June 4, 2004

Dr. Ayman Hawari
2500 Stinson Drive
North Carolina State University
Post Office Box 7909
Raleigh, NC 27695-7909

SUBJECT: INITIAL EXAMINATION REPORT NO. 50-297/OL-04-02, NORTH CAROLINA STATE UNIVERSITY

Dear Dr. Hawari:

During the week of May 17, 2004, 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 2.390 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 Agencywide Documents Access and Management System (ADAMS). ADAMS is accessible from the NRC Web site at (the Public Electronic Reading Room) http://www.nrc.gov/NRC/ADAMS/index.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/

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

Docket No. 50-297

Enclosures:
1. Initial Examination Report No. 50-297/OL-04-02
2. Facility comments with NRC resolution
3. Examination and answer key (RO/SRO)

cc w/encls:
Please see next page

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

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

REPORT NO.: 50-297/OL-04-02

FACILITY DOCKET NO.: 50-297

FACILITY LICENSE NO.: R-120

FACILITY: North Carolina State University

EXAMINATION DATES: May 19 – 21, 2004

SUBMITTED BY: /RA/ 6/3/04
Paul Doyle, Chief Examiner Date

SUMMARY:

During the week of May 17, 2004, the NRC administered Operator Licensing examinations to five reactor operator candidates and one senior operator candidate. All six candidates passed all portions of their respective examinations.

REPORT DETAILS

1. Examiners: Paul Doyle, Chief Examiner

2. Results:

	RO PASS/FAIL	SRO PASS/FAIL	TOTAL PASS/FAIL
Written	5/0	0/0	5/0
Operating Tests	5/0	1/0	6/0
Overall	5/0	1/0	6/0

3. Exit Meeting:
Paul Doyle, NRC, Examiner
Larry Broussard, Chief Reactor Operator, PULSTAR Reactor, NCSU
Kerry Kincaid, Chief Reactor Maintenance, PULSTAR Reactor, NCSU
Andrew Cook, Associate Director, PULSTAR Reactor, NCSU

The examiner thanked Mr. Broussard for proctoring the examination while the examiner was examining the SRO (Upgrade) candidate. The examiner told the facility that in general the candidates were well prepared with the exception of knowledge of Surveillance requirements. This was noted a generic weakness for all candidates. The facility e-mailed comments on the written which have been incorporated into the attached examination. Questions B.15 and B.19 answer changed from b to d. Question C.13 is no longer applicable and will be removed from future examinations and the facility has been changed such that the answer for question C.15 is now b, instead of c.

NORTH CAROLINA STATE UNIVERSITY
With Answer Key

UNITED STATES NUCLEAR REGULATORY COMMISSION

OPERATOR LICENSING EXAMINATION
May 19, 2004

Enclosure 2

QUESTION A.1 [1.0 point]
Which one of the following terms of the six factor formula is most affected by "Poisons"?

a. Fast Fission Factor

b. Thermal Non-Leakage Probability

c. Reproduction Factor

d. Thermal Utilization Factor

QUESTION A.2 [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 $.70 when the reactor is prompt critical.

d. Equal to 1.00 $\Delta K/K$ when the reactor is prompt critical.

QUESTION A.3 [1.0 point]
Reactor power doubles in 18 seconds. How long will it take to increase power from 10 kilowatts to 100 kilowatts?

a. 10 seconds

b. 1 minute

c. 1.5 minutes

d. 10 minutes

QUESTION A.4 [1.0 point]
Which one of the following statements best describes the difference between a moderator and a reflector. A reflector …

a. increases the neutron production factor and a moderator increases the fast fission factor.

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

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

d. decreases the fast non-leakage factor and a moderator increases the thermal utilization factor.

QUESTION A.5 [1.0 point]
Which ONE of the following is an example of alpha (α) 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]
Given a fuel temperature coefficient of -2×10^{-4} ΔK/K/°C and the INSERTION of a control rod 5 inches with an average worth of 0.1% ΔK/K/inch. After stabilization of reactor power what will be the new fuel temperature? (Assume no other reactivity changes.)

a. 2.5°C lower

b. 2.5°C higher

c. 25°C lower

d. 25°C higher

QUESTION A.7 [1.0 point]
Following a reactor trip from sustained high power operation, Xe^{135} concentration in the reactor will:

a. decrease because Xenon is produced directly from fission.

b. increase due to the decay of Iodine already in the core.

c. remain the same because the decay of Iodine and Xenon balance each other out.

d. decrease immediately, then slowly increase due to the differences in the half-lives of Iodine and Xenon.

QUESTION A.8 [1.0 point]
Given the following conditions which one of the following reactions has the highest probability of occurrence? A beam of thermal neutrons is aimed at a thin foil target made of 10% copper and 90% aluminum.

σ_a Cu = 3.79 barns σ_a Al = 0.23 barns
σ_s Cu = 7.90 barns σ_s Al = 1.49 barns

a. A neutron absorption in copper

b. A neutron absorption in aluminum

c. A neutron scattering reaction with copper

d. A neutron scattering reaction with aluminum

QUESTION A.9 [1.0 point]
K_{eff} for the reactor is 0.95. What is the shutdown margin for this condition? (I am NOT looking for Technical Specification definition)

a. 5.00% ΔK/K

b. 5.26% ΔK/K

c. 5.00¢

d. 5.26¢

QUESTION A.10 [1.0 point]
The number of neutrons passing through a one square centimeter of target material per second is the definition of which one of the following?

a. Neutron Population (np)

b. Neutron Impact Potential (nip)

c. Neutron Flux (nv)

d. Neutron Density (nd)

QUESTION A.11 [1.0 point]
Assuming the Samarium worth is 0.006 ΔK/K at full power, which one of the following is the Samarium worth 10 days after shutdown from full power?

a. Essentially zero.

b. 0.012 ΔK/K

c. < 0.006 ΔK/K but > zero

d. > 0.006 ΔK/K

QUESTION A.12 [1.0 point]
Which ONE of the following isotopes will cause a neutron to lose the most energy during an elastic scattering reaction?

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

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

c. ${}_{8}O^{16}$

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

QUESTION A.13 [1.0 point]
You enter the control room and note that all nuclear instrumentation show a steady level and not 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.14 [1.0 point]
For U^{235}, the thermal fission cross-section is 582 barns, and the capture cross-section is 99 barns. When a thermal neutron is absorbed by U^{235}, the probability that a fission will occur is:

a. 0.146

b. 0.170

c. 0.830

d. 0.855

QUESTION A.15 [1.0 point]
With the reactor on a constant period, which of the following changes in reactor power would take the LONGEST time?

a. 5% — from 1% to 6%

b. 15% — from 20% to 35%

c. 20% — from 40% to 60%

d. 25% — from 75% to 100%

QUESTION A.16 [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.17 [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.18 [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.19 [1.0 point]
The term ***"Prompt Jump"*** refers to:

a. the instantaneous change in power due to raising a control rod.

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

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

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

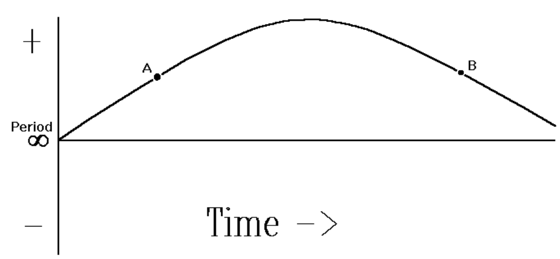
QUESTION A.20 [1.0 point]
Shown below is a trace of reactor period as a function of time. Between points A and B reactor power is:

a. continually increasing.

b. continually decreasing.

c. increasing, then decreasing.

d. constant.



QUESTION B.1 [1.0 point, ⅓ each]
Identify the ***PRIMARY*** source of each of the radioisotopes listed below as coming from irradiation of air or water, or is a fission product.

a. N^{16}

b. Ar^{41}

c. Xe^{135}

QUESTION B.2 [1.0 point]
If it is true that a ½ thickness for gammas in water is about 12 inches, then the 20 feet of water between the core and the top of the pool the radiation intensity due to gammas will have decreased by a factor of approximately …

a. 40

b. 400

c. 1,000

d. 1,000,000

QUESTION B.3 [1.0 point]
You hear the Evacuation alarms sounding and you note that the Over-the-Pool radiation monitor is in alarm. Which ONE of the following actions with respect to reactor operations must you perform?

a. Determine if reactor operations may continue.

b. Shutdown the reactor.

c. SCRAM the Reactor.

d. Nothing, the reactor automatically scrams on an evacuation alarm.

QUESTION B.4 [1.0 point]
Which ONE of the following disconnect switches on MCC #1 is NORMALLY locked in the “OFF” position?

a. Service Demineralizer Pump

b. Confinement Fan #2

c. Sump Pump

d. Crane control

QUESTION B.5 [1.0 point]
A radiation survey of an area reveals general radiation readings of 1 mrem/hr. A valve however, reads 10 mrem/hr at 30 cm. Assuming the valve may be considered a point source Per 10 CFR 20 the area must be posted as a …

a. Restricted Area

b. Radiation Area

c. High Radiation Area

d. Very High Radiation Area

QUESTION B.6 [1.0 point]
A survey instrument with a windowed probe is used to measure beta and gamma radiation. The measured dose with the window open is 100 mrem/hr and the dose with the window closed is 60 mrem/hr. The gamma dose is …

a. 160 mrem/hr

b. 100 mrem/hr

c. 60 mrem/hr

d. 40 mrem/hr

QUESTION B.7 [1.0 point]
The ***<u>SITE BOUNDARY</u>*** for the facility is …

a. The border that outlines the Reactor Building.

b. The border within a 50 m circle with the stack at the center.

c. The border that includes the BEL, the area between Lampe and Broughton Drive and the Area between Stinson Drive and the North face of BEL.

d. The border within a 50 m circle with the reactor core at the center.

QUESTION B.8 [1.0 point]
Following a reactor scram reverse action of the control rod position indicates does NOT occur. As Reactor Operator your immediate action is to …

a. place the ganged insert switch to the ***<u>IN</u>*** position.

b. initiate a manual ***<u>SCRAM</u>***

c. turn the reactor keyswitch ***<u>OFF</u>***.

d. inform the ***<u>DRSO</u>***

QUESTION B.9 [1.0 point]
The Total Effective Dose Equivalent is equal to the …

a. sum of external and internal dose.

b. dose equivalent at a tissue depth of 1 cm.

c. dose equivalent to organs or tissues

d. sum of dose multiplied by weighting factors.

QUESTION B.10 [2.0 points, ½ each]
Identify for each of the activities listed in column A wether the DSRO ***MUST*** be in the facility, ***MAY*** be on call or is not required.

	COLUMN A		COLUMN B
a.	Recovery from a planned shutdown	1.	In Facility
b.	Insertion/Removal of a routine experiment (℞ shutdown)	2.	On Call
c.	Operation at a steady-state power level	3.	SRO Not Required
d.	Initial startup of the day to full power.		

QUESTION B.11 [1.0 point]
Which ONE of the following persons is allowed to operate the facility under YOUR direction as a licensed Reactor Operator (RO)?

a. School newspaper reporter, writing a story on the safety of nuclear reactors.

b. An NCSU student, as part of a curriculum for Nuclear Physics class.

c. An NCSU student, in training to certify as a health physicist.

d. An NRC inspector, attempting to ensure that all set points for the reactor are as listed in Technical Specifications.

QUESTION B.12 [1.0 point]
Which ONE of the listed radio-isotopes produces the highest ionizing energy gamma?

a. H^3

b. N^{16}

c. Ar^{41}

d. U^{235}

QUESTION B.13 [1.0 points, ¼ each]
Identify whether each of the following would require a Danger Tag (Red) or a Caution Tag (Yellow)

a. A portable monitor calibration sticker date is past due.

b. A failure of the Primary Pump packing.

c. The Regulating Rod is stuck out at 80% withdrawn position.

d. The Demineralizer Area Radiation Monitor is inoperative. No maintenance is scheduled at this time.

QUESTION B.14 [1.0 point]
Which ONE of the following conditions is a violation of your requalification plan?

a. Last quarter you operated the reactor for six hours.

b. You last took a requalification operating test 13 months ago.

c. You last took a requalification written examination 17 months ago.

d. Your last medical examination was 26 months ago.

QUESTION B.15 [1.0 point]
Per the PULSTAR Emergency Plan the maximum TEDE which may be authorized for life-saving actions or for the protection of large populations is not practicable is … (not voluntary, by someone who is NOT fully aware of the risks involved)

a. >25 rem

b. Up to 25 rem

c. Up to 10 rem

d. Up to 5 rem

QUESTION B.16 [1.0 point]
The standard ANSI/ANS 15.16 defines four Emergency Action Levels (EAL). Which ONE of the listed EALs is the most severe ***CREDIBLE*** accident which could occur at your reactor? (Note: EALs are listed in alphabetical order, NOT necessarily in order of severity.)

a. Alert

b. General Emergency

c. Notification of Unusual Event

d. Site Area Emergency

QUESTION B.17 [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. 600 pcm, 200 pcm

b. 500 pcm, 300 pcm

c. 400 pcm, 400 pcm

d. 300 pcm, 500 pcm

QUESTION B.18 [1.0 point]
The Pulstar reactor is operating with a heatup rate of 1.0°F/hr and a ΔT across the primary side of the heat exchanger of 13.2°F. What is the nominal power of the reactor? Also given: Primary flow = 500 gpm, Primary Volume = 15,650 gal, c_p = 0.998 BTU/lbm°F, Density H_2O = 8.272 lbm/gal and 1 MW = 3.413 x 10^6 BTU/hr.

a. 0.9 MW

b. 2.8 MW

c. 5.6 MW

d. 10.8 MW

QUESTION B.19 [1.0 point]
Which ONE of the following statements describe a "Radiation Area"?

a. Any area, accessible to personnel, in which there exists radiation at such levels that a major portion of the body could receive in excess of 100 mr/hr.

b. Any area, accessible to personnel, in which there exists radiation at such levels that a major portion of the body could receive in 5 consecutive days a dose in excess of 100 mr.

c. Any area, accessible to personnel, in which there exists radiation in excess of 25 percent of the amounts specified in Appendix B, Table I, Column I of 10 CFR 20.

d. Any accessible area, controlled by the licensee, where an individual could receive a dose in excess of 5 mr/hr.

QUESTION C.1 [1.0 point]
The purpose of the aluminum-to-stainless steel transition couplings are to prevent:

a. buildup of fission gases in the beamports.

b. Fatigue (Vibrational) Failure of the piping.

c. galvanic corrosion in the primary system.

d. stress corrosion of the stainless steel due to chlorine leaching from the barytes concrete.

QUESTION C.2 [2.0 points, ¼ each]
Referring to the diagram of the primary system provided, identify whether the listed valves are open, throttled or closed for NORMAL operation.

a. P-1

b. P-3

c. P-5

d. P-7

e. P-9

f. P-11

g. P-14

h. P-17

QUESTION C.3 [1.0 point]
Which of the following correctly describes the flow path through the primary coolant system?

a. Pool, Delay Tank, Heat Exchanger, Primary Pump, Core

b. Pool, Delay Tank, Primary Pump, Heat Exchanger, Core

c. Core, Delay Tank, Primary Pump, Heat Exchanger, Pool

d. Core, Delay Tank, Heat Exchanger, Primary Pump, Pool

QUESTION C.4 [1.0 point]
The auxiliary generator emergency latch relay will open if either oil pressure is …

a. low or water temperature is low

b. low or water temperature is high

c. high or water temperature is low

d. high or water temperature is high

QUESTION C.5 [1.0 point]
An Area Radiation Monitor has the RANGE light indicating solid red and the display reads EEEEE. This indicates that …

a. the alarm circuitry self-test has detected an anomaly.

b. the reading is off-scale HIGH.

c. the reading is off-scale LOW.

d. the detector circuitry self-test has detected an anomaly.

QUESTION C.6 [1.0 point]
Typically for a fuel leak within the pool, some isotopes are not detected by the air radiation monitors. Which ONE of the following would NOT be detected by the air monitors, and why.

a. Cs^{131}, because it is a daughter product of a noble gas and will dissipate.

b. I^{131}, because it is soluble, and will never make it out of the pool (except in the demineralizer).

c. Xe^{131}, because it has too short a half-life

d. Kr^{88}, because it is a noble gas which cannot be detected.

QUESTION C.7 [1.0 point]
Which ONE of the following detectors is used to detect the amount Ar^{41} released to the environment?

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

b. Stack Gas Monitor

c. Stack Particulate Monitor

d. Bridge Area Monitor

QUESTION C.8 [2.0 points, ½ each]
Match the Instrumentation channel in column A with its associated detector type in Column B. (Note: detectors in Column B may be used more than once or not at all.)

Column A	Column B
a. Linear	1. Gamma Sensitive Ionization Chamber
b. Log N	2. Boron lined Uncompensated Ionization Chamber
c. Safety	3. Boron lined Compensated Ionization Chamber
d. N^{16}	4. Fission Chamber

QUESTION C.9 [2.0 points, ½ each]
Match the purification system symptoms listed in column A with the causes listed in Column B. (No changes have been made to any equipment, i.e. no valves have been manipulated. Each item in column B with match up with only one item in column A.)

Column A	Column B
a. High Radiation level in demineralizer tank	1. Resin separation (channeling)
b. High radiation level at demineralizer outlet	2. Fission product release
c. High flow through demineralizer tanks	3. High water temperature
d. High pressure on demineralizer inlet	4. Clogging

QUESTION C.10 [2.0 points, ½ each]
Identify the characteristics for each of the radiation monitors listed.

a. Waste Tank #1	1. Warn = “High Radiation” annunciation, Alarm = Evacuation Signal
b. Continuous Air Monitor	2. Warn = “High Radiation” annunciation, Alarm ≠ Evacuation Signal
c. Demineralizer	3. Local audible and Visual
d. Stack Gas	4. No Console annunciation

QUESTION C.11 [1.0 point]
Which ONE of the following statements is FALSE?

a. Only one confinement fan is required to achieve negative air pressure in the Reactor Building.

b. If confinement Fan #1 fails to start manually, Confinement Fan #2 will self-energize

c. The main Heating and Ventilation system must be off to start one of the confinement fans manually.

d. Upon initiation of Confinement, the Beam Tube and Thermal Column exhaust fan is switched off.

QUESTION C.12 [1.0 point]
The confinement fan damper-verification lights on the Radiation-Monitoring Panel indicate which one of the following conditions?

a. power is available to the controlled dampers

b. negative air pressure in the Reactor Building is achieved

c. the damper for the confinement fan is fully open

d. the damper for the confinement fan is partially open

QUESTION C.13 [1.0 point]
Technical Specifications allow operation without the required differential pressure during repair of the ventilation system. Per the technical specification power is limited to …

a. 500 KW for less than 24 hours

b. 500 KW for less than 72 hours

c. 100 KW for less than 24 hours

d. 100 KW for less than 72 hours

QUESTION C.14 [1.0 point]
The Main Exhaust Fan directly takes a suction on the following components except:

a. BP&TC Exhaust Fan

b. Reactor Bridge Glove Box

c. Control Room louvers

d. Reactor Bay Hood

QUESTION C.15 [1.0 point]
Following a complete loss of commercial power, the Auxiliary Generator is started and the Reactor Operator places the Control Room distribution TRANSFER CONTROL switch in the "on" position. Which ONE of the following instrumentations will be inoperable?

a. Linear Power channel

b. VAMP

c. Startup channel

d. Log N channel

QUESTION C.16 [1.0 point]
Which ONE of the following radiation detectors does not have an output intensity (current or pulse height) proportional to the incident radiation energy? (i.e., if the incident energy increases, the output intensity increase)

a. Ion Chamber

b. Geiger Mueller

c. Proportional Counter

d. Scintillation

A.1 d
REF:

A.2 b
REF: Standard NRC question

A.3 b
REF: 1st solve for period(τ) $\ln(2) = 18$ seconds/τ → $\tau = 18$ seconds/$\ln(2) = 18/0.693 = 26$ seconds
Next, solve for time $\ln(10) = \text{time}/26$ sec → time $= \ln(10) \times 26 = 60$ seconds $= 1$ minute

A.4 c
REF:

A.5 a
REF:

A.6 c
REF: Inserting the rod 5 inches gives (-5 inches) x 0.1% ΔK/K/inch = -0.5% ΔK/K. Temperature coefficient = -2×10^{-4} ΔK/K/°C or -0.02% ΔK/K/°C. The temperature coefficient must compensate for the reactivity added by the rod movement. ∴ since the insertion of a rod added negative reactivity the fuel temperature must add positive reactivity (temperature decrease).
-0.02% ΔK/K/°C (-X°C) = 0.5% ΔK/K. -X°C = (0.5% ΔK/K) ÷ (-0.02% ΔK/K/°C) X°C = 25

A.7 b
REF:

A.8 d
REF: $0.1 \times \sigma_{aCu} = 0.379$; $0.1 \times \sigma_{sCu} = 0.79$; $0.9 \times \sigma_{aAl} = .207$ **$0.9 \times \sigma_{sAl} = 1.341$**

A.9 b
REF: $SDM = (1 - K_{eff})/K_{eff} = (1 - 0.95)/0.95 = 0.05/0.95 = 0.0526$

A.10 c
REF:

A.11 d
REF:

A.12 a
REF: Chart of the nuclides

A.13 c
REF:

A.14 d
REF:

A.15 a
REF:

A.16 c
REF:

A.17 c
REF:

A.18 c
REF:

A.19 a
REF:

A.20 a
REF:

B.1 a, water; b, air; c, Fission Product
REF: NCS Reactor Operating Procedures Section 3 Sub 3.4.5.2 page 3-62

B.2 d
REF: $2^{20} = 1{,}048{,}576$ distractors: a = 2 ×20; b= 20^2, c = bogus

B.3 c
REF: PULSTAR Operating Manual § 3.4.1.2 step 1. Page 3-25.

B.4 d
REF: PULSTAR Operating Manual § 3.5.2 Part E step 5. Page 3-29.

B.5 b
REF: 10 CFR 20.

B.6 c
REF: Standard Health Physics Question Dose due to Gamma = Dose with window closed.

B.7 c
REF: PULSTAR Emergency Plan § 2.13.

B.8 a
REF: PULSTAR Operating Manual, Reactor Operating Procedures § 3.4.1.2.

B.9 a
REF: 10 CFR 20

B.10 a, 1; b, 3; c, 2; d, 1
REF:

B.11 b
REF:

B.12 b
REF: Chart of the Nuclides

B.13 a, Y; b, R; c, R; d, Y
REF: PULSTAR Operations Manual, § 2.x

B.14 d
REF: Special procedure 2.6 *PULSTAR Operator Requalification Program* and 10 CFR 55.59

B.15 ~~b~~ d answer changed per facility comment.
REF: PULSTAR Emergency Plan § 7.5.7.

B.16 a
REF: PULSTAR Emergency Plan § 5.0 *Emergency Action Levels (EALs).*

B.17 c
REF: NCS Special Procedure 3.3 Fuel Handling Procedures page

B.18 a
REF: Nuclear Training Manual pg. RX 8-3
$Q = m \bullet cPprimary\ \Delta Tprimary + mpool\ c_P\ \Delta Tpool/\Delta t$
$Q = 500$ gal/min × 8.272 lbm/gal × 0.998 BTU/lbm°F × 13.2°F × 60 min/hr + 15650 gal × 8.272 lbm/gal ×0.998 BTU/lbm °F × 1°F/hr = 3269160.58 + 12878.51 = 3282039.09 ÷ 3.413 × 106 = 0.9616 Mwatts

B.19 ~~b~~ d answer changed per facility comment.
REF: POM pg. 2-21

C.1: c
Ref: PULSTAR Operating Manual § 5.1.3.6

C.2: a, Open; b, Throttled; c, Open; d, Closed; e, Open; f, Closed;
g, Closed; h, Open
Ref: PULSTAR Operating Manual § 5.1.5.1 Normal valve lineup.

C.3 c
REF: NCSU, Ops Manual, Figure 5.1

C.4 b
Ref: PULSTAR Operating Manual § 6.2.1 3rd ¶.

C.5 b
Ref: PULSTAR Operating Manual §7.2.2.1.d

C.6: b
REF: New NRC question based on knowledge from xxxxxxxx

C.7 b
REF: PULSTAR Operating Manual §7.2.2.

C.8 a, 3; b, 3; c, 2; d, 1
REF: SAR § 7.1, NRC examination administered July, 1992.

C.9 a, 2; b, 3; c, 1; 4
REF:

C.10 a, 4; b, 3; c, 2; d, 1
REF: POM, Table 7.1

C.11 b
REF: POM Sect 8.2.4 and 8.2.5

C.12 c
REF: PULSTAR Ops. Manual, Sect. 8 pg. 8-8

C.13 c
REF: T.S. 3.6 pg. 24

C.14 c
REF: SAR Figure 5-1

C.15 ~~c~~ b answer changed per facility comment.
REF: POM Sect. 3 pg. 3.63/64

C.16 b
REF: Health Physics and Radiation Protection Lesson Plans, pp. 41-46

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

FACILITY: North Carolina State University

REACTOR TYPE: TANK

DATE ADMINISTERED: 2004/05/19

CANDIDATE: ___________________________

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

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		______	____% FINAL GRADE		TOTALS

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

____
Candidate's Signature

NRC RULES AND GUIDELINES FOR LICENSE EXAMINATIONS

During the administration of this examination the following rules apply:

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

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

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

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

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

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

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

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

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

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

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

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

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

EQUATION SHEET

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

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

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

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

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

$$R_1(1-K_{eff_1}) = CR_2(1-K_{eff_2})$$
$$CR_1(-\rho_1) = CR_2(-\rho_2)$$

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

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

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

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

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

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

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

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

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

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

$$T_{½} = \frac{0.693}{\lambda}$$

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

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

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

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

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

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

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.1a 1 2 3 4 ___

~~A.1b 1 2 3 4 ___~~

~~A.1c 1 2 3 4 ___~~

~~A.1d 1 2 3 4 ___~~

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.9a 1 2 3 4 5 ___

A.9b 1 2 3 4 5 ___

A.9c a b c d ___

A.9d a b c d ___

A.9e 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 ___

B.1a air water fission product ___

B.1b air water fission product ___

B.1c air water fission product ___

B.2 a b c d ___

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.9 a b c d ___

B.10a 1 2 3 ___

B.10b 1 2 3 ___

B.10c 1 2 3 ___

B.10d 1 2 3 ___

B.11 a b c d ___

B.12 a b c d ___

B.13a Yellow Red ___

B.13b Yellow Red ___

B.13c Yellow Red ___

B.13d Yellow Red ___

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 ___

B.19 a b c d ___

~~B.19 a b c d ___~~

C.1 a b c d ___

C.2a OPEN CLOSED THROTTLED __

C.2b OPEN CLOSED THROTTLED __

C.2c OPEN CLOSED THROTTLED __

C.2d OPEN CLOSED THROTTLED __

C.2e OPEN CLOSED THROTTLED __

C.2f OPEN CLOSED THROTTLED __

C.2g OPEN CLOSED THROTTLED __

C.2h OPEN CLOSED THROTTLED __

C.3 a b c d ___

C.4 a b c d ___

C.5 a b c d ___

C.6 a b c d ___

C.7 a b c d ___

C.8a 1 2 3 4 ___

C.8b 1 2 3 4 ___

C.8c 1 2 3 4 ___

C.8d 1 2 3 4 ___

C.9a 1 2 3 4 ___

C.9b 1 2 3 4 ___

C.9c 1 2 3 4 ___

C.9d 1 2 3 4 ___

C.10a 1 2 3 4 ___

C.10b 1 2 3 4 ___

C.10c 1 2 3 4 ___

C.10d 1 2 3 4 ___

C.11 a b c d ___

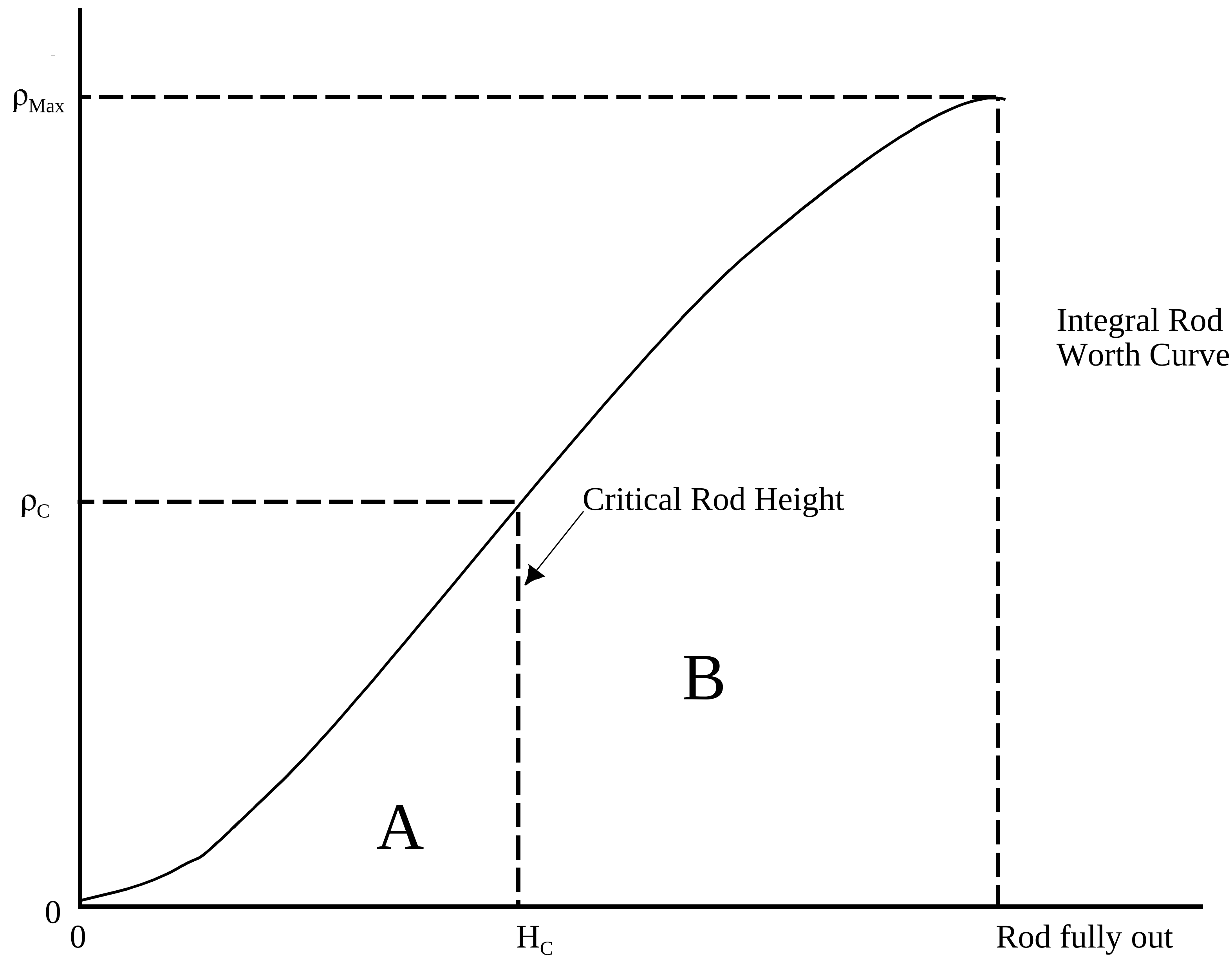
C.12 a b c d ___

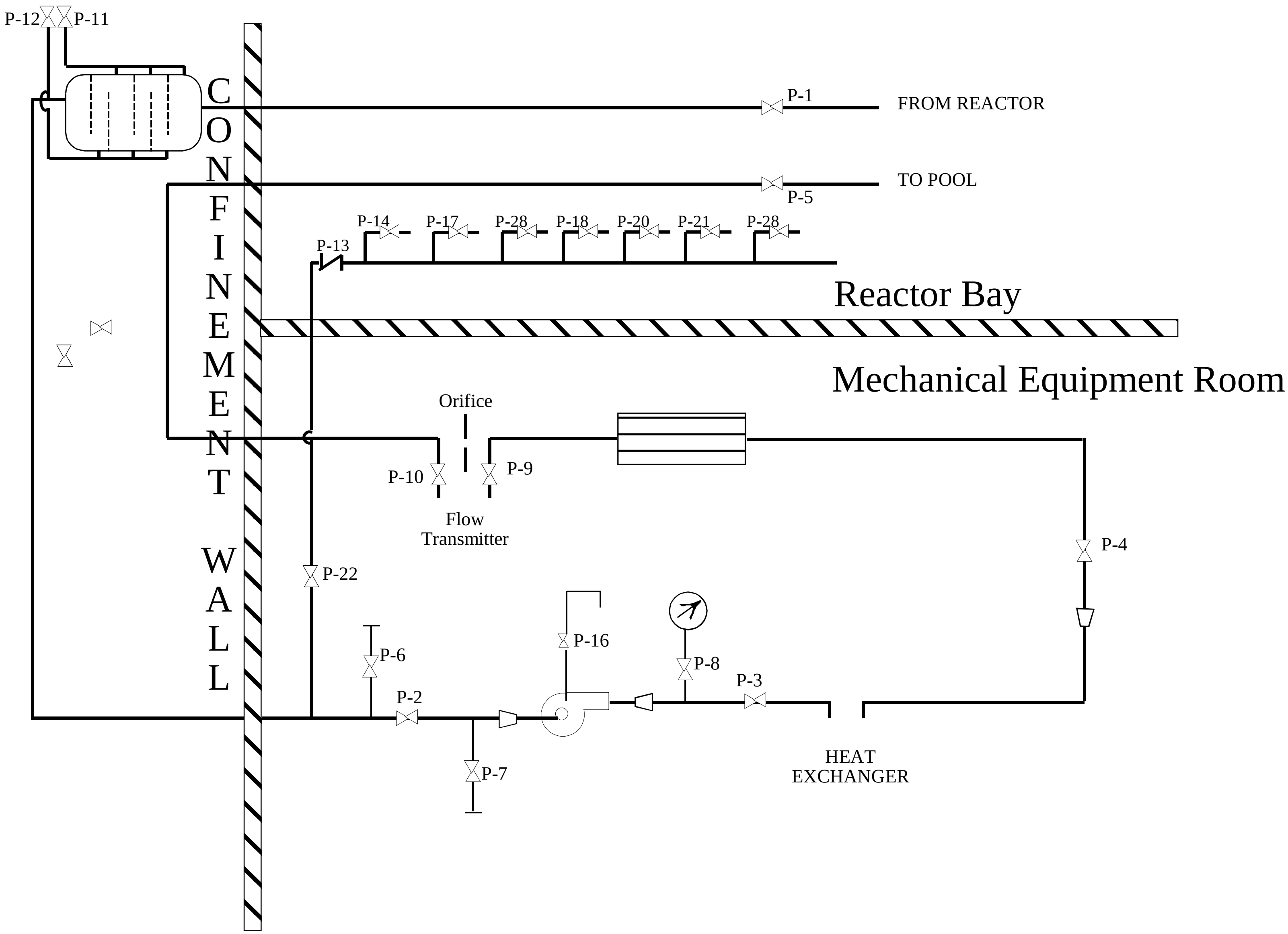
C.13 a b c d ___

C.14 a b c d ___

C.15 a b c d ___

C.16 a b c d ___


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



PRIMARY SYSTEM