September 3, 2010

Paul Whaley, Associate Director
Nuclear Engineering Teaching Lab
University of Texas at Austin
NETL-PRC Bldg 159
10100 Burnet Rd
Austin, TX 78758

SUBJECT: INITIAL EXAMINATION REPORT NO. 50-602/OL-10-02, UNIVERSITY OF TEXAS AT AUSTIN

Dear Mr. Whaley:

During the week of August 16, 2010, the Nuclear Regulatory Commission (NRC) administered an operator licensing examination at your TRIGA Reactor. The examination was conducted according to NUREG-1478, "Operator Licensing Examiner Standards for Research and Test Reactors," Revision 2. Examination questions and preliminary findings were discussed with those members of your staff identified in the enclosed report at the conclusion of the examination.

In accordance with Title 10 of the *Code of Federal Regulations* Section 2.390, a copy of this letter and the enclosures will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records (PARS) component of NRC's Agencywide Documents Access and Management System (ADAMS). ADAMS is accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html. The NRC is forwarding the individual grades to you in a separate letter which will not be released publicly. Should you have any questions concerning this examination, please contact Mr. Paul V. Doyle Jr, at (301) 415-1058 or via internet e-mail 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. 50-602

Enclosures:
1. Initial Examination Report No. 50-602/OL-10-01
2. Facility comments on written examination with NRC Resolution
3. Written examination with facility comments incorporated

cc: Michael Krause, Reactor Supervisor
cc without enclosures: See next page

September 3, 2010

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cc: Michael Krause, Reactor Supervisor
cc without enclosures: Please see next page

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ADAMS ACCESSION No. ML102440792 **TEMPLATE #:NRR-074**

OFFICE	PROB:CE		IOLB:LA	E	PROB:SC	
NAME	PDoyle		CRevelle		JEads	
DATE	09/1/2010		09/2/2010		09/3/2010	

C = COVER E = COVER & ENCLOSURE N = NO COPY

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cc:

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

Bureau of Radiation Control
State of Texas
1100 West 49th Street
Austin, TX 78756

Mr. William Powers, Jr., President
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Nuclear Engineering teaching Laboratory
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  Laboratory
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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.: 50-602/OL-10-01

FACILITY DOCKET NO.: 50-602

FACILITY LICENSE NO.: R-129

FACILITY: University of Texas TRIGA Reactor

EXAMINATION DATES: August 20, 2010

SUBMITTED BY: ***/RA/*** 8/31/2010
Paul V. Doyle Jr., Chief Examiner Date

SUMMARY:

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

REPORT DETAILS

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

2. Results:

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

3. Exit Meeting:
   Paul V. Doyle Jr., NRC, Examiner
   P. Michael Whaley, Associate Director, NETL, University of Texas
   Michael Krause, Reactor Supervisor, TRIGA Reactor, University of Texas

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

Facility Comments with NRC Resolution

COMMENT 1 - Question B.09 actually has more than one correct answer.

Question B.09: Which ONE of the following statement is TRUE with regard to visitors?

a. Any licensed operator or senior operator may escort visitors into restricted areas

b. Each member of a tour group must have a pocket dosimeter

c. Authorization for visitor access to the reactor floor must be obtained from the Health Physicist

d. Each visitor is responsible for adherence to radiological procedures and response to emergency operations

The key indicates the correct answer is "c," however the procedure step (HP00-1 II.E.1.e) indicates that "Authorization for visitor access to the reactor floor must be obtained from the Health Physicist or, in his or her absence, the NETL Director or Reactor Supervisor." Since the Director or Reactor Supervisor can authorize access to the reactor floor, "c" is not exclusively correct. Secondly, step "a" of the same HP procedure reference indicates personnel authorized to escort visitors into restricted areas are listed in the visitor log book, and this list includes all licensed operators (as well as others), which makes answer "a" also correct.

NRC Resolution:

Agree with facility comment. The answer key has been modified to recognize ‘a’ as a second correct answer. The NRC will review this question for clarification prior to using it for another examination.

COMMENT 2 - This question is actually somewhat confusing as written since some ports actually open at the same time when others close so two answers are possible the way the question is written.

Question C.04: A three-way solenoid valve controls the air supplied to the pneumatic cylinder of the transient rod. De-energizing the solenoid causes the valve to shift to:

a. open, admitting air to the cylinder

b. close, admitting air to the cylinder

c. open, removing air from the cylinder

d. close, removing air from the cylinder

The key indicates answer 'd' is correct. However, the valve has two ports, one managing the connection to allow air into the cylinder and the other managing the connection that provides a vent/relief path for cylinder air. De-energizing the solenoid opens the port to remove air from the cylinder and also closes the supply port to the compressed air source. Therefore both answer "c" and "d" are correct. Suggest rewording question to include a reference to either the "open vent" or "close supply" port.

NRC Resolution:

Agree with facility comment. The answer key has been modified to recognize ‘c’ as a second correct answer. The NRC will review this question for clarification prior to using it for another examination.

COMMENT 3 - This question points out a possible averaging, a discrepancy, or a rounding of numbers in information in the training documents as compared to actual set points measured during surveillances and thus does not have a correct answer listed unless one might round off and/or average the values from the different measuring channels..

Question C.18: The reactor protection system will generate a scam signal if neutron detector high voltage drops by ...

a. 10%

b. 20%

c. 80%

d. 90%

The key indicates answer "a" is correct however it also references a hand written change from 20 % to 10%. This set point is not specified in Technical Specifications. This value is actually not the same for each of the power monitoring channels. The two NP's actually trip at ~630 V with normal HV at 750 V - this is a decrease of 16% which one might tend to round up to 20% from the given answers, however the NM1000 fission chamber which has a nominal operating HV of 800 V trips at 750 V, a decrease of only 6.25%, which one might round up to 10 %. One could also look at it such as some trip at a 16 % decrease and the other trips at a 6% decrease so on average they trip at (16+6)/2 = 11% which is close to the 10% answer in the answer key. This question should be revised to either reference which system (NP's or NM) is being referred to or possibly reworded to somehow reference the word "average" to make a single answer the only possible correct answer.

NRC Resolution:

Agree with facility comment. This question has been deleted. The NRC will review this question for clarification prior to using it for another examination.

Please let me know if you have any questions about my comments.

Michael Krause
Reactor Supervisor, Manager of Operations
Nuclear Engineering Teaching Laboratory
University of Texas at Austin

U.S. Nuclear Regulatory Commission
Research and Test Reactors
Operator Licensing Examination
WITH ANSWER KEY

University of Texas TRIGA Reactor
Week of August 16, 2010

ENCLOSURE 3

Question B.01 [1.0 point]
The Ar^{41} monitor is not operable. Per Technical Specifications operating the reactor with the auxiliary air purge system shall be limited to a period of …

a. two hours.

b. seven days.

c. ten days.

d. indefinitely if corrective action is being taken.

Question B.02 [2.0 points, ½ each]
Match the terms in column A with their respective definitions in column B.

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

Question B.03 [1.0 point]
Many research reactors use different methods to reduce the dose due to N^{16} at the pool top. If the method used keeps the N^{16} ten (10) feet below the surface of the water, and a half-thickness for the N^{16} gamma(s) is one foot for water, then the dose due to N^{16} is reduced (approximately) by a factor of … (Note: Neglect any reduction in dose rate due to half-life.)
a. 20
b. 100
c. 200
d. 1000

Question B.04 [2.0 points, ½ each]
Match type of radiation (a thru d) with the proper penetrating power (1 thru 4). Each

	Radiation		Penetrating Power
a.	Gamma	1.	Stopped by thin sheet of paper
b.	Beta	2.	Stopped by thin sheet of metal
c.	Alpha	3.	Best shielded by light material
d.	Neutron	4.	Best shielded by dense material

Question B.05 [1.0 point, ¼ each]
Identify the PRIMARY source (irradiation of air, irradiation of water, or fission product) of EACH of the radioisotopes listed.

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

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

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

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

Question B.06 [1.0 point]
You initially remove a sample from the pool reading 1 R/hr at 30 cm from the source. You then replace the sample in the pool. An hour later you remove the sample and the reading is now 390 mR/hr at 30 cm. You again replace the sample back in the pool. How much longer should you wait to be able to bring out the sample without generating a high radiation area?

a. ½ hour

b. 1 hour

c. 1½ hours

d. 2 hours

Question B.07 [1.0 point, ¼ each]
Identify each of the following actions as either a channel **CHECK**, a channel **TEST**, or a channel **CALI**BRATION.

a. Prior to startup you place a known radioactive source near a radiation detector, noting meter movement and alarm function operation.

b. During startup you compare all of your nuclear instrumentation channels ensuring they track together.

c. At power, you perform a heat balance (calorimetric) and determine you must adjust Nuclear Instrumentation readings.

d. During a reactor shutdown you note a -80 second period on Nuclear Instrumentation.

Question B.08 [2.0 points, ½ each]
Identify each of the following as either a Safety Limit (**SL**) a Limiting Safety System Setting (**LSSS**) or a Limiting Condition for Operation (**LCO**).

a. The maximum transient reactivity insertion for the pulse operation of the reactor shall be 2.2%Δk/k in the pulse mode.

b. Maximum excess reactivity shall be 4.9% Δk/k.

c. "The temperature of a fuel element shall not exceed 1150°C for fuel element temperatures less than 500°C…"

d. During steady-state operation a minimum of three Reactor Power Level Channels shall be operable.

Question B.09 [1.0 point]
Which ONE of the following statements is **TRUE** with regard to visitors?

a. Any licensed operator or senior operator may escort visitors into restricted areas.

b. Each member of a tour group must have a pocket dosimeter.

c. Authorization for visitor access to the reactor floor must be obtained from the Health Physicist.

d. Each visitor is responsible for adherence to radiological procedures and response to emergency signals.

Question B.10 [1.0 point]
The Emergency Planning Zone (EPZ) for the UT TRIGA reactor is established at the...

a. University Safety Office.

b. Operations boundary.

c. Brackenridge Hospital.

d. Health physics room.

Question B.11 [1.0 point]
Which ONE of the following is **NOT** a condition for the Technical Specification limit on Shutdown Margin?

a. All experiments in most reactive state.

b. Core at maximum Xenon concentration.

c. Most reactive rod in fully out position.

d. Core at ambient temperature.

Question B.12 [1.0 point]
During work in a Restricted Area the pocket dosimeter is required to be checked periodically and re-zeroed when it reads ______ of scale.

a. 65%

b. 75%

c. 85%

d. 95%

Question B.13 [1.0 point]
The radiological design goal for the accessible areas of the pool water system and shield structure is ______ .

a. 0.5 mrem/hour

b. 1.0 mrem/hour

c. <2.5 mrem/hour

d. $\leq$5.0 mrem/hour at the hottest spot

Question B.14 [1.0 point]
Which **ONE** of the following types of experiments is **NOT** required to be doubly encapsulated? Experiments which contain …

a. explosive materials.

b. solid fissionable materials

c. compounds highly reactive with water.

d. materials corrosive to reactor components.

Question B.15 [1.0 point]
Class C experiments require the direction of a(n)_______________, Class B experiments require the direction of a(n) ____________, and Class A experiments require the direction of a(n)_____________.

a. senior operator; reactor operator; experimenter.

b. experimenter; senior operator; reactor operator.

c. reactor operator, senior operator, experimenter.

d. experimenter; reactor operator; senior operator.

Question B.16 [1.0 point]
In the event of an area evacuation, personnel should proceed to the emergency assembly area, located in:

a. the health physics room.

b. the reception office.

c. the control room.

d. the library/conference room.

Question B.17 [1.0 point]
A survey instrument with a window probe is used to measure the beta-gamma dose rate from an irradiated experiment. The dose rate is 100 mrem/hour with the window open and 60 mrem/hour with the window closed. The gamma dose rate is:

a. 100 mrem/hour.

b. 60 mrem/hour.

c. 40 mrem/hour.

d. 160 mrem/hour.

Question C.01 [1.0 point]
Which ONE of the following parameters is NOT measured in the Purification System?

a. Pressure

b. Flow Rate

c. Conductivity

d. pH

Question C.02 [1.0 point]
Which of the rings include the chromel-alumel thermocouples?

a. A and B

b. A and C

c. B and C

d. B and D

Question C.03 [1.0 point]
The neutron source used in the UT-TRIGA reactor consists of:

a. americium and beryllium.

b. antimony and beryllium.

c. plutonium and beryllium.

d. californium and beryllium.

Question C.04 [1.0 point]
A three-way solenoid valve controls the air supplied to the pneumatic cylinder of the transient rod. De-energizing the solenoid causes the valve to shift to:

a. open, admitting air to the cylinder.

b. close, admitting air to the cylinder.

c. open, removing air from the cylinder.

d. close, removing air from the cylinder.

Question C.05 [1.0 point]
A diffuser nozzle is located a short distance above the top grid plate and directs water downward over the core. The purpose of this diffuser is to:

a. enhance heat transfer across all fuel elements in the core.

b. ensure consistent water chemistry in the core.

c. better distribute heat throughout the pool.

d. reduce the dose rate at the pool surface from N-16.

Question C.06 [1.0 point]
Which ONE of the following is the purpose of the ½-inch aluminum safety plate suspended beneath the lower grid plate?

a. Prevents the control rods from dropping out of the core if the mechanical connections fail.

b. Provides a catch plate for small tools and hardware dropped while working on the core.

c. Provides structural support for the lower grid plate and the suspended core.

d. Prevents fuel rods from dropping out of the core.

Question C.07 [1.0 point]
Which ONE of the following statements correctly describes the purpose of the potentiometer in the control rod drive assembly?

a. Provides rod position indication when the electromagnet engages the connecting rod armature.

b. Provides a variable voltage to the rod drive motor for regulating control rod speed.

c. Provides the potential voltage to relatch the connecting rod to the electromagnet.

d. Provides potential voltage as required for resetting the electromagnet current.

Question C.08 [1.0 point]
In order to prevent radiation streaming through a beam port, each beam port contains:

a. a step (or steps) to provide for divergence of the radiation beam.

b. an inner shield plug and an outer shield plug.

c. a lead-filled shutter and a lead-lined door.

d. a removable cover plate.

Question C.09 [1.0 point]
The reactor is in the **AUTOMATIC** mode at a power level of 500 kW. The neutron detector from which the control system receives its input signal fails low (signal suddenly goes to zero). As a result:

a. the control system inserts the regulating rod to reduce power, to try to match the power of the failed detector.

b. the control system withdraws the regulating rod to increase power.

c. the control system drops out of the AUTOMATIC mode.

d. the reactor scrams.

Question C.10 [2.0 points, ½ each]
For the measurements listed in Column I, select the appropriate neutron monitoring system from Column II. Items in Column II may be used once, more than once, or not at all.

	Column I		Column II
a.	Reactor period.	1.	NM-1000
b.	Pulse energy.	2.	NP-1000
c.	Safety Channel #2.	3.	NPP-1000
d.	Log power.		

Question C.11 [1.0 point]
Which one of the following statements describes the moderating properties of Zirconium Hydride?

a. The hydride mixture is very effective in slowing down neutrons with energies below 0.025 eV.

b. The ratio of hydrogen atoms to zirconium atoms affects the moderating effectiveness for slow neutrons.

c. The probability that a neutron will return to the fuel element before being captured elsewhere is a function of the temperature of the hydride.

d. Elevation of the hydride temperature increases the probability that a thermal neutron will escape the fuel-moderator element before being captured.

Question C.12 [1.0 point]
The control rods must drop in the core in less than 1 second. How is damage to the rods prevented at the end of their travel?

a. A spring mechanism reduces bottom impact.

b. The small gap between the rod and adjacent fuel elements acts as a brake.

c. Large slotted openings in the upper portion of the barrel restrain rod motion by a dashpot action.

d. Small vent holes in the lower end of the barrel in conjunction with the piston act to slow down the rod down motion.

Question C.13 [1.0 point]
Which one of the following beam ports does **NOT** penetrate the graphite reflector?

a. 5

b. 4

c. 3

d. 1

Question C.14 [1.0 point]
There are small holes at various positions in the top grid plate. These holes are provided in order to:

a. ensure unimpeded coolant flow through the core.

b. ensure proper alignment of the top and bottom grid plates.

c. permit insertion of wires or foils into the core to obtain flux data.

d. allow thermocouple leads from instrumented fuel elements to pass out of the core.

Question C.15 [1.0 point]
A control rod is partially withdrawn from the core. At this point, the source level, for some unknown reason, drops below the minimum count. As a result:

a. the control rod cannot be withdrawn any further.

b. the control rod cannot be moved in any direction.

c. the control rod can only be inserted by means of a SCRAM.

d. the control rod can only be inserted by placing the key switch in the “OFF” position.

Question C.16 [1.0 point]
The pool level indications are provided by ___ dowels (rods) positioned by ___ floats.

a. 2 dowels and 5 floats

b. 2 dowels and 4 floats

c. 3 dowels and 3 floats

d. 5 dowels and 5 floats

Question C.17 [1.0 point]
WHICH ONE of the following experimental facilities can be modified to supply a highly collimated beam of neutron and gamma radiation?

a. Pneumatic Transfer system

b. Hollow Element Assembly

c. Central Thimble

d. Lazy Susan

~~Question C.18 [1.0 point]~~ Question deleted per facility comment
~~The reactor protection system will generate a scram signal if neutron detector high voltage drops by …~~

~~a. 10%~~

~~b. 20%~~

~~c. 80%~~

~~d. 90%~~

Question C.19 [1.0 point]
Which **ONE** of the following detectors is used to detect the amount Ar^{41} released to the environment?

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

b. Stack Gas Monitor

c. Stack Particulate Monitor

d. Bridge Area Monitor

B.01 c
Ref: Technical Specifications 3.3.3.b 2nd ¶.

B.02 a, 4; b, 2; c, 3; d, 1
Ref: Standard NRC question

B.03 d
Ref: Basic Radiological Controls knowledge: “Half-Thickness and Tenth-Thickness". $2^{10} = 1024$

B.04 a, 4; b, 2; c, 1; d, 3
Ref: Standard NRC Health Physics Question

B.05 a, Water; b, Air; c, Water; d, Fission
Ref: Standard NRC question.

B.06 c
Ref: $I_t = I_0 e^{-\lambda t}$ 390 mR/hr ÷ 1000 mR/hr = $e^{-\lambda 1hr}$ ln(0.39) = -λ * 1 hr. λ = 0.9416 $hour^{-1}$
SOLVING for additional time: $If = I_t e^{-\lambda t}$ 100mR/hr = 390 mR/hr $e^{-0.9416\,(time)}$ ln (0.25) = -0.9163 * time time = 1.4454

B.07 a. = Test; b. = Check; c. = Cal; d. = Check
Ref: Technical Specification 1.2.1-3

B.08 a. = LSSS; b. = LCO; c. = SL; d. = LCO
Ref: Tech Spec §§ 2.1, 2.2.3, 3.1.1 and 3.2.4 (table).

B.09 **c or a, 2nd correct answer added per facility comment**
Ref: HP-1, Radiation Monitoring - Personnel

B.10 b
Ref: Emergency Plan

B.11 b
Ref: Tech Spec§ 1.20 Definition of Reference Core and § 3.1.4 Shutdown Margin.

B.12 b
Ref: HP00-1 Radiation Monitoring - Personnel

B.13 b
Ref: SAR 7.2.1 page 7-2

B.14 b
Ref: Technical Specification 3.4.2.a

B.15 d
Ref: ADMN-6, Authorization of Experiments.

B.16 a
Ref: Procedure Plan-E, Emergency Response.

B.17 b
Ref: Vol. IV, Radiation Detection the window stops the betas, and so the gamma dose rate is 60 mrem/hour.

C.01 d
Ref: SURV-4, Reactor Water Systems Surveillance step B.2.a. and b.

C.02 c
Ref: SURV-1

C.03 a
Ref: Vol. II, Description of TRIGA Mark II Reactor, page 16.

C.04 d **or c 2nd correct answer added per facility comment**
Ref: University of Texas SAR, page 4-69. SAR 4.4.6.3

C.05 d
Ref: Vol. II, Operation Support Systems, page 6.

C.06 a
Ref: Vol. II, Description of TRIGA Mark II Reactor, page 14.

C.07 a
Ref: Vol. II, Description of TRIGA Mark II Reactor, page 20.

C.08 a
Ref: Vol. II, Operation Support Systems, page 24.

C.09 b
Ref: Vol. II, Control Console Operator's Manual, page 5-3.

C.10 a. =1; b. = 3; c. = 2; d. = 1.
Ref: Vol. II, Reactor Instrumentation and Control Systems, figure 2-1.

C.11 d
Ref: GA - 3886 (Rev. A) TRIGA Mark III Reactor Hazards Analysis, Feb. 1965.

C.12 d
Ref: SAR 4.4.8.1

C.13 b
Ref: Support Systems Sect. 3.4

C.14 c
Ref: SAR 4.4.3

C.15 a
Ref: UT-TRIGA Training Manual, Vol. II, Description of TRIGA Mark II Reactor, page 31.

C.16 a
Ref: SURV-4, Reactor Water Systems Surveillance step B.1.f and MAIN-3, Support System Features step B.1 - B.4

C.17 c
Ref: UT TRIGA - Operational Support Systems, § 3.3, p. 21.

~~C.18 a~~ **Question deleted per facility comment.**
~~Ref: UT TRIGA - ℞ Description, Reactor Instrumentation and Controls § 2.1.6.2.2 on page 29. (Note: hand written change from 20% to 10%.)~~

C.19 b
Ref: Standard NRC Exam Question

U. S. NUCLEAR REGULATORY COMMISSION

NON-POWER INITIAL REACTOR LICENSE EXAMINATION

FACILITY: University of Texas

REACTOR TYPE: TRIGA (Pulsing)

DATE ADMINISTERED: 08/ /2010

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 two (2) hours after the examination starts.

% of Category Value	% of Total	Candidates Score	Category Value	Category
20.00	33.3	______	____	B. Normal and Emergency Operating Procedures and Radiological Controls
20.00	33.3	______	____	C. Facility and Radiation Monitoring Systems
46.00	______	____%		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 <u>only</u> to facilitate legible reproductions.

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

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

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

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

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

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

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

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

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

EQUATION SHEET

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

$$M = \frac{1 - K_{eff_0}}{1 - K_{eff_1}}$$

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

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

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

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

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

$$\lambda_{eff} = 0.1 \text{ seconds}^{-1}$$

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

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

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

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

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

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

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

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

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

$$T_{‰} = \frac{0.693}{\lambda}$$

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

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

$$DR = \frac{6CiE(n)}{R^2}$$

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

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

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

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

Section B Normal, Abnormal, Emergency and Radiological Controls Procedures

B.01 a b c d ___

B.02a 1 2 3 4 ___

B.02b 1 2 3 4 ___

B.02c 1 2 3 4 ___

B.02d 1 2 3 4 ___

B.03 a b c d ___

B.04 a 1 2 3 4 ___

B.04 b 1 2 3 4 ___

B.04 c 1 2 3 4 ___

B.04 d 1 2 3 4 ___

B.05a water air fission ___

B.05b water air fission ___

B.05c water air fission ___

B.05d water air fission ___

B.06 a b c d ___

B.07a CHECK TEST CAL ___

B.07b CHECK TEST CAL ___

B.07c CHECK TEST CAL ___

B.07d CHECK TEST CAL ___

B.08a SL LSSS LCO ___

B.08b SL LSSS LCO ___

B.08c SL LSSS LCO ___

B.08d SL LSSS LCO ___

B.09 a b c d ___

B.10 a b c d ___

B.11 a b c d ___

B.12 a b c d ___

B.13 a b c d ___

B.14 a b c d ___

B.15 a b c d ___

B.16 a b c d ___

B.17 a b c d ___

Section C Facility and Radiation Monitoring Systems

C.01 a b c d ___

C.02 a b c d ___

C.03 a b c d ___

C.04 a b c d ___

C.05 a b c d ___

C.06 a b c d ___

C.07 a b c d ___

C.08 a b c d ___

C.09 a b c d ___

C.10a 1 2 3 ___

C.10b 1 2 3 ___

C.10b 1 2 3 ___

C.10c 1 2 3 ___

Note: candidate's exam appropriately had this written in.

C.10d 1 2 3 ___

C.11 a b c d ___

C.12 a b c d ___

C.13 a b c d ___

C.14 a b c d ___

C.15 a b c d ___

C.16 a b c d ___

C.17 a b c d ___

C.18 a b c d ___

C.19 a b c d ___