June 19, 2002

Mr. Stephen Bilyj, Reactor Operations Manager
North Carolina State University
2120 Burlington Engineering Laboratories
Post Office Box 7909
Raleigh, NC 27695-7909

SUBJECT: INITIAL EXAMINATION REPORT NO. 50-297/OL-02-01, NORTH CAROLINA STATE UNIVERSITY

Dear Mr. Bilyj:

During the week of May 20, 2002, the NRC administered an operator licensing examination at your North Carolina State University Reactor. The examination was conducted according to NUREG-1478, "Non-Power Reactor Operator Licensing Examiner Standards," Revision 1. 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 via Internet E-mail pvd@nrc.gov.

Sincerely,

/RA by M. Mendonca Acting for/

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. 50-297

Enclosures: 1. Initial Examination Report No. 50-297/OL-02-01
2. Examination with facility comments added.

cc w/encls:
Please see next page

cc:

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

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DHughes Facility File (EBarnhill) O6-D17

ADAMS ACCESSION #: ML021570337 **TEMPLATE #:NRR-074**

OFFICE	RORP:CE		IEHB:LA	E	RORP:SC	
NAME	PDoyle		EBarnhill		PMadden	
DATE	06/ 07 /2002		06/ 13 /2002		06/ 18 /2002	

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

REPORT NO.: 50-297/OL-02-01

FACILITY DOCKET NO.: 50-297

FACILITY LICENSE NO.: R-120

FACILITY: North Carolina State University

EXAMINATION DATES: May 20 – 22, 2002

SUBMITTED BY: ***/RA/*** 6/4/2002
Paul Doyle, Chief Examiner Date

SUMMARY:

During the week of May 20, 2002, the NRC administered Operator Licensing examinations to three Reactor Operator and one Senior Reactor Operator (Instant) candidates. Two Reactor Operator candidates failed Section A of the written examination.

REPORT DETAILS

1. Examiners:
   Paul Doyle, Chief Examiner

2. Results:

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

3. Exit Meeting:
   Paul Doyle, NRC, Examiner
   Stephen Bilyj, NCSU, Reactor Operations Manager
   Larry Broussard, NCSU, Chief Reactor Operator
   Kerry Kincaid, NCSU, Chief Reactor Maintenance

   The NRC examiner thanked the facility staff for their prompt submission of written examination comments (incorporated in enclosure two to this report). The examiner reported that he did not observe any generic weaknesses. The examiner also reported that he noted a program strength: all candidates demonstrated a good knowledge of Technical Specification requirements.

ENCLOSURE 1

NORTH CAROLINA STATE UNIVERSITY

With Answer Key

OPERATOR LICENSING
EXAMINATION
May 20, 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]~~ Question Deleted (No correct answer)
~~A reactor (not NCSU) has the following reactivity characteristics.~~
~~K_{excess} ... $2.50 Control Rod 1 .... $2.25 Control Rod 2 .... $2.30 Reg Rod .... $1.10~~
~~Which ONE of the following is the shutdown margin allowable by Technical Specifications. (NOTE: Same condition as NCSU Technical Specifications, but all rods can scram).~~

~~a. $5.85~~

~~b. $4.15~~

~~c. $3.35~~

~~d. $1.10~~

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

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

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

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 a 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]
Several processes occur that may increase or decrease the available number of neutrons. SELECT from the following the six-factor formula term that describes an **INCREASE** in the number of neutrons during the cycle.

a. Thermal utilization factor (f).

b. Resonance escape probability (p).

c. Fast non-leakage probability ($\mathcal{L}_f$).

d. Fast Fission factor (ε).

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. $\rho_{max} - \rho_C$

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]
Which of the following statements best characterizes Natural Circulation?

a. Heat transfer is more efficient as the heat source decays.

b. The elevation of the heat source must be above that of the heat sink.

c. The driving force is a difference in density.

d. Heat transfer is more efficient if steam is mixed with water.

QUESTION A.19 [1.0 point]
Which ONE of the following is the correct definition of $\beta_{effective}$? 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, 0.4 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 provided by the remaining control rods with the highest worth scrammable rod fully withdrawn, the shim rod fully withdrawn, experiments in their most reactive condition , relative to the Cold Critical condition.	0.1% Δk/k
	0.4% Δk/k
	1.0% Δk/k
b. Total Maximum Reactivity worth of all experiments.	2.9% Δk/k
c. Maximum Excess Reactivity	3.9% Δk/k
d. Maximum rate of reactivity insertion (per second, critical region only).	
e. Maximum absolute worth of Non-Secured Experiment.	

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]
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, where possible, shall include comparison of the channel with other independent channels or systems measuring the same variable.

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

QUESTION B.5 [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.6 [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.7 [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.8 [1.0 point]
The ***Quality Factor*** is used to convert …

a. dose in rads to dose equivalent in rems.

b. dose in rems to dose equivalent in rads.

c. contamination in rads to contamination equivalent in rems

d. contamination in rems to contamination equivalent in rads

QUESTION B.9 [2.0 points, ½ each]
Identify each of the listed requirements as a Safety Limit (SL) a Limiting Safety System Setting (LSSS) or a Limiting Condition for Operation (LCO).

a. Maximum of 25 fuel assemblies.

b. Minimum height of water above the core of 14 feet, 2 inches.

c. The True value of reactor coolant inlet temperature shall not be greater than 120°F.

d. N^{16} Power Measuring channel is operable.

QUESTION B.10 [1.0 point]
Which ONE of the following conditions is an Reportable Event per the Technical Specification definition?

A. A reactor scram due to loss of site AC power, which inserts more than $1.00 worth of reactivity.

B. Operation of the reactor with the Over-the-Pool Area Radiation Monitor bypassed for 100 seconds during return of a pneumatic rabbit capsule from the core.

C. Irradiation of a sample containing 500 milligrams of U^{235}

D. Operation with a pool level scram setpoint of 15 ft. above the top of the core.

QUESTION B.11 [1.0 point]
The minimum level of review for a ***"Tried Experiment"*** is

a. DSRO and DHP

b. CRO and RHP

c. ROM and RHP

d. ROM, RHP and RSAC

QUESTION B.12 [1.0 point]
Fill in the blank: According to Technical Specifications, the "designated Senior Operator (DSRO) is considered on call if: ...is capable of getting to the reactor facility within a reasonable time under normal conditions e.g., _____ minutes …

A. 15

B. 30

C. 45

D. 60

QUESTION B.13 [1.0 point]
You (a licensed Senior Reactor Operator) and a Reactor Operator Assistant (ROA) are present in the control room operating the reactor on the weekend. You are both the control room operator and the SRO on-call position. To meet Technical Specifications …

a. a Designated Senior Reactor Operator (DSRO) is required.

b. you and the ROA must both remain in the control room.

c. you must remain in the control room, the ROA may be anywhere within 5 minutes distance.

d. either you or the ROA must be in the control room the other may be anywhere withi30 minutes distance.

QUESTION B.14 [1.0 point]
Which ONE of the materials listed is required to doubly encapsulated prior to irradiation per Technical Specifications?

a. Explosive

b. Corrosive

c. Fueled

d. Cryogenic

QUESTION B.15 [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.16 [1.0 point]
The Emergency Director (ED) must approve all emergency exposures in excess of …

a. 1 Rem

b. 5 Rem

c. 10 Rem

d. 25 Rem

QUESTION B.17 [1.0 point]
In order to work on energized electrical circuits you must obtain permission from either the Chief or Reactor Maintenance or …

a. Designated SRO

b. Chief Reactor Operator

c. Reactor Operations Manager

d. Associate Director

QUESTION B.18 [1.0 point]
During refueling operations the procedure states "All fuel additions shall be made with the rods "cocked"."
Which one of the following will correctly complete the definition of a "cocked" rod?

> "The rods positioned at some position at least _____ below the estimated critical position to ensure the reactor shall remain subcritical upon fuel loading and concurrently a position that provides at least _____ shutdown capability by rod insertion."

a. 200 pcm, 200 pcm

b. 200 pcm, 400 pcm

c. 400 pcm, 200 pcm

d. 400 pcm, 400 pcm

QUESTION C.1 [2.0 points, ½ each]
Match the core materials listed in column A with their primary purpose in column B.

Column A	Column B
a. Zircaloy	1. Reflector
b. Beryllium	2. Cladding
c. silver-indium-cadmium alloy	3. Poison
d. Graphite	

QUESTION C.2 [1.0 point]
To minimize the production of Ar^{41}, a purge gas is connected to the pneumatic transfer system, when operating above 500 Kw for longer than 10 minutes.

a. H_2

b. He

c. CO_2

d. N_2

QUESTION C.3 [1.0 point]
A facility Evacuation signal will also cause an automatic confinement initiation. In Confinement, the Heating & Ventilation fans…

a. automatically secure, but the confinement fans must be started manually.

b. must be manually secured, but the confinement fans start automatically.

c. automatically secure, and **BOTH** of the confinement fans automatically start immediately.

d. automatically secure, and Confinement Fan #1 automatically starts immediately.

QUESTION C.4 [1.0 point]
Which ONE of the following statements is true?

a. The primary pump must be operating for the secondary pump to operate.

b. The secondary pump must be operating for the primary pump to operate.

c. The secondary pump must be operating for the cooling tower fans to operate

d. The cooling tower fans must be operating for the secondary pump to operate.

QUESTION C.5 [2.0 points, ½ each]
Match each Beam Tube listed in column B with the correct description from column A.

Column A	Column B
a. 6" circular thru-tube	1
b. Contains Neutron Radiography Facility	2
c. Contains Prompt Gamma Facility	3
d. 12' square beam tube	4
	5
	6

QUESTION C.6 [1.0 point]
On a loss of control air the secondary system valve S-5 will

a. fail as is.

b. fail to the maximum bypass of the cooling towers position

c. fail to the maximum flow through the cooling tower position.

d. continue to operate (electric motor backup).

QUESTION C.7 [1.0 point]
Which of the listed Radiation Monitors does NOT provide an evacuation signal?

a. Control Room Area Radiation Monitor

b. Stack Gas Monitor

c. Primary Demineralizer Area Radiation Monitor

d. Air Particulate Detector

QUESTION C.8 [10 point]
On a loss of commercial power which ONE of the following components CANNOT receive power from the auxiliary generator?

a. Confinement Fan #1

b. Control Room Distribution Panel

c. VAMP Area Radiation Monitor

d. Confinement Fan #2

QUESTION C.9 [1.0 point]
WHICH ONE of the following detectors is used primarily to measure Ar^{41} release to the environment?

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

b. Stack Gas Monitor

c. Air Particulate Monitor

d. Continuous Air Radiation Monitor

QUESTION C.10 [1.0 point]
An experimenter drops and breaks open a sample vial in a laboratory room. He immediately runs out of the room and closes the door. You are called in to assist in the cleanup. Prior to opening the door you would take a reading using a(n)

a. Ion Chamber portable radiation detector to determine the radiation field strength.

b. Geiger-Müller portable radiation detector to determine the radiation field strength.

c. Ion Chamber portable radiation detector to determine whether contamination is present.

d. Geiger-Müller portable radiation detector to determine whether contamination is present.

QUESTION C.11 [1.0 point]
On a loss of the Reactor Air compressor, an auxiliary compressor may be used to supply air to all normal Reactor Air loads **EXCEPT** the

a. Reactor building ventilation control dampers.

b. Pool Level Measuring Channel.

c. Pulse Air System.

d. Service Air System.

QUESTION C.12 [1.0 point]
Upon the loss of commercial power, the RO attempts to start the Auxiliary Generator but the cranking limiter contact opens up. What action is necessary to allow him to restart the Aux. Generator?

a. Place the Start switch to stop then to start

b. Reset the cranking limiter at the Aux. Generator control panel

c. Place the Auxiliary Distribution Panel switch in the open position

d. Place the Run-Stop-Remote switch in the Run position

QUESTION C.13 [1.0 point]
Which ONE of the following conditions (events) will NOT cause a Reverse Drive?

a. Ganged Insert" switch in the IN position

b. Loss of magnet power with the Reactor Keyswitch "ON"

c. Linear Power channel at 80%

d. Startup channel at greater than 9×10^4 cps

QUESTION C.14 [1.0 point]
Which of the following methods is used to remove the gamma signal from the neutron signal in the LOG-and Linear Channel?

a. One chamber is lined with B^{10}, which therefore has no neutron signal. The other chamber has a signal due to both neutrons and gammas. The signals from the two chambers are added algebraically to cancel the signal due to gammas.

b. Inner chamber current cancels out gamma current in the outer chamber.

c. A pulse height discriminator does not allow the gamma signals to be counted.

d. One chamber is lined with B^{10}, which therefore has a neutron and gamma signal. The other chamber has a signal only due to gammas. The signals from the two chambers are added algebraically to cancel the signal due to gammas.

QUESTION C.15 [1.0 point]
What type of detector does the N^{16} channel use?

a. Compensated ion chamber

b. Uranium lined, fission chamber

c. SEMIRAD burst

d. Xenon filled ionization chamber

QUESTION C.16 [2.0 points, ⅓ each]
Indicate whether each of the primary/purification system parameters listed in column A provides Indication Only (I); an Alarm (without a scram) (A); or a SCRAM (S).

a. Resistivity

b. Temperature

c. Pressure

d. Radioactivity (N^{16} monitor)

e. Water Level

f. Flow

QUESTION C.17 [1.0 point]
Which ONE of the following will NOT be affected by a failure of the Linear Power channel High Voltage Power Supply (HVPS)?

a. Flow/Flapper scram enable

b. Automatic Power Controller

c. Control Rod Reverse Drive

d. Linear Channel Overpower SCRAM

A.1 c
REF:

A.2 c
REF:

~~A.3 c~~ Question Deleted (No correct answer)
~~Worth of rods: $2.50 + $2.25 + $1.10 = $5.85. SDM = Worth of rods less K_{excess} less reactivity of most worth rod. SDM = $5.85 - $2.50 - 2.25 = 5.85 - $4.75~~
~~REF:~~

A.4 b
REF:

A.5 d
REF:

A.6 a
REF:

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:

A.9 a
REF:

A.10 c
REF:

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:

A.13 b
REF:

A.14 ~~b~~ a Answer changed per facility comment
REF: $(4.5 \times 0.001) \div 9 = 0.0045 \div 9 = 0.0005 = 5 \times 10^{-4}$

A.15 d
REF:

A.16 c
REF:

A.17 c
REF: ln (2) = -time/τ τ = time/(ln(2)) = 60.59 $\approx$ 61 seconds

A.18 c
REF: General Physics, HT&FF, pp. 355 - 358

A.19 d
REF:

A.20 a
REF:

B.1 a
REF: Technical Specifications § 1.0 which references 10CFR50.36

B.2 a, 0.4; b, 2.9; c, 3.9 d, 0.1; e, 1.0
REF: Technical Specification 3.2 *Reactivity*

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: Technical Specifications § 1, Definitions

B.5 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.6 b
REF: 10CFR20.1003

B.7 c Question deleted for RO candidates. Beyond scope of RO knowledge without formula.
REF: First calculate μ = 0.051 $cm^2/g \times 11.4\ g/cm^3 = 0.5814\ cm^{-1}$.
Next calculate thickness. $I = I_0\ e^{-\mu x}$ $\ln(1/10) = -\mu x$
$x = -[\ln(1/10)]/\mu = \ln(0.1)/0.5814 = 3.96 \approx 4.0$ cm
Finally calculate number of sheets: (4.0 cm)/(2.54cm/in) = 1.57 inches or about 3 sheets.

B.8 a
REF: 10CFR20.1004.

B.9 a, LCO; b, LSSS; c, SL; d, LCO
REF: Technical Specifications 2.1, 2.2, 3.1 and 3.4

B.10 c
REF: Technical Specifications,1.22, 2.1.1, 3.5.a (note 2), and 3.8

B.11 c
REF: Technical Specification 6.4.2

B.12 b
REF: Technical Specification 6.1.2

B.13 c or a Second correct answer added per facility comment.
REF: Technical Specifications 6.1.2.

B.14 b
REF: Technical Specifications 3.7 and 3.8.

B.15 b
REF: 10CFR20.2001.a(1)

B.16 b
REF: Emergency Plan § 7.5.7 *Personnel Exposure Guidelines,* p. 18.

B.17 ~~a~~ c Answer changed per facility comment.
REF: POM, Section 2 *Administrative Controls* § 2.9.4, p. 2-17.

B.18 d
REF: Special Procedure 3.3 “Fuel Handling Procedures,§ 3.0(1), p. 1.

C.1 a, 2; b, 1; c, 3; d, 1
REF: SAR Chapter 3 Reactor, §§ 3.2.2.4, 3.2.2.5, also PULSTAR Data Summary II, Reflected Core #4.

C.2 d
REF: Pulstar Operations Manual § 9.2.4, Pneumatic Nitrogen Purge System

C.3 d
REF: POM § 8.2.5.

C.4 c
REF: POM, § 5.2

(C.5) a, 2 b, 4 c, 5 d, 6
REF: POM, § 9.4, also, Figure 8 from Pulstar Data Summary vol. II. p. 17.

C.6 c
REF: NRC examination administered February 1993.

C.7 c
REF: POM, Table 7-1.

C.8 c
REF: POM § 6

C.9 b
REF: Technical Specification 3.5.b.i.

C.10 a
REF: Standard NRC question.

C.11 a or c Second correct answer added per facility comment.
REF: POM §§ 5.6 and 5.6

C.12 b
REF: POM Sect. 6.3, also NRC Exam administered July 1992

C.13 d or c Second correct answer added per facility comment.
REF: SAR § 7.4.4

C.14 d or b Second correct answer added per facility comment.
REF: POM SEC. 4, also rewrite of NRC question administered July 1992.

C.15 d
REF: POM Sect. 4 pg. 4-8

C.16 a, A; b, A or S; c, I; d, I; e, S; f, S Second correct answer added per facility comment.[1]
REF: POM, § 5.1.4

C.17 a
REF: POM Sect. 4 Fig. 4.1, also NRC examination administered November, 1991.

[1] High temperature does not cause scram directly, but procedure **REQUIRES** manual scram.

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

FACILITY: North Carolina State University

REACTOR TYPE: PULSTAR

DATE ADMINISTERED: 2002/05/20

CANDIDATE: _____

INSTRUCTIONS TO CANDIDATE:
Answers are to be written on the answer sheets provided. Points for each question are indicated in brackets for each question. You must score 70% in each section to pass. Examinations will be picked up three (3) hours after the examination starts.

Category Value	% of Total	% of Candidates Score	Category Value	Category
20.00	33.3	_____	____	A. Reactor Theory, Thermodynamics and Facility Operating Characteristics
20.00	33.3	_____	____	B. Normal and Emergency Operating Procedures and Radiological Controls
20.00	33.3	_____	____	C. Facility and Radiation Monitoring Systems
60.00		_____	____%	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 only 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

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

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

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

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

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

$$CR_1(1 - K_{eff_1}) = CR_2(1 - K_{eff_2})$$
$$CR_1(-\rho_1) = CR_2(-\rho_2)$$

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

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

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

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

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

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

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

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

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

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

$$T_{½} = \frac{0.693}{\lambda}$$

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

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

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

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

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

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

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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

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.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.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 ___

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 0.1 0.4 1.0 2.9 3.9 ___

B2b 0.1 0.4 1.0 2.9 3.9 ___

B.2c 0.1 0.4 1.0 2.9 3.9 ___

B.2d 0.1 0.4 1.0 2.9 3.9 ___

B.2e 0.1 0.4 1.0 2.9 3.9 ___

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.7 a b c d ___

B.8 a b c d ___

B.9a SL LSSS LCO ___

B.9b SL LSSS LCO ___

B.9c SL LSSS LCO ___

B.9d SL LSSS LCO ___

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 ___

B.18 a b c d ___

C.1a 1 2 3 ___

C.1b 1 2 3 ___

C.1c 1 2 3 ___

C.1d 1 2 3 ___

C.2 a b c d ___

C.3 a b c d ___

C.4 a b c d ___

C.5a 1 2 3 4 5 6 ___

C.5b 1 2 3 4 5 6 ___

C.5c 1 2 3 4 5 6 ___

C.5d 1 2 3 4 5 6 ___

C.6 a b c d ___

C.7 a b c d ___

C.8 a b c d ___

C.9 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.16a I A S ___

C.16b I A S ___

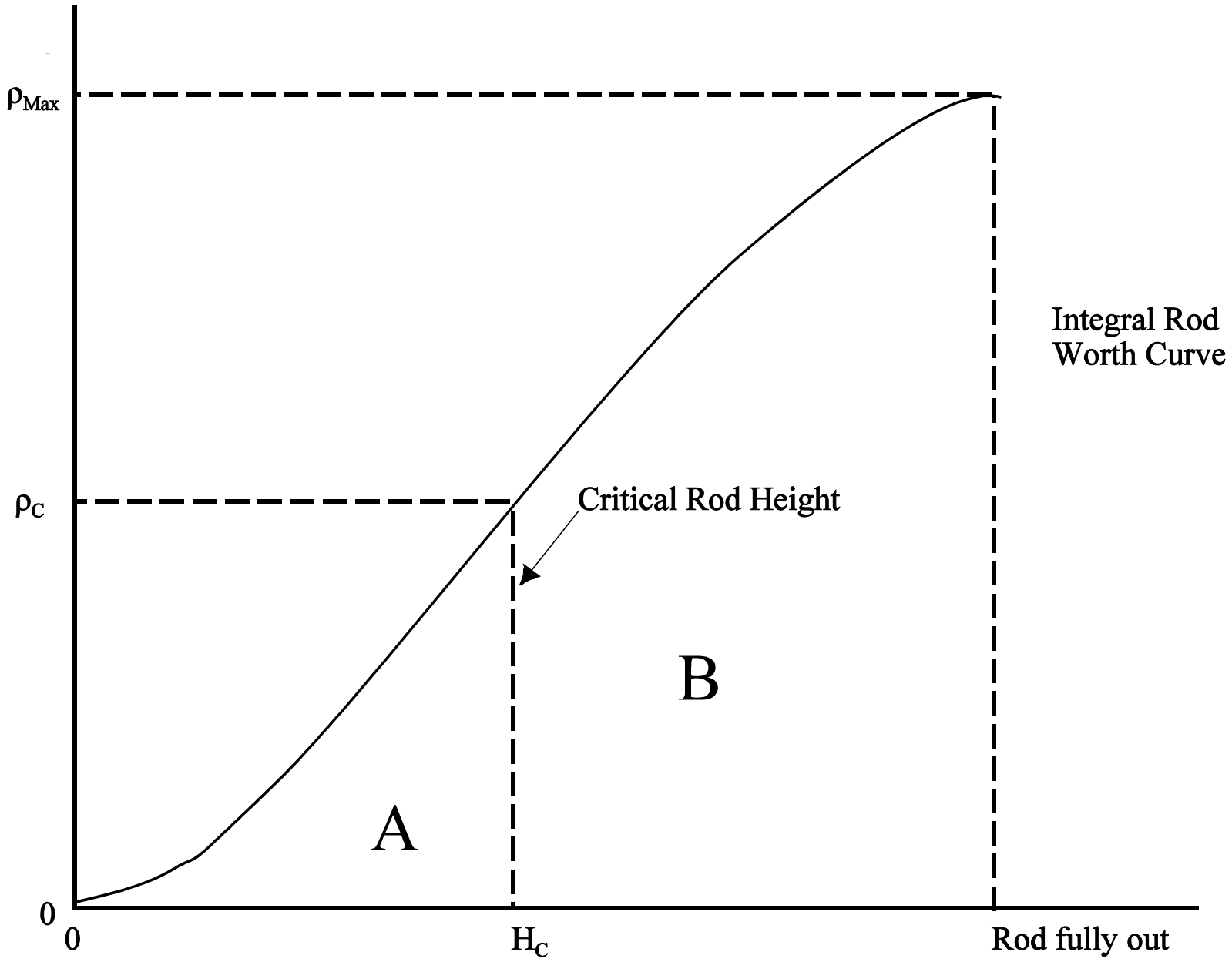
C.16c I A S ___

C.16d I A S ___

C.16d I A S ___

C.16f I A S ___

C.17 a b c d ___


ρ_{Max}
ρ_C
0
0
H_C
Rod fully out
Integral Rod
Worth Curve
Critical Rod Height
A
B