January 2, 2008

Dr. Samuel Frimpong, Chair
Mining and Nuclear Engineering
226 McNutt Hall
University of Missouri-Rolla
Rolla, MO 65409-0450

SUBJECT: INITIAL EXAMINATION REPORT NO. 50-123/OL-08-01,
UNIVERSITY OF MISSOURI–ROLLA

Dear Dr. Frimpong:

During the week starting Monday December 3, 2007, the NRC administered an operator licensing examination at the University of Missouri-Rolla Reactor. The examination was conducted according to NUREG-1478, "Operator Licensing Examiner Standards for Research and Test Reactors," Revision 2. Examination questions and preliminary findings were discussed with those members of your staff identified in the enclosed report at the conclusion of the examination.

In accordance with Title 10 of the Code of Federal Regulations Section 2.390, 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 http://www.nrc.gov/reading-rm/adams.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. Phillip T. Young at 301.415.4094 or via internet e-mail pty@nrc.gov.

Sincerely,

/RA/

Johnny Eads, Chief
Research and Test Reactors Branch B
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Docket No. 50-123

Enclosures: 1. Initial Examination Report No. 50-50-123/OL-08-01
2. Written examination with facility comments incorporated

cc without enclosures:
Please see next page

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Docket No. 50-123
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2. Written examination
cc without enclosures:
Please see next page
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ADAMS ACCESSION #: ML073510376 TEMPLATE #:NRR-074

OFFICE	PRTB:CE		IOLB:LA	E	PRTB:SC	
NAME	PYoung pty		CHart cah		JEads jhe	
DATE	12/17/2007		12/20/2007		1/2/2007	

OFFICIAL RECORD COPY

cc:

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

ENCLOSURE 1

EXAMINATION REPORT NO: 50-123/OL-08-01

UNIVERSITY OF MISSOURI – ROLLA

FACILITY LICENSE NO.: R-79

SUBMITTED BY: */RA/* 12/ 18 /2007

Phillip T. Young, Chief Examiner Date

SUMMARY:

During the week of December 3, 2007, the NRC administered an operator licensing examination to one Senior Reactor Operator. The applicant passed all portions of the examination

Exit Meeting:
Phillip T. Young, Chief Examiner
Dan Estel, Training Coordinator
William E. Bonzer, Reactor Manager

At the conclusion of the site visit, the examiner met with representatives of the facility staff to discuss the results of the examinations. The examiner thanked the facility for their support of the examination. The facility presented comments on the written examination, and these comments have been incorporated into the examination attached to this report.

U.S. NUCLEAR REGULATORY COMMISSION
RESEARCH AND TEST REACTOR LICENSE EXAMINATION

UNIVERSITY OF MISSOURI – ROLLA

WRITTEN EXAMINATION

12/05/2007

ENCLOSURE 2

Question A.001 [1.0 point] (1.0)
Control Rod withdrawal predominantly changes K_{eff} by changing the …

a. fast fission factor (ε).
b. thermal utilization factor (f).
c. neutron reproduction factor (η).
d. resonance escape probability (p).

Answer: A.001 b.
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, §

Question A.002 [1.0 point] (2.0)
Using the Integral Rod Worth Curve provided identify which ONE of the following represents ρ_{excess}

a. Area under curve "B"
b. ρ_C
c. $\rho_{max} - \rho_C$
d. Area under curve "A" and "B"

Answer: A.002 c.
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, §

Question A.003 [1.0 point] (3.0)
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}

Answer: A.003 c.
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, §

Question A.004 [1.0 point] (4.0)
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

Answer: A.004 b.
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, §

Question A.005 [1.0 point] (5.0)
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

Answer: A.005 c.
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, §
$CR_1/CR_2 = (1-k_{eff2})/(1 - k_{eff1}) = (1 - keff_2) = (1 - 0.98) \times 50/55 = 0.02 \times 50/55 =$
-0.018182 or $k_{eff} = 0.98182$
$\Delta\rho = (k_{eff2} - k_{eff1})/(k_{eff2}\ k_{eff1}) = (098182 - 0.98000)/(098182 \times 0.98000) =$
$1.890 \times 10^{-3} = 0.189\%$ delta k/k

Question A.006 [1.0 point] (6.0)
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

Answer: A.006 b.
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, §

Question A.007 [1.0 point] (7.0)
Two critical reactors at low power are identical except that Reactor 1 has a beta fraction of 0.0072 and Reactor 2 has a beta fraction of 0.0060. An equal amount of positive reactivity is inserted into both reactors. Which ONE of the following will be the response of Reactor 2 compared to Reactor 1?

a. The resulting power level will be lower.

b. The resulting power level will be higher.

c. The resulting period will be longer.

d. The resulting period will be shorter.

Answer: A.007 d.
Reference: Equation Sheet. $\tau = (\ell^*/\rho) + [(\beta-\rho)/\lambda_{eff}\rho]$

Question deleted per facility comment.
~~**Question A.008** [1.0 point] (8.0)~~
~~You perform two initial startups a week apart. Each of the startups has the same starting conditions, (core burnup, pool and fuel temperature, and count rate are the same). The only difference between the two startups is that during the SECOND one you stop for 10 minutes to answer the phone. For the second startup compare the critical rod height and count rate to the first startup.~~

	~~Rod Height~~	~~Count Rate~~
~~a.~~	~~Higher~~	~~Same~~
~~b.~~	~~Lower~~	~~Same~~
~~c.~~	~~Same~~	~~Lower~~
~~d.~~	~~Same~~	~~Higher~~

~~Answer: A.008 d.~~
~~Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, §~~

Question A.009 [1.0 point] (9.0)
Reactor Power increases from 15 watts to 65 watts in 30 seconds. The period of the reactor is:

a. 7 seconds

b. 14 seconds

c. 21 seconds

d. 28 seconds

Answer: A.009 c.
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, §
$P = P_0 e^{t/\tau}$, $\ln(65/15) = 30\text{sec}/\tau$ $\tau = (30 \text{ sec})/(\ln 4.3333) = 20.456$

Question A.010 [1.0 point] (10.0)
Delayed neutron precursors decay by beta decay. Which ONE reaction below is an example of beta decay?

a. $_{35}Br^{87}$ -> $_{35}Kr^{86}$
b. $_{35}Br^{87}$ -> $_{36}Kr^{87}$
c. $_{35}Br^{87}$ -> $_{34}Kr^{86}$
d. $_{35}Br^{87}$ -> $_{33}Kr^{83}$

Answer: A.010 b.
Reference: Burn, Introduction to Nuclear Reactor Operations, Page 2-30.

Question A.011 [1.0 point] (11.0)
A reactor is subcritical with a Keff of 0.955. A positive reactivity of 3.5% delta k/k is inserted into the core. At this point, the reactor is:

a. supercritical.
b. exactly critical.
c. subcritical.
d. prompt critical.

Answer: A.011 c.
Reference: Burn, Introduction to Nuclear Reactor Operations, Page 3-20.
Initial Reactivity = (K-1)/K = (0.955 -1)/0.955 = - 0.047 delta k/k
After reactivity insertion, net reactivity = - 0.047 + 0.035 = - 0.012 delta k/k

Question A.012 [1.0 point]
During the time when reactor power increases, the delayed neutron fraction, β:

a. remains unchanged.
b. increases because prompt neutrons are being produced at a faster rate.
c. increases because delayed neutron precursors are being produced at a faster rate.
d. decreases because delayed neutrons are being produced from precursors that were formed at a lower power level.

Answer: A.012 d.
Reference: Burn, Introduction to Nuclear Reactor Operations, Page 4-8.

Question A.013 [1.0 point] (13.0)
A thermal neutron is a neutron which:

a. is produced as a result of thermal fission.
b. possesses thermal rather than kinetic energy.
c. has been produced several seconds after its initiating fission occurred.
d. experiences no net change in its energy after several collisions with atoms of the diffusing medium.

Answer: A.013 d.
Reference: Burn, Introduction to Nuclear Reactor Operations, Pages 2-36, 2-45.

Question A.014 [1.0 point] (14.0)
Which ONE of the following factors in the six-factor formula is the simplest to vary by the operator?

a. reproduction factor.
b. thermal utilization factor.
c. thermal non-leakage factor.
d. resonance escape probability.

Answer: A.014 b.
Reference: Burn, Introduction to Nuclear Reactor Operations, Page 3-19.

Question A.015 [1.00 point] (15.0)
Which ONE of the following statements describes the difference between Differential Rod Worth (DRW) and Integral Rod Worth (IRW)?

a. DRW relates the worth of the rod per increment of movement to rod position. IRW relates the total reactivity added by the rod to rod position.
b. DRW relates the time rate of reactivity change to rod position. IRW relates the total reactivity in the core to the time rate of reactivity change.
c. IRW relates the worth of the rod per increment of movement to rod position. DRW relates the total reactivity added by the rod to rod position.
d. IRW is the slope of the DRW at a given rod position.

Answer: A.015 a.
Reference: Burn, Introduction to Nuclear Reactor Operations, Pages 7-1 thru 7-5.

Question B.001 [1.0 point] (1.0)
While working on an experiment, you receive the following radiation doses: 100 mrem (β), 25 mrem (γ), and 5 mrem (thermal neutrons). Which ONE of the following is your total dose?

a. 175 mrem

b. 155 mrem

c. 145 mrem

d. 130 mrem

Answer: B.001 d.
Reference: A rem is a rem is a rem.

Question B.002 [2.0 points, ½ point each] (3.0)
Identify each of the following actions as either a **channel CHECK** (1), a **channel TEST** (2), or a **channel Calibration** (3).

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

b. Prior to the day's operation, you turn the Log Count Rate selector switch to 102, 103, and 104, verifying that the meter and recorder follow.

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

d. During a reactor shutdown you note a -80 second period on Nuclear Instrumentation.

Answer: B.002 a. = 1; b. = 2; c. = 3; d. = 1
Reference: Technical Specification 1.3 Definitions, p. 2.

Question B.003 [1.0 point] (4.0)
In accordance with the Emergency Plan, the site boundary is:

a. the outside walls of the reactor confinement building.

b. a 500 meter radius from the reactor building.

c. the Emergency Support Center.

d. the UMR campus boundary.

Answer: B.003 d.
Reference: University of Missouri-Rolla Emergency Plan, Page 4.

Question B.004 [1.0 point] (5.0)
The reactor parameter which is protected by a Safety Limit is:

a. fuel element cladding temperature.
b. fuel element temperature.
c. primary coolant flow rate.
d. reactor power level.

Answer: B.004 a.
Reference: University of Missouri-Rolla Technical Specifications, Section 2.1.

Question B.005 [1.0 point] (6.0)
A radioactive sample is to be removed from the reactor pool. The sample is surveyed and the dose rate is found to be 60 mR/hr at 1 foot. In accordance with SOP-601, the sample may be handled:

a. by the reactor staff.
b. only with permission from the Health Physicist.
c. by students with the permission of the reactor staff.
d. by students under the direct supervision of the reactor staff.

Answer: B.005 a.
Reference: SOP 601, Handling of Radioactive Samples.

Question B.006 [1.0 point] (7.0)
The Technical Specifications require that experimental verification of calculated values of airborne radioactive effluents be performed annually. The purpose of this requirement is to measure the airborne radioactivity associated with:

a. Nitrogen-16.
b. Argon-41.
c. Iodine-131.
d. Cesium-137.

Answer: B.006 b.
Reference: SAR, Section 7.6.1.

Question B.007 [1.00 point] (8.0)
A radiation survey of an area reveals a general radiation reading of 1 mrem/hr. There is, however, a small section of pipe (point source) which reads 10 mrem/hr at one (1) meter. Which ONE of the following defines the posting requirements for the area in accordance with 10CFR20?

a. "CAUTION RADIATION AREA."
b. "CAUTION RADIOACTIVE MATERIAL."
c. "CAUTION HIGH RADIATION AREA."
d. "GRAVE DANGER, VERY HIGH RADIATION AREA."

Answer: B.007 c.
Reference: 10 CFR 20.1003 DR1D12 = DR2D22
10 mR/hr at 1 meter = 111 mR/hr at 30 cm.

Question B.008 [1.00 point] (9.0)
Which ONE of the operations below does NOT require the authorization or supervision of the Senior Reactor Operator on Duty?

a. Bypass High Radiation Area alarm.
b. Place reactor in automatic control.
c. Power increase on a 35-second period.
d. Operation at greater than 20 kW with no nitrogen diffuser on.

Answer: B.008 b.
Reference: SOP 104, Reactor Power Changes and Stable Operations.

Question B.009 [1.00 point] (10.0)
To maintain an active Reactor Operator or Senior Reactor Operator license, the functions of an operator or senior operator must be actively performed for at least:

a. one hour per month.
b. three hours per calendar quarter.
c. four hours per calendar quarter.
d. twelve hours per year.

Answer: B.009 c.
Reference: 10 CFR 55.53.

Question B.010 [1.00 point] (11.0)
According to SOP 104, "Reactor Power Changes and Stable Operations", at least one diffuser pump should be turned on for operations above …

a. 1 Kilowatt
b. 2 Kilowatts
c. 10 Kilowatts
d. 20 Kilowatts

Answer: B.010 d.
Reference: SOP 104, § B.3.

Question B.011 [1.00 point] (12.0)
You (a licensed Reactor Operator) and a Senior Reactor Operator (SRO) are operating the reactor on the weekend. No one else is available. In order to meet Technical Specifications requirements if you are on the console the SRO must be …

a. within the Reactor Building.
b. within the reactor control room.
c. within the confines of the Campus.
d. within 15 minutes walk of the Reactor Facility.

Answer: B.011 a.
Reference: SOP 101, General Operating Procedures, § B.2

Question B.012 [1.00 point] (13.0)
Because the regulating rod may move without operator action (Auto control) it is limited to a total reactivity worth of less than …

a. 0.03% Δk/k
b. 0.07% Δk/k
c. 0.3% Δk/k
d. 0.7% Δk/k

Answer: B.012 d.
Reference: Technical Specifications § 3.1, specification (4).

Question B.013 [1.00 point] (14.0)
The MINIMUM pool temperature for operation of the reactor is …

a. 12.8°C (55°F)

b. 15.5°C (60°F)

c. 18.3°C (65°F)

d. 21.1°C (70°F)

Answer: B.013 b.
Reference: Technical Specifications § 5.2.1

Question B.014 [1.00 point] (15.0)
The CURIE content of a radioactive source is a measure of

a. the number of radioactive atoms in the source.

b. the amount of energy emitted per unit time by the source

c. the amount of damage to soft body tissue per unit time.

d. the number of nuclear disintegrations per unit time.

Answer: B.014 d.
Reference: Standard Health Physics Definition.

Question C.001 [1.0 point] (1.0)
The Ventilation system consists of three fans mounted on the Reactor Building roof. On a Building Evacuation Alarm from the Reactor Bridge Radiation Area Monitor, the

a. All three fans will secure automatically.

b. All three fans must be secured by the Reactor Operator.

c. The two normal exhaust fans will secure automatically, the emergency exhaust fan will start automatically.

d. The Reactor Operator must secure the two normal exhaust fans and start the emergency exhaust fan.

Answer: C.001 b.
Reference: SOP-501

Question C.002 [1.0 point] (2.0)
Which ONE of the following is the reason that primary temperature is maintained below 57°C (135°F)? This temperature is based upon …

a. the purification system filter melts.

b. a jump in the diffusion of N^{16} from the pool.

c. the bath temperature coefficient changes from negative to positive.

d. the upper limit of the effective temperature range for the ion exchange resin.

Answer: C.002 d.
Reference: SAR § 5.2, p. 5-3.

Question C.003 [1.0 point] (3.0)
Inadvertent movement of the reactor bridge will result in …

a. illumination of a status light only.

b. an evacuation alarm.

c. a reactor scram.

d. a rod rundown.

Answer: C.003 c.
Reference: SAR § 3.2.6, p. 3.19.

Question C.004 [1.0 point] (4.0)
Which ONE of the following is the method used to minimize mechanical shock to the control rods on a scram?

a. A small spring located at the bottom of the rod.

b. An electrical-mechanical brake energizes when the rod down limit switch is energized.

c. A piston (part of the connecting rod) drives air out of a dashpot as the rod nears the bottom of travel.

d. A piston attached to the upper end of the safety rod enters a special damping cylinder as the rod approaches the full insert position.

Answer: C.004 d.
Reference: SAR § 3.2.3, p. 3-13

Question C.005 [1.0 points, ¼ each] (6.0)
Correctly identify the correct protective action {items 1 through 4} with each of the following situations {a. through g.}. Items 1 through 4 may be used more than once.

Protective Actions:

1. Scram
2. Rundown
3. Rod Withdrawal Prohibit
4. Operator Response

Situations:

a. Period < 30 seconds

b. Log N and Period Amp. Not Operative

c. Effluent Pool Demineralizer Conductivity high

d. High Neutron Flux in Beam Room

e. Safety Rods Below Shim Range

f. Reg rod on insert limit in auto control

Answer: C.005 a. = 3; b. = 1; c. = 4; d. = 4; e. = 3; f. = 2
Reference: SAR page 3-41, Table IX

Question C.006 [1.0 point] (7.0)
Which ONE of the following radiation monitors will energize the evacuation alarm?

a. Experiment Room RAM

b. Demineralizer RAM

c. Reactor Bridge RAM

d. CAM

Answer: C.006 c.
Reference: Technical Specifications Table 3.3 and SAR § 3.6.2, pp. 3-46 – 3-48.

Question C.007 [1.0 point] (8.0)
A student operating the reactor attempts to withdraw all four control rods simultaneously. Which ONE of the following describes the correct system response?

a. All four control rods will withdraw.

b. An interlock will prevent all four control rods from withdrawing.

c. The three shim/safety rods will withdraw, an interlock will prevent the regulating rod from withdrawing.

d. The regulating rod will withdraw, an interlock will prevent the three shim/safety rods from withdrawing.

Answer: C.007 c.
Reference: SAR 3.5.5, page 3-36

Question C.008 [1.0 point] (9.0)
On receipt of a scram signal, with the regulating rod controlling in AUTO, the regulating rod will:

a. remain at its position at the time of the scram.

b. receive a rod run-in signal and be driven into the core.

c. be magnetically decoupled from the drive, and drop into the core via gravity.

d. receive a mismatch signal and be driven out of the core attempting to maintain power stable.

Answer: C.008 a.
Reference: SAR § 3.2.3 6th ¶

Question C.009 [1.00 point] (10.0)
During a loss of coolant accident the purification system may be used to refill the pool at a rate of …

a. 10 gpm
b. 20 gpm
c. 30 gpm
d. 40 gpm

Answer: C.009 c.
Reference: SAR § 5.2

Question C.010 [1.00 point] (11.0)
The radiation area monitor located near the thermal column and beam port can automatically initiate:

a. a rundown only.
b. a reactor scram only.
c. a rod withdrawal prohibit only.
d. a reactor scram and building evacuation.

Answer: C.010 a.
Reference: University of Missouri-Rolla SAR, page 3-47.

Question C.011 [1.00 point] (12.0)
Nitrogen gas is used as the transport medium for the pneumatic sample transfer system because:

a. it is non-combustible.
b. it is more compressible than air.
c. it minimizes the production of N-16.
d. it minimizes the production of Ar-41.

Answer: C.011 d.
Reference: University of Missouri-Rolla SAR, page 4-5.

Question C.012 [1.00 point] (13.0)
Compensating voltage to the compensated ion chambers is lost while the reactor is operating. As a result, the power level indication will:

a. increase
b. decrease
c. remain unchanged
d. increase or decrease, depending on the power level

Answer: C.012 a.
Reference: When compensation voltage is lost, detector reads both the neutron & gamma signals.

Question C.013 [1.00 point] (14.0)
Why is one of the pneumatic tube system core termini (plural of terminus), lined with cadmium?

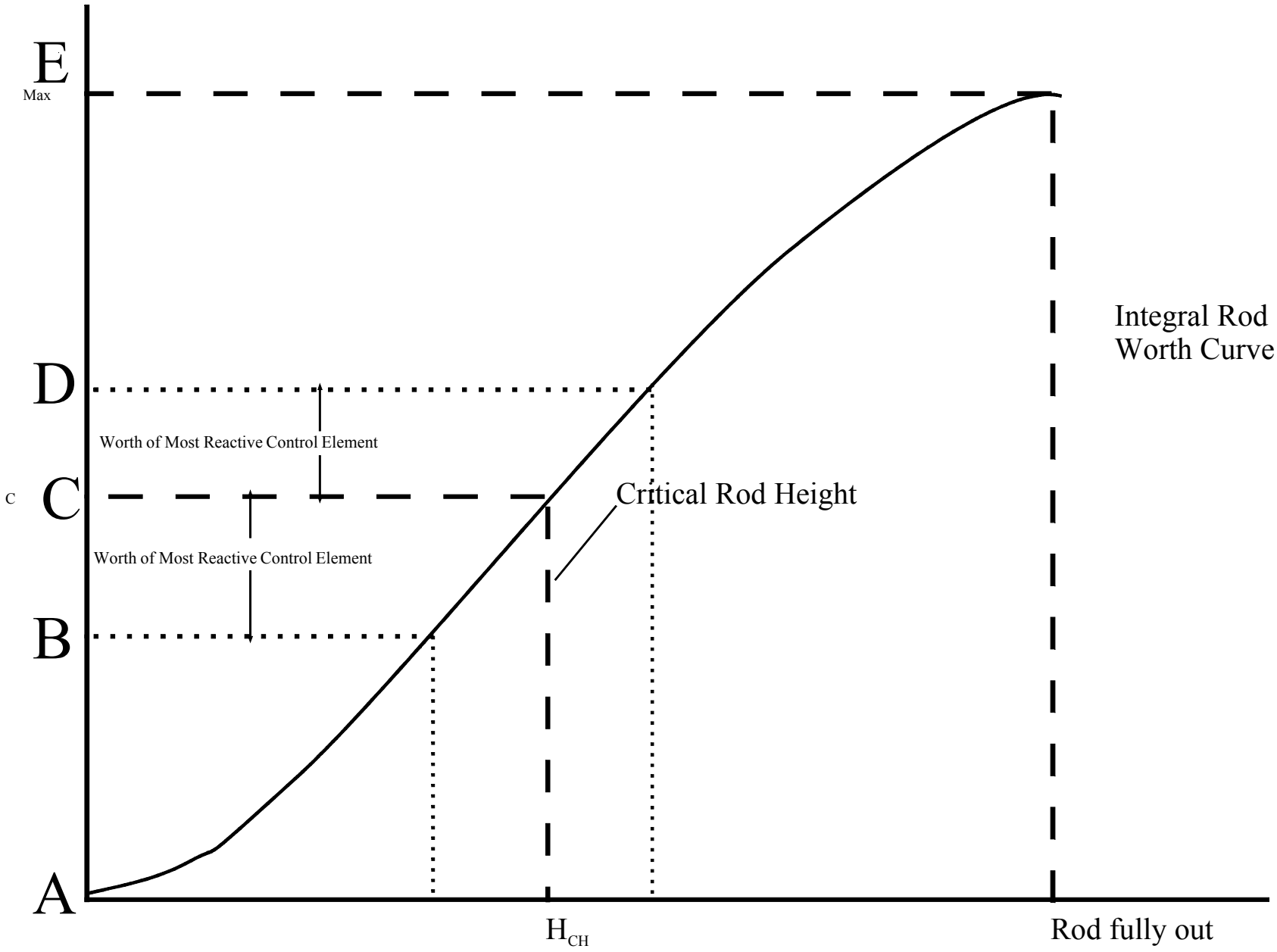
a. Reduce effect of gammas on the sample.
b. Reduce the effect of Fast Neutrons on the sample
c. Reduce the effect of Thermal Neutrons on the sample.
d. Increase the effect of high energy betas on the sample.

Answer: C.013 c.
Reference: SAR § 4.3

Question C.014 [1.00 point] (15.0)
Which ONE of the following describes the action of the shim-safety rod drive system following a reactor scram?

a. The magnet remains in its present position until driven in.
b. The scram signal automatically causes the magnet to be driven in.
c. Activation of the INSERT LIMIT microswitch initiates the down motion of the magnet.
d. Deactivation of the contact-actuated microswitch initiates the down motion of the magnet.

Answer: C.014 a.
Reference: University of Missouri-Rolla SAR, page 3-11.


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