October 3, 2003

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

SUBJECT: RETAKE EXAMINATION REPORT NO. 50-186/OL-03-01R, UNIVERSITY OF MISSOURI-COLUMBIA

Dear Mr. Butler:

During the week of June 30, 2003, your staff administered an NRC prepared operator licensing examination at your University of Missouri – Columbia Reactor. The examination was conducted according to NUREG-1478, "Non-Power Reactor Operator Licensing Examiner Standards," Revision 1.

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 at pvd@nrc.gov.

Sincerely,

/RA/

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

Docket No. 50-186

Enclosures: 1. Initial Examination Report No. 50-186/OL-03-01R
2. Examination and answer key (RO/SRO)

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) O6-D17	

ADAMS PACKAGE ACCESSION NO.: ML032410275 **TEMPLATE #:NRR-074**
ADAMS REPORT ACCESSION NO.: ML032410295

OFFICE	RNRP:CE		IROB:LA	E	RNRP:SC	
NAME	PDoyle:rdr		EBarnhill		PMadden	
DATE	09/ 27 /2003		09/ 26 /2003		09/ 29 /2003	

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Jefferson City, MO 65102

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

REPORT NO.: 50-186/OL-03-01R

FACILITY DOCKET NO.: 50-186

FACILITY LICENSE NO.: R-103

FACILITY: University of Missouri-Columbia

EXAMINATION DATES: July 3, 2003

SUBMITTED BY: **/RA/** 07/08/2003
Paul Doyle, Chief Examiner Date

SUMMARY:

On July 3, 2003, the facility administered an NRC prepared written examination (Section A only) to one Reactor Operator Retake candidate. The candidate passed the examination.

REPORT DETAILS

1. Examiners:
   Paul Doyle, Chief Examiner

2. Results:

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

UNIVERSITY OF MISSOURI–COLUMBIA

With Answer Key

UNITED STATES NUCLEAR REGULATORY COMMISSION

OPERATOR LICENSING EXAMINATION

Week of June 30, 2003

Enclosure 2

QUESTION A.1 [1.0 point]
The reactor is at a power of 1 watt, with a 26 second stable period. How long will it take for power to reach 1000 watts?

a. ≈180 seconds

b. ≈153 seconds

c. ≈121 seconds

d. ≈78 seconds

QUESTION A.2 [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.3 [1.0 point]
If the primary flow rate is 3700 gpm and the ΔT across the primary side of the heat exchanger is 15.5°F, what is the power being transferred to the secondary side of the heat exchanger? (Assume no losses to the ambient surroundings, including the pool).

a. 12 megawatts.

b. 10 megawatts.

c. 8 megawatts.

d. 6 megawatts.

QUESTION A.4 [1.0 point]
An experimenter makes an error loading a rabbit sample. Sample injection results in a 100 millisecond period. If the scram set point is 12.5 MW and the scram delay time is 0.1 seconds, WHICH ONE of the following is the peak power of the reactor at shutdown. (Assume Rabbit system is operational for this question.)

a. 12.5 MW

b. 25 MW

c. 34 MW

d. 125 MW

QUESTION A.5 [1.0 point]
The reactor had been running for 36 hours straight at 10 megawatts when it was shutdown for maintenance. The maintenance took six hours, and you have just restarted the reactor and raised power to 10 megawatts and placed the reactor in auto control. Which ONE of the following is the expected response of the regulating rod for the next half hour? (Assume no fuel replacement during shutdown.)

a. Drive in

b. Drive out

c. Not move

d. Drive out then back in

QUESTION A.6 [1.0 point]
You perform two startups with exactly the same conditions (temperature, xenon, samarium, rod speed, etc.). For the first startup you proceed directly to criticality. For the second startup, you stop after pulling the rods in gang to 10 inches, to speak on the phone for 10 minutes. Which ONE of the following best describes the rod height and power at criticality for the second startup relative to the first startup?

a. Rod height will be lower, Power will be the same.

b. Rod height will be higher, Power will be the same.

c. Rod height will be the same, Power will be higher.

d. Rod height will be the same, Power will be the same.

QUESTION A.7 [1.0 point]
You enter the control room and note that all nuclear instrumentation show a steady neutron level, and no rods are in motion. Which ONE of the following conditions CANNOT be true?

a. The reactor is critical.

b. The reactor is subcritical.

c. The reactor is supercritical.

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

QUESTION A.8 [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.9 [1.0 point]
ELASTIC SCATTERING is the process by which a neutron collides with a nucleus and …

a. recoils with the same kinetic energy it had prior to the collision

b. recoils with less kinetic energy than it had prior to the collision with the nucleus emitting a gamma ray.

c. is absorbed, with the nucleus emitting a gamma ray.

d. recoils with a higher kinetic energy than it had prior to the collision with the nucleus emitting a gamma ray.

QUESTION A.10 [1.0 point]
Which ONE of the following statements concerning reactor poisons is NOT true?

a. Following shutdown, Samarium concentration will increase to some value then stabilize.

b. Following shutdown, Xenon concentration will initially increase to some value then decrease exponentially

c. During reactor operation, Samarium concentration is independent of reactor power level.

d. During reactor operation, Xenon concentration is dependent on reactor power level.

QUESTION A.11 [1.0 point]
Which of the following statements describes the concentration of Xenon in the core after a scram from extended operation at 10 MW? Xenon concentration …

a. initially decreases due to the loss of Iodine production then increases to maximum concentration

b. decreases to a Xenon free condition in approximately ten (10) hours

c. increases to maximum in approximately ten (10) hours due to the reduction in Xenon burnup

d. remains at equilibrium value since power level has no effect on Xenon concentration

QUESTION A.12 [1.0 point]
Reactivity is …

a. a measure of the core's deviation from criticality.

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

c. negative when K_{eff} is greater than 1.0.

d. equal to 5% $\Delta K/K$ when the reactor is prompt critical.

QUESTION A.13 [1.0 point]
Which ONE of the following conditions will INCREASE the shutdown margin of a reactor.

a. Insertion of a positive reactivity worth experiment

b. Lowering moderator temperature (Assume negative temperature coefficient).

c. Burnout of a burnable poison.

d. Fuel depletion.

QUESTION A.14 [1.0 point]
The effective neutron multiplication factor, K_{eff} is defined as…

a. absorption/(production + leakage)

b. (production + leakage)/absorption

c. (absorption + leakage)/production

d. production/(absorption + leakage)

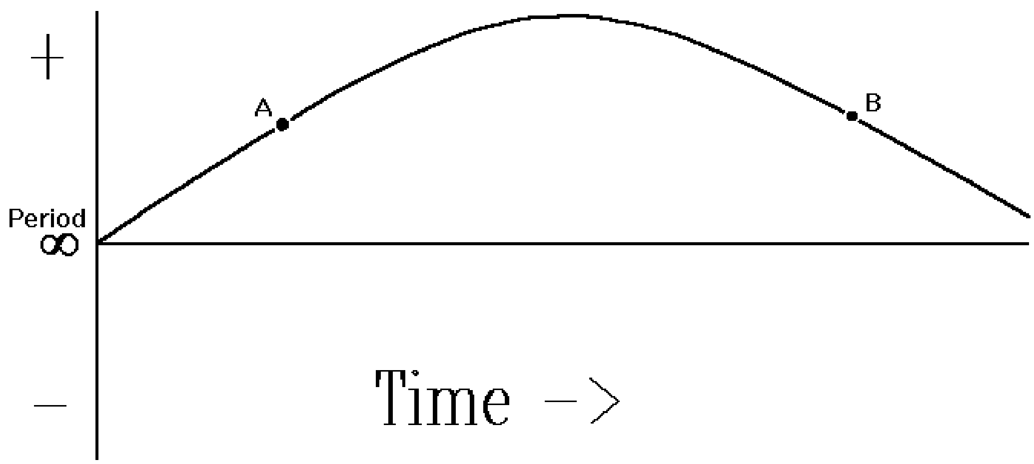
QUESTION A.15 [1.0 point]
Shown below is a trace of reactor period as a function of time. Between points A and B reactor power is:

a. continually increasing.

b. continually decreasing.

c. increasing, then decreasing.

d. constant.



QUESTION A.16 [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.17 [1.0 point]
A reactor is slightly supercritical with the following values for each of the factors in the six-factor formula…

Fast Fission Factor (ε)	= 1.03	Fast Non-Leakage probability ($\mathcal{L}_f$)	= 0.84
Resonance Escape probability (p)	= 0.96	Thermal Non-Leakage probability ($\mathcal{L}_{th}$)	= 0.88
Thermal Utilization Factor (f)	= 0.70	Reproduction Factor (η)	= 1.96

A control rod is inserted to bring the reactor back to critical. Assuming all other factors remain unchanged, the new value for the thermal utilization factor (f) is…

a. 0.698

b. 0.702

c. 0.704

d. 0.708

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. ρ_{max} - ρ_C

d. Areas under curve “A” & “B”

QUESTION A.19 [1.0 point]
Which ONE of the following is the correct definition of $\beta_{effective}$? The number of delayed neutrons compared to the total number of neutrons per generation …

a. corrected for resonance escape.

b. corrected for leakage.

c. corrected for time after the fission event.

d. corrected for both leakage and resonance escape.

QUESTION A.20 [1.0 point]
To make a just critical reactor "PROMPT CRITICAL", by definition you must add reactivity equal to …

a. τ_{eff}

b. λ_{eff}

c. β_{eff}

d. K_{eff}

A.1	a, $P = P_0\, e^{t/T}$ ➔ ln(1000/1) = t/26sec ➔ 26sec × 6.9078 = 179.6 ≈ 180
REF:	Primary Reference, Volume 2, Module 4, Reactor Theory (Reactor Operations), Enabling Objective 2.1.

A.2	a
REF:	Primary Reference, Volume 2, Module 4, Reactor Theory (Reactor Operations), Enabling Objective 2.1.

A.3	c

$$Q = mc_P \Delta T$$

$$\dot{Q} = 3700\frac{gallons}{\quad} \times 8\frac{lbm}{\quad} \times 60\frac{minutes}{\quad} \times 1\frac{BTU}{\circ \quad -} \times 15.5^{\circ}F \times \frac{1Mw{-}Hr.}{6}$$

REF:	DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory.

A.4	c, $P = P_0\, e^{t/\tau}$, P = 12.5 Mwatt × $e^{0.1/0.1}$ = 12.5 × e = 33.979.
REF:	Primary Reference, Volume 2, Module 4, Reactor Theory (Reactor Operations), Enabling Objective 2.6.

A.5	a
REF:	Primary Reference, Volume 2, Module 3, Reactor Theory (Nuclear Parameters), Enabling Objective 4.5.

A.6	c
REF:	Primary Reference, Volume 2, Module 4, Reactor Theory (Reactor Operations), Enabling Objective 1.1.

A.7	c
REF:	Primary Reference, Volume 2, Module 4, Reactor Theory (Reactor Operations), Enabling Objectives 1.1, and 3.3.

A.8	c
REF:	Primary Reference, Volume 1, Module 2, Reactor Theory (Nuclear Characteristics), Enabling Objective 2.1.b.

A.9	a
REF:	Primary Reference, Volume 1, Module 1, Atomic and Nuclear Physics, Enabling Objective 3.1

A.10	c
REF:	Primary Reference, Volume 2, Module 3, Reactor Theory (Nuclear Parameters), Enabling Objectives 4.1 through 4.15.

A.11	c
REF:	Primary Reference, Volume 2, Module 3, Reactor Theory (Nuclear Parameters), Enabling Objective 4.5.

A.12	a
REF:	Primary Reference, Volume 2x, Module 4, Reactor Theory (Nuclear Parameters), Enabling Objective 1.9.

A.13	d
REF:	Primary Reference, Volume 2, Module 4, Reactor Theory (Reactor Operations), Enabling Objective 3.6

A.14	d
REF:	Primary Reference, Volume 2, Module 4, Reactor Theory (Reactor Operations), Enabling Objective 1.1

A.15	a
REF:	Standard NRC Question

A.16	c
REF:	Primary Reference, Volume 2, Module 4, Reactor Theory (Reactor Operations), Enabling Objective 5.4

A.17	a
REF:	Primary Reference, Volume 2, Module 3, Reactor Theory (Nuclear Parameters), Enabling Objective 1.2

A.18 c
REF: Standard NRC Question covering Technical Specification Parameter.

A.19 d
REF: Primary Reference, Volume 2, Module 4, Reactor Theory (Reactor Operations), Enabling Objective 2.2

A.20 c
REF: Primary Reference, Volume 2, Module 4, Reactor Theory (Reactor Operations), Enabling Objective 2.8

Primary Reference: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory.

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

FACILITY: University of Missouri-Columbia

REACTOR TYPE: TANK

DATE ADMINISTERED: Week of June 30, 2003

CANDIDATE: ______________________________

INSTRUCTIONS TO CANDIDATE:
Circle correct answers on the answer sheets provided. If you wish to change your answer, cross out the incorrect answer and write the correct answer on the line provided to the right. If you wish to change your answer again, cross out the incorrect answer and write the correct answer to the right of the last answer. Points for each question are indicated in brackets for each question number. You must achieve a grade of 70% in each section is required to pass the examination. Examinations will be picked up three (1) hour 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		______	____%	TOTALS
			FINAL GRADE	

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

____
Candidate's Signature

NRC RULES AND GUIDELINES FOR LICENSE EXAMINATIONS

During the administration of this examination the following rules apply:

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

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

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

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

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

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

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

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

9. When turning in your examination, assemble the completed examination 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 one (1) hour 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.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 ___

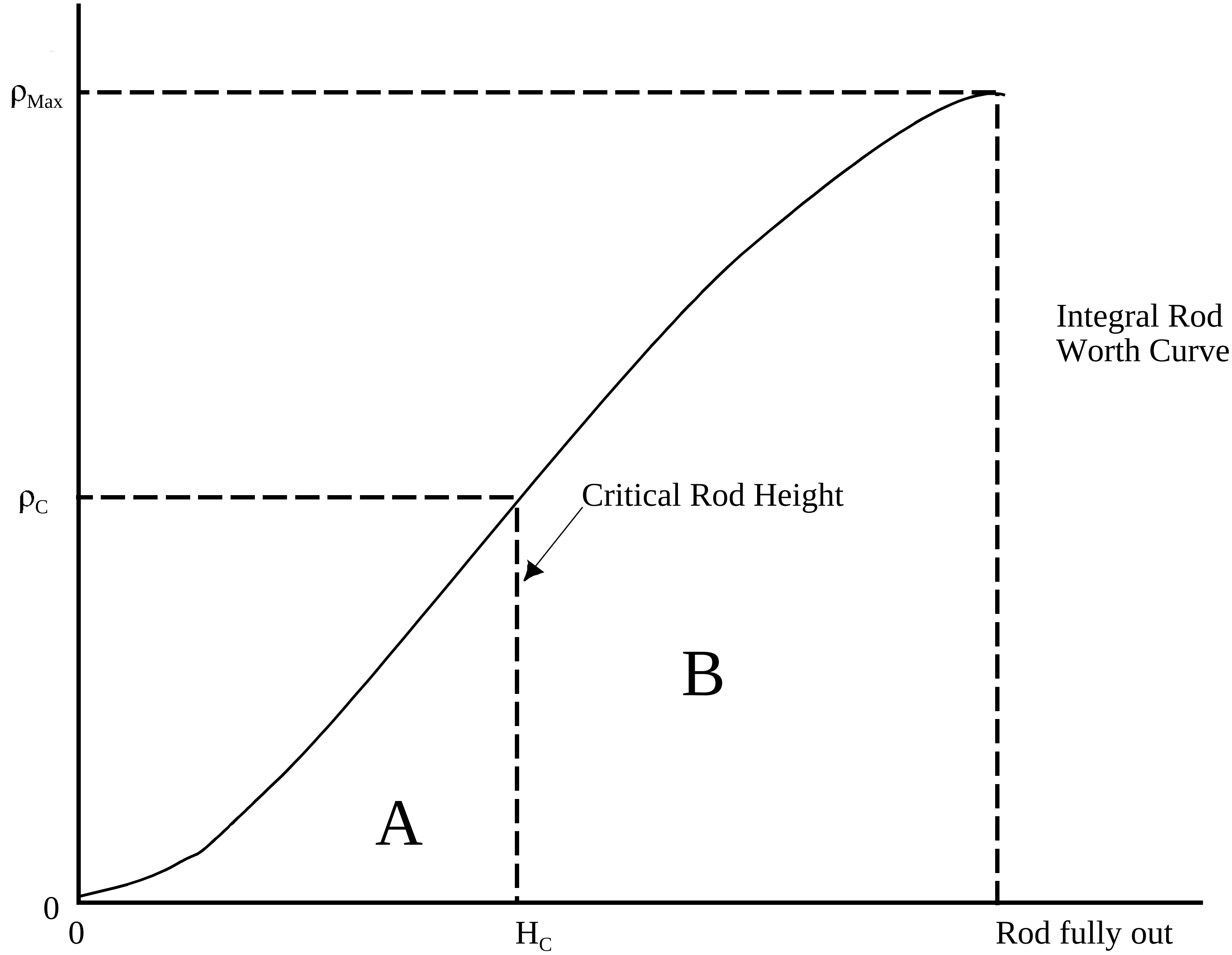
A.16 a b c d ___

A.17 a b c d ___

A.18 a b c d ___

A.19 a b c d ___

A.20 a b c d ___



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