November 23, 2005

Dr. Gunter Kegel, Director
Nuclear Radiation Laboratory
University of Massachusetts – Lowell
One University Avenue
Lowell, MA 01854

SUBJECT: INITIAL EXAMINATION REPORT NO. 50-223/OL-05-01, UNIVERSITY OF MASSACHUSETTS – LOWELL

Dear Dr. Kegel:

During the week of September 5, 2005, the NRC administered an operator licensing examination at your University of Massachusetts – Lowell 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/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. Paul V. Doyle Jr. at 301-415-1058 or via internet e-mail pvd@nrc.gov.

Sincerely,

/RA/

Brian E. Thomas, Branch Chief
Research and Test Reactors Branch
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Docket No. 50-223

Enclosures: 1. Initial Examination Report No. 50-223/OL-05-01
2. Examination with Facility Comments Incorporated

cc w/encls: Please see next page

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EXAMINIATION PACKAGE # : ML051810517
ADAMS ACCESSION #: ML052930390 **TEMPLATE #:NRR-074**

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NAME	PDoyle		EBarnhill		BThomas	
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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.: 50-223/OL-05-01

FACILITY DOCKET NO.: 50-223

FACILITY LICENSE NO.: R-125

FACILITY: University of Massachusetts – Lowell

EXAMINATION DATES: September 6, 2005

SUBMITTED BY: /RA/ 10/5/2005
Paul V. Doyle Jr., Chief Examiner Date

SUMMARY:

During the week of September 6, 2005, the NRC administered operator licensing examinations to two Reactor Operator candidates. One RO passed the examination, the other RO failed sections A and C of the written examination.

REPORT DETAILS

1. Examiners:
Paul V. Doyle Jr., Chief Examiner

2. Results:

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

3. Exit Meeting:
Paul V. Doyle Jr., NRC, Examiner
Toungporn Angwongtrakool, Thailand, Office of Atoms for Peace
Leo Bobek, Reactor Manager, University of Massachusetts-Lowell Reactor

The examiner thanked Mr. Bobek for his support of the examination and for his work in allowing Ms. Angwongrakool to visit his facility. The examiner did not note any generic weaknesses on the part of the license candidates. Mr. Bobek's comments on the written examination have been incorporated into the examination attached to this report.

B2(d): Because (d) reads 520mRem as opposed to >500Rad, the correct answer would be (1).

B.11: Either (a) (see UML TS 3.6.8) or the given answer (d) are correct.

B.14: The correct answer is (d) (see UML TS 5.4)

C.1: No answer change, though I believe (b) should replace the words High Radiation with High Temperature

C.5: The correct answer is (c). Answer (d) would be correct if the words "...inner airlock door is..." were placed between the last two words of answer (d).

ENCLOSURE 1

OPERATOR LICENSING EXAMINATION
With Answer Key

UNITED STATES NUCLEAR REGULATORY COMMISSION

UNIVERSITY OF MASSACHUSETTS-LOWELL
September 6, 2005

ENCLOSURE 2

QUESTION A.01 [1.0 point]
From the data and the graph provided, calculate when criticality will be reached. After the loading of the …

a. 20th bundle

b. 22nd bundle

c. 24th bundle

d. 26th bundle

Count Rate	No. of Fuel Bundles
842	2
936	4
1123	7
1684	12
2807	16

QUESTION A.02 [1.0 point]
The two figures below represent the order (number in box) and direction used in placing fuel into a reactor pool. Which of the following choices shows the preferred method for performing a 1/M plot, along with the correct reason.

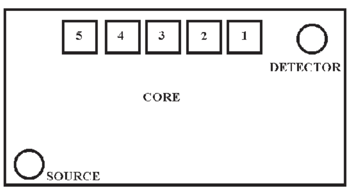


Figure 1

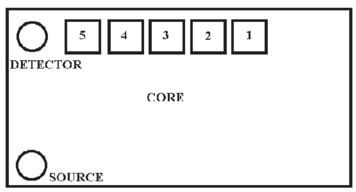


Figure 2

a. Figure 1 because loading from the detector towards the source gives the first fuel element more emphasis resulting in a more conservative estimate of criticality.

b. Figure 2 because loading towards the detector and the source gives the first fuel element more emphasis resulting in a more conservative estimate of criticality.

c. Figure 1 because loading from the detector towards the source gives the last fuel element more emphasis resulting in a more conservative estimate of criticality.

d. Figure 2 because loading towards the detector and the source gives the last fuel element more emphasis resulting in a more conservative estimate of criticality.

QUESTION A.03 [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.04 [1.0 point]
As primary coolant (moderator) temperature increases, control rod worth …

a. decreases due to lower reflector efficiency.

b. decreases due to higher neutron absorption in the moderator.

c. increases due to the increase in thermal diffusion length.

d. remains the same due to constant poison cross-section of the control rods.

QUESTION A.05 [1.0 point]
The Chief Reactor Operator tells you that the reactor is shutdown with a Shutdown Margin of 12.0%. Nuclear Instrumentation reads 100 cpm. The CRO inserts an experiment into the core and counts increase to 200 cpm. What is the resulting K_{eff} for the core?

a. 0.920

b. 0.946

c. 0.973

d. 1.000

QUESTION A.06 [1.0 point]
Which ONE of the following is the cause of the indicated power to stabilize several hours following a reactor scram. (Assume source inserted in core, source range instrument on and reading 3 counts/second and no reactivity changes, i.e. no temperature changes, no fuel movement, no experiments added, etc.)

a. Continuing decay of the shortest lived delayed neutron precursor.

b. Gamma saturation of the source range detector.

c. Subcritical multiplication of source neutrons.

d. Neutron activation of the Source Range Detector.

QUESTION A.07 [1.0 point]
During a startup you increase reactor power from 50 watts to 1000 watts in 100 seconds. What is reactor period?

a. 25

b. 33

c. 41

d. 50

QUESTION A.08 [1.0 point]
The reactor is operating with the Regulating Rod in Automatic mode. The Reactor Operator starts the secondary pump and both cooling tower fans. Average coolant temperature in the core decreases from 28EC to 20EC. Assume Regulating rod worth over the range of travel for this problem is 0.03% ΔK/K/inch, and average temperature coefficient over this temperature range is -0.88×10^{-4} ΔK/K/EC. How far, and in which direction will the regulating rod move to maintain constant power?

a. 2.35 inches, inward

b. 2.35 inches, outward

c. 2.73 inches, inward

d. 2.73 inches, outward

QUESTION A.09 [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.10 [1.0 point]
An experimenter makes an error loading a rabbit sample. Injecting the sample into the core results in a 100 millisecond period. If the first scram trip setpoint (actual) is 125%, and the scram delay time is 0.1 seconds, which ONE of the following is the resulting peak reactor power before the reactor shuts down?

a. 1.4 Megawatts

b. 2.8 Megawatts

c. 3.4 Megawatts

d. 5.0 Megawatts

QUESTION A.11 [1.0 point]
In a reactor the thermal neutron flux (Ø) is 2.5×10^{12} fissions/cm^2/second, and the macroscopic cross-section (Σ_f) for fission is 0.1 cm^{-1}. The fission rate is

a. 2.5×10^{11} fissions/cm/second

b. 2.5×10^{13} fissions/cm/second

c. 2.5×10^{11} fissions/cm^3/second

d. 2.5×10^{13} fissions/cm^3/second

QUESTION A.12 [1.0 point]
Given: Primary Flow rate through heat exchanger = 1400 GPM; Secondary Flow rate through heat exchanger = 1200 GPM; $\Delta T_{Primary}$ = 13EF and Secondary INLET temperature is 73EF. Which one of the following should be the secondary OUTLET temperature?

a. . 58EF

b. . 62EF

c. . 84EF

d. . 88EF

QUESTION A.13 [1.0 point]
Which ONE of the following parameters is MOST significant in determining the differential worth of a control rod?

a. Rod Speed

b. Reactor Power

c. Flux Shape

d. Fuel Loading

QUESTION A.14 [1.0 point]
A fissile material is one which will fission upon absorption of a THERMAL neutron. A fertile material is one which upon absorption of a neutron becomes a fissile material. Which ONE of the following isotopes is an example of a fertile material.

a. U^{233}

b. U^{235}

c. U^{238}

d. Pu^{239}

QUESTION A.15 [1.0 point]
Which one of the graphs supplied in figure A.1, most closely depicts the reactivity versus time plot for xenon for the following set of evolutions?

TIME	Evolution
1	Startup to 100% power, clean core
2	100% operation for four days
3	Shutdown for 15 hours
4	50% operation for 29 hours

a. a

b. b

c. c

d. d

QUESTION A.16 [1.0 point]
Five minutes after shutting down the reactor, reactor period is 3×10^6 counts per minute. Which ONE of the following is the count rate you would expect to three minutes later?

a. 1×10^6 cpm

b. 8×10^5 cpm

c. 5×10^5 cpm

d. 3×10^5 cpm

QUESTION A.17 [1.0 point]
Excess reactivity is the amount of reactivity …

a. associated with burnable poisons

b. needed to achieve prompt criticality

c. available below that which is required to make the reactor subcritical.

d. available above that which is required to keep the reactor critical.

QUESTION A.18 [1.0 point]
Which ONE of the following describes the MAXIMUM amount of Xenon in the core?

a. 4 to 6 hours following Power Increase, 50% to 100%.

b. 4 to 6 hours following Power Decrease, 100% to 50%.

c. 8 to 12 hours following Power startup to 100%.

d. 8 to 12 hours following Power shutdown from 100%.

QUESTION A.19 [1.0 point]
The listed isotopes are all potential daughter products due to the radioactive decay of $_{35}Br^{87}$. Identify the type of decay necessary (Alpha, Beta, Gamma or Neutron emission) to produce each of the isotopes.

a. $_{33}As^{83}$

b. $_{35}Br^{86}$

c. $_{35}Br^{87}$

d. $_{36}Kr^{87}$

(*** END OF SECTION A ***)

QUESTION B.1 [1.0 point]
According to the Emergency plan, the Emergency Planning Zone …

a. is the area enclosed within the containment vessel.

b. specifies contamination levels (airborne, radiation dose, or dose rates) that may be used as thresholds for establishing emergency classes.

c. is the geographical area beyond the site boundary, where the Reactor Director has direct authority over all activities.

d. lies within the site boundary and is bounded by a 150 meter radius from the exhaust stack.

QUESTION B.2 [2.0 points, 0.5 each]
Match the general area radiation levels listed in column A with the corresponding type of radiation area listed in column B. (Note: Only one answer for each item in column A. Items from column B may be used more than once or not at all.)

Column A	Column B
a. 15 mRem/hr.	1. High Radiation Area
b. 65 mRem/hr.	2. Radiation Area
c. 203 mRem/hr.	3. Unrestricted Area
d. 520 mRem/hr.	4. Very High Radiation Area

QUESTION B.3 [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 management which may authorize this action is …

a. any Reactor Operator licensed at the facility.

b. any Senior Reactor Operator licensed at the facility.

c. Facility Manager (or equivalent at facility).

d. NRC Project Manager

QUESTION B.4 [1.0 point]
When removing a sample from the pneumatic tube receiver, Health Physics coverage is required if the sample reads greater than …

a. 0.001 Rem/hr.

b. 0.01 Rem/hr.

c. 0.1 Rem/hr.

d. 1 Rem/hr.

QUESTION B.5 [1.0 point]
Which ONE of the following correctly describes a Safety Limit?

a. Limits on important process variables which are found to be necessary to reasonably protect the integrity of certain physical barriers which guard against the uncontrolled release of radioactivity.

b. The Lowest functional capability of performance levels of equipment required for safe operation of the facility.

c. Settings for automatic protective devices related to those variables having significant safety functions.

d. a measuring or protective channel in the reactor safety system.

QUESTION B.6 [1.0 point]
So far this calendar year, you have received 3.3 Rem whole body dose. You must work on a control drive mechanism where there is an average dose of 250 mR/hr. Which ONE of the following times is closest to your stay time WITHOUT going over? (Assume you are over the age of 18.)

a. 3¼ hours.

b. 6½ hours.

c. 12¾ hours.

d. 19 hours.

QUESTION B.7 [1.0 point]
An experimenter wishes to irradiate three specimens with reactivity worths of 0.15% Δk/k, 0.17% Δk/k and 0.3% Δk/k. Can these specimens be placed in the reactor as ***SECURED*** experiments and why (why not).

a. Yes, the sum of the three specimens is less than 2.5% Δk/k.

b. No, the sum of the three specimens is greater than 0.5% Δk/k.

c. No, each of the experiments is greater than 0.1% Δk/k.

d. No, one of the specimens is greater than 0.25% Δk/k.

QUESTION B.8 [2.0 points, ½ each]
Identify the modes [Forced Convection (above 0.1 Mw) (FC), Natural Convection (NC), Cross-Pool flow pattern (CP) or Down-Comer flow pattern (DC), or all modes (ALL)] for which each of the following scrams is required to be operational. (Modes may be used more than once or not at all.)

a. Pool level 2'3" above centerline of core.

b. Either Coolant Riser Gate or Downcomer Gate opens

c. Coolant Inlet Temperature 108EF

d. Manual Scram button

QUESTION B.9 [1.0 point]
According to Technical Specifications an individual meets the definition of "ON CALL" if …

a. is capable of arriving at the reactor facility within 30 minutes.

b. is within the confines of the Pinanski building while the reactor is in operation.

c. keeps the operator posted of his/her whereabouts and telephone number.

d. calls in to the operator at the controls every half hour.

QUESTION B.10 [1.0 point]
You are the console operator during insertion of a sample into and later removal of a sample from the core. Which ONE of the following items are you NOT required to log in the console operator's log?

a. Sample Number

b. Time In/Out

c. Exposure

d. Total Reactivity worth of all incore samples

QUESTION B.11 [1.0 point]
Which **ONE** of the following conditions regarding experiments is not allowed under ***ANY*** condition? The experiment …

a. contains cryogenic liquids.

b. contains 2.1 milligrams of explosive material

c. causes a reduction in the reading for the startup channel.

d. causes the outside temperature of a submerged material to reach 90EC (176EF)

QUESTION B.12 [1.0 point]
You bring a radiation monitor into the pump room during reactor operation. If you were to open the window on the detector you would expect the meter reading to … (Assume no piping leaks.)

a. increase, because you would now be receiving signal due to H^3 and O^{16} betas.

b. remain the same, because the Quality Factors for gamma and beta radiation are the same.

c. increase, because the Quality Factor for betas is greater than for gammas.

d. remain the same, because you still would not be detecting beta radiation.

QUESTION B.13 [1.0 point]
According to the Safety Analysis Report (SAR), which ONE of the following locations has the potential of generating the greatest amount of Ar^{41}?

a. Thermal Column Case Vent

b. Beam Port

c. Pneumatic Tube

d. Primary Coolant (Pool)

QUESTION B.14 [1.0 point]
What is the maximum K_{eff} allowed (per Technical Specifications) for reactor fuel element storage under quiescent flooding with water.

a. 0.7

b. 0.75

c. 0.8

d. 0.85

QUESTION B.15 [1.0 point]
The Co^{60} source is in use. RO-13, *Radiation Monitoring Equipment Checkout*, states that you shall not perform checks on channel Q (Gamma Cave) and channel …

a. F (Facilities Filter)

b. G (Rabbit Filter)

c. H (Hot Cell)

d. O (Stairwell)

QUESTION B.16 [1.0 point]
All of the monitors checked by RO-13 are checked using a Co^{60} source, except one which uses a Cf^{252} neutron emitting source. The channel which uses the Cf^{252} source is channel …

a. C (Continuous Air Monitor #1)

b. E (Fission Product Monitor)

c. I (Plenum)

d. L (Thermal Column)

QUESTION B.17 [1.0 point]
When taking logs readings, you must inform the Chief Reactor Operator when you notice a discrepancy between power channels greater than …

a. 2%

b. 3%

c. 4%

d. 5%

QUESTION C.1 [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.2 [1.0 point]
The baffles in the holdup tank are designed to allow which two isotopes time to decay?

a. ${}_{1}H^{3}$ and ${}_{6}C^{14}$

b. ${}_{1}H^{3}$ and ${}_{7}N^{16}$

c. ${}_{6}C^{14}$ and ${}_{8}O^{19}$

d. ${}_{7}N^{16}$ and ${}_{8}O^{19}$

QUESTION C.3 [1.0 point]
Which ONE of the following is the type of startup neutron source use for your reactor?

a. Californium

b. Plutonium-Beryllium

c. Neptunium-Antimony

d. Americium-Beryllium

QUESTION C.4 [1.0 point]
Which ONE of the following communications systems allows all stations to talk to each other simultaneously?

a. main intercom system

b. phone system

c. sound powered headset system

d. public address system

QUESTION C.5 [1.0 point]
Which ONE of the following conditions would cause the reactor to scram?

a. The outer airlock door lost its pneumatic seal.

b. The inner airlock door lost its pneumatic seal.

c. The truck door lost its pneumatic seal.

d. The outer airlock door lost its pneumatic seal while open.

QUESTION C.6 [1.0 point]
A severe storm causes a loss of power while you were maintaining the reactor at 1 megawatt. The emergency generator did NOT start. Select the condition of the ventilation system. The ventilation fans …

a. have stopped and the ventilation valves, except valve F have closed.

b. continue to run and the ventilation valves, except valve F have closed.

c. have stopped and the ventilation valves, except valve F remain open.

d. continue to run and the ventilation valves, except valve F remain open.

QUESTION C.7 [1.0 point]
You are instructed to place the core in the #1 position, and align the primary system for minimum flow induced vibration. Identify the position of the core and the primary flow mode.

	Core Position	Flow Mode
a.	Bulk Pool	Downcomer
b.	Stall Pool	Cross-Stall
c.	Bulk Pool	Cross-Stall
d.	Stall Pool	Downcomer

QUESTION C.8 [1.0 point]
During shutdown, the source range indication does NOT come on-scale until AFTER the intermediate range instrumentation went off-scale low. Which ONE of the following could be the reason for the lack of overlap?

a. Source range high voltage was lost.

b. Source range high voltage was set too high.

c. Intermediate range compensating voltage was set too low.

d. Intermediate range compensating voltage was set too high.

QUESTION C.9 [2.0 points, 0.4 each]
Identify the ***NEAREST*** upstream power distribution panel (panels listed in column B), for each of hte electrical loads listed in column A. (NOTE: Responses may be used more than once or not at all.)

a. Reactor Compressors	1. ELPL-R1
b. Sump Pump	2. Motor Control Center #1
c. Emergency Exhaust Fan	3. Motor Control Center #2
d. Main Exhaust Fan	4. PPL-R1
e. Primary Pump	5. Emergency Distribution Switchboard

QUESTION C.10 [1.0 point]
The purpose of the Thermal Column is to …

a. enhance heat transfer characteristics of the core.

b. provide a thermal temperature rise for experiments.

c. enhance forced convection flow.

d. provide neutrons in the thermal energy range.

QUESTION C.11 [2.0 points, 0.25 each]
The liquid radwaste system divides cooling water into four sections for the purpose of performance checks/monitoring. Match the cooling water sections in Column A with its appropriate performance checks from Column B. Note that some performance checks in Column B may be used more than once or not at all.

Column A	Column B
a. Pool	1. External gamma monitor and delayed neutron detector.
b. Primary Loop	2. Continuous conductivity measurements.
c. Cleanup Loop	3. Periodic sampling for quality and presence of radionuclides.
d. Secondary Loop	4. Daily sampling for Na^{24}.

QUESTION C.12 [1.0 point]
Which ONE of the following devices is designed to prevent the reactor pool from being completely drained by a leak in the primary coolant piping?

a. Primary Delay Tank

b. Pool Wall Liner

c. Primary Coolant Pump

d. Break Valve

QUESTION C.13 [1.0 point]
Which ONE of the following correctly describes how a compensated ion chamber detects neutrons. A neutron interacts with the …

a. U^{235} lining of the tube.

b. B^{10} lining of the tube.

c. BF_3 gas which fills the tube

d. N_2 gas which fills the tube.

QUESTION C.14 [1.0 point]
Which ONE of the following is used when the reactor is operating to reduce the buildup of Ar^{41} in the reactor bay?

a. Operation of the ventilation system, which releases the Ar^{41} through the stack.

b. Diffuser pumps which decrease the release of Ar^{41} from the pool.

c. Purification system via the ion bed.

d. None required due to the relatively short half-life of Ar^{41} (seven seconds).

QUESTION C.15 [1.0 point]
Which ONE of the following correctly describes the manual operation of Valve A in the ventilation system? The valve is opened …

a. by air acting on a piston against a spring. The valve is closed by opening a quick release valve which bleeds off air from the piston.

b. by air acting on a piston against a spring. The valve is closed by opening a quick release avle which bleeds air off of an auxiliary piston which in turn opens a port bleeding air off the main piston.

c. by spring pressure. The valve is closed by an explosive blast of high pressure air from an accumulator.

d. and closed via an air motor, using higher pressure air from an accumulator for quick closure.

QUESTION C.16 [1.0 point]
Which ONE of the following correctly describes the operation of the RTD (temperature detector used for the temperature recorder).

a. A bimetallic strip which because of differing thermal expansion coefficients causes the strip to bend proportional to temperature.

b. A bimetallic junction, which generates a potential (micro-volt range) proportional to temperature.

c. A precision wound resistor, which changes resistance proportional to temperature.

d. A precision wound inductor, which changes inductance proportional to temperature.

QUESTION C.17 [1.0 point]
Which ONE of the following describes the purpose of the filter in the reactor pool cleanup system?

a. Prevents demineralizer resin fines from entering the pool.

b. Prevents larger particles from plugging the demineralizer resin.

c. Removes CRUD from the coolant limiting the radiation levels associated with the demineralizer.

d. Removes particulates that could clog the cleanup system pump seals.

A.1 b (See attached sketch)
REF: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, § 5.5, pp. 5-18, through 5-25.

A.2 a
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 5.5, pp. 5-18, through 5-25.

A.3 a, 7; b, 5; c, 6; d, 2
REF: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, § 6.2.1, p. 6-3

A.4 c
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 7.2, p. 7-1–7-9.

A.5 b
REF: $K_{eff}(I) = 1/(1+SDM) = 1/1.120 = 0.892857$ $CR(I)[1 - K_{eff}(I)] = CR(f)[1 - K_{eff}(f)]$ $100(1 - 0.893) = 200 (1 - x)$ ½(1 - 0.893)= 1 - x 1 - x = 0.0535714; x = 1 - 0.0535714 = <u>0.94643</u>

A.6 c
REF: Burn, R. R., *Introduction or Nuclear Reactor Operations,* June 1984, § 5.3

A.7 b
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 4.3, p. 4-4. $P = P_0 e^{t/\tau}$ $\ln(P/P_0) = t/\tau$ $\tau = t/(\ln(P/P_0)$ $\tau = 100/\ln(20) = 33.381$

A.8 a
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 6.4.1, p. 6-5.
Reactivity due to temperature: -0.88×10^{-4} ΔK/K/EC × -8EC = $+7.04 \times 10^{-4}$ ΔK/K
Movement: Rod must add -7.04×10^{-4} ΔK/K, therefore (7.04×10^{-4} ΔK/K) ÷ 0.0003 ΔK/K = 2.346 inches in the negative (inward) direction.

A.9 c
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, §§ 8.4, & 8.6 pp. 8.10 through 8.14.

A.10 c
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 4.3, p. 4-4. $P = P_0 e^{t/\tau}$ $P = 1.25$ Mwatt × $e^{0.1/0.1}$ = 1.25 Mwatt × 2.7183 = 3.3978 Mwatt

A.11 c
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 2.6.2, p. 2-50.

A.12 d
REF: ΔT_{sec} = 1400/1200 * 13EF = 7/6 * 13 = 15.2EF T_{OUT} = 73 + 15.2 = 88.2

$$\dot{m}_{pri} c_p \Delta T_{pri} = \dot{m}_{sec} c_p \Delta T_{sec}$$

A.13 c
REF: Burn, R. R., Introduction or Nuclear Reactor Operations, June 1984, § 7.2, p. 7-4.

A.14 c
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 3.2, Example 3.2, p. 3-2.

A.15 a
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 8.4.3, p. 8-19.

A.16 d
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 4.6, pp. 4-14 thru 4-17. For S/D reactor τ = -80 seconds. Time = 180 seconds. $P = P_0 e^{t/\tau} = 3 \times 10^6 e^{-180/80} = 3.162 \times 10^5$

A.17 d
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 6.2.2. p. 6-6.

A.18 d
REF: Burn, R. R., Introduction or Nuclear Reactor Operations, June 1984, § 8.4, pp. 8-12 to 8-19.

A.19 a, alpha; b, neutron; c, gamma; d, Beta
Ref: Standard NRC Question

B.1 a
REF: Emergency Plan Chapter 2.0, Definitions, § 2.11.

B.2 a, 2; b, 2; c, 1; d, ~~4~~ 1 answer changed per facility comment. (Typo in question)
REF: 10 CFR20 Definitions

B.3 b
REF: 10CFR50.54(y).

B.4 d
REF: U. Mass.-Lowell, RO-4 § 4.1.7, p. 4-2.

B.5 a
REF: Standard NRC Question.

B.6 b *5.0 - 3.3 = 1.7 Rem allowable. 1.7 Rem ÷ 0.25 Rem/hr = 6.8 . 6½*
REF: 10CFR20.1201

B.7 a
REF: Technical Specifications 3.1. Specification 9.

B.8 a, NC; b, DC; c, FC; ALL
REF: T.S. § 3.3, table

B.9 b
REF: Technical Specifications 6.1.5 page 42.

B.10 c
REF: NRC examination 01/27/87 and RO

B.11 c
REF: T.S. § 3.6, specifications 3, 5, 7 and 8.

B.12 d
REF: BASIC Radiological Concept (Betas don't make it through piping.)

B.13 b
REF: SAR pp. 3-18 and 7-2.

B.14 ~~c~~ d answer changed per facility comment (typo).
REF: Technical Specifications § 5.4, p. IV

B.15 a
REF: RO-13, § 13.1.b.2.

B.16 b
REF: RO-13 § 13.1.a.

B.17 b
REF: Standing Order #4, *Sequence of Operations during Startup and at Rated Power.*

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

C.2 d
REF: Study Guide for Key Access and Intro. To Operator Training, § covering primary system and NRC exam administered September, 1997.

C.3 d
REF: SAR § 4.1.4, page 4-6

C.4 c
REF: UMLR Safety Analysis Report, § 6.3.1, *Communications System*

C.5 ~~d~~ c answer changed per facility comment (typo)
REF: SAR, § 3.1.2.1, last ¶.

C.6 a
REF: SAR § 3.4.2.1, *System Closure* and § 3.4.2.2 *Response to Initiation of System Closure.*

C.7 b
REF: SAR § 4.1.10 *Reactor Pool*

C.8 b
REF: Standard NRC question

C.9 a, 5; b, 3; c, 1; d, 3; e, 2
REF: SAR Figures 5.2 and 5.3.

C.10 d
REF: SAR § 4.3.1, *Thermal Column*

C.11 a, 3; b, 1; c, 2; d, 4
REF: SAR § 7.2.4, Page 7-5

C.12 d
REF: Modified question from NRC examination bank.

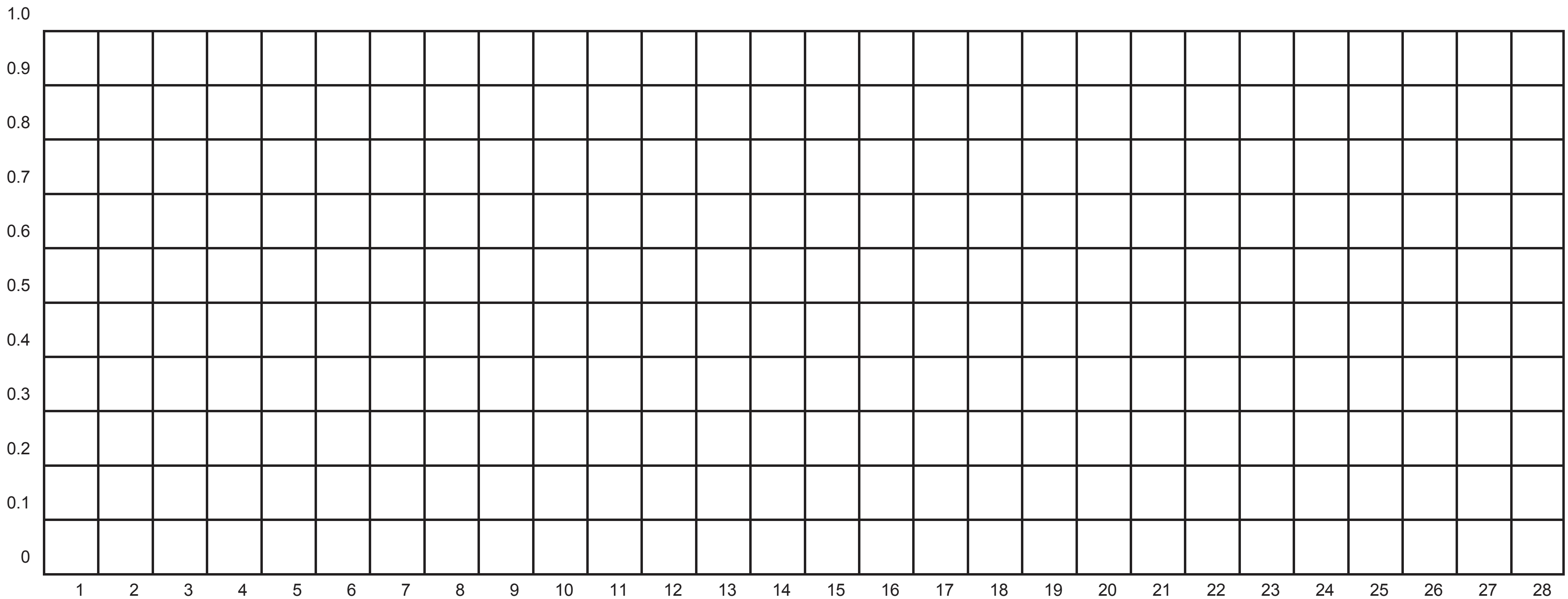
C.13 b
REF: Standard NRC Question

C.14 a
REF: SAR §

C.15 b
REF: SAR figure 3.7, page 3-16

C.16 c
REF: SAR § 4.4.17.5

C.17 a
REF: SAR § 4.2.5, page 4-29



2 Bundles: 842 ÷ 842 = 1.0
4 Bundles: 842 ÷ 936 = 0.9
7 Bundles: 842 ÷ 1123 = 0.75
12 Bundles: 842 ÷ 1684 = 0.50
16 Bundles: 842 ÷ 2807 = 0.3

U. S. NUCLEAR REGUL

NON-POWER INITIAL REA

University of Massachus

2003/06/16

CANDIDATE: / REACTOR TYPE: / DATE ADMINISTERED:

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

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

FINAL GRADE

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

$$\dot{Q} = \dot{m} c_p \Delta T = \dot{m} \Delta H = UA\Delta T \qquad P_{max} = \frac{(\rho - \beta)^2}{2\alpha(k)} \qquad \ell^* = 1 \times 10^{-4} \text{ seconds}$$

$$\lambda_{eff} = 0.1 \text{ seconds}^{-1} \qquad SCR = \frac{S}{-\rho} \approx \frac{S}{1 - K_{eff}} \qquad CR_1(1 - K_{eff_1}) = CR_2(1 - K_{eff_2})$$

$$CR_1(-\rho_1) = CR_2(-\rho_2)$$

$$SUR = 26.06\left[\frac{\lambda_{eff}\,\rho}{\beta - \rho}\right] \qquad M = \frac{1 - K_{eff_0}}{1 - K_{eff_1}} \qquad M = \frac{1}{1 - K_{eff}} = \frac{CR_1}{CR_2}$$

$$P = P_0 10^{SUR(t)} \qquad P = P_0 e^{\frac{t}{\tau}} \qquad P = \frac{\beta(1 - \rho)}{\beta - \rho} P_0$$

$$SDM = \frac{(1 - K_{eff})}{K_{eff}} \qquad \tau = \frac{\ell^*}{\rho - \beta} \qquad \tau = \frac{\ell^*}{\rho} + \left[\frac{\beta - \rho}{\lambda_{eff}\,\rho}\right]$$

$$\Delta\rho = \frac{K_{eff_2} - K_{eff_1}}{K_{eff_1} \times K_{eff_2}} \qquad T_{1/2} = \frac{0.693}{\lambda} \qquad \rho = \frac{(K_{eff} - 1)}{K_{eff}}$$

$$DR = DR_0 e^{-\lambda t} \qquad DR = \frac{6CiE(n)}{R^2} \qquad DR_1 d_1^2 = DR_2 d_2^2$$

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.01 a b c d ___

A.02 a b c d ___

A.03a 1 2 3 4 5 6 7 ___

A.03b 1 2 3 4 5 6 7 ___

A.03c 1 2 3 4 5 6 7 ___

A.03d 1 2 3 4 5 6 7 ___

A.04 a b c d ___

A.05 a b c d ___

A.06 a b c d ___

A.07 a b c d ___

A.08 a b c d ___

A.09 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.19a α β γ n ___

A.19b α β γ n ___

A.19c α β γ n ___

A.19d α β γ n ___

B.01	a b c d ___	B.08c	FC NC CP DC ALL ___
B.02a	1 2 3 4 ___	B.08d	FC NC CP DC ALL ___
B.02b	1 2 3 4 ___	B.09	a b c d ___
B.02c	1 2 3 4 ___	B.10	a b c d ___
B.02d	1 2 3 4 ___	B.11	a b c d ___
B.03	a b c d ___	B.12	a b c d ___
B.04	a b c d ___	B.13	a b c d ___
B.05	a b c d ___	B.14	a b c d ___
B.06	a b c d ___	B.15	a b c d ___
B.07	a b c d ___	B.16	a b c d ___
B.08a	FC NC CP DC ALL ___	B.17	a b c d ___
B.08b	FC NC CP DC ALL ___		

C.01a 1 2 3 4 ___

C.01b 1 2 3 4 ___

C.01c 1 2 3 4 ___

C.01d 1 2 3 4 ___

C.02 a b c d ___

C.03 a b c d ___

C.04 a b c d ___

C.05 a b c d ___

C.06 a b c d ___

C.07 a b c d ___

C.08 a b c d ___

C.09a 1 2 3 4 5 ___

C.09b 1 2 3 4 5 ___

C.09c 1 2 3 4 5 ___

C.09d 1 2 3 4 5 ___

C.09e 1 2 3 4 5 ___

C.10 a b c d ___

C.11a 1 2 3 4 ___

C.11b 1 2 3 4 ___

C.11c 1 2 3 4 ___

C.11d 1 2 3 4 ___

C.12 a b c d ___

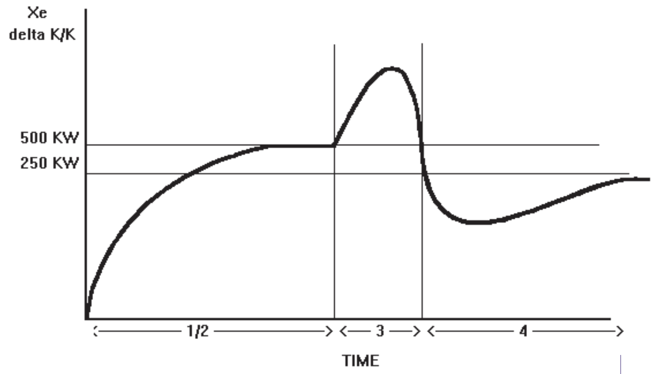
C.13 a b c d ___

C.14 a b c d ___

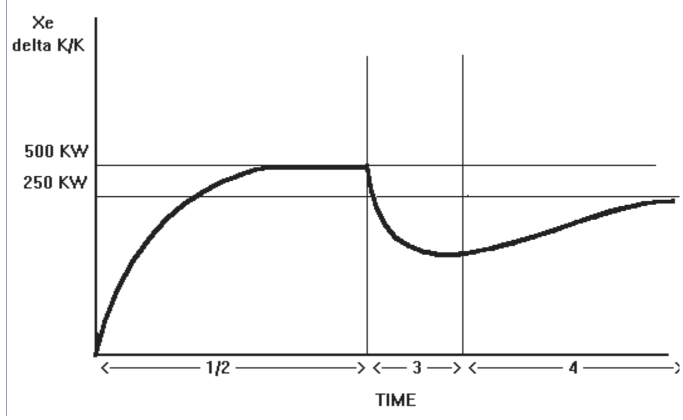
C.15 a b c d ___

C.16 a b c d ___

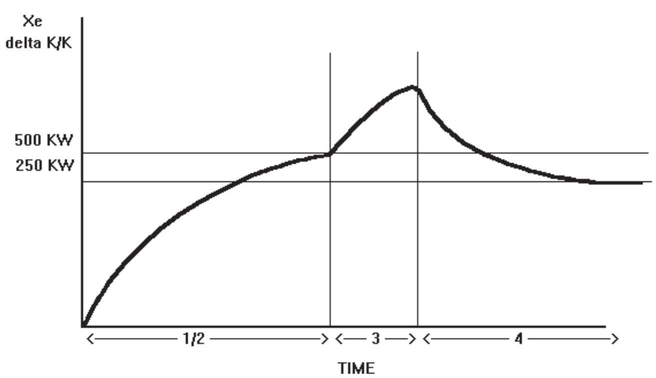
C.17 a b c d ___



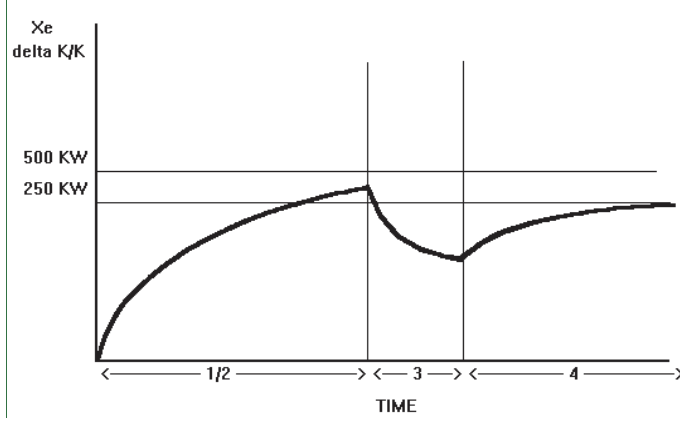
a



b

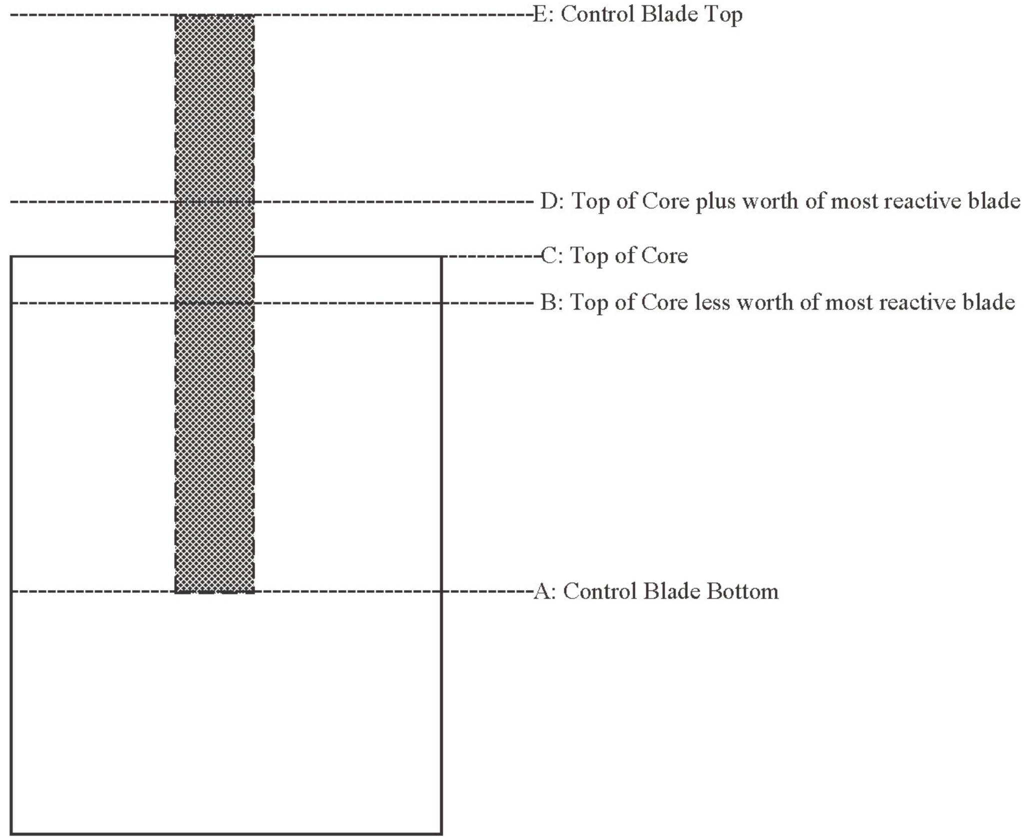


c



d

FIGURE A.15


E: Control Blade Top
D: Top of Core plus worth of most reactive blade
C: Top of Core
B: Top of Core less worth of most reactive blade
A: Control Blade Bottom