, safety event

c. safety event, unusual event, alert

d. unusual event, safety event, alert

QUESTION B.06 [1.0 point]
Per TABLE 3.5: Extreme Emergency Exposure Guidelines, in the Emergency plan the limit for "protecting valuable property" is …

a. 5 Rem

b. 10 Rem

c. 15 Rem

d. 25 Rem

QUESTION B.07 [1.0 point] Question Deleted: Highlighted words in question stem were omitted from the administered examination.
The Emergency Plan defines "Emergency Planning Zone" as …

a. The area encompassed by within a 150 foot (~50 meter) perimeter measured from the centerline of the reactor core.

b. The area encompassed by within a 150 foot (~50 meter) perimeter measured from the centerline of the ventilation stack.

c. The perimeter of the main Nuclear Radiation Center building as modified by the two small fences at the freight doors.

d. The perimeter of the main Nuclear Radiation Center building as modified by the two small fences at the freight doors, and the area over the radiation liquid waste tanks.

QUESTION B.08 [1.0 point]
Per Technical Specifications regarding the Ventilation System: "The reactor shall not be operated unless the facility ventilation system is operable, except for periods of time not to ____ exceed hours to permit repair or testing of the ventilation system.".

a. 12 (½ day)

b. 24 (1 day)

c. 48 (2 days)

d. 168 (1 week)

QUESTION B.09 [1.0 point]
Which ONE of the following evolutions does **NOT** require the presence of a Senior Reactor Operator in the facility?

a. Performing a Startup Checklist.

b. Shutting down the reactor.

c. Lowering Power from 500 kilowatts to 50 Kilowatts.

d. Performing a Fuel element Inspection.

QUESTION B.10 [1.0 point]
Which one of the following is the MINIMUM required initial for startup permission after a non-emergency SCRAM recovery and resolution?

a. The WSU NRC Director.

b. The Reactor Supervisor.

c. The Senior Reactor Operator.

d. The Reactor Operator.

QUESTION B.11 [1.0 point]
Which one of the following statements is TRUE concerning experiments? Per the technical specifications …

a. the total inventory of iodine isotopes 131 through 135 in the experiment is no greater than 150 Ci.

b. the maximum limit for reactivity worth of any experiment NOT fixed in place shall not exceed 2.00$

c. maximum amount of explosive materials, such as gunpowder, TNT, nitroglycerin, or PETN is 25 mg.

d. the maximum limit for reactivity worth of all experiments shall NOT exceed 6.00$.

QUESTION B.12 [1.0 point]
Which one of the following does NOT require NRC approval for changes?

a. Technical Specifications

b. Requalification plan

c. Emergency Implementation Procedures

d. Emergency Plan

QUESTION B.13 [1.0 point]
The maximum dose rate of a sample (measured at 1 foot) removed from the reactor, which does NOT require a special procedure approved by the Reactor safeguard committee is …

a. 0.5 Rem

b. 1.0 Rem

c. 5.0 Rem

d. 10 Rem

QUESTION B.14 [1.0 point]
Which one of the followings correctly describes the term “ALI” ?

a. The sum of the products of the dose equivalent to the organ and the weighing factors applicable to each of the body organs that are irradiated.

b. The smaller value of intake of a given radionuclide in a year by a reference man that would result in a committed dose equivalent of 5 rem.

c. A unit of measurement of radioactivity.

d. The limit on concentration of certain radionuclides listed in 10 CFR 20 that could result in an annual dose in excess of 5 rem.

QUESTION B.15 [1.0 point]
Limiting Safety System Settings (LSSS) are …

a. limits on important process variables that are found to be necessary to reasonably protect the integrity of certain of the 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. settings for ANSI 15.8 suggested reactor scrams and/or alarms which form the protective system for the reactor or provide information which requires manual protective action to be initiated.

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

QUESTION B.16 [1.0 point]
Two point sources have the **SAME CURIE STRENGTH**. Source A emits 1 MeV gammas whereas Source B emits 2 MeV gammas. You obtain a reading from the same Geiger counter 10 feet from each source. Concerning the two readings, which one of the following statements is correct?

a. The reading from Source B is four times that of Source A.

b. The reading from Source B is twice that of Source A.

c. Both readings are the same.

d. The reading from Source B is half that of Source A.

QUESTION B.17 [1.0 point]
You are giving a tour to twelve students. The tour includes entry into a radiation area. The students are divided into three groups of four; each group led by a NRL staff member. How many dosimeter devices must be issued?

a. None, since they won't get any dose.

b. None, the senior NRL staff member's dosimetry will be used to estimate the dose to his/her group.

c. Three, one member of each group will give a representative reading.

d. Twelve, one for each student.

QUESTION B.18 [1.0 point]
A small radioactive source is to be stored in the reactor bay. 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.19 [1.0 point]
Which one of the following is NOT a general principle of the As Low As Reasonably Achievable (ALARA) policy?

a. Control Contamination.

b. Use proper shielding.

c. Use respirators.

d. Minimize time.

QUESTION C.01 [1.0 point]
Which ONE of the following is the purpose of the diffuser pump?

a. Increase heat transfer rate due to increased mixing in the pool.

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.02 [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.03 [2.0 points, ⅓ each]
Identify whether each of the listed console indications cause a scram, or only an alarm condition.

a. Blade Disengaged

b. Exhaust Gas Monitor

c. Seismic detection

d. CIC HV failure

e. Building Evacuation

f. Conductivity

QUESTION C.04 [2.0 points, ½ each]
Match the problems on the left with its possible plant conditions on the right. (No changes to any equipment have been made, e.g. no valves manipulated)

Symptom	Cause
a. High radiation level in demineralizer tanks	1. Resin separation (channeling)
b. High radiation level on demineralizer outlet	2. Fission product release
c. High flow through demineralizer tanks	3. High water temperature
d. High pressure on demineralizer inlet	4. Clogging

QUESTION C.05 [1.0 point]
How does the purification system ensure that impure make-up water is not added to the pool? When the conductivity cell …

a. downstream of the culligan system filters detects a high conductivity, it closes a solenoid valve upstream of the culligan system.

b. at the suction of the mixed bed ion exchanger a high conductivity, it closes a solenoid valve upstream of the culligan system.

c. at the suction of the mixed bed ion exchanger a high conductivity, it shuts down the purification system pump.

d. at the discharge of the mixed bed ion exchanger a high conductivity it shuts down the purification system pump.

QUESTION C.06 [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.07 [1.0 point]
WHICH ONE of the following detectors is used primarily to measure N^{16} release to the environment?

a. NONE, N^{16} has too short a half-life to require environmental monitoring.

b. Stack Gas Monitor

c. Stack Particulate Monitor

d. Bridge Area Monitor

QUESTION C.08 [1.0 point]
Which one of the following describes the operation of the containment building ventilation automatic dampers on a signal which causes the system to go from normal to dilute mode?

a. Dampers 1 and 4 close. Dampers 2 and 3 open. Damper 6 maintains static pressure.

b. Dampers 2, 3 and 6 close. Dampers 1 opens. Damper 4 maintains static pressure.

c. Dampers 2 and 3 close. Dampers 1 and 4 open. Damper 6 maintains static pressure.

d. All Dampers close.

QUESTION C.09 [1.0 point]
Which one of the following methods is used to prevent freezing in the secondary system during cold weather?

a. A heater in the secondary sump, controlled from by the control room operator.

b. A heater in the secondary sump, automatically controlled by a thermostat.

c. Addition of chemicals (anti-freeze) to reduce the freezing temperature of the secondary coolant.

d. The cooling tower fans reverse direction upon low temperatures.

QUESTION C.10 [1.0 point]
Which ONE of the following describes the response of the five control blades (rods) to a reactor scram signal during NORMAL operation.

a. All five control blades (rods) will scram.

b. Shim blades #1, #2 and #4 will scram. Transient rod #3 and regulating blade #5 will remain as is.

c. Shim blades #1, #2 and #4, and Transient rod #3 will scram. Regulating blade #5 will remain as is.

d. Shim blades #1, #2 and #4 and Regulating blade #5 will scram. Transient Rod #3 will remain as is.

QUESTION C.11 [1.0 point]
Which ONE of the following ABNORMAL conditions does not require either a reactor shut down or a reactor scram?

a. Beam Port Plugs Alarm

b. Low Pulse Air Alarm

c. Pool Water Level Low Alarm

d. CAM High Alarm

QUESTION C.12 [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.

QUESTION C.13 [1.0 point]
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.14 [1.0 point]
Which ONE of the following is **NOT** an interlock associated with pulsing operations.

a. Prevent application of air to Transient Rod unless fully inserted.

b. Transient Rod scram 15 seconds after pulse

c. Prevent withdrawal of standard control and regulation elements

d. Power less than 1 Kwatt.

QUESTION C.15 [2.0 points, 0.4 each]
Identify each of the listed scrams as having input into the logic element, the slow scram relay or both.

a. High Fuel Temperature

b. Building Evacuation

c. Safety Channel # 1

d. Short Period

e. Manual

QUESTION C.16 [1.0 point]
Which ONE of the following materials is **NOT** used for neutron absorption in the control blades (1 through 5).

a. hafnium

b. boron-carbide

c. boral (boron and aluminum alloy)

d. stainless-steel

QUESTION C.17 [1.0 point]
Fuel Temperature is detected using …

a. Expanding Liquid with moving coil inductor

b. Bi-metallic Temperature Detectors

c. Resistance Temperature Detectors (RTDs)

d. “K” type (alumel-chromel) Thermocouples

A.01 d
REF: Lamarsh, J.R., *Introduction to Nuclear Engineering,* - 1983. § 7.2, p. 300
Burn, R., *Introduction to Nuclear Reactor Operations,* © 1982, § 3.3, pp. 3-13 — 3-18.

A.02 c
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1982, § 6.4.1, pp. 6-5.

A.03 d
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 6.2.3, p. 6-4.

A.04 b
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1982, § 4.2 pp. 4-1

A.05 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.

A.06 a, 2; b, 4; c, 1; d, 3
REF: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, §§ 3.2.2, p. 3-7

A.07 c
REF: $SDM = 1 - K_{eff}/K_{eff}$ → $K_{eff} = 1/SDM + 1$ → $K_{eff} = 1/0.0526 + 1$ → $K_{eff} = .95$
$CR_1/CR_2 = (1 - K_{eff2}) / (1 - K_{eff1})$ → $10/20 = (1 - K_{eff2}) / (1 - 0.95)$
$(0.5) \times (0.05) = (1 - K_{eff2})$ → $K_{eff2} = 1 - (0.5)(0.05) = 0.975$

A.08 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.

A.09 a
REF: T.S. Definition 1.8, Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 6.2.1, pp. 6-2.

A.10 d
REF: Standard NRC Question Burn, R., © 1982, §5.2, p. 5-1

A.11 b
REF: Standard NRC Question Burn, R., © 1982, §5.2, p. 5-1

A.12 c
REF: Lamarsh, J.R., *Introduction to Nuclear Engineering,* 1983. § 5.1, pp. 189 –191.
$R = \varphi \Sigma_f = (2.5 \times 10^{12}) \times 0.1 = 2.5 \times 10^{11}$

A.13 d
REF: Glasstone, S. And Sesonske, A, *Nuclear Reactor Engineering,* Kreiger Publishing, Malabar, Florida, 1991, § 3.154, p. 188

A.14 b
REF: Introduction to Nuclear Reactor Operations, Reed Robert Brown, Section 3.2.2, Delayed Neutrons.

A.15 d
REF: WSU RO Training Manual, Unit 6, § 2.2 Delayed Neutrons, also NRC exam administered 1997

A.16 ~~a~~ c, Typographical error, c is the correct answer for the calculation below.
REF: A 9°F HEATUP, will add 9°F × -0.0005 ΔK/K/°F = -0.0045 ΔK/K. To compensate, the regulating rod must add 0.0045 positive reactivity, which implies move out. +0.0045 ΔK/K ÷ 0.001 ΔK/K/inch = 4.5 inches

A.17 c
REF: $P = P_0 e^{-t/T}$, Reactor period stabilizes at - 80 seconds. Time (t) = 180 seconds (three minutes). $P = 1000 e^{-180/80} = 1000 (e^{-9/4}) = 1000 (0.1054) = 105.4$

A.18 b
REF: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, §

A.19 b
REF: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, §

B.01 b
REF: Requalification Plan, § 3.

B.02 d
REF: Standard NRC Radiation Protection Question

B.03 d
REF: 10CFR20.1003

B.04 a, Check; b, Test; c, Cal; d, Check
REF: WSU Modified TRIGA Reactor Technical Specifications, Definitions § 1.4, pg. 4

B.05 c
REF: Emergency Plan § 4.1

B.06 b
REF: Emergency Plan, TABLE 3.5: Extreme Emergency Exposure Guidelines.

~~B.07 c~~ Question deleted per facility comment. Question stem missing.
~~REF: Emergency Plan § 6.0.~~

B.08 c
REF: Technical Specifications § 3.9 Engineered Safety Feature - Ventilation System

B.09 c (b requires SRO signature in the log). Per facility comment either c or b could be correct.
REF: SOP 4 *Standard Procedure for Startup, Operation and Shutdown of the Reactor*, § A.3

B.10 c
REF: WSU NRC SOP #4, Page 14, Appendix B.

B.11 c
REF: Technical Specifications 3.10 and 3.11.

B.12 c
REF: 10 CFR 50.54 (q); 10 CFR 50.59; 10 CFR 55.59

B.13 b
REF: SOP 2 "Standard Procedure for Performing Irradiations Using the Reactor", § A item 2 from 2nd list.

B.14 b
REF: 10CFR20.1003 "Annual Limit on Intake (ALI)

B.15 b
REF: WSU Modified TRIGA reactor Technical Specifications, Definitions § 1.4, pg. 5

B.16 c
REF: GM is not sensitive to energy.

B.17 ~~d~~ c answer changed per facility comment to reflect the actual process in use at the facility.
REF: Administrative Procedure 4, "Access Control at the Nuclear Radiation Center, § C, *Visitors*", pg. 2

B.18 c
REF:

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

B.19 c
REF: WSU NRC Administrative Procedure, "Radiation Protection Program," Page 5, Section G, also NRC retake examination administered 1997.

C.01 c
REF: Standard NRC question. SOP-4, § B.c.b p. 4, also NRC examination administered April 1997

C.02 b
REF: WSU SOP #8, Standard Procedure for Control Element Maintenance, Removal and Replacement, CAUTION on page 4, also NRC examination administered April 1997.

C.03 a, alarm; b, alarm; c, scram; d, scram; e, scram; f, alarm
REF: Modification of two very old NRC Examination Question Bank questions

C.04 a, 2; b, 3; c, 1; d, 4
REF: Standard NRC question

C.05 a
REF: WSU SAR, Figure 4.10, also NRC examination administered April 1997

C.06 b
REF: Standard NRC question

C.07 a
REF: Standard NRC question, also Chart of Nuclides N^{16} half-life is ~ 7 seconds.

C.08 a
REF: SOP 5, p. 13. Also NRC examination administered 2006

C.09 b
REF: SAR § 4.9, also modification of NRC question administered 2006.

C.10 c
REF: SOP 5 § D, pp. 2 – 4.

C.11 b
REF: SOP 18 §§ C.2.a, C.2.g, C.2.f and C.2.d.ii

C.12 c
REF: SAR § 4.4

C.13 b
REF: SOP-17, § B.1 p. 1.

C.14 a
REF: Technical Specifications Table 3.2

C.15 a, ~~both~~ SR; b, SR; c, both; d, SR; e, both Answer changed per facility comment.
REF: NRC examination administered 1997.

C.16 a
REF: SAR §§ 4.5, 4.6 and 4.7.

C.17 d
REF: SOP 14