December 8, 2005

Mr. William E. Bonzer, Interim Reactor Director
University of Missouri–Rolla
Nuclear Reactor Facility
1870 Miner Circle
Rolla, MO 65409-0630

SUBJECT: INITIAL EXAMINATION REPORT NO. 50-123/OL-06-01, UNIVERSITY OF MISSOURI–ROLLA

Dear Mr. Bonzer:

During the week of October 24, 2005, the NRC administered an operator licensing examination at your University of Missouri–Rolla 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, Chief
Research and Test Reactors Branch
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Docket No. 50-123

Enclosures: 1. Initial Examination Report No. 50-123/OL-06-01
2. Facility comments with NRC resolution
3. Examination and modified answer key

cc w/encls:
Please see next page

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Please see next page
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PIsaac Facility File (EBarnhill) O-6 F-2

EXAMINATION PACKAGE ACCESSION NO.:ML051820280
ADAMS ACCESSION #: ML053420319 **TEMPLATE #:NRR-074**

OFFICE	PRTA:CE		IOLB:LA	E	PRTA:BC	
NAME	PDoyle		EBarnhill		BThomas	
DATE	12/ 8 /2005		12/08 /2005		12/ 9 /2005	

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cc:

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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.: 50-123/OL-06-01

FACILITY DOCKET NO.: 50-123

FACILITY LICENSE NO.: R-79

FACILITY: University of Missouri–Rolla

EXAMINATION DATES: October 24 - 27, 2005

SUBMITTED BY: ***/RA/*** 11/02/2005
Paul V. Doyle Jr., Chief Examiner Date

SUMMARY:

During the week of October 24, 2005, the NRC administered operator licensing examinations to four Reactor Operator license candidates and one Senior Reactor Operator (Upgrade) license candidate. One Reactor Operator license candidate failed section A of the written examination. All other license candidates passed all applicable portions of their examinations.

REPORT DETAILS

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

2. Results:

	RO PASS/FAIL	SRO PASS/FAIL	TOTAL PASS/FAIL
Written	3/1	0/0	3/1
Operating Tests	4/0	1/0	5/0
Overall	3/1	1/0	4/1

3. Exit Meeting:
   Paul V. Doyle Jr., NRC, Examiner
   William E. Bonzer, Interim Reactor Director, University of Missouri-Rolla
   Daniel N. Estel, Training Coordinator, University of Missouri-Rolla

   The examiner discussed weaknesses identified during the facility operating tests, and thanked the facility for their support of the examinations. The facility staff told the examiner they would have their comments on the written examination soon. Those comments were e-mailed to the examiner and are included as enclosure 2 to this document.

ENCLOSURE 1

FACILITY COMMENTS ON NRC WRITTEN EXAMINATION WITH
NRC RESOLUTIONS ADDED.

Email From: "Estel, Daniel Nelson" <destel@umr.edu>
To: <pvd@nrc.gov>
Subject: NRC Exam at UMRR/Facility Docket 50-123/License No. R-79
Hello Paul,

We request to make changes to the written examination given on October 24, 2005 at the University of Missouri – Rolla Reactor Facility. Each proposed change is individually addressed below.

Question A.01 We wish to eliminate this question.
We believe the correct answer to the question is 22 fuel bundles, which is not listed in the answers. All of the answers listed less fuel bundles than the last number of fuel bundles listed in the data table, which were 16 bundles. We are assuming the 16 bundles with a count rate of 2807 is representing a subcritical reactor.
NRC Resolution: Agree with comment. This question is eliminated.

Question B.01(d) We would like the answer changed to 4: 1.0% Δk/k.
The UMRR tech spec limit 3.1(3) lists the minimum shutdown margin as no less than 1.0 % Δk/k under any condition of operation with the highest worth control rod and any non-scrammable control rod fully withdrawn.
NRC Resolution: Agree with comment. The answer key has been changed to show 1.0% Δk/k as the correct answer for question B.01(d).

Question B.11 We would like the answer changed to d: 100pCi/10 cm^3.
SAR 7.2.2(d) page 7-7 and SOP 651.C.5 lists 100pCi/10 cm3 as the level for "no contamination evident".
NRC Resolution: Agree with comment. The answer key has been changed to show d as the correct answer. This was a typographical error on the part of the examiner.

Question B.16 We would like the answer changed to b: General Emergency.
The UMRR emergency plan and SOPs list the other answers Alert, Unusual Event and Site Area Emergency as emergency classifications.
NRC Resolution: Agree with comment. The answer key has been changed to show b as the correct answer. This was a typographical error on the part of the examiner.

C.04(e) We wish to have two correct answers, RR and BOTH.
The regulating rod is made of stainless steel, but the shim-safety rods also contain stainless steel in addition to the boron.
NRC Resolution: Agree with comment. The answer key has been changed to show both RR and BOTH as correct answers. Also part (e) will be rewritten to state "*Primary* poison material is Stainless Steel."

Question C.06 We would like the answer changed to b.

Indicated power is slightly higher than actual power. We have tested this question by taking our reactor to 10W and adjusting the compensating voltage from - 6.9 volts to - 0.8 volts (this is as close as we could get to 0 volts) while at 10W. As we adjusted towards a no compensating voltage setting we manually maintained a 10W power setting on the Linear Channel. The actual reactor power as observed by the startup channel and log power channel decreased. If we would have not manually maintained a 10W setting on the Linear Channel we would have seen the Linear Channel indication increase while the Start-up and Log Power channels would have maintained a stable power. If the High Voltage would have been reduced to 0 volts the indication would have read zero on the Linear Channel.

NRC Resolution: Agree with comment. The answer key has been changed to show b as the correct answer. This was a typographical error on the part of the examiner.

Question C.07(f) We wish to have the answer changed to two correct answers 2 and 4, instead of 2 only.

C.07(f) refers to the Basement RAM, which is singular in its context. We have two RAM circuits in the UMRR lower level basement, which are for detecting gamma and neutron radiation. The two circuits are independent units each having their own detector. We also have another RAM system in our mid-level basement, which is a gamma detector system only.

NRC Resolution: Agree with comment. The answer key has been changed to show both 2 and 4 as correct answers. This question will be rewritten to say "Basement RAMs" which will correct the problem.

Question C10.f We would like the answer change to 5: Rotameter.

The answer key lists the answer as 10, which was not listed in column B.

NRC Resolution: Agree with comment. The answer key has been changed to show b as the correct answer. This was a typographical error on the part of the examiner.

C15 We wish to eliminate this question.

All the channels listed in the answers have recorders with rod withdrawal prohibit trips. We check these trips on our weekly checklist as listed on SOP 810.C.1(1.1) Recorders Off. This test verifies the rod withdrawal prohibit trip is working for each recorder when we turn off the recorder's ac power.

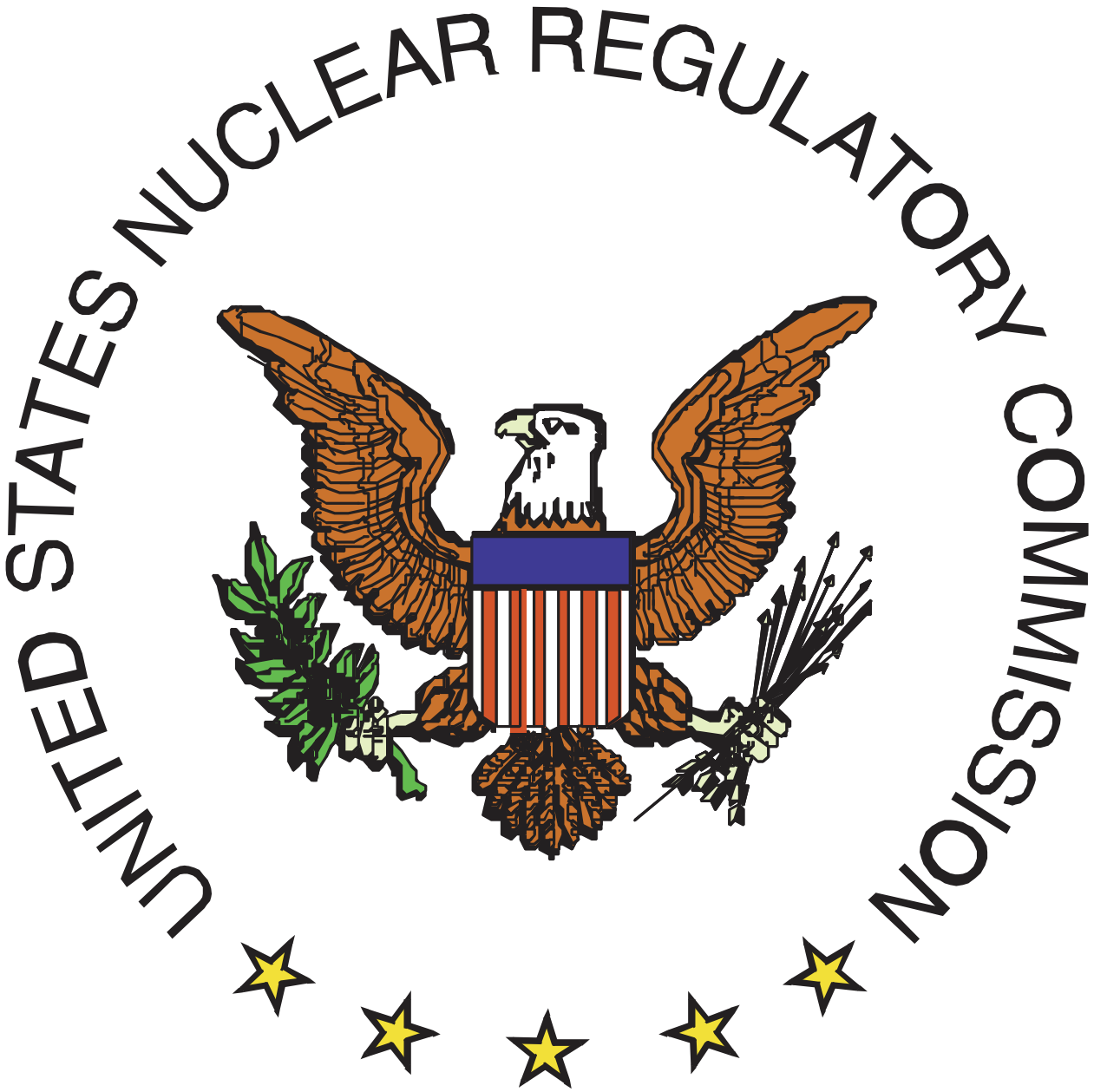
NRC Resolution: Agree with comment. This question is eliminated.

Thank you,

Daniel N. Estel/Training Coordinator

OPERATOR LICENSING EXAMINATION

With Answer Key



UNIVERSITY OF MISSOURI-ROLLA

Week of October 24, 2005

Enclosure 3

~~**Question A.01 [1.0 point]**~~ Question Deleted per facility comment.
~~Using the data taken during a core loading fuel (Table A.1, provided), estimate the number of fuel elements needed to go critical.~~

~~a. 9~~

~~b. 11~~

~~c. 13~~

~~d. 15~~

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

~~A.01 b (See attached sketch ~ 11 fuel elements)~~
~~REF: Burn, R., *Introduction to Nuclear Reactor Operations*, © 1988, § 5.5, pp. 5-18, through 5-25.~~

Question A.02 [1.0 point]
The Reactor Supervisor(RS) tells you that the reactor is shutdown with a Shutdown Margin of 12.0%. Nuclear Instrumentation reads 100 cpm. The RS 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

A.02 b
REF: $K_{effl} = 1/(1+SDM) = 1/1.120 = 0.892857$ $CR_l[1 - K_{eff(l)}] = CR_f[1 - K_{eff(f)}]$ $100(1 - 0.893) = 200 (1 - x)$ ½(1 - 0.893)= 1 - x 1 - x = 0.0535714; x = 1 - 0.0535714 = 0.94643

Question A.03 [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.
A.03 c
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 7.2, p. 7-1–7-9.

Question A.04 [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.
A.04 c
REF: Burn, R. R., *Introduction or Nuclear Reactor Operations,* June 1984, § 5.3

Question A.05 [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
A.05 b
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 4.3, p. 4-4. $P = P_0 e^{t/\tau}$
$\ln(P/P_0) = t/\tau$ $\tau = t/(\ln(P/P_0)$ $\tau = 100/\ln(20) = 33.381$

Question A.06 [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? (Assume time is too short for rundown to have an affect.)

a. 280 Kilowatts

b. 560 Kilowatts

c. 680 Kilowatts

d. 1.0 Megawatt

A.06 c
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 4.3, p. 4-4. $P = P_0 e^{t/\tau}$
$P = 250 \text{ kilowatts} \times e^{0.1/0.1} = 250 \text{ kilowatt} \times 2.7183 = 679.6 \text{ Mwatt}$

Question A.07 [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

A.07 c
REF: Burn, R. R., Introduction or Nuclear Reactor Operations, June 1984, § 7.2, p. 7-4.

Question A.08 [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}

A.08 c
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 3.2, Example 3.2, p. 3-2.

Question A.09 [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

A.09 a
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 8.4.3, p. 8-19.

Question A.10 [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

A.10 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. $P = P_0 e^{t/\tau}$ = $3 \times 10^6 e^{-180/80} = 3.162 \times 10^5$

Question A.11 [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.

A.11 d
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 6.2.2. p. 6-6.

Question A.12 [1.0 point]
Which one of the following is the primary reason a neutron source is installed in the core?

a. To allow for testing and irradiation of experiments when the reactor is shutdown.

b. To supply the neutrons required to start the chain reaction for subsequent reactor startups.

c. To provide a neutron level high enough to be monitored for a controlled reactor startup.

d. To increase the excess reactivity of the reactor which reduces the frequency for refueling.

A.12 c
REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1982, § 5.2 (b), p. 5-4.

Question A.13 [1.0 point]
INELASTIC 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. is absorbed, with the nucleus emitting a gamma ray, and the neutron with a lower kinetic energy.

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.

A.13 b
REF: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, §

Question A.14 [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

A.14 b
REF: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, §

Question A.15 [1.0 point]
Which ONE of the following is the correct reason that delayed neutrons enhance control of the reactor?

a. There are more delayed neutrons than prompt neutrons.

b. Delayed neutrons increase the average neutron generation time.

c. Delayed neutrons are born at higher energies than prompt neutrons and therefore have a greater effect.

d. Delayed neutrons take longer to reach thermal equilibrium.

A.15 b
REF: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, §

Question A.16 [1.0 point]
K_{eff} is K_4 times …

a. the fast fission factor (ε)

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

c. the reproduction factor (η)

d. the resonance escape probability (p)

A.16 b
REF: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, §

Question A.17 [1.0 point]
Which one of the following is the calculated SDM assuming no experiments are in the core, xenon free conditions, and the following rod and reactivity worths?

	worth %ΔK/K		worth %ΔK/K
Shim-Safety Blade #1:	2.41	Shim-Safety Blade #2:	2.32
Shim-Safety Blade #3:	2.49	Shim-Safety Blade #4:	2.60
Regulating rod:	0.084	Excess Reactivity:	3.42

a. 9.90%

b. 6.48%

c 6.40%

d. 3.80%

A.17 d

REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 6.2.3 p. 6-4. SDM (cold/clean) = Total Rod worth - K_{excess} - Most reactive blade - Reg Rod SDM = (2.41 + 2.32 + 2.49 + 2.60 + 0.084) - 3.42 - 2.60 - 0.084 = 3.80%

Question A.18 [1.0 point]
The reactor is operating at 100 KW. The reactor operator withdraws the Regulating Rod allowing power to increase. The operator then inserts the same rod to its original position, decreasing power. In comparison to the rod withdrawal, the rod insertion will result in:

a. a longer period due to long lived delayed neutron precursors.

b. a shorter period due to long lived delayed neutron precursors.

c. the same period due to equal amounts of reactivity being added.

d. the same period due to equal reactivity rates from the rod.

A.18 a

REF: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1982, §§ 3.2.2–3.2.3, pp. 3-7–3-12.

Question A.19 [1.0 point]
[2.0 points, ½ each]
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.

A.19 a, 2; b, 4; c, 1; d, 3
REF: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, §

Question B.01 [2.0 point, 0.4 each]
Match the terms listed in column A with the respective reactivity limit from column B. (Note: Only one answer for each item in column A. Items in column B may be used more than once or not at all.)

Column A	Column B
a. Maximum Single Moveable	1. 0.1% ΔK/K
b. Maximum All Experiments	2. 0.4% ΔK/K
c. Maximum Excess Reactivity (Normally)	3. 0.7% ΔK/K
d. Minimum Shutdown Margin	4. 1.0% ΔK/K
e. Maximum Regulating Rod Worth	5. 1.2% ΔK/K
	6. 1.5% ΔK/K

B.01 a, 0.4; b, 1.2; c, 1.5; d, ~~1.2~~ 1.0; e, 0.7 Answer changed per facility comment.
REF: Technical Specifications §§ 3.1 and 3.7.1

Question B.02 [1.0 point]
Which ONE of the following is the lowest level of management who has the authority to extend a Radiation Work Permit?

a. Reactor Manager

b. Reactor Director

c. Any licensed Senior Reactor Operator

d. Any licensed Reactor Operator

B.02 a (b and a both have authority, a is less senior.)
REF: SOP 615 pg 2

Question B.03 [1.0 point]
Which **TWO** of the following types of experiments **MUST** be specifically approved by the Radiation Safety Committee?

a. Experiments containing explosive materials and fueled experiments

b. Experiments containing explosive materials and experiments containing materials corrosive to reactor components.

c. Experiments containing materials corrosive to reactor components and fueled experiments

d. Experiments compounds highly reactive with water and explosive materials.

B.03 a
Ref: Technical Specifications § 5.7.2 (1), (2) and (3).

Question B.04 [2.0 points, ½ each]
Identify each of the following as either a Safety Limit (SL), a Limiting Safety System Setting (LSSS) or as a Limiting Condition for Operations (LCO).

a. Fuel Cladding Temperature shall be less than 580EC

b. … (pool level) is at least 16 feet (4.88 m) of water above the core.

c. … The reactor shall not be operated unless the Reactor Building bay door, ventilation Intake and exhaust duct louvers, and the personnel security door are operable.

d. … Reactor Power (P) shall not exceed 300 Kilowatts (thermal)

B.04 a, SL; b, LCO; c, LCO; d, LSSS;
Ref: Technical Specifications §§ 2.1, 2.2, 3.3 and 3.4.

Question B.05 [1.0 point]
Which ONE of the following experiments is not allowed under any condition?

a. An experiment containing Corrosive Materials.

b. A fueled experiment generating 200 watts of power.

c. An experiment containing 20 milligrams of explosive material

d. An experiment with cooling where the calculated temperature outside the capsule will be 90EC.

B.05 b
Ref: Technical Specifications § 3.7.2, Limitations on Experiments

Question B.06 [1.0 point, ¼ each]
Identify the source for the listed radioisotopes. Irradiation of air, water, structural material or fission product.

a. N^{16}

b. Na^{24}

c. Ar^{41}

d. Xe^{133}

B.06 a, water; b, structural material; c, air; d, fission product
REF: Standard NRC Question, source: Chart of the Nuclides

Question B.07 [1.0 point]
Which ONE of the following conditions is an Reportable Occurrence per the Technical Specification definition?

a. Operation of the reactor with the Reactor Period scram set at 4 seconds.

b. Operation of the reactor with a secured experiment worth 0.25% ΔK/K.

c. A rabbit sample injects 0.3% Δk/k reactivity when anticipated was 0.1% Δk/k.

d. Operation with a pool level of 19 ft. above the top of the core.

B.07 a
REF: Technical Specifications,

Question B.08 [1.0 point, ¼ each]
Identify the correct number which correctly defines the maximum period between testing intervals per the Technical Specifications definitions.

a. Weekly: ___ days

b. Monthly: ___ weeks

c. Quarterly: ___ months

d. Annually: ___ months

B.08 a, 10; b, 6; c, 4; d, 15
Ref: Technical Specifications, § 1.3 Definitions

Question B.09 [1.0 point]
Which ONE of the following is the definition of a ***CHANNEL TEST***?

a. the combination of sensor, line, amplifier, and output devices which are connected for the purpose of measuring the value of a parameter.

b. an adjustment of the channel such that it output corresponds with acceptable accuracy to known values of the parameter which the channel measures.

c. a qualitative verification of acceptable performance by observation of channel behavior.

d. the introduction of a signal into the channel for verification that It Is operable.

B.09 d
Ref: Technical Specifications § 1.3 Definitions

Question B.10 [1.0 point, ¼ each]
Match type of radiation (1 thru 4) with the proper penetrating power (a thru d)

a. Gamma	1. Stopped by thin sheet of paper
b. Beta	2. Stopped by thin sheet of metal
c. Alpha	3. Best shielded by light material
d. Neutron	4. Best shielded by dense material

B.10 a, 4; b, 2; c, 1; d, 3
Ref: Standard NRC Question

Question B.11 [1.0 point]
According to both the Safety Analysis Report and UMR Reactor Standard Operating Procedure 650, when performing a swipe contamination survey, activities below ____ are reported as “no contamination evident.”

a. 100 FCi/100 cm^2

b. 10 FCi/100 cm^2

c. 1 FCi/100 cm^2

d. 100 pCi/100 cm^2

B.11 ~~c~~ d, answer changed per facility comment
REF: T.S. §§ 1.3 Definitions, p. 7, and 4.2.1 Specification (1), p. 27.

Question B.12 [1.0 point]
A radiation survey instrument was used to measure an irradiated experiment. The results were 100 mrem/hr with the window open and 60 mrem/hr with the window closed. What was the beta dose rate?

a. 40 mrem/hr

b. 60 mrem/hr

c. 100 mrem/hr

d. 140 mrem/hr

B.12 a
Ref: Instrument reads only γ dose with window closed. Instrument reads both β and γ dose with window open. Therefore, β dose is window open dose less window closed dose.

Question B.13 [1.0 point]
Before you remove a control rod for inspection or maintenance you must remove fuel elements to insure the loading is below …

a. 25% of a critical mass when all rods are removed.

b. 40% of a critical mass when all rods are removed.

c. 50% of a critical mass when all rods are removed.

d. 75% of a critical mass when all rods are removed.

B.13 c
Ref: Facility SOP 302

Question B.14 [1.0 point]
Technical Specification 3.5 states "A ventilation fan with a capacity of at least 4,500 cubic feet per minute (cfm) (127.4 m^3/min) shall be turned on when the reactor is at full power. An additional requirement in SOP 104 states that at least one building exhaust fan should be turned on when the …

a. the constant air monitor reaches a value of about 600 cpm.

b. the bridge monitor reaches a value of about 15 mrem/hr

c. the purification system water temperature reaches a value of about 50EC

d. the reactor room air temperature reaches 88EF

B.14 a
Ref: SOP 104, § B.6

Question B.15 [1.0 point]
Per the Emergency plan, “If an emergency situation requires personnel to search for and remove injured person(s) or entry is necessary to prevent conditions that would probably injure numbers of people, a planned emergency exposure to the whole body could be allowed up to ____ to save a life.”

a. 25 rem

b. 50 rem

c. 75 rem

d. 100 rem
B.15 c
Ref: Emergency Plan § 7.4.6 4th ¶, p. 18.

Question B.16 [1.0 point]
Which ONE of the following Emergency classifications is **NOT** used at UMRR? (Note: The Classifications are listed alphabetically, not in order of severity.)

a. Alert

b. General Emergency

c. Notification of Unusual Event

d. Site Area Emergency
B.16 ~~d~~ b, answer changed per facility comment.
Ref: Emergency Plan, §§ 4.1 through 4.3.

Question B.17 [1.0 point]
A small radioactive source is to be stored in the reactor building. The source reads 2 Rem/hr at 1 foot. Assuming no shielding is to be used, a Radiation Area barrier would have to be erected from the source at least a distance of approximately:

a. 400 feet

b. 40 feet

c. 20 feet

d. 10 feet
B.17 c
Ref: $\frac{D_1}{X_2} = \frac{D_2 X_2}{X_1^2} = \frac{D_1 X_1^2}{D_2}$ $X_2 = \frac{20 \times 4}{5} = 4 \times 2 = 8$

Question B.18 [1.0 point]
In case of an emergency where the normal Emergency Support Center is **NOT** available the alternate Emergency Support Center will be setup in …

a. Physics Building Main Office(Room 102)

b. Reactor Control Room.

c. Nuclear Engineering Department Office (Room 101, 102, 102A, Fulton Hall).

d. Health/Information Security Building, Campus Police Main Office.

B.18 c
Ref: Emergency Plan, § 8.1, Emergency Support Center, p. 21.

Question C.01 [2.0 points, ½ each]
Match the problems on the left with its possible plant conditions on the right. (No changes to any equipment have been made, e.g. no valves manipulated)

a. High radiation level in demineralizer tanks
b. High radiation level on demineralizer outlet
c. High flow through demineralizer tanks
d. High pressure on demineralizer inlet

1. Resin separation (channeling)
2. Fission product release (fuel leak)
3. High water temperature
4. Clogging

C.01 a, 2; b, 3; c,1; d, 4
REF: New NRC Question, 2nd verification.

Question C.02 [1.0 point]
Which one of the following is NOT a reason for having excess reactivity in the core?

a. Fission Product poisons buildup

b. Pool Temperature changes

c. Insertion of Experiments

d. The use of a neutron source
C.02 d
Ref: Standard NRC question

Question C.03 [1.0 point]
Which ONE of the following detectors is used primarily to measure N^{16} release to the environment?

a. NONE, N^{16} has too short a half-life to require environmental monitoring.

b. Reactor Building Gaseous Effluent Monitor

c. Rabbit Blower Effluent Monitor

d. Area Monitor above the pool
C.03 a
Ref: Standard NRC question

Question C.04 [2.0 points, $^{2}/_{5}$ each]
Identify each of the following characteristics as belonging to either the regulating rod (RR), the shim-safety rods (SSR) or both (BOTH).

a. The poison section is attached directly to the drive screw.

b. Active length = 24"

c. Rod is grooved

d. Rod is hollow (a tube)

e. Primary Poison material is Stainless Steel

C.04 a, RR; b, Both; c, SSR; d, RR; e, RR or Both. **NOTE**: 2nd correct answer added per facility comment. Additionally, part e reworded to clarify question.
Ref: Safety Analysis Report § 3.2.3.

Question C.05 [1.0 point]
Which ONE of the following is the main function performed by the DISCRIMINATOR circuit in the Startup Channel?

a. To generate a current signal equal and of opposite polarity as the signal due to gammas generated within the Startup Channel Detector.

b. To filter out small pulses due to gamma interactions, passing only pulses due to neutron events within the Startup Channel Detector.

c. To convert the linear output of the Startup Channel Detector to a logarithmic signal for metering purposes.

d. To convert the logarithmic output of the metering circuit to a δt (delta time) output for period metering purposes.

C.05 b
Ref: Standard NRC Question

Question C.06 [1.0 point]
Which ONE of the following correctly describes how indicated power will compare to actual power for a loss of compensating voltage to the Linear Channel detector. Power level is at 10 watts, when the compensating voltage is lost.

a. Indicated power is the same as actual power.

b. Indicated power is slightly higher than actual power.

c. Indicated power is slightly lower than actual power.

d. Indication will read zero.

C.06 ~~d~~ b, answer changed per facility comment (typo)
REF: Standard NRC Question

Question C.07 [2.0 points, ⅓ each]
Match the Instrument Channel listed in Column A with the correct detector listed in column B. (Note: Items listed in column B may be used more than once or not at all.)

Column A	Column B
a. Log-N	1. Fission Chamber
b. Startup	2. Geiger-Müeller Detector and BF_3
c. Safety Channel	3. Na-I Scintillation Detector
d. Bridge RAM	4. Geiger-Müeller Detector
e. CAM	5. Compensated Ion Chamber
f. Basement RAMs	6. Uncompensated Ion Chamber

C.07 a, 5; b, 1; c, 6; d, 4; e, 4; f, 2 or 4
2nd correct answer added per facility comment. RAM changed to plural to clarify question.
REF: SAR §§ 3.5.1, 3.5.3, 3.5.6, 3.6.2.

Question C.08 [1.0 point]
Two water pumps are operated to force water downward over the core. The purpose of this downward flow is to …

a. aid in the mixing of pool water, minimizing hot spots.

b. aid in minimizing the temperature of the water entering the purification system, increasing resin life.

c. slow down the rising of hot water, thereby decreasing radiation levels due to radioisotopes produced in the water next to the core.

d. aid in the mixing of water, maximizing the effectiveness of the pool skimmer.
C.08 c
REF: § 3.6.1 2nd ¶

Question C.09 [1.0 point]
Input to the servo system is provided by the:

a. Log and Linear Power Channel.

b. Linear Power Channel.

c. Safety Channel #1.

d. Safety Channel #2.
C.09 b
REF: SAR § 3.5.2 page 3-34.

Question C.10 [2.0 points, ¼ each]
Using the drawing of the purification system provided, identify the components (a through h) with the correct name from Column B. (Note only one answer per item, not all choices in column B are used.)

Column A		Column B
a.	A	1. Demineralizer (Ion Bed)
b.	B	2. Filter
c.	C	3. Conductivity Cell
d.	D	4. Pressure Gage
e.	E	5. Rotameter
f.	F	6. Normally Closed Valve
g.	G	7. Normally Open Valve
h.	H	8. Raw Water Supply Tank
		9. Discharge Tank

C.10 a, 6; b, 7; c, 4; d, 3; e, 8; f, ~~10~~ 5; g, 2; h, 1

Answer changed per facility comment.

REF: SAR § 5.2, pp. 5-1 – 5-3, also Figure 22, p. 5-4.

Question C.11 [1.0 point]
Which ONE of the following is NOT a feature of the Pneumatic Sample Transfer system designed to reduce overall radiation levels in the facility?

a. The tube has a slight curve through the pool (preventing a beam of radiation directly from the core).

b. Exhaust of the system is sent through a high efficiency filter (Reduces the amount of radioactive particles released to the atmosphere in the reactor room).

c. The tubes are lined with Cadmium (reduces the fast neutron flux at the surface of the pool).

d. N_2 gas is used to move the rabbit (reduces the generation of gaseous radioisotopes).

C.11 c
REF: SAR § 4.3, p. 4-5.

Question C.12 [1.0 point]
The purification pump is located on the intermediate basement level of the facility, well below the top of the pool. What design characteristic of the system prevents draining the pool on a pipe failure downstream of the pump?

a. On low pump torque, due to low discharge pressure, a circuit automatically stops the pump.

b. A vacuum break in the purification piping about 16 feet above the top of the core.

c. On high pump current a circuit automatically stops the pump.

d. On low pump discharge pressure, a circuit automatically stops the pump.

C.12 b
REF: SOP 309 § B

Question C.13 [1.0 point, ¼ each]
Match each of the radiation monitors in column A with its associated actions in Column B.

a. Demineralizer RAM	1. Indication Only
b. Experiment Room RAM	2. Indication and Runback Only
c. Reactor Bridge RAM	3. Indication, Runback and Evacuation.
d. CAM	

C.13 a, 2; b, 2; c, 3; d, 1
REF: Facility Technical Specifications Table 3.3, and SAR § 3.6.2, pp., 3-46 – 3-38.

Question C.14 [1.0 point]
Core inlet temperature is measured using two thermocouples. A thermocouple is …

a. a precision wound resistor which changes resistance proportional to the change in temperature.

b. a bi-metallic junction which changes voltage proportional to the change in temperature.

c. a sphere containing a liquid which changes volume with temperature. Expansion and contraction cause an arm in an inductor to move changing inductance proportional to the change in temperature.

d. a mercury filled balloon inside an inductor, the expansion and contraction of the mercury causes a variation in the circuit inductance proportional to the change in temperature.

C.14 b
REF: SAR § 3.5.3

~~**Question C.15 [1.0 point]**~~ Question Deleted per facility comment. (No correct answer)
~~All of the Nuclear Instrumentation channels listed below have a rod withdrawal prohibit if its respective recorder is off **EXCEPT** the …~~

~~a. Log Count Rate Channel~~

~~b. Log Power Channel~~

~~c. Period recorder Channel~~

~~d. Linear Power Channel~~
~~C.15 d~~
~~REF: SAR 3.5.1, 3.5.2, 3.5.3 and Table IX~~

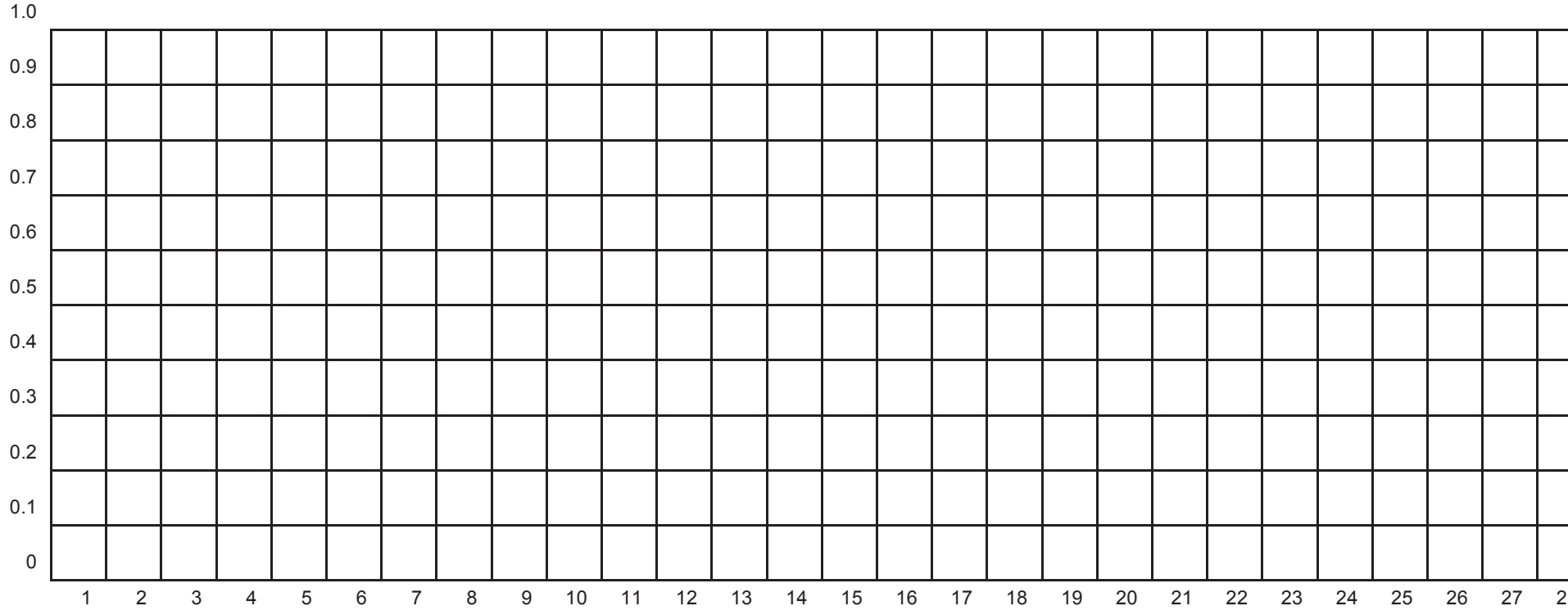
Question C.16 [1.0 point]
How is heat removed from the core at 100% power?

a. Forced flow due to the diffuser pumps.

b. Natural convection of the water within the core.

c. Forced flow due to flow through the demineralizer system.

d. Nucleate boiling of the water within the core.
C.16 b
REF: Standard NRC Question



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

All work done on this examination is my own. I have [illegible]

Category	A.	B.	C.	Total
Value	20.00	20.00	20.00	60.00
% of Candidates Score	33.3	33.3	33.3	%

FINAL GRADE

Category	A.	B.	C.	Total
Value				
%				%

Candidate's Signature

CANDIDATE AREA OF RESPONSIBILITY:

NON-POWER INITIAL REACTO

U. S. NUCLEAR REGULATO

University of Missouri – Rolla

2007FR/24

Category

Operating Characteristics and Radiation Protection

Theory of Reactor Operations

Facility Systems and Procedures

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

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

$$P_{max} = \frac{(\rho\beta\gamma)^2}{2(\lambda)}$$

$$R = 1 \times 10^{6} \text{ sec}$$

$$\lambda_{eff} = \frac{1}{\text{sec}}$$

$$SCR = \frac{S}{\rho} = \frac{1}{1 - K_e}$$

$$C_1(1 - K_{eff}) = C_2(1 - K_{eff})$$
$$C_1(R_1) = C_2(R_2)$$

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

$$M = \frac{1 - K_{eff}^{n}}{1 - K_{eff}}$$

$$M = \frac{1}{1 - K_{eff}} = \frac{1}{\rho}$$

$$P = P_0 10^{SUR \cdot t}$$

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

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

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

$$T = \frac{K - 1}{\rho - \beta}$$

$$T = \frac{K - 1}{\rho} + \left[\frac{\beta - \rho}{\lambda_{eff} \rho} \right]$$

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

$$T_{1/2} = \frac{0.693}{\lambda}$$

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

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

$$DR = \frac{6 \cdot (Ci)(E)}{R^2}$$

$$DR_2 = DR_1 \left(\frac{1}{2} \right)^{n}$$

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

$$\frac{(\rho - \beta)_2}{Peak} = \frac{(\rho - \beta)_1}{Peak}$$

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

EF = 9/5 EC + 32

1 gal (H_2O) . 8 lbm

EC = 5/9 (EF - 32)

c_P = 1.0 BTU/hr/lbm/EF

c_p = 1 cal/sec/gm/EC

Section A Rx Therapeutics

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.19a 1 2 3 4 ___

A.19b 1 2 3 4 ___

A.19c 1 2 3 4 ___

A.19d 1 2 3 4 ___

Section B Normal

B.01a % ΔK/K 0.1 0.4 0.7 1.0 1.2 1.5 ___

B.01b % ΔK/K 0.1 0.4 0.7 1.0 1.2 1.5 ___

B.01c % ΔK/K 0.1 0.4 0.7 1.0 1.2 1.5 ___

B.01d % ΔK/K 0.1 0.4 0.7 1.0 1.2 1.5 ___

B.01e % ΔK/K 0.1 0.4 0.7 1.0 1.2 1.5 ___

B.02 a b c d ___

B.03 a b c d ___

B.04a SL LSSS LCO ___

B.04b SL LSSS LCO ___

B.04c SL LSSS LCO ___

B.04d SL LSSS LCO ___

B.05 a b c d ___

B.06a Air Water S.M. F.P. ___

B.06b Air Water S.M. F.P. ___

B.06c Air Water S.M. F.P. ___

B.06d Air Water S.M. F.P. ___

B.07 a b c d ___

B.08a _____

B.08b _____

B.08c _____

B.08d _____

B.09 a b c d ___

B.10a a b c d ___

B.10b a b c d ___

B.10c a b c d ___

B.10d 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.18 a b c d ___

Section C Facilit

C.1a 1 2 3 4 ___

C.1b 1 2 3 4 ___

C.1c 1 2 3 4 ___

C.1d 1 2 3 4 ___

C.2 a b c d ___

C.3 a b c d ___

C.4a RR SSR BOTH ___

C.4b RR SSR BOTH ___

C.4c RR SSR BOTH ___

C.4d RR SSR BOTH ___

C.4e RR SSR BOTH ___

C.5 a b c d ___

C.6 a b c d ___

C.7a 1 2 3 4 5 6 ___

C.7b 1 2 3 4 5 6 ___

C.7c 1 2 3 4 5 6 ___

C.7d 1 2 3 4 5 6 ___

C.7e 1 2 3 4 5 6 ___

C.7f 1 2 3 4 5 6 ___

C.08 a b c d ___

C.09 a b c d ___

C.10a 1 2 3 4 5 6 7 8 9 ___

C.10b 1 2 3 4 5 6 7 8 9 ___

C.10c 1 2 3 4 5 6 7 8 9 ___

C.10d 1 2 3 4 5 6 7 8 9 ___

C.10e 1 2 3 4 5 6 7 8 9 ___

C.10f 1 2 3 4 5 6 7 8 9 ___

C.10g 1 2 3 4 5 6 7 8 9 ___

C.10h 1 2 3 4 5 6 7 8 9 ___

C.11 a b c d ___

C.12 a b c d ___

C.13a 1 2 3 ___

C.13b 1 2 3 ___

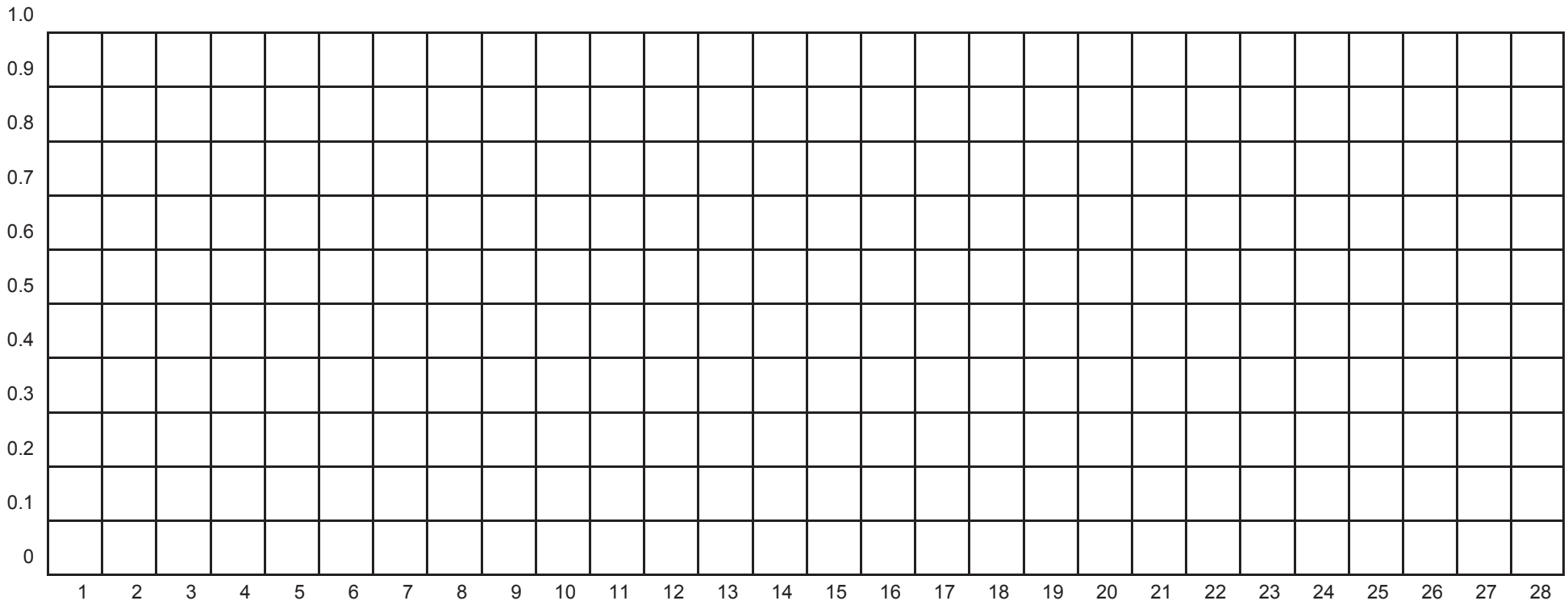
C.13c 1 2 3 ___

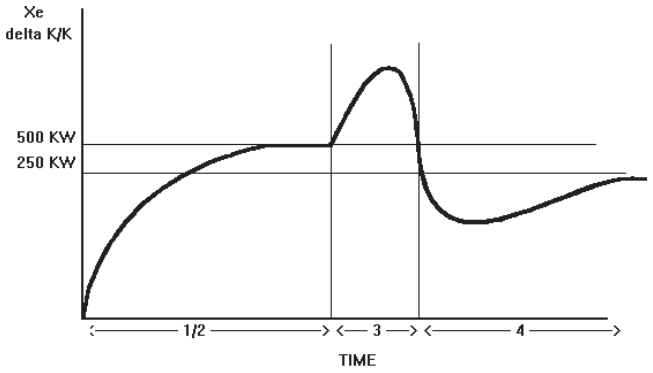
C.13d 1 2 3 ___

C.14 a b c d ___

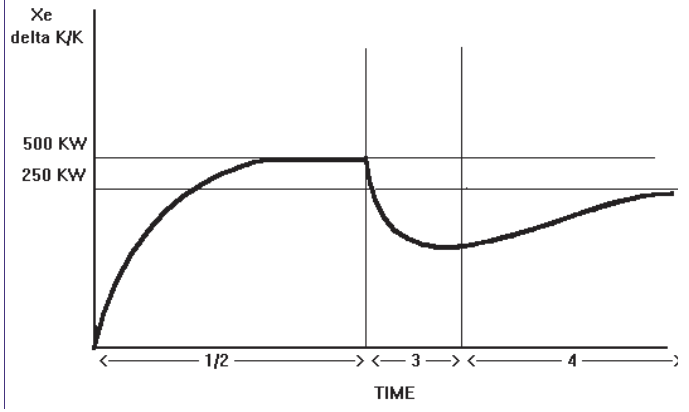
C.15 a b c d ___

C.16 a b c d ___

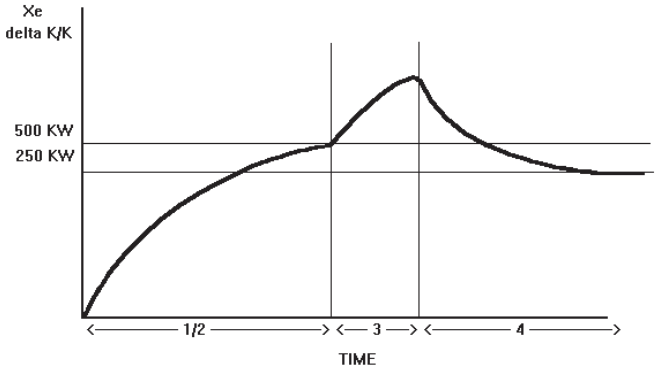

1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28



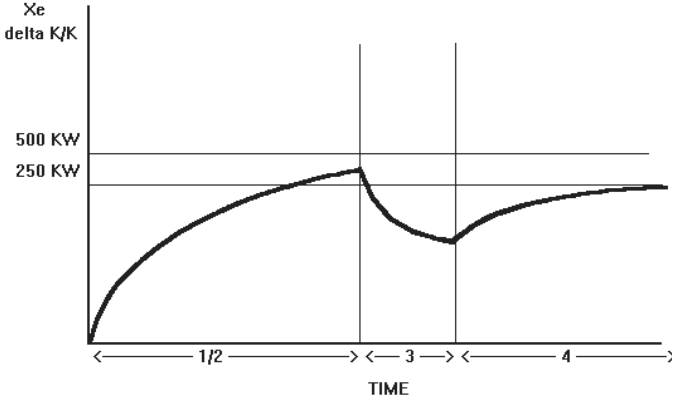
a



b

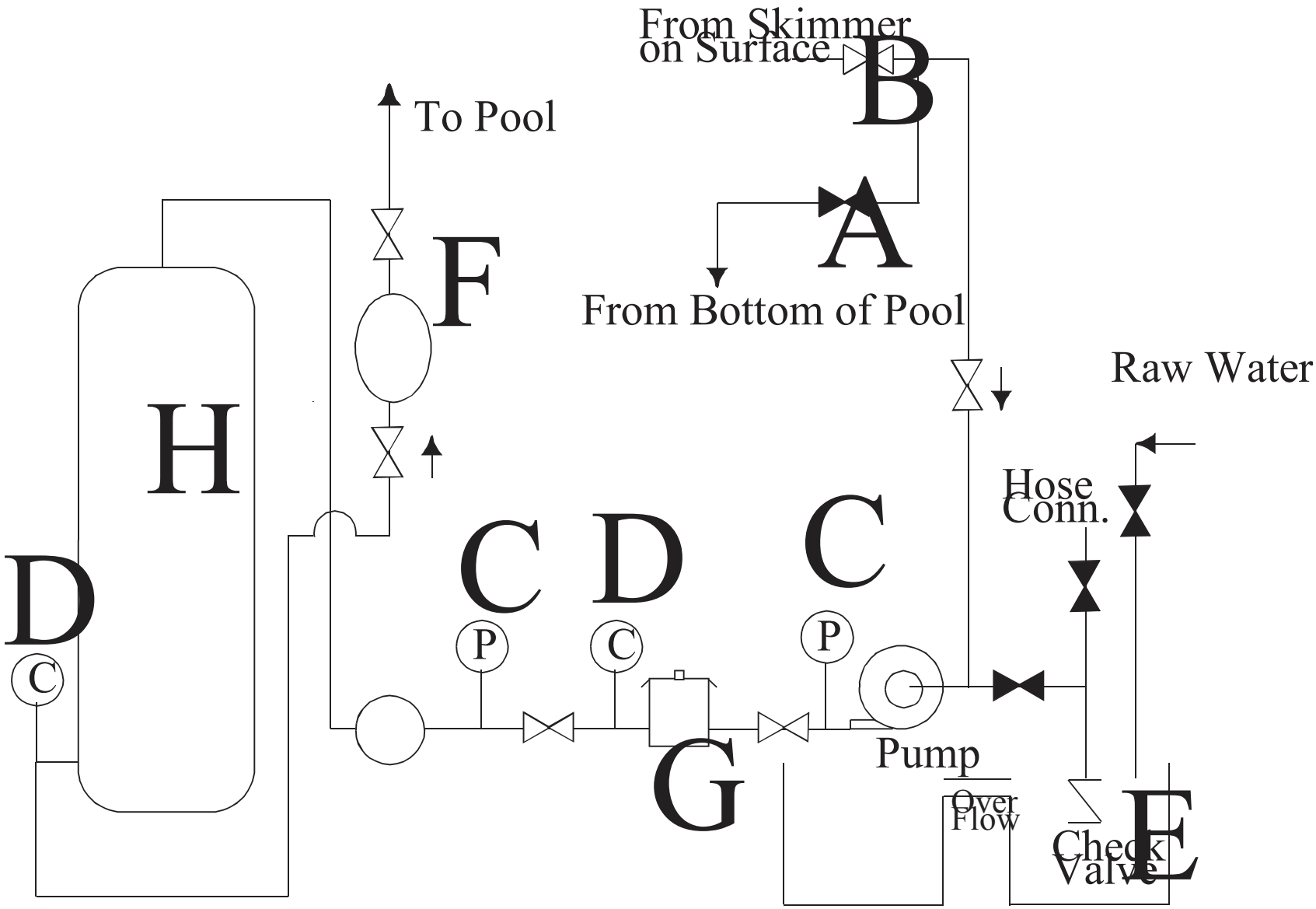


c



d

FIGURE FOR A.09


From Skimmer
on Surface
B
To Pool
A
F
From Bottom of Pool
Raw Water
H
Hose
Conn.
D
C
C
D
C
P
C
P
Pump
G
Over
Flow
Check
Valve
E