June 5, 2002

Dr. Steven E. Binney, Director
Oregon State University
Radiation Center, A100
Corvallis, OR 97331-5903

SUBJECT: INITIAL EXAMINATION REPORT NO. 50-243/OL-02-01, OREGON STATE UNIVERSITY

Dear Dr. Binney:

On April 28, 2002, the NRC administered an operator licensing examination at your Oregon State University Reactor. The examination was conducted according to NUREG-1478, "Non-Power Reactor Operator Licensing Examiner Standards," Draft 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 10 CFR 2.790 of the Commission's 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 document system (ADAMS). ADAMS is accessible from the NRC Web site at (the Public Electronic Reading Room) http://www.nrc.gov/NRC/ADAMS/indesx.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 Paul Doyle at (301)415-1058 or pvd@nrc.gov.

Sincerely,

/RA/

Patrick M. Madden, Section Chief
Research and Test Reactors Section
Operating Reactor Improvements Program
Division of Regulatory Improvement Programs
Office of Nuclear Reactor Regulation

Docket No. 50-243

Enclosures: 1. Initial Examination Report No. 50-243/OL-02-01
2. Examination and answer key (RO/SRO)

cc w/encls:
Please see next page

cc:

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Corvallis, OR 97331

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Dr. Jack F. Higginbotham, Chairman
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Test, Research, and Training
  Reactor Newsletter
University of Florida
202 Nuclear Sciences Center
Gainesville, FL 32611

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PUBLIC RORP/R&TR r/f PMadden

AAdams Facility File (EBarnhill) O6-D17

ADAMS ACCESSION #: ML021350400 **TEMPLATE #:NRR-074**

OFFICE	RORP:CE		IEHB:LA	E	RORP:SC	
NAME	PDoyle:rdr		EBarnhill		PMadden	
DATE	05/ 25 /2002		05/ 24 /2002		05/ 28 /2002	

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EXAMINATION REPORT NO: 50-243/OL/02-01

Oregon State University TRIGA Reactor

Facility Docket No.: 50-243 Facility License No.: R-160

SUBMITTED BY: ***/RA/*** __05/25/02__
Paul V. Doyle Jr., Chief Examiner Date

Summary:

On April 29, 2002, the NRC administered a licensing examination to one SRO (Instant) license applicant. The applicant passed the examination.

Additional Examiners: None

Exit Meeting:

Attendees:
Gary Wachts, Reactor Supervisor, Oregon State Triga Reactor (OSTR)
Steven Reese, Reactor Administrator, OSTR
Paul Doyle, Examiner, NRC

At the conclusion of the site visit, the examiner met with representatives of the facility staff to discuss the results of the examinations. The examiners made the following observations concerning your training program:

a. The examiner did not note any areas of generic weakness during the administration of the operating tests.

ENCLOSURE 1

ENCLOSURE 1

UNITED STATES NUCLEAR REGULATORY COMMISSION

OREGON STATE UNIVERSITY

With Answer Key

OPERATOR LICENSING
EXAMINATION
April 29, 2002

Enclosure 2

QUESTION A.1 [1.0 point]
Which ONE of the following isotopes has the largest microscopic cross-section for absorption for thermal neutrons?

a. Sm^{149}

b. U^{235}

c. Xe^{135}

d. B^{10}

QUESTION A.2 [1.0 point]
Which ONE of the following factors is the most significant in determining the differential worth of a control rod?

a. The rod speed.

b. Reactor power.

c. The flux shape.

d. The amount of fuel in the core.

QUESTION A.3 [1.0 point]
A reactor (not OSTR) has the following reactivity characteristics.
K_{excess} ... $2.50 Standard Rod 1 .... $2.25 Standard Rod 2 .... $2.30 Reg Rod $1.10
Which ONE of the following is the shutdown margin allowable by Technical Specifications. (NOTE: All rods are able to scram, same condition as OSTR Tech Spec.)

a. $5.65

b. $4.00

c. $3.10

d. $0.85

QUESTION A.4 [1.0 point]
Which ONE of the following conditions describes a critical reactor?

a. K_{eff} = 1; $\Delta k/k$ (ρ) = 1

b. K_{eff} = 1; $\Delta k/k$ (ρ) = 0

c. K_{eff} = 0; $\Delta k/k$ (ρ) = 1

d. K_{eff} = 0; $\Delta k/k$ (ρ) = 0

QUESTION A.5 [1.0 point]
Which ONE of the following is an example of beta decay?

a. ${}_{35}Br^{87} \rightarrow {}_{33}As^{83}$

b. ${}_{35}Br^{87} \rightarrow {}_{35}Br^{86}$

c. ${}_{35}Br^{87} \rightarrow {}_{34}Se^{86}$

d. ${}_{35}Br^{87} \rightarrow {}_{36}Kr^{87}$

QUESTION A.6 [1.0 point]
A thin foil target of 10% copper and 90% aluminum is in a thermal neutron beam. Given $\sigma_{a\ Cu}$ = 3.79 barns, $\sigma_{a\ Al}$ = 0.23 barns, $\sigma_{s\ Cu}$ = 7.90 barns, and $\sigma_{s\ Al}$ =1.49 barns, which ONE of the following reactions has the highest probability of occurring? A neutron …

a. scattering reaction with aluminum

b. scattering reaction with copper

c. absorption in aluminum

d. absorption in copper

QUESTION A.7 [1.0 point]
You are increasing reactor power on a steady +26 second period. How long will it take to increase power by a factor of 1000?

a. 60 seconds (1 minute)

b. 180 seconds (3 minutes)

c. 300 seconds (5 minutes)

d. 480 seconds (8 minutes)

QUESTION A.8 [1.0 point]
Which **ONE** of the following statements is the definition of **REACTIVITY**?

a. A measure of the core's fuel depletion.

b. A measure of the core's deviation from criticality.

c. Equal to 1.00 ΔK/K when the reactor is critical.

d. Equal to 1.00 ΔK/K when the reactor is prompt critical.

QUESTION A.9 [1.0 point]
Which ONE of the following correctly describes the generation of neutrons from the Am-Be source?

a. ${}_{95}Am^{241} \rightarrow {}_{93}Np^{237} + {}_{2}\alpha^{4}$; ${}_{2}\alpha^{4} + {}_{4}Be^{9} \rightarrow [{}_{6}C^{13}]^{*} \rightarrow {}_{6}C^{12} + {}_{0}n^{1}$

b. ${}_{95}Am^{241} \rightarrow {}_{96}Np^{241} + {}_{-1}\beta^{0} + \gamma$; ${}_{0}\gamma^{0} + {}_{4}Be^{9} \rightarrow [{}_{4}Be^{9}]^{*} \rightarrow {}_{4}Be^{8} + {}_{0}n^{1}$

c. ${}_{95}Am^{241} \rightarrow {}_{96}Np^{241} + {}_{-1}\beta^{0} + \gamma$; ${}_{-1}\beta^{0} + {}_{4}Be^{9} \rightarrow [{}_{3}Li^{9}]^{*} \rightarrow {}_{3}Li^{8} + {}_{0}n^{1}$

d. ${}_{95}Am^{241} \rightarrow$; [S.F.] $\rightarrow$ 2 fission products + ${}_{0}n^{1}$

QUESTION A.10 [1.0 point]
A complete core load is in progress on a research reactor. The following data has been taken.

Number of Elements Installed	Detector A (cpm)	Detector B (cpm)
0	11	13
2	13	15
4	17	18
6	22	22
8	34	30

Using the graph paper provided, determine which of the following is the approximate number of fuel elements that will be required to be loaded for a critical mass.

a. 8

b. 10

c. 12

d. 14

QUESTION A.11 [1.0 point]
Initially Nuclear Instrumentation is reading 30 CPS and the reactor has a K_{eff} of 0.90. You add an experiment which causes the Nuclear instrumentation reading to increase to 60 CPS. Which ONE of the following is the new K_{eff}?

a. 0.91

b. 0.925

c. 0.95

d. 0.975

QUESTION A.12 [1.0 point]
Which ONE of the following describes the difference between a moderator and reflector?

a. A reflector increases the fast non-leakage factor and a moderator increases the thermal utilization factor.

b. A reflector increases the neutron production factor and a moderator increases the fast fission factor.

c. A reflector decreases the thermal utilization factor and a moderator increases the fast fission factor.

d. A reflector decreases the neutron production factor and a moderator decreases the fast non-leakage factor.

QUESTION A.13 [1.0 point]
After a week of full power operation, Xenon will reach its peak following a shutdown in approximately:

a. 6 hours

b. 12 hours

c. 24 hours

d. 48 hours

QUESTION A.14 [1.0 point]
Regulating rod worth for a reactor is 0.001 ΔK/K/inch. Moderator temperature increases by 9°F, and the regulating rod moves 4½ inches inward to compensate. The moderator temperature coefficient α_{Tmod} is …

a. $+5 \times 10^{-4}$

b. -5×10^{-4}

c. $+2 \times 10^{-5}$

d. -2×10^{-5}

QUESTION A.15 [1.0 point]
Which ONE of the following is the difference between prompt and delayed neutrons? Prompt neutrons …

a. account for less than 1% of the neutron population, while delayed neutrons account for the rest.

b. are released during fast-fission events, while delayed neutrons are released during the decay process.

c. are released during the fission process (fast & thermal), while delayed neutrons are release during the decay process.

d. are the dominating factor in determining reactor period, while delayed neutrons have little effect on reactor period.

QUESTION A.16 [1.0 point]
Using the Integral Rod Worth Curve provided identify which ONE of the following represents K_{excess}

a. Area under curve “B”

b. ρ_C

c. ρ_{max} - ρ_C

d. Area under curve “A” and “B”

QUESTION A.17 [1.0 point]
When performing rod calibrations, many facilities pull the rod out a given increment, then measure the time for reactor power to double (doubling time), then calculate the reactor period. If the doubling time is 42 seconds, what is the reactor period?

a. 29 sec

b. 42 sec

c. 61 sec

d. 84 sec

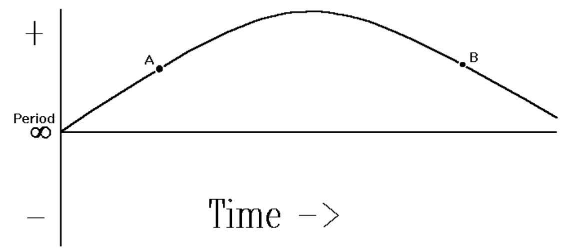
QUESTION A.18 [1.0 point]
Shown below is a trace of reactor period as a function of time. Between points A and B reactor power is:

a. continually increasing.

b. continually decreasing.

c. increasing, then decreasing.

d. constant.



QUESTION A.19 [1.0 point]
Which ONE of the following is the correct definition of $\beta_{effective}$ for a TRIGA reactor? The relative amount of delayed neutrons …

a. per generation corrected for resonance absorption.

b. per generation corrected for leakage.

c. per generation corrected for time after the fission event.

d. per generation corrected for both leakage and resonance absorption.

QUESTION A.20 [1.0 point]
During a reactor startup, criticality occurred at a lower rod height than the last startup. Which ONE of the following reasons could be the cause?

a. Adding an experiment with positive reactivity.

b. Xe^{135} peaked.

c. Moderator temperature increased.

d. Maintenance on the control rods resulted in a slightly faster rod speed.

QUESTION B.1 [1.0 point]
Which ONE of the following correctly defines a Safety Limit?

a. Limits on important process variables which are found to be necessary to reasonably protect the integrity of certain physical barriers which guard against the uncontrolled release of radioactivity.

b. The Lowest functional capability of performance levels of equipment required for safe operation of the facility.

c. Settings for automatic protective devices related to those variables having significant safety functions.

d. a measuring or protective channel in the reactor safety system.

QUESTION B.2 [2.0 points, 0.5 each]
Match the values from column B for the Technical Specification limits listed in column A. (Values in Column B may be used more than once or not at all. Each limit in section A should have only one answer.)

	Column A	Column B
a.	Minimum Shutdown margin with the most reactive control rod fully withdrawn cold, no xenon, experimental facilities and experiments in place, with highest worth non-secured experiment in its most reactive state.	$0.57 $1.00
b.	Total Maximum Reactivity worth of all experiments.	$2.55
c.	Total Maximum Reactivity worth of any single experiment	$3.00
d.	Maximum allowable pulse (by Technical Specifications).	$4.25

QUESTION B.3 [1.0 point]
A radiation survey instrument was used to measure an irradiated experiment. The results were 100 mrem/hr with the window open and 60 mrem/hr with the window closed. What was the beta dose rate?

a. 40 mrem/hr

b. 60 mrem/hr

c. 100 mrem/hr

d. 140 mrem/hr

QUESTION B.4 [1.0 point]
You use a Geiger-Müller detector at the same distance from two point sources having the same curie strength. Source A's gammas have an energy of 1.0 MeV, while Source B's gammas have an energy of 2.0 MeV. Which ONE of the following would you expect for the readings due to each source?

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

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

c. Both readings are the same.

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

QUESTION B.5 [1.0 point]
Which ONE of the following is the correct definition of a CHANNEL CHECK?

a. The combination of sensor, line, amplifier, and output devices which are connected for the purposes of measuring the value of a parameter.

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

c. A qualitative verification of acceptable performance by observation of channel behavior. This verification, may include comparison with independent channels measuring the same variable or other measurements of the variable.

d. The introduction of a signal into the channel for verification that it is operable.

QUESTION B.6 [1.0 point]
While working in an area marked "Caution, Radiation Area," you discover your dosimeter is off scale and leave the area. Assuming you had been working in the area for 45 minutes, what is the maximum dose you would have received?

a. 3.8 mr

b. 35.6 mr

c. 75 mr

d. 100 mr

QUESTION B.7 [1.0 point]
Which ONE of the following is the definition for “Annual Limit on Intake (ALI)”?

a. The concentration of a radio-nuclide in air which, if inhaled by an adult worker for a year, results in a total effective dose equivalent of 100 millirem.

b. 10CFR20 derived limit, based on a Committed Effective Dose Equivalent of 5 Rems whole body or 50 Rems to any individual organ, for the amount of radioactive material inhaled or ingested in a year by an adult worker.

c. The effluent concentration of a radio-nuclide in air which, if inhaled continuously over a year, would result in a total effective dose equivalent of 50 millirem for noble gases.

d. Projected dose commitment values to individuals, that warrant protective action following a release of radioactive material.

QUESTION B.8 [1.0 point]
You been assigned to decrease the dose rate from a point source by about a factor of 10. The point source emits a 1.5 MeV gamma. Your shielding consists of ½ inch thick lead sheets. How many sheets (minimum) are required? Given: the mass attenuation coefficient for lead (for 1.5 MeV gammas = 0.051 cm^2/gram and density of lead is 11.4 gram/cm^3.

a. 1 sheet

b. 2 sheets

c. 3 sheets

d. 5 sheets

QUESTION B.9 [1.0 point]
Which ONE of the following conditions is a Reportable Occurrence per Technical Specifications?

a. Operation of the reactor with a fuel temperature scram set at 500°C.

b. Operation of the reactor with bulk water temperature at 45°C.

c. Irradiation of a sample containing 20 milligrams of explosive material.

d. Operation with pool water level 13 feet above the core.

QUESTION B.10 [1.0 point]
Your Annual limit (Occupational Dose Limit for an adult) for Total Effective Dose Equivalent is …

a. 1.25 rems

b. 5.0 rems

c. 15.0 rems

d. 50 rems

QUESTION B.11 [1.0 point]
A small experiment sample reads 200 mR/hr with the sample 1 foot under water and the meter at the surface of the water. A reading taken ½ hour ago with both the sample and the meter in the same positions was 400 mR/hr. Approximately how long will it take for the reading to drop to 20 mR/hr with the sample and the meter in the same positions?

a. 40 minutes

b. 70 minutes

c. 100 minutes

d. 130 minutes

QUESTION B.12 [1.0 point]
Which ONE of the following is the Technical Specification BASIS for the Limiting Condition of Operation for pool water temperature being maintained below 120°F?

a. To prevent damage to the resin in the purification system.

b. To prevent cavitation in the primary coolant pump.

c. To maintain the integrity of the Aluminum Reactor Tank.

d. to ensure correct operation of the conductivity cells in the purification system.

QUESTION B.13 [1.0 point]
Which **ONE** of the following is the maximum number of times the reactor may be pulsed in a one hour period **WITHOUT** Reactor Supervisor permission?

a. Three

b. Six

c. Nine

d. Twelve

QUESTION B.14 [2.0 points, ½ each]
Classify each of the experiments listed below as either Class A, Class B or Class C, according to **OSTROP 18,** *Procedures for the Approval and Use of Reactor Experiments.*

a. Placing an empty containment tube in the Lazy Susan to test new sample containers.

b. Placing a new experiment into a Beam Tube.

c. An experiment requiring the movement of reactor shielding.

d. An experiment containing explosives.

QUESTION B.15 [1.0 point]
Which ONE of the following materials would require suspension of reactor operations until approval from the Reactor Operations Committee, if that material were dropped (even in minute quantities) into the reactor tank?

a. Mercury

b. Copper or copper bearing alloys.

c. Glass

d. Type 18-8 Stainless Steel

QUESTION B.16 [1.0 point]
Which ONE of the listed measuring channels is REQUIRED by Technical Specifications for steady-state, pulsing and square wave modes of operation?

a. Linear Power Level

b. Log Power Level

c. Nvt circuit

d. Fuel Element Temperature

QUESTION B.17 [1.0 point]
Which ONE of the following correctly defines the Emergency Plan term “Protective Action Guide(s)”?

a. The person or persons appointed by the Emergency Coordinator to ensure that all personnel have evacuated the facility or a specific part of the facility.

b. a condition or conditions which call(s) for immediate action, beyond the scope of normal operating procedures, to avoid an accident or to mitigate the consequences of one.

c. Projected radiological dose or dose commitment values to individuals that warrant protective action following a release of radioactive material.

d. Specific instrument readings, or observations; radiological dose or dose rates; or specific contamination levels of airborne, waterborne, or surface- deposited radioactive materials that may be used as thresholds for establishing emergency classes and initiating appropriate emergency measures.

QUESTION B.18 [1.0 point]
Per the Emergency Plan the primary Emergency Support Center is Room A100. However, “for many of the more minor emergencies, the control point may be moved up to the …”

a. Health Physics Office (D204)

b. Reactor Conference Room (D300)

c. Common Room containing Large Emergency Cabinet (B134)

d. Reactor Control Room (D302)

QUESTION C.1 [1.0 point]
Primary system water returning to the pool is ejected from an angled nozzle, causing a swirling motion of the water in the pool. Which ONE of the following is the **PRIMARY** purpose for this design?

a. To increase the heat transfer rate due to increased convective flow.

b. To decrease the activation rate of O^{16} to N^{16} due to a decrease in time within the core.

c. To increase the transport time for N^{16} to reach the surface of the pool.

d. To break up O^{16} bubbles in the pool thereby decreasing the production of N^{16}.

QUESTION C.2 [1.0 point]
Which ONE of the listed Nuclear Instrumentation Channels/circuits listed below does NOT provide an input to the Regulating Rod Automatic Control Circuit.

a. Linear Power

b. Percent Power

c. Log-N

d. Percent Demand

QUESTION C.3 [1.0 point]
Which ONE of the following is **NOT** a design feature of the Purification System?

a. Reduce radiation levels due to dissolved ions.

b. Reduce corrosion rate due to dissolved ions.

c. Reduce radiation levels due to suspended ions.

d. Reduce radiation levels due to soluble gases.

QUESTION C.4 [2.0 points, ½ each]
Identify each of the control rods as having either a fuel follower or an air follower.

a. Shim

b. Safety

c. Transient

d. Regulating

QUESTION C.5 [1.0 point]
Which ONE of the following electrical load is NOT powered by the Emergency Generator or inverter batteries on a loss of site power?

a. Argon Fan

b. Television Monitor

c. Stack Monitor Pump

d. Cypher Lock

QUESTION C.6 [1.0 point]
Which ONE of the following is NOT an interlock associated with pulsing operations.

a. Switch in Pulse Mode.

b. Transient Rod fully inserted.

c. Period greater than 50 seconds.

d. Power less than 1 Kwatt.

QUESTION C.7 [1.0 point]
What design feature minimizes flux peaking in the central thimble.

a. Filling with N_2.

b. An aluminum plug.

c. A cadmium plug.

d. A Zirconium plug

QUESTION C.8 [1.0 point]
Which ONE of the following is the reason for the holes located at the bottom of the Central Thimble Assembly?

a. To allow cooling flow through the thimble, at power.

b. To allow for evacuation of the water in the thimble.

c. To allow for fasteners to bolt the thimble to the bottom support plate.

d. To fit over pins in the safety support plate for proper alignment.

QUESTION C.9 [1.0 point]
Which ONE of the following methods is the normal procedure for preventing basin water in the cooling tower from freezing?

a. Use of Hand-held heat guns.

b. Running fans in reverse.

c. Heaters built into water sump.

d. Steam connection from University facilities.

QUESTION C.10 [1.0 point]
Which ONE of the following components in the purification system is PRIMARILY responsible for maintaining the primary coolant system conductivity low.

a. The surface skimmer

b. The pre-demineralizer filter

c. The demineralizer

d. The post-demineralizer filter

QUESTION C.11 [1.0 point]
What is the purpose of the Cadmium Lined In-Core Irradiation Tube (CLICIT)

a. To allow irradiation of samples by neutrons with an energy level greater than 0.5 ev.

b. To allow irradiation of samples by neutrons with an energy level of less than 0.5 ev.

c. To allow irradiation of samples by gammas within the core.

d. To allow irradiation of samples by alphas produced by the neutron interaction with the cadmium.

QUESTION C.12 [1.0 point]
The ventilation system is designed to maintain reactor bay pressure slightly negative pressure with respect to the atmospheric pressure. If the outside atmospheric pressure increases, which ONE of the following actions will automatically occur to compensate the reactor bay pressure? A pressure regulator will generate a signal to …

a. Increase the Reactor Bay Supply fan speed to increase bay pressure.

b. Decrease the Reactor Bay Exhaust fan speed to increase bay pressure.

c. Go more closed on a damper in the ventilation exhaust ducting increasing bay pressure.

d. Go more open on a damper in the ventilation supply ducting increasing bay pressure.

QUESTION C.13 [1.0 point]
While operating in AUTOMATIC mode, the reactor operator depresses the UP button for a control rod. At the same time, the AUTOMATIC circuit energizes to drive the regulating rod up. Which ONE of the following will actually take place.

a. Due to the ONE ROD WITHDRAWAL interlock, only the CONTROL ROD will move.

b. Due to the ONE ROD WITHDRAWAL interlock, only the REGULATING ROD will move.

c. Due to the ONE ROD WITHDRAWAL neither rod will move.

d. THE ONE ROD WITHDRAWAL does not apply and both rods will move.

QUESTION C.14 [1.0 point]
Which ONE of the following is the actual method used to generate the rod position indication on the control panel?

a. Voltage changes generated by the movement of a lead screw between two coils of a transformer.

b. A potentiometer linked to the rod drive motor

c. A series of several reed switches which as the rod moves up close to generate a current proportional to rod position.

d. A servo motor connected to the UP and DN buttons which when either button is depressed generates a signal proportional to rod speed.

QUESTION C.15 [1.0 point]
WHICH ONE of the following detectors is used primarily to measure N^{16} release to the environment?

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

b. Stack Gas Monitor

c. Air Particulate Monitor

d. Area Radiation Monitor Channel # 5

QUESTION C.16 [1.0 point]
You (the console operator) receive a report of thick black smoke coming from the demin pump. Where would you send someone to deenergize the breaker that supplies the pump?

a. Room 106 to Sub Distribution Panel A

b. Room 106 to Panel “G”

c. Reactor Bay Panel “A”

d. First Floor Hallway Panel “F”

QUESTION C.17 [1.0 point]
To detect Neutrons, the Uncompensated Ion Chambers are lined with

a. ${}_{5}B^{10}$

b. ${}_{6}C^{12}$

c. ${}_{92}U^{235}$

d. ${}_{94}Pu^{239}$

QUESTION C.18 [1.0 point]
Match each purpose in column A with its associated fuel element component listed in column B.

	Column A	Column B
a.	moderator	1. Graphite
b.	reflector	2. Zirconium-Hydride
c.	resonance absorber	3. Erbium
d.	burnable poison	

A.1 c
REF: Glasstone, S. and Sesonske, A, *Nuclear Reactor Engineering,* Kreiger Publishing, Malabar, Florida, 1991, §

A.2 c
REF: OSU Training Manual Vol. 3, p. 17

A.3 d
Worth of rods: \$2.30 + \$2.25 + \$1.10 = \$5.65. SDM = Worth of rods less K_{excess} less reactivity of most worth rod. SDM = \$5.65 - \$2.50 - 2.30 = 5.65 - \$4.80 = 0.85
REF: OSU Training Manual Vol. 3, p. 29

A.4 b
REF: OSU Training Manual Vol. 3, p. 11

A.5 d
REF: Standard NRC Question

A.6 a
REF: Glasstone, S. and Sesonske, A, *Nuclear Reactor Engineering,* Kreiger Publishing, Malabar, Florida, 1991, §

A.7 b
REF: $\ln(P/P_0) \times \text{period} = \text{time}$, $\ln(1000) \times 26 = 6.908 \times 26 = 179.6 \approx 180$ seconds

A.8 b
REF: OSU Training Manual Vol. 3, p. 10

A.9 a
REF: OSU Training Manual Vol. 3, pp. 41-43.

A.10 c
REF: OSU Training Manual Vol. 3, pp. 45-50

A.11 c
REF: $CR_2/CR_1) = (1 - K_{eff1})/(1 - K_{eff2})$ $60/30 = (1 - 0.900)/(1 - K_{eff2})$
$1- K_{eff2} = ½ \times 0.1 = 0.05$ $K_{eff2} = 1 - 0.05 = 0.95$

A.12 a
REF: OSU Training Manual Vol. 3, pp. 12 and 15.

A.13 b
REF: OSU Training Manual Vol. 3, p. 24.

A.14 a
REF: $(4.5 \times 0.001) \div 9 = 0.0045 \div 9 = 0.0005 = 5 \times 10^{-4}$, also OSU Training Manual Vol. 3, p. 19

A.15 c
REF: OSU Training Manual Vol. 3, p. 30.

A.16 c
REF: OSU Training Manual Vol. 3, p. 29.

A.17 c
REF: $\ln(2) = -\text{time}/\tau$ $\quad \tau = \text{time}/(\ln(2)) = 60.59 \approx 61$ seconds

A.18 a
REF: Standard NRC Question

A.19 d
REF: OSU Training Manual Vol. 3, p. 30.

A.20 a
REF: OSU Training Manual Vol. 3, p. 30.

B.1 a
REF: Technical Specifications § 1.22

B.2 a, $0.57; b, $3.00; c, $2.55 d, $2.55
REF: Technical Specification §§ 3.2, 3.3 and 3.8

B.3 a
REF: Instrument reads only γ dose with window closed. Instrument reads both β and γ dose with window open. Therefore, β dose is window open dose less window closed dose.

B.4 c
REF: GM tubes are NOT sensitive to energy level.

B.5 c
REF: Technical Specifications § 1.31

B.6 c
REF: 10 CFR 20.1003 Maximum dose in a radiation area is 100 mr/hr. 100 mr/hr × 0.75 hr = 75 mr.

B.7 b
REF: 10CFR20.1003

B.8 c
REF: First calculate $\mu = 0.051\ cm^2/g \times 11.4\ g/cm^3 = 0.5814\ cm^{-1}$.
Next calculate thickness. $I = I0\ e^{-\mu x}$ $\ln(1/10) = -\mu x$ $x = -[\ln(1/10)]/\mu = \ln(0.1)/0.5814 = 3.96 \approx 4.0$ cm
Finally calculate number of sheets: (4.0 cm)/(2.54cm/in) = 1.57 inches or about 3 sheets.

B.9 d
REF: Technical Specifications, 2.2, 3.3.a, 3.6.d and 3.2.2 (Table 2)

B.10 b
REF: 10CFR20.2001.a(1)

B.11 c
REF: $A = A0\ e^{-\lambda t}$ Solve for λ $200 = 400\ e^{-\lambda 30minutes}$ $\ln(200/400) = -\lambda \times 30$minutes
$\ln(½)/30$ minutes $= -\lambda = 0.0231$
Next solve for time $20 = 200\ e^{(-0.0231 \times time)}$ $\ln(1/10)/-0.0231$ = time = 99.7 minutes ≈ 100 minutes

B.12 c

REF: Technical Specification 3.7.

B.13 b
REF: OSTROP 4, Reactor Operation Procedures, p. 9.

B.14 a, A; b, B; c, B; d, C
REF: Technical Specifications, 1.0 Definitions.

B.15 a
REF: OSTROP 7, *Operating Procedures for Reactor Water Systems,* § I.F, Warning p. 3.

B.16 d
REF: Technical Specification Table in § 3.5.2.

B.17 c
REF: Emergency Plan § 2.0 *Definitions.*

B.18 d
REF: Emergency Plan § 8.0 *Emergency Equipment and Facilities.*

C.1 c
REF: Oregon State (OSTR) Training Manual Vol. I, page 106.

C.2 b
REF: ORST Training Manual Volume II, Figure 2.16

C.3 d
REF: ORST Training Manual Volume I, p. 106

C.4 a, Fuel; b, Fuel; c, Air; d, Fuel
REF: NRC Examination Question Bank, also Volume 1, pages 40-44, OSU Triga Manual

C.5 a
REF: OSTROP 22

C.6 c
REF: NRC Exam Question Bank, also: *Volume 2, pages 23-28, OSU Triga Manual*

C.7 b
REF: NRC Exam administered 1998, also, OSU Training Manual Vol I, p, 89 second paragraph.

C.8 b
REF: *OSU Training Manual, p. 90*

C.9 c
REF: OSU Training Manual, p. 126, last paragraph.

C.10 c
REF: NRC exam administered 1996, also OSTR Training Manual Vol. I, p. 116.

C.11 a
REF: OSTR Training Manual, Vol. I, p. 81

C.12 c
REF: OSTR Training Manual, Vol. I p. 148.

C.13 d
REF: OSTR Training Manual Vol II, p. 9.

C.14 b
REF: OSTR Training Manual, Vol I, fig. 1.26 TRIGA Control Rod Drive Mechanism, p. 48.

C.15 a
REF: Standard NRC Question

C.16 b
REF OSTROP 22.0 Emergency Power System, Fig. 22.1 One-Line Schematic Power Distribution

C.17 a
REF: ORST Training Manual Volume 2, § III.C.

C.18 a, 2; b, 1; c, 3; d, 3
REF: ORST Training Manual Volume 1.

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

FACILITY: Oregon State University

REACTOR TYPE: TRIGA (Pulsing)

DATE ADMINISTERED: 2002/04/29

CANDIDATE: ______________________________

INSTRUCTIONS TO CANDIDATE:
Write answers on the answer sheet provided. Attach answer sheets to the examination. Points for each question are indicated in brackets. A 70% overall is required to pass the examination. Examinations will be picked up three (3) hours after the examination starts.

Category Value	% of Total	Candidate's Score	%of Category Value	Category
20	33	_____	_____	A. Reactor Theory, Thermodynamics, and Facility Operating Characteristics
20	33	_____	_____	B. Normal and Emergency Operating Procedures and Radiological Controls
20	33	_____	_____	C. Plant and Radiation Monitoring Systems

60 ______ ______ 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 answer sheets.

10. Ensure all information you wish to have evaluated as part of your answer is on your answer sheet.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$\tau = \frac{\ell^*}{\rho - \bar{\beta}}$$

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

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

$$\tau = \frac{\ell^*}{\rho} + \left[\frac{\bar{\beta}-\rho}{\lambda_{eff}\rho}\right]$$

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

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

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

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

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

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

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

Fuch's Pulse Model Equations (Estimates)

$I = 39 \times 10^{-6}$ sec. $\alpha = 1.26 \times 10^{-4} \Delta k/k/^{\circ}C$ $k = 9.6$

---

1 Curie = 3.7×10^{10} dis/sec
1 kg = 2.21 lbm
1 Horsepower = 2.54×10^{3} BTU/hr
1 Mw = 3.41×10^{6} BTU/hr
1 BTU = 778 ft-lbf
$^{\circ}F = 9/5\ ^{\circ}C + 32$
1 gal (H_2O) ≈ 8 lbm
$^{\circ}C = 5/9\ (^{\circ}F - 32)$
$c_P = 1.0$ BTU/hr/lbm/°F
$c_p = 1$ cal/sec/gm/°C

A.1 a b c d ___

A.2 a b c d ___

A.3 a b c d ___

A.4 a b c d ___

A.5 a b c d ___

A.11 a b c d ___

A.12 a b c d ___

A.13 a b c d ___

A.14 a b c d ___

A.15 a b c d ___

$$T_{max} = T_0 \frac{2(\rho - \beta)}{\alpha} {^{\circ}C} \qquad P_{max} = \frac{(\rho - \beta)^2}{2\alpha(k)I} MW \qquad E_{tot} = \frac{2(\rho - \beta)}{k(\alpha)} MWS$$

A.6 a b c d ___

A.7 a b c d ___

A.8 a b c d ___

A.9 a b c d ___

A.10 a b c d ___

A.16 a b c d ___

A.17 a b c d ___

A.18 a b c d ___

A.19 a b c d ___

A.20 a b c d ___

B.1 a b c d ___

B.2a ($) 0.57 1.00 2.55 3.00 5.00 ___

B.2b ($) 0.57 1.00 2.55 3.00 5.00 ___

B.2c ($) 0.57 1.00 2.55 3.00 5.00 ___

B.2d ($) 0.57 1.00 2.55 3.00 5.00 ___

B.3 a b c d ___

B.4 a b c d ___

B.5 a b c d ___

B.6 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.14a A B C ___

B.14b A B C ___

B.14c A B C ___

B.14d A B C ___

B.15 a b c d ___

B.7 a b c d ___

B.8 a b c d ___

B.9 a b c d ___

B.16 a b c d ___

B.17 a b c d ___

B.18 a b c d ___

C.1 a b c d ___

C.2 a b c d ___

C.3 a b c d ___

C.4a Air Fuel ___

C.4b Air Fuel ___

C.4c Air Fuel ___

C.4d Air Fuel ___

C.5 a b c d ___

C.6 a b c d ___

C.10 a b c d ___

C.11 a b c d ___

C.12 a b c d ___

C.13 a b c d ___

C.14 a b c d ___

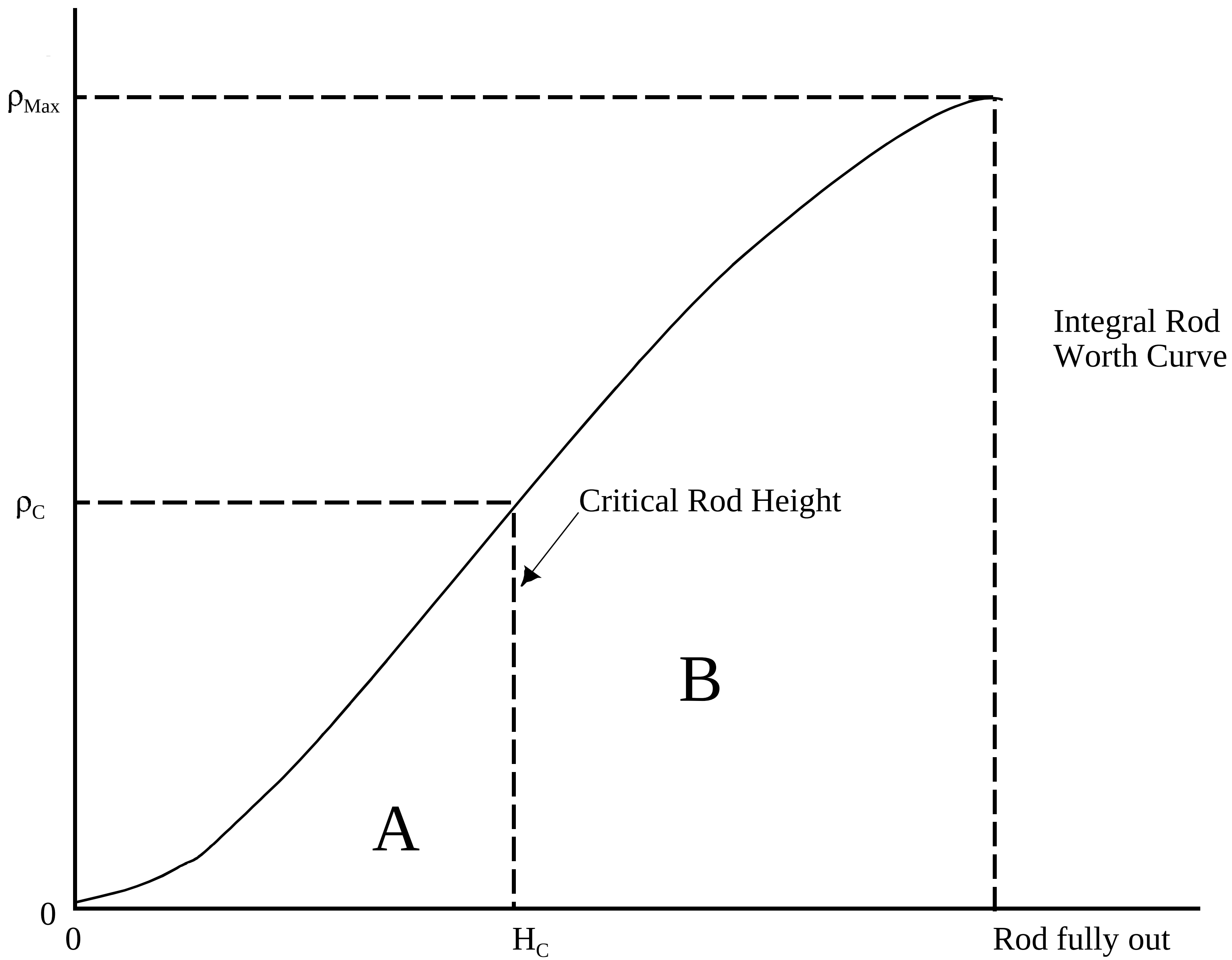
C.15 a b c d ___

C.16 a b c d ___

C.17 a b c d ___

C.18a 1 2 3 ___

C.7	a b c d ___	C.18b	1 2 3 ___
C.8	a b c d ___	C.18c	1 2 3 ___
C.9	a b c d ___	C.18d	1 2 3 ___


ρMax
ρC
0
0
HC
Rod fully out
Critical Rod Height
Integral Rod
Worth Curve
A
B