October 4, 2004

Mr. Ralph A. Butler, Chief Operating Officer
Research Reactor Facility
University of Missouri
Columbia, MO 65211

SUBJECT: INITIAL EXAMINATION REPORT NO. 50-186/OL-04-01, UNIVERSITY OF MISSOURI – COLUMBIA

Dear Mr. Butler:

During the week of August 15, 2004, the NRC administered operator licensing examinations at your University of Missouri – Columbia Reactor. The examinations were 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 Mr. Paul Doyle at (301) 415-1058 or via internet e-mail at 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. 50-186

Enclosures: 1. Initial Examination Report No. 50-186/OL-04-01
2. Examination and answer key (with NRC resolution of comments)

cc w/encls: Please see next page

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DISTRIBUTION w/ encls.:

PUBLIC	RNRP R&TR r/f	PMadden
AAdams	Facility File (EBarnhill) O-6 F-2	

EXAMINATION PACKAGE ACCESSION NO.: ML041730287
EXAMINATION REPORT ACCESSION #: ML042670028 **TEMPLATE #: NRR-074**

OFFICE	RNRP:CE		IROB:LA	E	RNRP:SC	
NAME	PDoyle		EBarnhill		PMadden	
DATE	9/23/2004		9/27/2004		10/1/2004	

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

REPORT NO.: 50-186/OL-04-01

FACILITY DOCKET NO.: 50-186

FACILITY LICENSE NO.: R-103

FACILITY: University of Missouri – Columbia

EXAMINATION DATES: August 16 - 17, 2004

SUBMITTED BY: _____ _____
Paul Doyle, Chief Examiner Date

SUMMARY:

During the week of August 15, 2004, the NRC administered operator licensing examinations to three Reactor Operator, and three Senior Reactor Operator (Upgrade) candidates. All 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	3/0	0/0	3/0
Operating Tests	3/0	3/0	6/0
Overall	3/0	3/0	6/0

3. Exit Meeting:
   Paul Doyle, NRC, Examiner
   Michael Dixon, MURR, Assistant Reactor Manager - Operations
   Robert Hudson, MURR, Training Coordinator

   At the exit meeting the examiner reported that he observed no generic weaknesses, and thanked the facility for ensuring that the candidates were so well prepared for their examinations. The facility reported that they had completed their review of the written examination. Facility comments have been incorporated into the examination contained in Enclosure 2 to this report.

UNIVERSITY OF MISSOURI–COLUMBIA

With Answer Key

OPERATOR LICENSING EXAMINATION

August 17, 2004

Enclosure 2

QUESTION A.1 [2.0 points, 0.4 each]

Match the isotope from column A with its origin in column B. (Column b items may be used more than once.)

a. N^{16}	1. Water
b. Ar^{41}	2. Air
c. H^{3}	3. Aluminum Canned Reflectors
d. Na^{24}	4. Fuel (Fission Product)
e. I^{135}	

QUESTION A.2 [1.0 point] Question deleted per facility comment.

~~You are the reactor operator controlling the reactor in manual. An experimenter is preparing to inject an experiment worth -1%ΔK/K into the reactor. What type of reactor period do you expect to see?~~

~~a. ≈ 2 sec.~~

~~b. ≈ 10 sec.~~

~~c. ≈ 20 sec~~

~~d. ≈ 40 sec~~

QUESTION A.3 [1.0 point]

The term "***PROMPT JUMP***" refers to:

a. The instantaneous jump in power due to a rod withdrawal.

b. A reactor which is critical using only prompt neutrons.

c. A reactor which is critical using both prompt and critical neutrons.

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

QUESTION A.4 [1.0 point]

Reactor power is rising on a 30 second period. Approximately how long will it take for power to double?

a. 35 seconds

b. 50 seconds

c. 70 seconds

d. 100 seconds

QUESTION A.5 [1.0 point]

Which ONE of the following is the correct reason burnable poison is added to the core?

a. To minimize the effects of a rod withdrawal accident.

b. To increase the power achievable for a given core size.

c. To allow addition of additional fuel to compensate for burnup.

d. To decrease the effects of Xenon and Samarium on the core.

QUESTION A.6 [1.0 point]

Which one of the following describes the characteristics of a good moderator?

a. Low scattering cross section and low absorption cross section

b. Low scattering cross section and high absorption cross section

c. High scattering cross section and low absorption cross section

d. High scattering cross section and high absorption cross section

QUESTION A.7 [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 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 $\Delta K/K$ when the reactor is critical.

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

QUESTION A.9 [1.0 point]

Match each term in column A with the correct definition in column B.

Column A	Column B
a. Prompt Neutron	1. A neutron in equilibrium with its surroundings.
b. Fast Neutron	2. A neutron born directly from fission.
c. Thermal Neutron	3. A neutron born due to decay of a fission product.
d. Delayed Neutron	4. A neutron at an energy level greater than its surroundings.

QUESTION A.10 [1.0 point]

Given the following data, which ONE of the following is the closest to the half life of the material?

TIME	ACTIVITY
0	2400 cps
10 min.	1757 cps
20 min.	1286 cps
30 min.	941 cps
60 min.	369 cps

a. 11 minutes

b. 22 minutes

c. 44 minutes

d. 51 minutes

QUESTION A.11 [1.0 point]

The neutron microscopic cross-section for absorption σ_a generally …

a. increases as neutron energy increases

b. decreases as neutron energy increases

c. increases as target nucleus mass increases

d. decreases as target nucleus mass increases

QUESTION A.12 [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.13 [1.0 point]

K_{eff} is K_{∞} times …

a. the fast fission factor (ε)

b. the total non-leakage probability ($\mathcal{L}_f \times \mathcal{L}_{th}$)

c. the reproduction factor (η)

d. the resonance escape probability (p)

QUESTION A.14 [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.15 [2.0 points, ½ each]

Using the drawing of the Integral Rod Worth Curve provided, identify each of the following reactivity worths.

a. Total Rod Worth

b. Actual Shutdown Margin

c. Technical Specification Shutdown Margin Limit

d. Excess Reactivity

1. B - A
2. C - A
3. C - B
4. D - C
5. E - C
6. E - D
7. E - A

QUESTION A.16 [1.0 point]
Which ONE of the following is the reason that Xenon Peaks after a shutdown?

a. Iodine decays faster than Xenon decays

b. Promethium decays faster than Xenon decays

c. Xenon decays faster than Iodine decays

d. Xenon decays faster than Promethium

QUESTION A.17 [1.0 point]
During a fuel loading of the core, as the reactor approaches criticality, the value of 1/M:

a. Increases toward one

b. Decreases toward one

c. Increases toward infinity

d. Decreases toward zero

QUESTION B.1 [1.0 point]

What is the minimum amount of primary grade makeup water allowable for reactor operation?

a. 1000 gallons

b. 2000 gallons

c. 3000 gallons

d. 4000 gallons

QUESTION B.2 [1.0 point]

N^{16} has a very short half-life. If you assume that it takes ***10 HALF-LIVES*** worth of time for the water to get from the core to the sample connection, then the activity due to N^{16} will have decrease by a factor of approximately ___ with respect to the level at the exit of the core.

a. 20

b. 100

c. 200

d. 1000

QUESTION B.3 [1.0 point]

What is the maximum allowable dose which the facility director can authorize for a volunteer to receive to save the life of someone injured and trapped in the reactor compartment?

a. 125 Rem

b. 100 Rem

c. 75 Rem

d. 50 Rem

QUESTION B.4 [1.0 point]

During a normal reactor startup you must stop pulling the shim-safety blades in gang when you reach the position equivalent to _____ inches below the ECP position.

a. 5

b. 2-½

c. 2

d. 1-¼

QUESTION B.5 [1.0 point]

The reactor has been shutdown for the last three hours due to electrical storms, (intermittent loss of power). No shutdown checksheet has been performed. Which of the following meets the MINIMUM requirements to restart the reactor?

a. You may perform a hot startup with the SRO directing.

b. You may startup after performing a short form Startup Checksheet.

c. You may startup after ensuring the Primary system is on-line per the applicable SOP, then performing a short form Startup Checksheet.

d. You may startup after performing a Full Power Startup Checksheet.

QUESTION B.6 [2.0 points, ½ point each]

Identify each of the actions listed below as either a Channel Check (Check), a Channel Test (Test), or a Channel Calibration (Cal).

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

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

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

d. During reactor shutdown you note -80 second period on nuclear instrumentation.

QUESTION B.7 [1.0 point, ¼ each]

The appropriate federal regulation contains many requirements for Operator Licenses, match each of the requirements listed in column A with it's appropriate time period in column B. (Note: Periods from column B may be used more than once or not at all.)

	Column A (Requirements)	Column B (Years)
a.	License Renewal	1
b.	Requalification Written Examination	2
c.	Requalification Operating Test	4
d.	Medical Examination	6

QUESTION B.8 [1.0 point]
During normal operation of the reactor, you take a complete set of process data every …

a. ½ hour

b. hour

c. 2 hours

d. 4 hours

QUESTION B.9 [1.0 point]
Annual maintenance was last performed on a system on July 31, 2004. The last date annual maintenance may be performed on the system without being late is …

a. July 31, 2005

b. August 31, 2005

c. September 30, 2005

d. October 31, 2005

QUESTION B.10 [1.0 point]
During a startup the reactor is not critical at ECP, per AP-RO-110, the minimum level of staff authorized to permit a continuation of the startup is …

a. Any licensed Senior Reactor Operator

b. Lead Senior Reactor Operator

c. Assistant Reactor Manager

d. Reactor Manager

QUESTION B.11 [1.0 point]
10CFR50.54(x) states: *"A licensee may take reasonable action that departs from a license condition or a technical specification (contained in a license issued under this part) in an emergency when this action is immediately needed to protect the public health and safety and no action consistent with license conditions and technical specifications that can provide adequate or equivalent protection is immediately apparent."* 10CFR50.54(y) states that the minimum level of staff which may authorize this action is …

a. any Reactor Operator licensed at facility

b. any Senior Reactor Operator licensed at facility

c. Facility Manager (or equivalent name at facility).

d. NRC Manager

QUESTION B.12 [1.0 point]

In the case of a partial site area evacuation, according to EP-RO-013, all personnel who have evacuated the reactor building will proceed to

a. USDA Research Laboratory parking lot

b. Dalton parking lot

c. Science Instrument Shop

d. Research Park Development Building

QUESTION B.13 [1.0 point]

Which ONE of the following types of experiments may NOT be irradiated within the confines of the pool?

a. explosive materials

b. fueled experiments

c. materials corrosive to reactor components

d. cryogenic liquids

QUESTION B.14 [1.0 point]

You are operating the reactor when it scrams (unscheduled). After looking for hours neither you nor the SRO, nor the shift supervisor can find the reason for the scram. Which one of the following conditions must be met to restart the reactor?

a. You may NOT startup the reactor under any conditions until the cause of the scram is found and corrected.

b. You may startup the reactor if authorized by any Senior Reactor Operator.

c. You may startup the reactor if authorized by the Lead Senior Reactor Operator.

d. You may startup the reactor if authorized by the Reactor Manager.

QUESTION B.15 [1.0 point]

An experimenter wishes to irradiate three specimens with reactivity worths of 0.0005 Δk/k, 0.0013 Δk/k and 0.0027 Δk/k. Can these specimens be placed in the reactor as UNSECURED experiments and why (why not).

a. Yes, the sum of the three specimens is less than 0.025 Δk/k.

b. No, the sum of the three specimens is greater than 0.01 Δk/k.

c. Yes, each specimen is less than 0.006 Δk/k.

d. No, one of the specimens is greater than 0.0025 Δk/k.

QUESTION B.16 [1.0 point]

Which ONE of the following Reactor Emergencies would require you to insert a manual rod run-in as an immediate action?

a. Failure of experimental apparatus

b. High radiation levels

c. Nuclear instrumentation failure

d. Control rod drive failure/stuck rod

QUESTION B.17 [1.0 point]

Which ONE of the following immediate actions should be taken by the operator if he detects a stuck rod drive mechanism during reactor power operation?

a. Attempt to drive the affected rod in until power decreases by 2%.

b. Drive all shim rods in, verifying the stuck rod fails to move.

c. Scram the reactor by placing the Master Control Switch 1S1 in TEST.

d. Stop all rod movement and notify the shift supervisor.

QUESTION B.18 [1.0 point]

Identify each of the following reactor plant limitations as a Safety Limit (SL), Limiting Safety System Setting (LSSS) or a Limiting Condition for Operation (LCO). (Choices may be used more than once or not at all.)

a. Reactor Inlet Temperature 155°F (Maximum)

b. Primary Coolant Flow, 1625 gpm either Loop (Minimum)

c. The reactor shall be subcritical by a margin at least 0.02 ΔK with an any one shim blade fully withdrawn.

d. The reactor shall not be operated … unless the following are operable: The Siphon Break System

QUESTION C.1 [1.0 point]

Which ONE of the following conditions will cause Secondary Coolant Pump SP-4 to stop?

a. Secondary coolant pump SP-1 is also running, and you start secondary coolant pump SP-2.

b. Secondary coolant pump SP-1 which is also running, fails.

c. Building Supply Fan SF-1, fails.

d. Building Exhaust Fans EF-13 and 14 both fail.

QUESTION C.2 [2.0 points, ½ each]

Match the purification system conditions listed in column A with their respective causes listed in column B. Each choice is used only once.

Column A	Column B
a. High Radiation Level at Demineralizer.	1. Channeling in Demineralizer.
b. High Radiation Level downstream of Demineralizer.	2. Fuel element failure.
c. High flow rate through Demineralizer.	3. High temperature in Demineralizer system.
d. High pressure upstream of Demineralizer.	4. Clogged Demineralizer.

QUESTION C.3 [1.0 point]

Which one of the following design features minimizes the effects of H^3 (Tritium)?

a. Vents at the top of the pool

b. Hold up tanks in the primary coolant system

c. Primary demineralizer system

d. Controlled release of the gases held in the beam ports

QUESTION C.4 [1.0 point]

Which one of the following describes the automatic operation of the Shim Rods?

a. The Shim Rods insert when the Regulating Rod position decreases to 20% withdrawn

b. The Shim Rods withdraw when the Regulating Rod position decreases to 20%

c. The Shim Rods insert when the Regulating Rod position increases to 20% withdrawn

d. The Shim Rods withdraw when the Regulating Rod position increases to 10% withdrawn-81

QUESTION C.5 [1.0 point]

Which ONE of the following describes the response of the regulating blade to a reactor scram signal?

a. It's electromagnetic clutch deenergizes and the rod falls into the core via the force of gravity.

b. The rod will be driven into the core.

c. The rod will withdraw in an attempt to compensate for the shim blades insertion.

d. The rod will remain in its position.

QUESTION C.6 [1.0 point]

The corrosion inhibitors require a pH range between 7 and 8 to work correctly. Which ONE of the following is added to the secondary to maintain the pH?

a. Carbonic Acid

b. Sulfuric Acid

c. Sodium Hydroxide

d. Potassium-Tetraborate-Tetrahydrate.

QUESTION C.7 [1.0 point]

Match the channel in column A with the correct detector in column B.

Column A	Column B
a. Fission Product Monitor	1. Geiger Müeller
b. Secondary Coolant Monitor	2. Scintillation Detector
c. Stack Gas Monitor	3. GeLi Detector
d. Stack Particulate Monitor	4. BF_3 Ion Chamber Detector
e. Stack Iodine Monitor	
f. Bridge ARMS	
g. Exhaust Plenum 1	
h. Room 114 ARMS	

QUESTION C.8 [1.0 point]

The ventilation system has two backup doors located in the ventilation supply and return plenums which shut on containment isolation. Which ONE of the following is the method used to shut these doors? The doors are …

a. air motor operated, with their own emergency air supply tanks.

b. motor operated, with air supplied from the emergency air supply system.

c. held open by solenoid, which when deenergized, the door closes via gravity.

d. held open by air pistons, which when vented, the doors close via gravity.

QUESTION C.9 [1.0 point]

During normal operation a thermal column door open alarm will …

a. have no effect on the operation of the reactor.

b. cause a rod run-in.

c. cause a reactor scram.

d. prevent withdrawal of control rods.

QUESTION C.10 [1.0 point]

Which one of the following describes the operation of the emergency power system on a loss of normal power? The emergency generator starts …

a. five (5) seconds after the loss of normal power, closes in on the bus, and automatically transfers back to normal power as soon as it is restored

b. one (1) second after the loss of normal power, and must be manually transferred back to normal power when it is restored

c. five (5) seconds after the loss of normal power, and automatically shuts down ten (10) minutes after normal power is restored

d. one (1) second after the loss of normal power and automatically transfers back to normal power ten (10) minutes after normal power is restored

QUESTION C.11 [1.0 point]

Which ONE of the following conditions will NOT result in the changing the regulating blade control from automatic to manual.

a. Scram

b. Run-In

c. Shimming a control blade

d. Operating the regulating blade switch

QUESTION C.12 [2.0 points, ¼ each]

Identify the components labeled a through h on the figure of a Control Blade Drive Mechanism provided. (Note: Items are used only once. Only one answer per letter.)

a. ___ 1. Drive Tube Bearing

b. ___ 2. Gear Motor

c. ___ 3. Lead Screw

d. ___ 4. Limit Switch Actuator

e. ___ 5. Lower Limit Switch and Stop

f. ___ 6. Position Transmitter

g. ___ 7. Scram Magnet Assembly

h. ___ 8. Upper Limit Switch and Stop

QUESTION C.13 [1.0 point]

The purpose of the thermal column is to …

a. enhance heat transfer characteristics of the core.

b. enhance natural convection flow.

c. provide a thermal temperature rise for experiments.

d. provide a thermal neutron flux for experiments.

QUESTION C.14 [1.0 point]

The normal path for adding water to the pool is by way of gravity drain from either demineralized water tank to …

a. a diffuser header located about a foot below the normal fill line.

b. the suction of the pool coolant system pump.

c. a garden hose located at the top of the reactor pool.

d. The suction of the pool skimmer pump.

QUESTION C.15 [1.0 point]

The reactor has been operating for six days straight at full power when the facility has a complete loss of power. How is damage to the fuel prevented?

a. Two thermally (temperature) actuated valves open allowing steam to escape from the primary system, which is quenched in the pool water.

b. Two air operated valves fail open due to loss of electrical power, lining up the primary to an in-pool heat exchanger. Water flow is via natural convection.

c. Two thermally (temperature) actuated valves open, lining up the primary to an in-pool heat exchanger. Water flow is via natural convection.

d. Two motor operated valves (powered off the diesel) open, lining up the primary to an in-pool heat exchanger.

QUESTION C.16 [1.0 point]

Which ONE of the following is the method used to DE-ICE the cooling tower fans.

a. Run the cooling tower fan in reverse.

b. Use the facilities steam line located in the area for that purpose.

c. Use a heat gun (similar to a hair dryer) designated for de-icing use.

d. De-icing is not necessary due to anti-freeze added to cooling tower water.

QUESTION C.17 [1.0 point]

Which ONE of the following is the reason that the pool DI system water returns to the pool about 2 feet below the pool surface? In order to …

a. aid in the mixing of the water, which results in a more even temperature distribution.

b. create a blanket of warmer water at the top of the pool to reduce mixing, and therefore reduce the dose rate at the surface of the pool.

c. reduce pool surface temperature, since DI water is cooler than pool water.

d. reduce interference between the pool cooling system and the pool skimmer, which takes its suction at the pool surface.

A.1 a 1; b, 2; c, 1; d, 3; e, 4
REF: Standard NRC question.

~~A.2 a~~ Question deleted per facility comment.
~~REF:~~

A.3 a
REF: Reference 1, Module 4, R Theory (R Operations), E.O. 2.7, pg. 17

A.4 c
REF: $P = P_0 e^{t/T}$ —> ln(2) = time ÷ 100 seconds –> time = ln (2) x 100 sec.
0.693 x 100 ≈ 0.7 x 100 ≈ 70 sec. Reference 1, Module 4, R Theory (R Operations), E.O. 2.1, pg. 17

A.5 c
REF: Reference 1, Module 3, R Theory (Nuclear Parameters), E.O. 3.1, pg. 30

A.6 c
REF: Reference 1, Module 2, R Theory (Neutron Characteristics), E.O. 2.13, ppg. 23 - 28.

A.7 a
REF: Reference 1, Module 4, R Theory (R Operations), E.O. 3.2, pg. 23

A.8 b
REF: Reference 1, Module 3, R Theory (Nuclear Parameters), E.O. 1.9, pg. 18

A.9 a, 2; b, 4; c, 1; d, 3
REF: Reference 1, Module 2, R Theory (Neutron Characteristics), E.O. 3.1, pg. 29

A.10 b (22 minutes)
REF: Standard NRC Question $A = A_0 e^{-\lambda T}$

A.11 b
REF: Reference 1, Module 2, R Theory (Neutron Characteristics), E.O. 2.3, pg. 9

A.12 c
REF: Reference 1, Module 2, R Theory (Neutron Characteristics), E.O. 2.1.b, pg. 15

A.13 b
REF: Reference 1, Module 3, R Theory (Nuclear Parameters), E.O. 1.1 a&b, pg. 9

A.14 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.15 a, 7; b, 2; c, 1; d, 5
REF: Standard NRC Question

A.16 a
REF: Reference 1, Module 3, R Theory (Nuclear Parameters), E.O. 4.5, pg. 38

A.17 d
REF: Reference 1, Module 4, R Theory (R Operations), E.O. 1.4, pg. 7
Reference 1: DOE Fundamentals Handbook Nuclear Physics and Reactor Theory Volumes 1 and 2, January 1993.

B.1 b
REF: Technical Specification 3.10

B.2 d $2^{10} = 1024 \approx 1000$
REF: Standard NRC Question

B.3 c
REF: EP-RO-018, *Emergency Radiation Exposure*, page 2.

B.4 c
REF: OP-RO-210, Precaution 3.4.

B.5 d
REF: NRC Examination administered September 11, 2001.

B.6 a, Test; b, Check; c, Cal; d, Check
REF: Technical Specification

B.7 a, 6; b, 2; c, 1; d, 2
REF: 10CFR55

B.8 c
REF: AP-RO-110, Conduct of Operations, § 6.5.6.b. pg. 11.

B.9 c
REF: T.S. 1.2 Calibration or Testing Interval.

B.10 c
REF: AP-RO-110, § 6.6.5.d

B.11 b
REF: 10CFR50.54(y)

B.12 b
REF: EP-RO-013, Facility Evacuation, Attachement 5.1, Evacuation Map

B.13 d
REF: Technical Specification 3.6(m)

B.14 d
REF: AP-RO-110, § 6.6.8.

B.15 d
REF: Technical Specifications, §§ 3.1(g)–(k).

B.16 a
REF: REP-12; REP-4; REP-5; REP-8

B.17 c
REF: REP-8

B.18 a, LSSS; b, LSSS; c, LCO; d, LCO
REF: Technical Specifications 2.2, 3.1.e and 3.9a(1).

C.1 c
REF: OP-RO-430 Secondary Coolant System, § 3.4

C.2 a, 2; b, 3; c, 1; d, 4
REF: Standard NRC question

C.3 a
REF: CAF

C.4 a
REF: HSR, § 9.6.2 last ¶,

C.5 d
REF: HSR, 9.6.

C.6 b
REF: HSR § 5.4.6, pg. 5-26.

C.7 a, 2; b, 2; c, 1; d, 2; e, 2; f, 1; g, 1; h, 1
REF: MURR Facility prepared Requalification Examination administered 11/93.

C.8 d
REF: HSR § 3.2.5, Last ¶ on pg. 3-4 and 1st ¶ on pg. 3-5.

C.9d
REF: Rewrite of facility supplied question, also HSR § 8.6 last sentence.

C.10 d.
REF: HSR § 7.1.4 pp 7-4

C.11 c
REF: HSR, § 9.6.2

C.12 a, 2; b, 6; c, 8; d, 3; e, 4; f, 5; g, 1; h, 7
REF: MURR Schematic Diagram of a Control Blade Mechanism

C.13 d
REF: HSR § 8.6.

C.14 d
REF: OP-RO-465, § 6.1

C.15 b
REF: HSR, §§ 5.2.7 and 7.1.1

C.16 a
REF: OP-RO-480, § 6.3

C.17 b
REF: MURR HSR, § 7.1.10 p. 7-15.

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

FACILITY: University of Missouri-Columbia

REACTOR TYPE: TANK

DATE ADMINISTERED: 2004/08/17

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. Facillity 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 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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$T_{½} = \frac{0.693}{\lambda}$$

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

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

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

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

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

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

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.1e 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 ___

A.9b 1 2 3 4 ___

A.9c 1 2 3 4 ___

A.9d 1 2 3 4 ___

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.15a 1 2 3 4 5 6 7 ___

A.15b 1 2 3 4 5 6 7 ___

A.15c 1 2 3 4 5 6 7 ___

A.15d 1 2 3 4 5 6 7 ___

A.16 a b c d ___

A.17 a b c d ___

B.1 a b c d ___

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.6a Check Test Cal ___

B.6b Check Test Cal ___

B.6c Check Test Cal ___

B.6d Check Test Cal ___

B.7a 1 2 4 6 ___

B.7b 1 2 4 6 ___

B.7c 1 2 4 6 ___

B.7d 1 2 4 6 ___

B.8 a b c d ___

B.9 a b c d ___

B.10 a b c d ___

B.11 a b c d ___

B.12 a b c d ___

B.13 a b c d ___

B.14 a b c d ___

B.15 a b c d ___

B.16 a b c d ___

B.17 a b c d ___

B.18a SL LSSS LCO ___

B.18b SL LSSS LCO ___

B.18c SL LSSS LCO ___

B.18d SL LSSS LCO ___

C.1 a b c d ___

C.2a a b c d ___

C.2b 1 2 3 4 ___

C.2c 1 2 3 4 ___

C.2d 1 2 3 4 ___

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.7a 1 2 3 4 ___

C.7b 1 2 3 4 ___

C.7c 1 2 3 4 ___

C.7d 1 2 3 4 ___

C.7e 1 2 3 4 ___

C.7f 1 2 3 4 ___

C.7g 1 2 3 4 ___

C.7h 1 2 3 4 ___

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.12a 1 2 3 4 5 6 7 8 ___

C.12b 1 2 3 4 5 6 7 8 ___

C.12c 1 2 3 4 5 6 7 8 ___

C.12d 1 2 3 4 5 6 7 8 ___

C.12e 1 2 3 4 5 6 7 8 ___

C.12f 1 2 3 4 5 6 7 8 ___

C.12g 1 2 3 4 5 6 7 8 ___

C.12h 1 2 3 4 5 6 7 8 ___

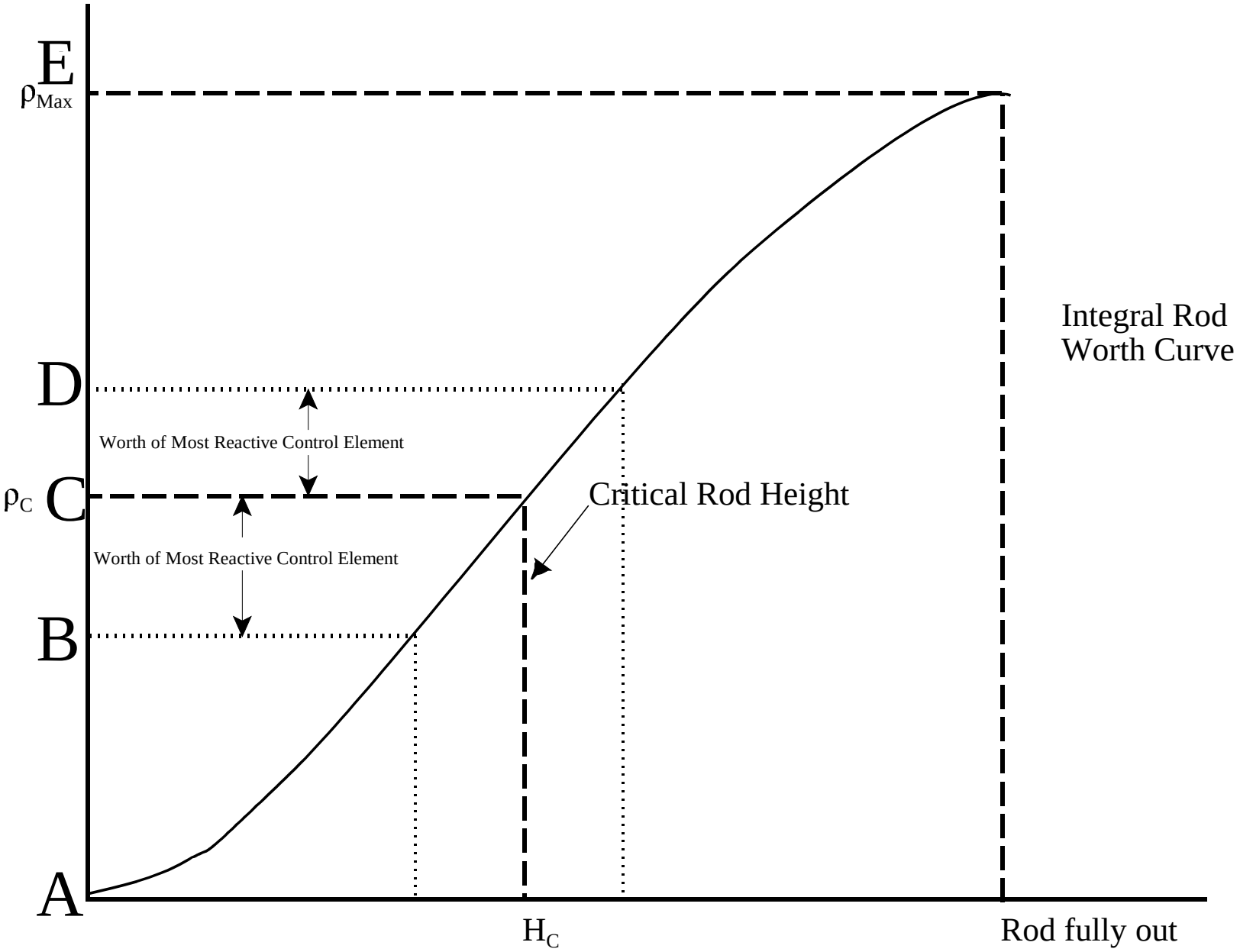
C.13 a b c d ___

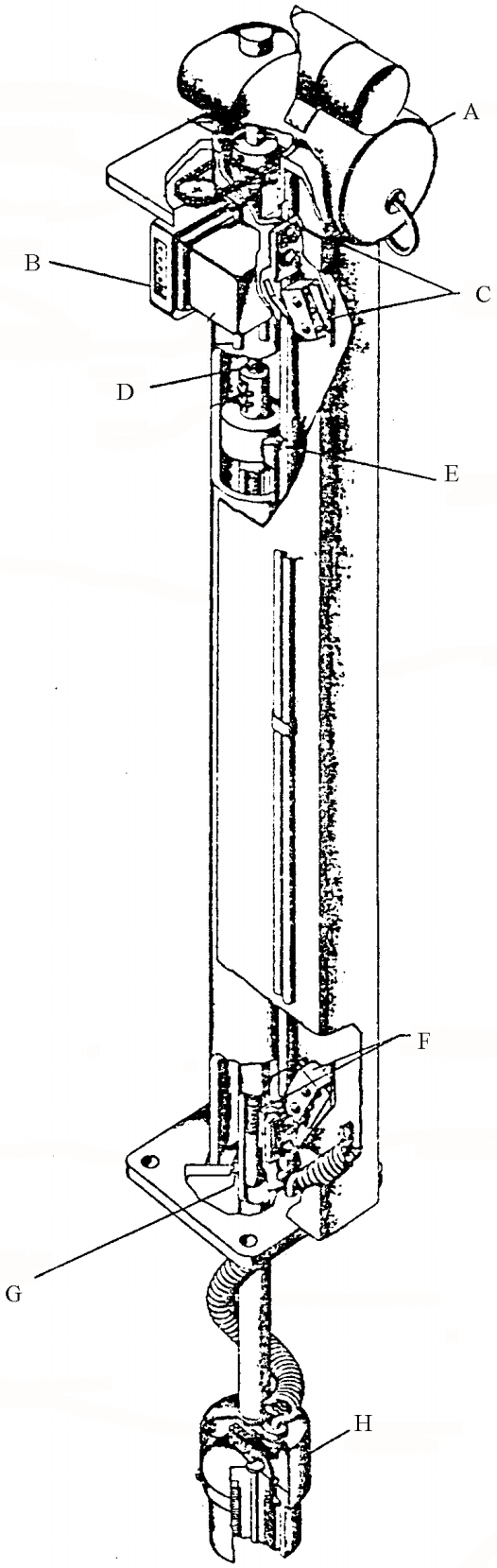
C.14 a b c d ___

C.15 a b c d ___

C.16 a b c d ___

C.17 a b c d ___


E
ρ_{Max}
D
Worth of Most Reactive Control Element
ρ_C C
Critical Rod Height
Worth of Most Reactive Control Element
B
A
H_C
Rod fully out
Integral Rod
Worth Curve



Control Blade Drive Mechanism