December 10, 2008

Dr. Mohamad Al-Sheikly, Director
Department of Materials and Nuclear Engineering
The University of Maryland
College Park, MD 20742

SUBJECT: INITIAL EXAMINATION REPORT NO. 50-166/OL-08-01, UNIVERSITY OF MARYLAND

Dear Dr. Mohamad Al-Shiekly:

During the week of November 10, 2008, the U.S. Nuclear Regulatory Commission (NRC) administered operator licensing examination at your Maryland University Training Reactor (MUTR). The examination was conducted according to NUREG-1478, "Operator Licensing Examiner Standards for Research and Test Reactors," Revision 2, published in June 2007. 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 Patrick Isaac at 301-415-1019 or via email at patrick.isaac@nrc.gov.

Sincerely,

/RA/

Johnny H. Eads Jr., Chief
Research and Test Reactors Branch B
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Docket No. 50-166

Enclosures:
1. Examination Report No. 50-166/OL-08-01
2. Written Examination

cc w/enclosures: Vince Adams, Facility Coordinator, MUTR

December 10, 2008

Dr. Mohamad Al-Sheikly, Director
Department of Materials and Nuclear Engineering
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College Park, MD 20742

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DISTRIBUTION w/ encls.:
PUBLIC PRTB r/f JEads Facility File (CRevelle) O-13 D-07

ADAMS ACCESSION #: ML083380476

OFFICE	PRTB:CE	IOLB:LA	PRTB:BC
NAME	PIsaac pxi	CRevelle car	JEads jhe
DATE	12/3/08	12/10/08	12/10/08

OFFICIAL RECORD COPY

University of Maryland Docket No. 50-166

cc:

Director, Dept. of Natural Resources
Power Plant Siting Program
Energy & Coastal Zone Administration
Tawes State Office Building
Annapolis, MD 21401

Mr. Roland Fletcher, Director
Center for Radiological Health
Maryland Department of Environment
201 West Preston Street
7th Floor Mail Room
Baltimore, MD 21201

Mr. Vincent G. Adams
Facility Coordinator
Chemical and Nuclear Engineering Building 090
University of Maryland
College Park, MD 20742

Maureen M. Kotlas, Director
Department of Environmental Safety
3115 Chesapeake Building 338
University of Maryland
College Park, MD 20742

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

EXAMINATION REPORT NO: 50-166/OL-08-01

FACILITY: Maryland University Training Reactor

FACILITY DOCKET NO.: 50-166

FACILITY LICENSE NO.: R-70

SUBMITTED BY: ________**/RA/**___________ December 3, 2008
Patrick J. Isaac, Chief Examiner Date

SUMMARY:

During the week of November 10, 2008, the NRC administered operator licensing examinations to one Senior Reactor Operator and three Reactor Operator (RO) and candidates. One of the RO candidates failed Section B of the written examination. The other candidates passed all sections of the examination.

REPORT DETAILS

1. Examiner: Patrick J. Isaac, Chief Examiner

2. Results:

	RO PASS/FAIL	SRO PASS/FAIL	TOTAL PASS/FAIL
Written	2/1	N/A	2/1
Operating Tests	3/0	1/0	4/0
Overall	2/1	1/0	3/1

3. Exit Meeting:

Vince Adams, Facility Coordinator, MUTR
Patrick Isaac, NRC, Examiner

The NRC Examiner thanked the facility for their support in the administration of the examinations.

ENCLOSURE 1

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

FACILITY: University of Maryland

REACTOR TYPE: TRIGA

DATE ADMINISTERED: November 13, 2008

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 parentheses 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.

CATEGORY VALUE	CANDIDATE'S SCORE	% OF CATEGORY VALUE		CATEGORY
17.00	___________	____	A.	REACTOR THEORY, THERMODYNAMICS AND FACILITY OPERATING CHARACTERISTICS
17.00	___________	____	B.	NORMAL AND EMERGENCY OPERATING PROCEDURES AND RADIOLOGICAL CONTROLS
17.00	___________	____	C.	FACILITY AND RADIATION MONITORING SYSTEMS
71.00	___________ FINAL GRADE	____%	TOTALS	

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

Candidate's Signature

ENCLOSURE 2

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.

MULTIPLE CHOICE

001 a ___ b ___ c ___ d ___

002 a b c d ___

003 a b c d ___

004 a b c d ___

005 a b c d ___

006 a b c d ___

007 a b c d ___

008 a b c d ___

009 a b c d ___

010 a b c d ___

011 a b c d ___

012 a b c d ___

013 a b c d ___

014 a b c d ___

015 a b c d ___

016 a b c d ___

(***** END OF CATEGORY A *****)

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.

001 a b c d ___

002 a b c d ___

003 a b c d ___

004 a b c d ___

005 a ___ b ___ c ___ d ___

006 a b c d ___

007 a b c d ___

008 a b c d ___

009 1 ___ 2 ___ 3 ___ 4 ___

010 a b c d ___

011 a b c d ___

012 a b c d ___

013 a b c d ___

014 a b c d ___

015 a b c d ___

(***** END OF CATEGORY B *****)

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.

001 a b c d ___

002 a b c d ___

003 a b c d ___

004 a b c d ___

005 a b c d ___

006 a b c d ___

007 a b c d ___

008 a b c d ___

009 a b c d ___

010 a ___ b ___ c ___ d ___

011 a ___ b ___ c ___ d ___

012 a b c d ___

013 a b c d ___

014 a b c d ___

015 a b c d ___

(***** END OF CATEGORY C *****)
(********** END OF EXAMINATION **********)

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.

EQUATION SHEET

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

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

$\dot{Q} = \dot{m} \Delta h$

$SCR = S/(1-Keff)$

$\dot{Q} = UA \Delta T$

$CR_1 (1-Keff)_1 = CR_2 (1-Keff)_2$

$SUR = \frac{26.06 (\lambda_{eff}\rho)}{(\beta - \rho)}$

$M = \frac{(1-Keff)_0}{(1-Keff)_1}$

$SUR = 26.06/\tau$

$M = 1/(1-Keff) = CR_1/CR_0$

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

$SDM = (1-Keff)/Keff$

$P = P_0 e^{(t/\tau)}$

$Pwr = W_f \dot{m}$

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

$\ell^* = 1 \times 10^{-5}$ seconds

$\tau = (\ell^*/\rho) + [(\bar{\beta}-\rho)/\lambda_{eff}\rho]$

$\tau = \ell^*/(\rho-\bar{\beta})$

$\rho = (Keff-1)/Keff$

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

$\rho = \Delta Keff/Keff$

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

$\bar{\beta} = 0.0070$

$DR_1 D_1^2 = DR_2 D_2^2$

$DR = DR_o e^{-\lambda t}$

$DR = \frac{6CiE(n)}{R^2}$ DR ≡ R/hr, Ci ≡ Curies, E ≡ Mev, R ≡ feet

1 Curie = 3.7×10^{10} dps

1 kg = 2.21 lbm

1 hp = 2.54×10^3 BTU/hr

1 Mw = 3.41×10^6 BTU/hr

1 BTU = 778 ft-lbf

°F = 9/5°C + 32

1 gal H_2O ≈ 8 lbm

°C = 5/9 (°F - 32)

QUESTION A.1 [2.0 points, 0.5 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.2 [1.0 point]

You enter the control room and note that all nuclear instrumentation show a steady neutron level, and no rods are in motion. Which one of the following conditions **CANNOT** be true?

a. The reactor is critical.

b. The reactor is subcritical.

c. The reactor is supercritical.

d. The neutron source has been removed from the core.

QUESTION A.3 [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.4 [1.0 point]

Which factor of the Six Factor formula is most easily varied by the reactor operator?

a. Thermal Utilization Factor (f)

b. Reproduction Factor (η)

c. Fast Fission Factor (ϵ)

d. Fast Non-Leakage Factor (L_f)

QUESTION A.5 [1.0 point]

You perform two initial startups a week apart. Each of the startups has the same starting conditions, (core burnup, pool and fuel temperature, and count rate are the same). The only difference between the two startups is that during the **SECOND** one you stop for 10 minutes to answer the phone while the reactor is still subcritical. For the second startup, compare the critical rod height and count rate to the first startup.

	Rod Height	Count Rate
a.	Higher	Same
b.	Lower	Same
c.	Same	Lower
d.	Same	Higher

QUESTION A.6 [1.0 point]

Reactor power decreases on a stable negative period after a reactor scram, following an initial prompt drop. Which ONE (1) of the following is the reason for this?

a. This rate of power change is dependent on the **MEAN** lifetime of the longest lived delayed neutron precursor.

b. This rate of power change is dependent on the **MEAN** lifetime of the shortest lived delayed neutron precursor.

c. All prompt neutrons decay during the prompt drop, and the subsequent rate of power change is dependent **ONLY** on the half-life of the longest lived prompt gamma emitter.

d. This rate of power change is dependent on the **CONSTANT** decay rate of prompt neutrons following a scram.

QUESTION A.7 [1.0 point]

Which one of the following atoms will cause a neutron to lose the most energy in an elastic collision?

a. $Uranium^{238}$

b. $Carbon^{12}$

c. $Hydrogen^{2}$

d. $Hydrogen^{1}$

QUESTION A.8 [1.0 point]

K_{eff} for the reactor is 0.98. If you place an experiment worth **+$1.00** into the core, what will the new K_{eff} be?

a. 0.982

b. 0.987

c. 1.013

d. 1.018

QUESTION A.9 [1.0 point]

About two minutes following a reactor scram, period has stabilized, and is decreasing at a CONSTANT rate. If reactor power is 10^{-5} % full power what will the power be in three minutes.

a. 5×10^{-8} % full power

b. 2×10^{-9} % full power

c. 1×10^{-6} % full power

d. 5×10^{-7} % full power

QUESTION A.10 [1.0 point]

A reactor contains three safety blades and a regulating blade. 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 blades full out and the regulating blade at some position. The reactivity remaining in the regulating blade (i.e. its worth from its present position to full out) is the excess reactivity.

b. The reactor is shutdown. Two safety blades are withdrawn until the reactor becomes critical. The total blade worth withdrawn is the excess reactivity.

c. The reactor is at full power. The total worth of all blades withdrawn is the excess reactivity.

d. The reactor is at full power. The total worth remaining in all the safety blades and the regulating blade (i.e. their worth from their present positions to full out) is the excess reactivity.

QUESTION A.11 [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.12 [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.13 [1.0 point]

Which one of the following is the **MAJOR** source of energy released during fission?

a. Kinetic energy of the fission neutrons.

b. Kinetic energy of the fission fragments.

c. Decay of the fission fragments.

d. Prompt gamma rays.

QUESTION A.14 [1.0 point]

As primary coolant temperature increases, rod worth:

a. increases due to higher reflector efficiency.

b. decreases due to higher neutron absorption in the moderator.

c. increases due to the increase in thermal diffusion length.

d. remains the same due to constant poison cross-section of the control rods.

QUESTION A.15 [1.0 point]

The term ***PROMPT JUMP*** refers to …

a. the instantaneous change in power due to withdrawal of a control rod.

b. a reactor which has attained criticality on prompt neutrons alone.

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

d. a negative reactivity insertion which is less than β_{eff}.

QUESTION A.16 [1.0 point]

Which one of the following is the correct reason that delayed neutrons enhance control of the reactor?

a. There are more delayed neutrons than prompt neutrons.

b. Delayed neutrons increase the average neutron generation time.

c. Delayed neutrons are born at higher energies than prompt neutrons and therefore have a greater effect.

d. Delayed neutrons take longer to reach thermal equilibrium.

Question B.1 [1.0 point]

In order to ensure the health and safety of the public, in an emergency, 10CFR50 allows the operator to deviate from Technical Specifications. What is the minimum level of authorization needed to deviate from Tech. Specs?

a. USNRC

b. Reactor Supervisor

c. Licensed Senior Reactor Operator.

d. Licensed Reactor Operator.

Question B.2 [1.0 point]

“The instrumented fuel element temperature shall not exceed 400^{o}C” This is an example of a:

a. safety limit.

b. limiting safety system setting.

c. limiting condition for operation.

d. surveillance requirement.

Question B.3 [1.0 point]

Which one of the following statements defines the Technical Specifications term "Channel Test?"

a. The adjustment of a channel such that its output corresponds with acceptable accuracy to known values of the parameter which the channel measures

b. The qualitative verification of acceptable performance by observation of channel behavior

c. The introduction of a signal into a channel for verification of the operability of the channel

d. The combination of sensors, electronic circuits and output devices connected to measure and display the value of a parameter

Question B.4 [1.0 point]

Per Technical Specifications, for a period of time not to exceed _______, the Exhaust Radiation Monitor may be taken out of service for maintenance if it is replaced with a portable gamma sensitive instrument observable by the reactor operator.

a. 8 hours

b. 24 hours

c. 48 hours

d. 7 days

Question B.5 [2.0 points, 0.5 each]

Match the radiation reading from column A with its corresponding radiation area classification (per 10 CFR 20) listed in column B.

COLUMN A	COLUMN B
a. 10 mRem/hr	1. Unrestricted Area
b. 150 mRem/hr	2. Radiation Area
c. 10 Rem/hr	3. High Radiation Area
d. 550 Rem/hr	4. Very High Radiation Area

Question B.6 [1.0 point]

A radioactive source generates a dose of 100 mr/hr at 10 feet. Using a two inch thick sheet of lead for shielding the reading drops to 50 mr/hr at 10 feet. What is the minimum number of sheets of the same lead shielding needed to drop the reading to less than 5 mr/hr at a distance of 10 ft?

a. 1

b. 3

c. 5

d. 7

Question B.7 [1.0 point]

Which one of the following is the 10 CFR 20 definition of **TOTAL EFFECTIVE DOSE EQUIVALENT (TEDE)**?

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

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

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

d. The dose to a specific organ or tissue resulting from an intake of radioactive material

Question B.8 [1.0 point]

A room contains a source which, when exposed, results in a general area dose rate of 175 mr/hr. This source is scheduled to be exposed continuously for 25 days. Select an acceptable method for controlling radiation exposure from the source within this room.

a. Post the area with words “Danger-Radiation Area”.

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

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

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

Question B.9 [2.0 points, 0.5 each]

Match the requirements (10 CFR 55) for maintaining an active operator license in column A with the correct time period from column B. (NOTE: Some time frame may be used more than once or not at all.)

Column A	Column B
1. Renewal of license	a. 4 months
2. Medical examination	b. 1 year
3. Console manipulation evaluation	c. 2 years
4. Requalification exam (written)	d. 6 years

Question B.10 [1.0 point]

Which one of the following is a Reportable Occurrence per Technical Specifications?

a. The reactor protection system is set to scram the reactor at 310 KW.

b. The interlock for the Beam Port is disabled by the Senior Reactor Operator while the reactor is at power.

c. One of the Bridge Radiation Monitor is inoperable while the reactor is a power.

d. An unexpected reactivity change of $0.75

Question B.11 [1.0 point]

Which ONE of the following events is designated as the Maximum Hypothetical Accident (MHA) for the University of Maryland reactor?

a. Fuel handling mishap resulting in fuel element failure outside the reactor.

b. Malfunction of an experiment or an experimental apparatus.

c. Loss of Coolant Accident.

d. Control Rod ejection accident.

Question B.12 [1.0 point]

The total reactivity worth of in-core experiments is 1.50 dollars.
What is the maximum excess reactivity allowed relative to cold critical conditions?

a. 3.50 dollars

b. 2.00 dollars

c. 1.50 dollars

d. 0.50 dollars

Question B.13 [1.0 point]

Which one of the following does NOT require NRC approval for changes?

a. Facility License

b. Requalification plan

c. Emergency Implementation Procedures

d. Emergency Plan

Question B.14 [1.0 point]

The reactor is operating with the following power indications:

- Safety Channel I = 75 %
- Safety Channel II = 80 %
- Linear Power Chart Recorder (Red Pen) = 63% with range switch on 30KW
- Log-Power Channel = 83 %

Which one of the indications should be used as true power level?

a. Safety Channel I

b. Safety Channel II

c. Linear Power Chart Recorder

d. Log-Power Channel

Question B.15 [1.0 point]

It is April 1, 2008. You have stood watch for the following hours during the last quarter:

Jan. 11, 2008	0.5 hours
Feb. 24, 2008	1.5 hours
Mar. 16, 2008	1.0 hours

What requirements must you meet in order to stand an RO watch today?

a. None. You've met the minimum requirements of 10 CFR 55.

b. You must perform 4 hours of shift functions under the direction of a licensed operator or licensed senior operator as appropriate.

c. You must perform 6 hours of shift functions under the direction of a licensed operator or licensed senior operator as appropriate.

d. You must submit a new application form to the NRC requesting a waiver to reactivate your license.

(*** End of Section B ***)

QUESTION C.1 [1.0 point]

Which ONE of the following describes the action of the rod control system to drive the magnet draw tube down after a dropped rod?

a. Deenergizing the rod magnet initiates the down motion of the draw tube.

b. MAGNET DOWN limit switch OFF initiates the down motion of the draw tube.

c. ROD DOWN limit switch ON initiates the down motion of the draw tube.

d. MAGNET DOWN limit switch OFF and ROD DOWN limit switch ON initiates the down motion of the draw tube.

QUESTION C.2 [1.0 point]

A break has occurred in the reactor coolant system on the pool inlet line to the pool. The break is outside of the pool. Select the level that the pool will drain to and why?

a. The top of the core because all reactor coolant piping external to the core is above the top of the core.

b. Two feet above the top of the core because this is the discharge point of the pool inlet line.

c. Approximately to the height of the elbow located on the pool inlet pipe.

d. Two feet below the top of the reactor pool due to the siphon break located on the pool water outlet pipe.

QUESTION C.3 [1.0 point]

The MUTR coolant system consists of 1) primary coolant pump, 2) outlet temperature probe, 3) micro filter, and 4) heat exchanger number 1.
Which one of the following orders describes the correct flow of the primary water system (assume that the water flow will begin at the reactor pool)?

a. 1,2,3,4

b. 1,4,2,3

c. 4,3,2,1

d. 1,3,4,2

QUESTION C.4 [1.0 point]

Which one of the following gases is the driving force for the pneumatic transfer system (rabbit) system?

a. CO_2

b. Air

c. H_2

d. O_2

QUESTION C.5 [1.0 point]

The ion chamber power indications are correlated to the heat balance calculated thermal power by:

a. adjusting the detector high voltage.

b. adjusting the circuit comparator voltage.

c. moving the graphite reflectors to change the neutron flux near the detectors.

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

QUESTION C.6 [1.0 point]

What is achieved by use of the diffuser above the core during operation?

a. Better distribution of heat throughout the pool.

b. Better heat transfer across all fuel elements in the core.

c. Reduced dose rate at the pool surface.

d. Consistent water chemistry in the core.

QUESTION C.7 [1.0 point]

Which one of the following is the PRIMARY function of graphite slugs at the top and bottom of the fuel element?

a. Reflector

b. Moderator

c. Absorber

d. Scatter

QUESTION C.8 [1.0 point]

When adding water to the pool, overflow from the pool will go:

a. into the holdup tank in the water handling room sump through the pool overflow piping.

b. directly into the water handling room sump through the pool overflow piping.

c. directly into the water handling room sump through the floor drain gratings around the base of the reactor.

d. directly into the sewer system through the floor drain gratings around the base of the reactor.

QUESTION C.9 [1.0 point]

The poison section of the MUTR control rods consist of:

a. Boron-Aluminum alloy (Boral)

b. powdered borated graphite

c. Boron Carbide mixed with Zirconium Hydride

d. compacted and sintered Boron Carbide

QUESTION C.10 [2.0 points, 0.5 each]

Identify the PRIMARY source (irradiation of air, irradiation of water, or fission product) of EACH of the radioisotopes listed below.

a. Br-82	1) irradiation of air
b. H-3	2) irradiation of water
c. N-16	3) fission product
d. Ar-41	

QUESTION C.11 [2 points, 0.5 each]

Match each of the following channel or interlock in Column A to the protection they provide in Column B.

Column A	Column B
a. Startup Count rate	1. Scram
b. Rod drive control	2. Interlock
c. HV to reactor power channel	
d. Log Power Level	

QUESTION C.12 [1 point]

Which one of the following is the specified limit for the pool water conductivity?

a. 6×10^{-5} mhos/cm

b. 5×10^{-6} mhos/cm

c. 6×10^{-8} mhos/cm

d. 8×10^{-6} mhos/cm

QUESTION C.13 [1 point]

Which one of the following is allowed per the T.Ss?

a. A non-secured experiment with a reactivity worth of $1.0

b. A single experiment with a reactivity worth of $1.10

c. Total reactivity worth of $2.5 in core experiment

d. 30 mg of gunpowder

QUESTION C.14 [1 point]

The output of the Uncompensated Ion Chamber provides the signal:

a. for the period circuit

b. for Safety Channel #1

c. to the % Demand Controller

d. for Safety Channel #2

QUESTION C.15 [1 point]

The thermocouples in the instrumented fuel bundle measure temperature at the:

a. interior surface of the cladding

b. center of the zirconium rod

c. outer surface of the fuel

d. interior of the fuel

(*** End of Examination ***)

A.1 a, 2; b, 4; c, 1; d, 3
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1982, § 2.5, p. 2-36.

A.2 c
REF: Standard NRC question

A.3 b
REF: Burn, R., *Introduction to Nuclear Reactor Operations*, © 1988, §§ 8.1 —8.4, pp. 8-3 — 8-14.

A.4 a
REF: Burn, R., *Introduction to Nuclear Reactor Operations*, © 1982, § 3.2, pp. 3-13 — 3-18.

A.5 d
REF: Burn, R., *Introduction to Nuclear Reactor Operations*, © 1982, § 5.7, pp. 5-28 — 5-38.

A.6 a
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1982, § 4.7, p. 4-21.

A.7 d
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 2.5.3 p. 2-45.

A.8 b
REF: SDM = $(1-k_{eff})/k_{eff}$ = (1-0.98)/0.98 = 0.02/0.99 = 0.02041 or 0.02041/.0075 = $2.72, or a reactivity worth (ρ) of -$2.72. Adding +$1.00 reactivity will result in a SDM of $2.72 - $1.00 = $1.72, or .0129081 ΔK/K
K_{eff} = 1/(1+SDM) = 1/(1 + 0.0129081) = 0.987

A.9 c
REF: $P = P_0\, e^{-T/\tau} = 10^{-5} \times e^{(-180sec/80sec)} = 10^{-5} \times e^{-2.25} = 0.1054 \times 10^{-5} = 1.054 \times 10^{-6}$

A.10 a
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, §§ 6.2.1, pp. 6-2.

A.11 b
REF: Burn, R., *Introduction to Nuclear Reactor Operations*, © 1982, § 2.4.5 p. 2-28.

A.12 d
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 6.2.3, p. 6-4.

A.13 b
REF: Burn, R., *Introduction to Nuclear Reactor Operations*, © 1982, § 3.2.1, p. 3-4.

A.14 c
REF: Burn, R., *Introduction to Nuclear Reactor Operations*, © 1982, § 3.3.2, p. 3-18

A.15 a
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 4.7, p. 4-21

A.16 b
REF: Burn, R., *Introduction to Nuclear Reactor Operations*, © 1982, § 3.2.4, p. 3-12.

B.1 c
REF: 10CFR50.54(y)

B.2 b
REF: TS 2.2

B.3 c
REF: TS 1.0

B.4 c
REF: TS 3.4

B.5 a – 2; b – 3; c – 3; d – 4
REF: 10 CFR 20.1003, Definitions

B.6 c
REF: Two inches = one-half thickness ($T_{½}$). Using 5 half-thickness will drop the dose by a factor of $(½)^5$ = 1/32 □ 100/32 = 3.13

B.7 a
REF: 10 CFR 20.1003 *Definitions*

B.8 d
REF: 10 CFR 20.1601

B.9 1 d   2 c   3 b   4 c
REF: 10CFR55

B.10 a
REF: Technical Specifications 1.21, "Definitions"
Technical Specifications 3.0

B.11 a
REF: FNR Safety Analysis, Section 13.0

B.12 a
REF: TS 3.1

B.13 c
REF: 10 CFR 50.54 q; 10 CFR 50.59; 10 CFR 55.59

B.14 b
REF: OP-104, Reactor Operations, Step 3.6

B.15 c
REF: 10CFR55.53(e) & (f)

(*** End of Section B ***)

C.1 d
REF ENNU 320 MANUAL VOL. 2, Page 6-7

C.2 c
REF FSAR section 4.1

C.3 d
REF SAR Figure 5-1

C.4 a
REF SAR Section 10.2.4

C.5 d
REF ENNU 320, Vol. 2, Sect. 7.3; SP-202, Step 5.6

C.6 c
REF FSAR section 8.3

C.7 a
REF SAR Section 4.2.1.1

C.8 a
REF ENNU 320, Vol.2, Sect. 8.1

C.9 b
REF FSAR Section 3.2.1

C.10 a (3), b (2), c (2), d (1)
REF: Lecture notes

C.11 a (2), b (2), c (1), d (2)
REF TS Section 3.2

C.12 b
REF: TS Section 3.3

C.13 c
REF TS Section 3.5

C.14 d
REF ENNU 320 MANUAL VOL. 2, Page 6-2

C.15 d
REF ENNU 320 MANUAL VOL. 2, Page 3-1

(***** End of Examination *****)