November 22, 2010

Dr. Warren D. Reece, Director
Texas A&M University System
Nuclear Science Center
1095 Nuclear Science Road
MS 3575
College Station, Texas 77843-3575

SUBJECT: INITIAL EXAMINATION REPORT NO. 50-128/OL-11-01, TEXAS A&M UNIVERSITY

Dear Dr. Reece:

During the week of October 18, 2010, the U.S. Nuclear Regulatory Commission (NRC) administered operator licensing examinations at your Texas A&M University 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 at the conclusion of the examination with those members of your staff identified in the enclosed report.

In accordance with Title 10, Section 2.390 of the Code of Federal Regulations, a copy of this letter and the enclosures will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records (PARS) component of NRC's Agencywide Documents Access and Management System (ADAMS). ADAMS is accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html (the Public Electronic Reading Room). The NRC is forwarding the individual grades to you in a separate letter which will not be released publicly. If you have any questions concerning this examination, please contact Mr. John T. Nguyen at (301) 415-4007 or via internet e-mail John.Nguyen@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. 50-128

Enclosures:
1. Initial Examination Report No. 50-128/OL-11-01
2. Written Exam with facility comments incorporated

cc: w/o enclosures: See next page

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Texas A&M University System
Nuclear Science Center
1095 Nuclear Science Road
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November 22, 2010

SUBJECT: INITIAL EXAMINATION REPORT NO. 50-128/OL-10-01, TEXAS A&M UNIVERSITY

Dear Dr. Reece:

During the week of October 18, 2010, the U.S. Nuclear Regulatory Commission (NRC) administered operator licensing examinations at your Texas A&M University 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 at the conclusion of the examination with those members of your staff identified in the enclosed report.

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<u>DISTRIBUTION</u> w/ encls:
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OFFICE	PRTB:CE		IOLB:LA	E	PRTB:BC
NAME	JNguyen		CRevelle		JEads
DATE	11/ 08/2010		11/ 19/2010		11/ 23/2010

OFFICIAL RECORD COPY

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

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

REPORT NO.: 50-128/OL-10-01

FACILITY DOCKET NO.: 50-128

FACILITY LICENSE NO.: R-83

FACILITY: Texas A&M University TRIGA Reactor

EXAMINATION DATES: October 18, 2010

SUBMITTED BY: /RA/ 11/9/2010
John T. Nguyen, Chief Examiner Date

SUMMARY:

During the week of October 18, 2010, the NRC administered operator licensing examinations to five Reactor Operator license candidates and two Senior Reactor Operator license candidates (one Upgrade and one Instant). Two Reactor Operator license candidates failed the written examination (one candidate failed section A and B and the other failed section B). All other license candidates passed all applicable portions of their examinations.

REPORT DETAILS

1. Examiners: John T. Nguyen, Chief Examiner, NRC

2. Results:

	RO PASS/FAIL	SRO PASS/FAIL	TOTAL PASS/FAIL
Written	3/2	1/0	4/2
Operating Tests	5/0	2/0	7/0
Overall	3/2	2/0	5/2

3. Exit Meeting:
   John Nguyen, Chief Examiner, NRC
   Jerry Newhouse, Reactor Supervisor, Texas A&M University TRIGA Reactor

   The examiner thanked the facility for their support during the examination.

TEXAS A&M UNIVERSITY TRIGA REACTOR

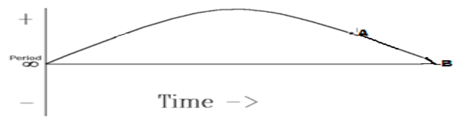
Operator Licensing Examination

Written Exam with Answer Key

October 18, 2010

ENCLOSURE 2

QUESTION A.01 [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. increasing, then constant.

QUESTION A.02 [1.0 point]
Which **ONE** of the following will be the resulting stable reactor period when a 0.312 %Δk/k reactivity is inserted into an exactly critical reactor core? Given β = 0.007

a. 12 seconds

b. 24 seconds

c. 38 seconds

d. 50 seconds

QUESTION A.03 [1.0 point]
Which ONE of the following parameters is MOST significant in determining the differential worth of a control rod?

a. Rod speed.

b. Flux Shape.

c. Fuel loading.

d. Reactor power.

QUESTION A.04 [1.0 point]
With a 30 second period, power would double in approximately:

a. 15 seconds

b. 21 seconds

c. 32 seconds

d. 60 seconds

QUESTION A.05 [1.0 point]
List from high to low by thermal neutron cross section of the following isotopes:
1. B-10 2. Sm-149 3. Xe-135 4. U-235

a. 3,2,1,4

b. 2,3,4,1

c. 3,1,4,2

d. 3,1,2,4

QUESTION A.06 [1 point]
Which ONE of the following materials is the best moderator for the reactor?

a. Water.

b. Beryllium.

c. graphite.

d. Uranium-238.

QUESTION A.07 [1.0 point]
Which ONE of the following is the MAJOR source of energy released during SHUTDOWN?

a. Prompt gamma rays.

b. Decay of the fission fragments.

c. Kinetic energy of the fission neutrons.

d. Kinetic energy of the fission fragments.

QUESTION A.08 [1.0 point]
Which ONE of the following is the correct amount of reactivity added if the multiplication factor, k, is increased from 0.800 to 0.950?

a. 0.150

b. 0.158

c. 0.188

d. 0.197

QUESTION A.09 [1.0 point]
Delayed neutrons are produced by:

a. decay of O-16.

b. Photoelectric Effect.

c. decay of fission fragments.

d. directly from the fission process.

QUESTION A.10 [1.0 point]
Which **ONE** of the following conditions will **INCREASE** the shutdown margin of a reactor?

a. Lowering moderator temperature (Assume negative temperature coefficient).

b. Insertion of a positive reactivity worth experiment.

c. Burnout of a burnable poison.

d. Fuel depletion.

QUESTION A.11 [2.0 points, 0.5 each]
Match each of the terms in column A with the correct definition from column B.

	Column A		Column B
a.	Fast neutrons	1.	Neutrons released directly from fission.
b.	Prompt neutrons	2.	High energy neutrons.
c.	Slow neutrons	3.	Neutrons released from decay of fission products.
d.	Delayed neutrons	4.	Low energy neutrons.

QUESTION A.12 [1.0 point]
The following data was obtained during a reactor fuel load.

No. of Elements	Detector A (cps)
0	30
10	40
20	60
30	100
50	300

Which **ONE** of the following is the closest number of fuel elements required to make the reactor critical? (The attached figure may be used to determine the correct response.)

a. 55

b. 60

c. 65

d. 70

QUESTION A.13 [1.0 point]
Given the following worth: ρ_{excess} = $0.90
SAFE = $2.20
REG blade = $0.30
SHIM = $1.55

Calculate the ***TECHNICAL SPECIFICATION LIMIT*** of Shutdown Margin for this core.

a. $0.95

b. $1.25

c. $1.55

d. $3.15

QUESTION A.14 [1.0 point]
In a just critical reactor, adding one dollar worth of reactivity will cause:

a. A sudden drop in neutron flux.

b. The reactor period to be equal to $(\beta-\rho)/\lambda\rho$.

c. All prompt neutron term to become unimportant.

d. The resultant period to be a function of the prompt neutron lifetime.

QUESTION A.15 [1.0 point]
The probability of neutron interaction per cm of travel in a material is defined as:

a. a neutron flux.

b. a mean free path.

c. a microscopic cross section.

d. a macroscopic cross section.

QUESTION A.16 [1.0 point]
Which **ONE** of the following is **NOT** a correct statement regarding the production/depletion of Xenon in an operating reactor?

a. Xe-135 is lost by alpha decay.

b. Xe-135 is lost by neutron absorption.

c. Xe-135 is formed by fission and I-135 decay.

d. I-135 is formed by fission and lost by beta decay to Xe-135.

QUESTION A.17 [1.0 point]

The delayed neutron fraction, β, is defined as a ratio of:

a. Thermal utilization over fast fission factor.

b. The number of thermal neutrons over the number of fast neutrons in the core.

c. The number of delayed neutrons over the number of total neutrons in the core.

d. The number of thermal neutrons absorbed in fuel over the number of thermal neutrons absorbed in core materials including in fuel.

QUESTION A.18 [1.0 point]

Following a scram, the value of the stable reactor period is:

a. approximately -10 seconds, as determined by the rate of decay of the shortest lived prompt neutrons.

b. approximately -80 seconds, as determined by the rate of decay of the shortest lived delayed neutron precursor.

c. approximately -80 seconds, as determined by the rate of decay of the longest lived delayed neutron precursors.

d. infinity because the control rods absorb all neutrons.

QUESTION A.19 [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. recoils with a lower 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.

***************** End of Section A *******************************

QUESTION B.01 [1.0 point]
Which **ONE** of the following conditions is a violation of Technical Specifications?

a. The pH of the pool water is between 7.2 and 7.8.

b. The reactivity worth of an individual experiment is $1.60.

c. Steady state power level of 1.2 megawatts for purpose of calibration.

d. The excess reactivity is 5.6 % $\Delta k/k$ (assume cold and xenon-free criticality).

QUESTION B.02 [1.0 point]
Which **ONE** of the following types of experiments shall **NOT** be irradiated at the NSC REACTOR?

a. The experiment contains iodine isotopes 131 through 135.

b. The in-pool experiment contains 25-milligram explosive materials.

c. The unsecured experiment has a reactivity worth of $0.75.

d. The total single experiment activity of Xe-124 is 1000 Ci.

QUESTION B.03 [1.0 point]
Which **ONE** of the following is the correct statement when the airborne activity in the NSC Control Access Area (CAA) exceeds the preset level of Xe-125 Air Monitor?

a. The ventilation system is MANUALLY secured and the reactor is permitted to operate a period of time not to exceed 24 hours.

b. The ventilation system is AUTOMATICALLY secured and the reactor is permitted to operate a period of time not to exceed 48 hours.

c. The ventilation system is AUTOMATICALLY secured and the reactor is permitted to operate a period of time not to exceed 24 hours.

d. The ventilation system is AUTOMATICALLY secured and the reactor shall not be operated.

QUESTION B.04 [1.0 point]
A radioactive source reads 160 Rem/hr on contact. Four hours later, the same source reads 40 Rem/hr. How long is the time for the source to decay from a reading of 160 Rem/hr to 10 Rem/hr?

a. 6.0 hours

b. 8.0 hours

c. 9.0 hours

d. 10.0 hours

QUESTION B.05 [1.0 point]
An example of Byproduct Material would be….

a. Pu-239

b. U-233

c. U-235

d. Co-60

QUESTION B.06 [1.0 point]
Which **ONE** of the following is the appropriate Emergency Classification when the Xe-125 monitor alarms and indicates a release of 150 Ci from the reactor building?

a. Operational Events

b. Notification of Unusual Events

c. Alert

d. Site Area Emergency

QUESTION B.07 [1.0 point]
Exposing a 2 mCi check source to the continuous air monitor (CAM) detector to verify whether it is operable is considered to be:

a. a channel test.

b. a channel check.

c. a channel calibration.

d. a channel verification.

QUESTION B.08 [1.0 point]
The following measurements are made from a beta-gamma point source:
- 2 R/hr at six inches
- 0.5 mR/hr at ten feet.

What are the relative fractions of betas and gammas emitted at six inches?

a. (1800/200) = 9

b. (2000/200) = 10

c. (1800/20) = 90

d. (2200/200) = 11

QUESTION B.09 [1.0 point]
"The concentration of Argon-41 in the effluent gas from the facility as diluted by atmospheric air in the lee of the facility due to the turbulent wake effect shall not exceed 1.0x 10-8 μCi/ml averaged over one year." 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]
An area in which radiation levels could result in an individual receiving a dose equivalent in excess of 120 mRem/hr is defined as:

a. Radiation area.

b. Restricted Area.

c. High Radiation Area.

d. Very High Radiation Area.

QUESTION B.11 [1.0 point]
Which **ONE** of the following is the NSC REACTOR Safety Limit?

a. Maximum pulse shall be limited to $2.00.

b. The power level shall not exceed 1.3 megawatts at steady state operation.

c. The temperature in a stainless-steel clad fuel element shall not exceed 830 °C under PULSE operation.

d. The temperature in a stainless-steel clad fuel element shall not exceed 1150 °C under any conditions of operation.

~~**QUESTION B.12 [1.0 point]**~~ Question deleted during administrative of the examination. No correct answer in the distractors. This question will not factor into the candidates' grades
~~Which ONE of the following is a MINIMUM number of staffing requirements for an OFFICIAL review and approval of an Experiment Authorization (EA)?~~

~~a. Deputy Director TEES (Licensee) only.~~

~~b. NSC Director and the RSO staff.~~

~~c. The operations staff, the RSO staff, and a member from the NRC.~~

~~d. The operations staff, the RSO staff, and a member from Deputy Director TEES.~~

QUESTION B.13 [1.0 point]
The radiation from an unshielded Co-60 source is 500 mrem/hr. What thickness of lead shielding will be needed to lower the radiation level to 5 mrem/hr? The HVL (half-value-layer) for lead is 6.5 mm.

a. 26 mm.

b. 33 mm.

c. 38 mm.

d. 44 mm.

QUESTION B.14 [1.0 point]
Select the list that gives the order of types of radiation from the **LEAST** penetrating to the **MOST** penetrating (i.e. travels the further in air).

a. neutron, gamma, beta, alpha.

b. alpha, beta, neutron, gamma.

c. beta, alpha, gamma, neutron.

d. alpha, neutron, beta, gamma.

QUESTION B.15 [2 points, 0.5 each]
Match the 10CFR55 requirements for maintaining an active operator license in column A with the corresponding time period from column B. Items in column B can be used once, more than once or not at all.

	Column A	Column B
a.	Renew License	1 year
b.	Medical Exam	2 years
c.	Pass Requalification Written Examination	4 years
d.	Pass Requalification Operating Test	6 years

QUESTION B.16 [1.0 point]
Which **ONE** of the following is considered a damaged fuel?

a. In measuring the transverse bend, its lateral bending exceeds 0.120 inches over the length of the cladding.

b. In measuring the elongation, its length exceeds its original length by 0.25 inches.

c. A reactivity worth of fuel element is $0.02 less than the previous measure.

d. Color of a fuel clad changes to brown.

QUESTION B.17 [2 points, 0.5 each]
Match each of the measuring channels in column A with the reactor modes for which it must be operable in column B. Items in column B can be used once, more than once or not at all.

Column A	Column B
a. Fuel Temperature	1. Steady State ONLY
b. Linear Power Level	2. Pulse ONLY
c. Preset Timer	3. All Modes
d. Log Power Level	4. During Reactor Startup

QUESTION B.18 [1.0 point]
As permitted by 10 CFR 50.59, the NSC reactor facility may:

a. Modify systems and change the Technical Specifications (TS) if the NRC is notified afterwards.

b. Perform a reactor calibration without a notification to the NRC.

c. Determine the affects of modifications and their impact on TS.

d. Redefine the boundaries of accidents previously analyzed in the Safety Analysis Report (SAR).

***************************** End of Section B ********************************

QUESTION C.01 [1.0 point]
Given the following sequence of events during the course of pulsing:

(1) The reactor is in steady state at a power of 100 watts
(2) Power is applied to the pulse integrator
(3) The mode selector switch is switched to the pulse mode
(4) A preset time sets 3 seconds

Reactor operator initiates a pulse by pressing the fire button. Which ONE of the following sequences of events takes place?

a. The transient rod air will be energized then de-energized in 1 second and the transient rod will drop back into the core.

b. The transient rod air will be energized then de-energized in 3 second and the transient rod will drop back into the core.

c. The transient rod air will be de-energized, rod will drop back into the core, and the reactor scram.

d. The transient rod air will be energized then de-energized in 1 second, rod will drop back into the core, and the integrator displays the total energy.

QUESTION C.02 [1.0 point]
What is the purpose of the exhaust duct in the lower irradiation cell?

a. To minimize buildup of water if a leak develops in the irradiation window.

b. To minimize radiation exposure due to production of Ar-41.

c. To minimize radiation exposure due to production of N-16.

d. To reduce humidity for experiment efficiency.

QUESTION C.03 [1.0 point]
Graphite inserts are placed in the top and bottom of the fuel element. Which ONE of the following best describes the function of these inserts?

a. To absorb thermal neutrons.

b. To reduce neutron leakage.

c. To absorb fission product gases.

d. To increase fast neutron flux.

QUESTION C.04 [1.0 point]
Which ONE of the following actions will cause the operating reactor to automatically SCRAM?

a. Opening the thermal column shield door with the reactor positioned at the centerline of BP 1 & 4.

b. Opening one of the beam port lead seal doors when the reactor is in the stall core position.

c. Opening the cave door to BP4 when the reactor is against the radiography reflector.

d. Opening the irradiation cell door when the reactor is in the pool core position.

QUESTION C.05 [1.0 point]
What is the maximum acceptable time between the initiation of a scram signal, and the time that the SHIM rod is fully inserted in the core?

a. 2.5 sec

b. 2.0 sec

c. 1.2 sec

d. 1.0 sec

QUESTION C.06 [1.0 point]
The output of 1kW interlock signal comes from:

a. Wide Range Linear Monitor

b. Log Power Channel Monitor

c. Safety Channel 1 Power Monitor

d. Safety Channel 2 Power Monitor

QUESTION C.07 [2.0 points, 0.25 each]
Match the input signals listed in column A with their display on reactor control room listed in column B. (Items in column B may be used more than once or not at all). Assume that the reactor is in operation.

Column A		Column B
a.	Bridge unlocked.	1. Indication only
b.	3-sec period.	2. Alarm only
c.	110% Safety Power channel.	3. Alarm and scram
d.	Building pressure system failure.	4. Alarm and interlock

QUESTION C.08 [1.0 point] "Transient" was added during the administrative of the examination
Which ONE of the following can cause the Transient control rod interlock when a steady state mode is selected?

a. SHIM rod drive DOWN and SHIM control rod DOWN.

b. Carriage DOWN and supply air energized.

c. SHIM rod drive UP and SHIM control rod DOWN.

d. Carriage UP and supply air energized.

QUESTION C.09 [1.0 point]
If the Power Channel output is higher than the calculated thermal power calibration (calorimetric), the reactor operator needs to adjust the Power Channel output by:

a. adjusting the detector high voltage.

b. adjusting the Full Power Gain potentiometer gain.

c. physically adjusting the height of the detectors in the support assembly.

d. move graphite reflector to change the neutron flux near the detectors.

QUESTION C.10 [1.0 point]
For calibration of the control rod, the operator calculates the reactor period by measuring the time required for the power to double or power to triple. This technique is called:

a. Rod Drop Method

b. Positive Period Method

c. Negative Period Method

d. Thermal Power Calibration Method

QUESTION C.11 [1.0 point]
Which **ONE** of the following will result in a reactor scram?

a. Log power < 2 cps

b. Conductivity of the bulk Water = 5×10^6 ohms/cm

c. Initiation of a pulse at 2 kW steady state power

d. Failure of the power supply for a safety chamber

QUESTION C.12 [1.0 point]
Which ONE of the following elements is used as the neutron absorber in the Shim-Safety rods?

a. Hafnium

b. Borated Graphite

c. Xenon

d. Cadmium

QUESTION C.13 [1.0 point]
Which **ONE** of the following air monitor channels is designated as the Fission Product Monitor?

a. Facility Air Monitor Channel 1

b. Facility Air Monitor Channel 2

c. Facility Air Monitor Channel 3

d. Facility Air Monitor Channel 4

QUESTION C.14 [1.0 point]
The primary isotope we worry when standing by the reactor pool surface at high power is …

a. N^{16} (O^{16} (n,p) N^{16}).

b. Kr^{80} (Kr^{79} (n, γ) kr^{80}).

c. Ar^{41} (Ar^{40} (n, γ) Ar^{41}).

d. H^{2} (H^{1} (n, γ) H^{2}).

QUESTION C.15 [1.0 point]
Which ONE of the following statements is <u>NOT TRUE</u> regarding the Servo Flux Control system?

a. Pressing the Gang-Up/Gang-Down switch will turn off the servo unit.

b. The regulating rod moves in response to the signal from compensated ion chamber.

c. The regulating rod moves in response to the signal from fission chamber.

d. Alarm if the REG rod is inserted less than 20% fully withdrawn.

QUESTION C.16 [1.0 point]
Which **ONE** of the following is the main function of the demineralizer in the primary purification system?

a. Remove soluble impurity to maintain low conductivity in the tank water.

b. Reduce N-16 formation, thus reduce the dose rate at the reactor pool.

c. Absorb thermal neutrons, thus increase life of the reactor pool.

d. Absorb tritium, thus maintain purity of the pool water.

QUESTION C.17 [1.0 point]
During a pulse channel calibration, reactor operator switches the reactor selector to PULSE mode, then he depresses and holds the “Pulse Cal” switch and fire the transient rod. The pulse integrator will display a reading of…

a. 100%

b. 1.0 MW

c. 55.5 MW-sec

d. 1999 MW

QUESTION C.18 [1.0 point]
During reactor operation, a leak develops in the primary to secondary heat exchanger. Which one of the following conditions correctly describes how the system will react?

a. Pool level will increase due to leakage from the secondary, the automatic level control will maintain level in the secondary.

b. Cooling tower basin level will decrease due to leakage from the secondary, pool level will increase.

c. Cooling tower level will increase due to leakage from the primary, automatic level control will maintain level in the primary.

d. Cooling tower basin level will increase due to leakage from the primary, pool level will decrease.

QUESTION C.19 [1.0 point]
What prevents a fuel followed control rod from falling out of the core should it become detached from its mounting?

a. Bottom of pool is within 2 inches of grid plate.

b. Notch in control rod pole connected to reactor frame.

c. Safety plate assembly beneath the reactor grid plate.

d. Tapered section above absorber prevents passage through reactor frame.

******************* End of Section C *****************************
******************* End of the Exam ***************************

A.01 d
REF: Standard NRC question. From point A to near point B, reactor period is positive, and since $P_f = P_o * e^{\frac{t}{T}}$, power will continue to increase. At point B, reactor period reaches to infinitive, $e^{\frac{t}{\inf initive}} = e^{0} = 1$, so $P_f = P_o$. Power is stable at point B.

A.02 a
REF: Glasstone, S. and Sesonske, A, *Nuclear Reactor Engineering,* 1991, § 5.18, p. 234.
T = (β-ρ)/λρ T = (.007 - .00312)/.1 x .00312 = 12 seconds

A.03 b
REF: Fund. Of Nuclear Engineering, Chapter 3, Section 4, page 75.

A.04 b
REF: $P = P_o e^{t/\tau}$ or t/T= ln (P/P_o). t=30*ln(2); t= 21 sec

A.05 a
REF Introduction to Nuclear Operation, Reed Burn, 1988, Table 2.5, page 2-59

A.06 a
REF NRC Standard Question

A.07 b
REF Introduction to Nuclear Operation, Reed Burn, 1988, Sec 3.2, page 3-5

A.08 d
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1982, Sec 3.3.3, page 3-21.
. In order to solve the question A.08, the applicant can use one of the following methods:
At k=0.8; ρ = ΔKeff/Keff or ρ = Keff-1/Keff = -0.2/0.8 =-0.25. At k=0.95, ρ =-0.05/0.95 ρ = -0.053. The difference between ρ is the answer ,i.e. -0.053-(-0.25)=0.197
Δ ρ = ρ1 – ρ2 where ρ1 = Keff1-1/Keff1 and ρ2 = Keff2-1/Keff2. Substitute ρ1 and ρ2 with Keff1 and Keff2 into the equation above, the result is Δρ = keff1-keff2/(keff1 x keff2)

A.09 c
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1982, Sec 3.2.

A.10 d
REF Standard NRC question

A.11 a, 2; b, 1; c, 4; d, 3
REF: FONRE, §§ 24 & 25, pp. 27 & 28

A.12 b

REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1982, § 5.5, pp. 5-18 — 5-25.

No. fuel	A(cps)	1/M (Source/Count)
0	30	1
10	40	0.75
20	60	0.5
30	100	0.3
50	300	0.1

A.13 a

REF: Total rod worth – (excess + most active rod)
$(2.20 +1.55+0.30) –$(0.90+2.20) =$0.95

A.14 d

REF Introduction to Nuclear Operation, Reed Burn, 1988, Sec 4.2, page 4-4

A.15 d

REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1982, Section 2.5.2, page 2-44.

A.16 a

REF: Burn, R., *Introduction to Nuclear Reactor Operations*, Sec 8.2, page 8-3.

A.17 c

REF Introduction to Nuclear Operation, Reed Burn, 1988, Sec 3.3.3, page 3-11.

A.18 c

REF Introduction to Nuclear Operation, Reed Burn, 1988, Sec 4.5, page 4-12

A.19 b

REF: FONRE, § 18.e.3.a(1), p. 10

B.01 d
REF: TS 3.1 and TS 3.6

B.02 b
REF: TS 3.6

B.03 d
REF: TS 3.5

B.04 b
REF: $DR = DR_o * e^{-\lambda t}$
40 rem/hr = 160 rem/hr* $e^{-\lambda(4hr)}$
Ln(40/160) = -λ*4 --> λ=0.347; solve for t: Ln(10/160)=-0.347 *t → t=8 hours

B.05 d
REF: 10 CFR 20.1003

B.06 b
REF: EP Table I, page 19

B.07 a
REF: TS 1.0, Definition

B.08 a
REF: Assume beta will not travel 10 feet in air, therefore 0.5 mr is gamma.
Gamma dose at ½ ft (6 in) is: $(DR1)(R1^2) = (DR2)(R2^2) \rightarrow DR2 = (DR1)(R1^2) / R2^2 =$ 0.5 mr x $(10\ ft)^2 / (0.5\ ft)^2$ = 200 mr/hr
Therefore, beta contribution at ½ ft is 2000 - 200 = 1800 mr/hr.
Beta contribution/Gamma contribution = 1800/200 = 9

B.09 c
REF: TS 3.5.2

B.10 c
REF: 10 CFR 20

B.11 d
REF: TSs 2.0 and 3.0

~~B.12 d~~ Question deleted during administrative of the examination. No correct answer in the distractors. This question will not factor into the candidates' grades
~~REF: Procedure F, Section I, page 2 of 3~~

B.13 d
REF: $DR = DR_o * e^{-\mu X}$
HVL (=6.5 mm) means the original intensity will reduce by half when a lead sheet of 6.5 mm is inserted. Find μ if the HVL is given as follows: 1 = 2* $e^{-\mu * 6.5}$;
μ = 0.10664 Find X: 5 mrem/hr = 500 mrem/hr* $e^{-0.10664 * X}$; X= 43.2 mm

B.14 b

REF: NRC standard question

B.15 a (6) b(2) c(2) d(1)
REF: 10 CFR 55.55(a)

B.16 b
REF: TS 4.4

B.17 a (3) b(1) c(2) d(1) or d(3) Answer key added during the administrative of the examination.
REF: TS 3.2.1

B.18 c
REF: 10 CFR 50.59

C.01 b
REF: SOP III, Procedure F

C.02 b
REF: SOP IV-E-1

C.03 b
REF Basic TRIGA fuel design

C.04 c
REF: SOP IV-F-3

C.05 c
REF: TS 3.2.3

C.06 b
REF: SAR, 7.2.3.1 Log Power Channel

C.07 ~~a(2)~~ a(3) b(3) c(1) d(2) Answer changed during the administrative of the examination.
REF: TS 3.3 and SAR 7.0, Instrumentation and Control

C.08 d
REF: SAR, 7.3 Reactor Control Systems

C.09 b
REF: SOP II, Procedure J

C.10 b
REF: SOP II, Procedure K

C.11 d
REF: TS 3.0

C.12 b
REF: TS 5.3

C.13 b
REF: SOP VII, Procedure B12

C.14 a
REF NRC Standard Question

C.15 c
REF: SAR, 7.1 Summary Description, Figure 7-1

C.16 a
REF: NRC Standard Question

C.17 c

REF: SOP II, Procedure L

C.18 d
REF SAR IV-B.2 and figure 4-6.

C.19 c
REF SAR, 4.2.5 Core Support Structure