April 26, 2012

Dr. Raymond J. Juzaitis
Nuclear Engineering Department Head
Texas A&M University
129 F Zachry Engineering Center
Mail Stop 3133
College Station, TX 77843-3133

SUBJECT: EXAMINATION REPORT NO. 50-059/OL-12-01, TEXAS A&M UNIVERSITY AGN-201M REACTOR

Dear Dr. Juzaitis:

During the week of April 2, 2012, the U.S. Nuclear Regulatory Commission (NRC) administered operator licensing examinations at your Texas A&M University AGN-201M Reactor. The examinations were conducted according to NUREG-1478, "Operator Licensing Examiner Standards for Research and Test Reactors," Revision 2. Examination questions and preliminary findings were discussed with those members of your staff identified in the enclosed report at the conclusion of the examination.

In accordance with Title 10 of the *Code of Federal Regulations* Section 2.390, a copy of this letter and the enclosures will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records (PARS) component of NRC's Agencywide Documents Access and Management System (ADAMS). ADAMS is accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html. The NRC is forwarding the individual grades to you in a separate letter which will not be released publicly. Should you have any questions concerning this examination, please contact Mr. 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. 50-059

Enclosures: 1. Examination Report No. 50-059/OL-12-01
2. Written examination

cc: Christopher Crouch, Reactor Supervisor
cc: w/o enclosures: See next page

Dr. Raymond J. Juzaitis
Nuclear Engineering Department Head
Texas A&M University
129 F Zachry Engineering Center
Mail Stop 3133
College Station, TX 77843-3133

April 26, 2012

SUBJECT: EXAMINATION REPORT NO. 50-059/OL-11-02, TEXAS A&M UNIVERSITY AGN-201M REACTOR

Dear Dr. Juzaitis:

During the week of April 2, 2012, the U.S. Nuclear Regulatory Commission (NRC) administered operator licensing examinations at your Texas A&M University AGN-201M Reactor. The examinations were conducted according to NUREG-1478, "Operator Licensing Examiner Standards for Research and Test Reactors," Revision 2. Examination questions and preliminary findings were discussed with those members of your staff identified in the enclosed report at the conclusion of the examination.

In accordance with Title 10 of the *Code of Federal Regulations* Section 2.390, a copy of this letter and the enclosures will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records (PARS) component of NRC's Agencywide Documents Access and Management System (ADAMS). ADAMS is accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html. The NRC is forwarding the individual grades to you in a separate letter which will not be released publicly. Should you have any questions concerning this examination, please contact Mr. 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. 50-059
Enclosures: 1. Examination Report No. 50-059/OL-12-01
2. Written examination

DISTRIBUTION w/ encls.:

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ADAMS ACCESSION #: ML121110018 **TEMPLATE #:NRR-074**

OFFICE	PROB:CE		IOLB:LA	E	PROB:BC	
NAME	JNguyen		CRevelle		JEads	
DATE	4/16/2012		4/20/2012		4/26/2012	

OFFICIAL RECORD COPY

cc:

Mayor, City of College Station
P.O. Box Drawer 9960
College Station, TX 77840-3575

Governor's Budget and
Planning Office
P.O. Box 13561
Austin, TX 78711

Radiation Program Officer
Bureau of Radiation Control
Dept. Of State Health Services
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Technical Advisor
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Texas Commission on Environmental Quality
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Austin, TX 78711-3087

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.: 50-059/OL-11-02

FACILITY DOCKET NO.: 50-059

FACILITY LICENSE NO.: R-23

FACILITY: TEXAS A&M UNIVERSITY AGN-201M Reactor

EXAMINATION DATES: April 4, 2012

SUBMITTED BY: **/RA/** 04/16/2012
John T. Nguyen, Chief Examiner Date

SUMMARY:

The NRC administered an operator licensing examination to one Senior Reactor Operator (Instant) (SRO-I) candidate and one Reactor Operator (RO) candidate. All candidates passed all portions of their respective examinations.

REPORT DETAILS

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

2. Results:

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

3. Exit Meeting:
John T. Nguyen, NRC, Examiner
Christopher Crouch, Reactor Supervisor, Texas A&M University

The chief examiner met with the facility staff to discuss the overall administration of the examination. The examiner did not note any serious weaknesses on the part of the candidates.

ENCLOSURE 1

OPERATOR LICENSING EXAMINATION

UNITED STATES NUCLEAR REGULATORY COMMISSION

ENCLOSURE 2

QUESTION A.01 [1.0 point]
Which one of the following statements describes on how moderator temperature affects the core operating characteristics?

a. Increase in moderator temperature will increase the neutron multiplication factor due to the resonance escape probability increase.

b. Increase in moderator temperature will decrease the neutron multiplication factor due to the resonance escape probability decrease.

c. Increase in moderator temperature will decrease the neutron multiplication factor due to the fast non leakage probability increase.

d. Increase in moderator temperature will increase the neutron multiplication factor due to the fast non leakage probability decrease.

QUESTION A.02 [1.0 point]
The effective neutron multiplication factor, K_{eff}, is defined as:

a. absorption/(production + leakage)

b. (production + leakage)/absorption

c. (absorption + leakage)/production

d. production/(absorption + leakage)

QUESTION A.03 [1.0 point]
Reactor power is increasing by a factor of 10 every minute. The reactor period is:

a. 65 seconds

b. 52 seconds

c. 26 seconds

d. 13 seconds

QUESTION A.04 [1.0 point]
Which **ONE** of the following conditions will **INCREASE** the core excess reactivity of a reactor?

a. Increase moderator temperature (Assume negative temperature coefficient)

b. Insertion of a negative reactivity worth experiment

c. Burnout of a burnable poison

d. Fuel depletion

QUESTION A.05 [1.0 point]
During the time following a reactor scram, reactor power decreases on an 80 second period, which corresponds to the half-life of the longest-lived delayed neutron precursors, which is approximately:

a. 80 seconds

b. 55 seconds

c. 40 seconds

d. 20 seconds

QUESTION A.06 [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.07 [1.0 point]
An experiment to be placed in the glory hole has been wrapped in cadmium. Which one of the following types of radiation will be **most effectively** blocked by the cadmium wrapping?

a. Thermal neutrons

b. Fast neutrons

c. Gamma rays

d. X-rays

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

a. 0.150

b. 0.158

c. 0.188

d. 0.197

QUESTION A.09 [1.0 point]
Which ONE of the following is the MAJOR source of energy released per U-235 fission?

a. Energy of neutrinos

b. Energy of prompt gamma rays

c. Kinetic energy of the fission neutrons

d. Kinetic energy of the decayed fission fragments

QUESTION A.10 [1.0 point]

Given the following: ρ_{excess} = 0.60% Δk/k, Safety rod 1 = 0.80% Δk/k
Safety rod 2 = 0.85% Δk/k, Coarse control rod = 0.80% Δk/k
Fine control rod =0.10% Δk/k

Calculate the Shutdown Margin specified in the TAMU AGN-201M Technical Specification.

a. 0.65% Δ k/k

b. 1.00% Δ k/k

c. 1.25% Δ k/k

d. 1.75% Δk/k

QUESTION A.11 [1.0 point]

Given a source strength of 200 neutrons per second (N/sec) and a multiplication factor of 0.6, which ONE of the following is the expected stable neutron count rate?

a. 125 N/sec

b. 250 N/sec

c. 400 N/sec

d. 500 N/sec

QUESTION A.12 [1.0 point]

K_{eff} is K_{∞} times …

a. the reproduction factor (η)

b. the resonance escape probability (p)

c. the fast fission factor (ε)

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

QUESTION A.13 [1.0 point]
The reactor is on a **CONSTANT** positive period. Which ONE of the following power changes will take the **longest time** to complete?

a. 5%, from 95% to 100%

b. 10%, from 80% to 90%

c. 15%, from 15% to 30%

d. 20%, from 60% to 80%

QUESTION A.14 [1.0 point]
By definition, an exactly critical reactor can be made prompt critical by adding positive reactivity equal to:

a. the shutdown margin

b. the K_{excess} margin

c. the β_{eff} value

d. 1.0 %ΔK/K

QUESTION A.15 [1.0 point]
Delayed neutrons comprise approximately what percent of all neutrons produced in the reactor?

a. 0.65%

b. 1.3%

c. 6.5%

d. 20%

QUESTION B.01 [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. 15 mm

b. 26 mm

c. 33 mm

d. 43 mm

QUESTION B.02 [1.0 point]
A radioactive source reads 35 Rem/hr on contact. Five hours later, the same source reads 1.5 Rem/hr. What will the sample read in another five hours?

a. 55 mrem

b. 65 mrem

c. 75 mrem

d. 120 mrem

QUESTION B.03 [1.0 point]
A room contains a source which, when exposed, results in a general area dose rate of 175 millirem per hour. This source is scheduled to be exposed continuously for 35 days. Select an acceptable method for controlling radiation exposure from the source within this room.

a. Lock the room to prevent inadvertent entry into the room

b. Post the area with the words "Danger-Radiation Area"

c. Equip the room with a motion detector that will alarm in the control room

d. Equip the room with a device to visually display the current dose rate within the room

QUESTION B.4 [1.0 point]
The special unit for absorbed dose "Rem" is defined in 10 CFR Part 20 in terms of a dose equivalent. What does the term dose equivalent relate to?

a. It is derived by accounting for the amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in one year

b. It is equal to the absorbed dose (rad) multiplied by the quality factor (Q) of the radiation

c. It is equal to the absorbed dose (rad) divided by the quality factor (Q) of the radiation

d. It is the equivalent dose one would receive during the 50-year period following intake

QUESTION B.05 [1.0 point]
Which ONE of the following is the definition of site boundary for the TAMU AGN-201M reactor facility?

a. Reactor room (Room 61B) only

b. Reactor room and Accelerator room

c. Entire Zachary Engineering building

d. Nuclear Engineer laboratory areas 60/61 and 133/134/135

QUESTION B.06 [2.0 point, 0.5 each]
Identify each of the following as a Safety Limit (SL), Limiting Safety System Setting (LSSS), or a limiting Condition for Operation (LCO).

a. The reactor power level shall not exceed 100 watts

b. The maximum core temperature shall not exceed 200°C during either steady state or transient operation

c. The shutdown margin with the most reactive safety or control rod fully inserted shall be at least 1% Δ k/k

d. The core thermal fuse shall melt when heated to a temperature of 120°C or less resulting in core separation and a reactivity loss greater than 5% Δ k/k

QUESTION B.07 [1.0 point]
Per TAMU 201-M Technical Specifications, what are the MINIMUM staffing requirements for reactor operations during a normal startup?

a. 1 RO on console and 1 knowledgeable person in the facility

b. 1 RO on console, 1 knowledgeable person in the facility, and 1 SRO on-call

c. 2 RO on console and 1 knowledgeable person in the facility

d. 1 SRO on console and the Reactor Director on campus

QUESTION B.08 [1.0 points, 0.25 each]
Identify each of the following surveillances as a channel check (**CHECK)**, a channel test (**TEST)**, or a channel calibration (**CAL)**.

a. During performance of the Daily Checklist, you depress the "Test Rate Meter" to verify the Channel #1 reading

b. During reactor operation, you compare the readings of Channel 1 and Channel 2

c. Drive the source to the inner limit and verify that the "IN" light is illuminated

d. Adjust the Log Power channel in accordance with recent data collected on the reactor power calibration

QUESTION B.09 [1.0 point]
What is the exposure rate at 1 ft from 2-curie Co-60 source? Co-60 emits two gamma photons per decay with energies of 1.17 Mev and 1.33 Mev.

a. 3 R/hr

b. 5 R/hr

c. 6 R/hr

d. 30 R/hr

QUESTION B.10 [1.0 point]
An area in which radiation levels could result in an individual receiving a dose equivalent of 120 mRem/hr at 30 cm is defined as:

a. Radiation area

b. Unrestricted Area

c. High Radiation Area

d. Very High Radiation Area

QUESTION B.11 [1.0 point]
Per TAMU 201-M Technical Specifications, what is the MINIMUM level of supervision requirements for a modification which could affect the reactivity of the reactor?

a. Reactor Operator in duty

b. Senior Reactor Operator on call

c. Senior Reactor Operator in duty

d. Reactor Supervisor

QUESTION B.12 [1.0 point]
Which ONE of the following materials shall NOT be irradiated at TAMU 201-M reactor?

a. corrosive material

b. explosive material

c. fissionable material

d. gaseous experiment

QUESTION B.13 [1.0 point]
Safety and control rod reactivity worths shall be measured:

a. semi-annually

b. annually

c. every two years

d. every five years

QUESTION B.14 [1.0 point]
Assume that there is no leak from outside of the radiation waste container. You use a survey instrument with a window probe to measure the dose rate from the shield. Compare to the reading with a window **CLOSED,** the reading with a window **OPEN** will :

a. increase, because it can receive an additional alpha radiation from (Al-27) (n,α), (Na-24) reaction

b. remain the same, because the Quality Factors for gamma and beta radiation are the same

c. increase, because the Quality Factor for beta and alpha is greater than for gamma

d. remain the same, because the survey instrument would not be detecting beta and alpha radiation from the container

QUESTION C.01 [1.0 point]
Which one of the following detectors is used for Nuclear Instrumentation Channel #1?

a. BF_3 filled Proportional Counter

b. BF_3 filled Ionization Chamber

c. BF_3 filled Geiger-Muller tube

d. U^{235} lined Fission Chamber

QUESTION C.02 [1.0 point, 0.25 each]
Match the input signals listed in column A with their respective responses listed in column B. (Items in column B may be used more than once or not at all.)

Column A	Column B
a. Count rate = 9 cps (Nuclear Safety # 1)	1. Indication only
b. Reactor period = 30 sec	2. scram
c. Linear Power = 10 watts	3. interlock
d. Try to move coarse control rod when both safety rods are fully down	

QUESTION C.03 [1.0 point]
The MAIN purpose of the thermal fuse is to:

a. measure the temperature of fuel core

b. measure any gases released from the fuel core

c. separate the reactor core to prevent exceeding the Safety Limit (SL)

d. send a scram signal to the Nuclear Safety # 2 if Limiting Safety System Setting (LSSS) is exceeded

QUESTION C.04 [1.0 point]
Which **ONE** of the following is the MAIN function of the high density graphite surrounding the reactor core?

a. To absorb thermal neutrons

b. To reduce neutron leakage

c. To absorb fission product gases

d. To reduce prompt gamma rays

QUESTION C.05 [1.0 point]
What is the maximum acceptable time between the initiation of a scram signal and the time that the SAFETY rods are fully withdrawn from the core?

a. 500 msec

b. 200 msec

c. 100 msec

d. 50 msec

QUESTION C.06 [1.0 point]
The calibration curve (see Figure attached) for the Fine Control rod depicts:

a. Rod Drop Worth curve

b. Integral Rod Worth curve

c. Differential Rod Worth curve

d. Thermal Power Calibration curve

QUESTION C.07 [1.0 point]
Which ONE of the following is the design features for the TAMU AGN-201M Core?

a. The reactor consists of 9 fuel disc with less than 20% U-235 enrichment

b. The reactor consists of 9 fuel disc with less than 30% U-235 enrichment

c. The reactor consists of 9 TRIGA fuel elements with less than 20% U-235 enrichment

d. The reactor consists of 9 TRIGA fuel elements with less than 30% U-235 enrichment

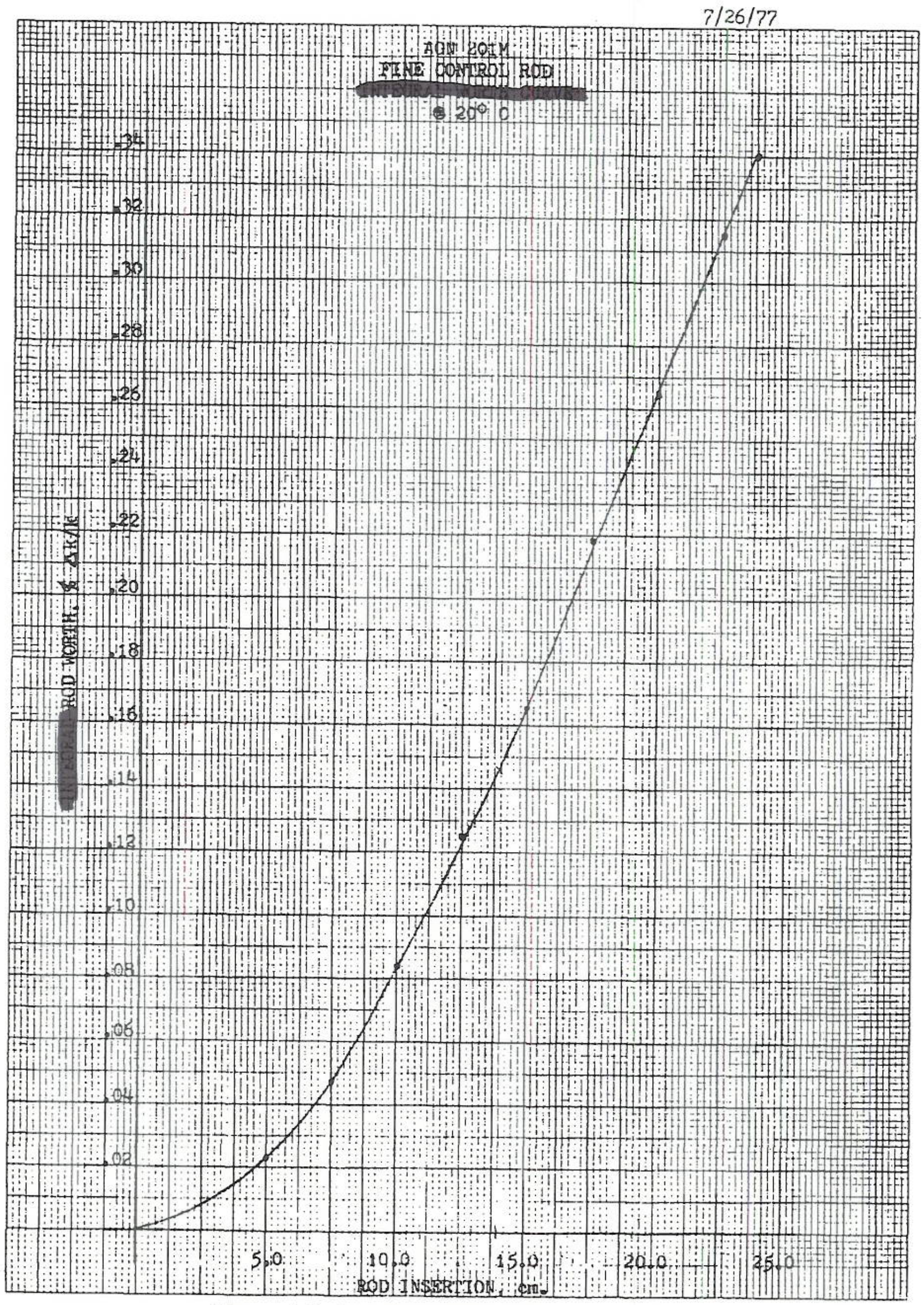

Figure 4-4: Fine Control Rod Calibration Curve

QUESTION C.08 [1.0 point]
How does the control rod position indicator measure rod height?

a. A radio frequency detector measures the height of the control rod extension tube above the piston

b. A series of 1000 limit switches open and close as the rod moves in giving rod position to 0.1% accuracy

c. A laser distance meter attached to top of control rod drive measures the height of the control rod

d. A synchronic generator attached to the control rod drive motor generates a signal proportional to rod position

QUESTION C.09 [1.0 point]
Per Procedure for Power Calibration, PWCL-3, the reactor operator will bring the power to:

a. 1 watts and a gold foil is used for the power calibration

b. 2 watts and a nickel foil is used for the power calibration

c. 5 watts and a gold foil is used for the power calibration

d. 7.5 watts and a nickel foil is used for the power calibration

QUESTION C.10 [1.0 point]
Which ONE of the following is the source presently used in the AGN-201M reactor?

a. Americium-Beryllium (Am-Be)

b. Plutonium-Beryllium (Pu-Be)

c. Radon-Beryllium (Ra-Be)

d. Uranium-Beryllium (U-Be)

QUESTION C.11 [1.0 point]
During a reactor operation, you observe that the shield water temperature indicates 14 ° C. For this temperature, you should:

a. continue to operate because the shield water temperature is within TS limit

b. increase power to 5 W so you can observe the temperature change

c. shutdown the reactor; immediately report the result to Reactor Manager because the control and safety system signals do not work

d. continue operation, but immediately report the result to the Senior Reactor Operator since the temperature is exceeding the facility operation limit

QUESTION C.12 [1.0 point]
Before setting High Voltage to Safety Channel, the first thing the Reactor Operator needs to do is to:

a. Insert in-core startup source

b. Set Safety Channel to 1×10^{-12}

c. Turn off Safety Channel High alarm

d. Verify that the cadmium shutdown rod is inserted in the glory hole

QUESTION C.13 [1.0 point]
In the event the reactor fails to scram, the TWO design features that serve to prevent exceeding core temperature limits are the:

a. large temperature coefficient and volume of water shield

b. Glory Hole Cadmium plug and volume of water shield

c. thermal fuse and large temperature coefficient

d. Glory Hole Cadmium plug and thermal fuse

A.01
Answer: b
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1982, Sec 3.3.1

A.02
Answer: d
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1982, Sec 3.3.1

A.03
Answer: c
Reference: $P=P_oe^{t/\tau}$ τ = 60 sec/ln(10) = 26.06 sec

A.04
Answer: c
Reference: Standard NRC question

A.05
Answer: b
Reference: Group 1 is the longest-lived delayed neutron precursor for thermal fission in U-235, with a half-life of 55.72 sec. Lamarsh, J. "Introduction to Nuclear Engineering" p. 88

A.06
Answer: c
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1982, Sec 3.2.1

A.07
Answer: a
Reference: NRC Standard Question.

A.08
Answer: d
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1982, Sec 3.3.3, page 3-21. At k=0.8; ρ = ∆Keff/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

A.09
Answer: d
Reference: Burn, R., *Introduction of Nuclear Reactor Operations*, © 1982, Sec 3.2

A.10
Answer: b
Reference: Total rod worth – (excess + most active control rod+ fine control rod);
(0.80+0.85+0.80+0.10) %Δk/k –(0.60+0.85+0.10) %Δk/k = (2.55 -1.55) %Δk/k = 1.00 %Δk/k

A.11
Answer: d
Reference:CR = S/(1-K) → CR = 200/(1 - .6) = 500

A.12
Answer: d
Reference: DOE Handbook Vol 2, ℞ Theory (Nuclear Parameters), E.O. 1.1 a&b, pg. 9

A.13
Answer: c
Reference: Time is related to ratio of final power to initial power. 2:1 is the largest ratio.

A.14
Answer: c
Reference: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory.

A.15
Answer: a.
Reference: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, Volume 2

B.1
Answer: d
Reference: $DR = DR_{\circ} * e^{-\mu X}$
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: $5 \text{ mrem/hr} = 500 \text{ mrem/hr} * e^{-0.10664 * X}$; X= 43.2 mm

B.2
Answer: b
Reference: $DR = DR_{\circ} * e^{-\lambda t}$
$1.5 \text{ rem/hr} = 35 \text{ rem/hr} * e^{-\lambda(5hr)}$
Ln(1.5/35) = -λ*5 --> λ=0.623; solve for another 5 hour later, DR $DR = 1.5 \text{ Rem} * e^{-0.623*(5)}$
$DR = 6.6 * 10^{-2}$ Rem or ~65 mrem

B.3
Answer: a
Reference: 10CFR20.1601(a)(3)

B.4
Answer: b
Reference: 10CFR20.1003 and NRC Training Material

B.05
Answer: d
Reference: Emergency Plan 2.2

B.06
Answer: a. = SL, b. = SL; c. = LCO; d. = LSSS;
Reference: TS 2.1- 2.3

B.07
Answer: b
Reference: Tech Spec 6.1.9

B.8
Answer: a, TEST b,CHECK c,TEST d, CAL
Reference: TS 1.0

B.9
Answer: d
Reference: R/hr = 6CE = 6 x 2 x 1*(1.17+1.33) = 30 R/hr

B.10
Answer: c
Reference: 10 CFR 20

B.11
Answer: c
Reference: TS 6.1.9

B.12
Answer: b
Reference: TS 3.3

B.13
Answer: b
Reference: TS 4.1.b

B.14
Answer: d
Reference: Basic knowledge of radiation.

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C.01
Answer: a
Reference: TAMU AGN-201M Safety Analysis Report § 7.2.3.

C.02
Answer: a, 2; b, 1; c, 2; d, 3
Reference: TAMU AGN-201M Technical Specifications 3.3

C.03
Answer: c
Reference: TAMU AGN-201M Safety Analysis Report § 4.5.3.

C.04
Answer: b
Reference: TAMU AGN-201M Safety Analysis Report § 4.2.3

C.05
Answer: b
Reference: TAMU AGN-201M Technical Specifications 3.2

C.06
Answer: b
Reference: TAMU AGN-201M Safety Analysis Report § Figure 4-4.

C.07
Answer: a
Reference: TAMU AGN-201M Safety Analysis Report § 4.2.1

C.08
Answer: d
Reference: Per pre-examination orientation, July, 2011.

C.9
Answer: c
Reference: PWCL-3

C.10
Answer: b
Reference: TAMU AGN-201M Safety Analysis Report § 4.2.4

C.11
Answer: c
Reference: TS 3.2.f

C.12
Answer: d
Reference: Maintenance Procedure for Setting Channel Two High Voltage (CH2P-3)

C.13
Answer: c
Reference: TS 2.2.b

U. S. NUCLEAR REGULATORY COMMISSION
RESEARCH AND TEST REACTOR
OPERATOR LICENSE EXAMINATION

FACILITY: Texas A&M University

REACTOR TYPE: AGN-201M

DATE ADMINISTERED: 4/4/2012

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
15.00	33.3	______	______	A. Reactor Theory, Thermodynamics and Facility Operating Characteristics
15.00	33.3	______	______	B. Normal, Emergency and Radiological Controls Procedures
13.00	33.3	______	______	C. Facility and Radiation Monitoring Systems
43.00		______ FINAL GRADE	______%	TOTALS

All work done on this examination is my own. I have neither given nor received aid.

____
Candidate's Signature

NRC RULES AND GUIDELINES FOR LICENSE EXAMINATIONS

During the administration of this examination the following rules apply:

1. Cheating on the examination means an automatic denial of your application and could result in more severe penalties.

2. After the examination has been completed, you must sign the statement on the cover sheet indicating that the work is your own and you have neither received nor given assistance in completing the examination. This must be done after you complete the examination.

3. Restroom trips are to be limited and only one candidate at a time may leave. You must avoid all contacts with anyone outside the examination room to avoid even the appearance or possibility of cheating.

4. Use black ink or dark pencil <u>only</u> to facilitate legible reproductions.

5. Print your name in the blank provided in the upper right-hand corner of the examination cover sheet and each answer sheet.

6. Mark your answers on the answer sheet provided. USE ONLY THE PAPER PROVIDED AND DO NOT WRITE ON THE BACK SIDE OF THE PAGE.

7. The point value for each question is indicated in [brackets] after the question.

8. If the intent of a question is unclear, ask questions of the examiner only.

9. When turning in your examination, assemble the completed examination with examination questions, examination aids and answer sheets. In addition turn in all scrap paper.

10. Ensure all information you wish to have evaluated as part of your answer is on your answer sheet. Scrap paper will be disposed of immediately following the examination.

11. To pass the examination you must achieve a grade of 70 percent or greater in each category.

12. There is a time limit of three (3) hours for completion of the examination.

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

A N S W E R S H E E T

Multiple Choice (Circle or X your choice)
If you change your Answer, write your selection in the blank.

A01 a b c d ___

A02 a b c d ___

A03 a b c d ___

A04 a b c d ___

A05 a b c d ___

A06 a b c d ___

A07 a b c d ___

A08 a b c d ___

A09 a b c d ___

A10 a b c d ___

A11 a b c d ___

A12 a b c d ___

A13 a b c d ___

A14 a b c d ___

A15 a b c d ___

ANSWER SHEET

Multiple Choice (Circle or X your choice)
If you change your Answer, write your selection in the blank.

B01 a b c d ___

B02 a b c d ___

B03 a b c d ___

B04 a b c d ___

B05 a b c d ___

B06 a ___ b ___ c ___ d ___ (2 points,0.5 each)

B07 a b c d ___

B08 a ___ b ___ c ___ d ___ (1 point, 0.25 each)

B09 a b c d ___

B10 a b c d ___

B11 a b c d ___

B12 a b c d ___

B13 a b c d ___

B14 a b c d ___

A N S W E R S H E E T

Multiple Choice (Circle or X your choice)
If you change your Answer, write your selection in the blank.

C01 a b c d ___

C02 a ___ b ___ c ___ d ___

C03 a b c d ___

C04 a b c d ___

C05 a b c d ___

C06 a b c d ___

C07 a b c d ___

C08 a b c d ___

C09 a b c d ___

C10 a b c d ___

C11 a b c d ___

C12 a b c d ___

C13 a b c d ___

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$${}^{135}_{52}Te \xrightarrow{(19\,\sec)} {}^{135}_{53}I \xrightarrow{(6.6\,hr)} {}^{135}_{54}Xe \xrightarrow{(9.1\,hr)} {}^{135}_{55}Cs \xrightarrow{(2.3\times10^6\ yr)} {}^{135}_{56}Ba$$

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

1 kg = 2.21 lbm

1 Horsepower = 2.54 x 10^3 BTU/hr

1 Mw = 3.41 x 10^6 BTU/hr

1 BTU = 778 ft-lbf

°F = 9/5 °C + 32

1 gal (H_2O) ≈ 8 lbm **°C = 5/9 (°F - 32)**

c_P = 1.0 BTU/hr/lbm/°F **c_p = 1 cal/sec/gm/°C**