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

REPORT NO.: 50-182/OL-97-01

FACILITY DOCKET NO.: 50-182

FACILITY LICENSE NO.: R-87

FACILITY: Purdue University

EXAMINATION DATES: June 2 – 3, 1997

EXAMINER: Paul Doyle, Chief Examiner

SUBMITTED BY: Paul Doyle, Chief Examiner   6/17/97
Date

SUMMARY:

During the week of June 2, 1997 the NRC administered an Operator Licensing Examination to one Reactor Operator Candidate at Purdue University. The candidate failed Section B of the written examination and passed all other portions of the examination.

REPORT DETAILS

1. Examiner: Paul Doyle, Chief Examiner

2. Results:

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

3. Exit Meeting:
Paul Doyle, NRC, Examiner
Ed Merrit, Purdue University, Reactor Supervisor
Frank Clikeman, Purdue University, Laboratory Director

During the exit meeting the facility staff gave their comments on the written examination. The examiner thanked the facility for their assistance in the adminstration of the examinations.

ENCLOSURE 1

Comments on NRC Written Examination along with NRC Resolutions

Question A.3

Comment:

This question has no correct answer.

NRC Resolution:

Agree. Question Deleted.

Question A.10

Comment:

Ensure people realize that correct answer should include neutrons due to gamma reactions within the shutdown core..

NRC Resolution:

Agree. There is no need to change answer key. Question will be modified prior to its next use on an examination.

Question A.17

Comment:

The answer to this question should be c instead of a.

NRC Resolution:

Agree. Answer key modified to accept c as correct answer.

Enclosure 2

United States Nuclear Regulatory Commission

PURDUE UNIVERSITY
06/02/97

Enclosure 3

QUESTION (A.1) [1.0]
Several processes occur during the neutron cycle which increase or decrease the number of neutrons. Which ONE of the following describes a process which INCREASES the number of neutrons?

a. Fast Non-Leakage probability ($\mathcal{L}_f$)

b. Resonance Escape Probability (p)

c. Thermal Utilization Factor (f)

d. Reproduction Factor (η)

~~QUESTION (A.2) [1.0]~~ **Question Deleted**
~~Which ONE of the following statements is the definition of *REACTIVITY*?~~

~~a. A measure of the core's fuel depletion.~~

~~b. A measure of the core's deviation from prompt criticality.~~

~~c. Equal to 1.00 ΔK/K when the reactor is critical.~~

~~d. Equal to 1.00 ΔK/K when the reactor is prompt critical.~~

QUESTION (A.3) [1.0]
A thin foil target of 10% copper and 90% aluminum is in a thermal neutron beam. Given $\sigma_{s\,al}$ = 3.79 barns, $\sigma_{s\,cu}$ = 0.23 barns, $\sigma_{a\,al}$ = 7.90 barns, and $\sigma_{a\,cu}$ =1.49 barns, which ONE of the following reactions has the highest probability of occurring? A neutron ...

a. scattering reaction with aluminum.

b. scattering reaction with copper.

c. absorption in aluminum.

d. absorption in copper.

QUESTION (A.7) [1.0]
Excess reactivity is the amount of reactivity ...

a. associated with samples.

b. required to achieve prompt criticality.

c. available above that required to make the reactor critical

d. associated with Xenon production.

QUESTION (A.8) [1.0]
Which ONE of the following is the purpose for having a neutron source?

a. To compensate for neutrons absorbed by experiments installed in the reactor.

b. To generate a sufficient population to start a fission chain reaction for reactor startup.

c. To provide a means for allowing reactivity changes to occur in a subcritical reactor.

d. To generate a detectable neutron level for monitoring reactivity changes in a shutdown reactor.

QUESTION (A.9) [1.0]
The reactor is shutdown by 0.015 ΔK/K. The Startup range count rate is 15 counts per minute. After placing a sample into the reactor the count rate increases to 60 counts per minute. What is the worth of the sample?

a. + 0.0006

b. + 0.0113

c. - 0,0006

d. - 0.0113

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QUESTION (A.4) [1.0]
Which ONE of the following is the MAJOR recoverable source of energy released during the fission process?

a. Prompt gamma rays

b. Neutrinos

c. Capture gamma rays

d. Kinetic energy of the fission fragments.

QUESTION (A.5) [1.0]
Which ONE of the following isotopes would cause a colliding neutron to lose the most energy?

a. H^{1}

b. H^{2}

c. C^{12}

d. U^{238}

QUESTION (A.6) [1.0]
Which ONE of the following describes the difference between prompt and delayed neutrons? Prompt neutrons ...

a. account for less than one percent of the neutron population, while delayed neutrons account for the rest.

b. are released during fast-fission events, while delayed neutrons are released during thermal neutron events.

c. are released during the fission process (fast & thermal), while delayed neutrons are released during the decay process.

d. are the dominating factor in determining reactor period, while delayed neutrons have little effect on reactor period.

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Excess reactivity is the amount of reactivity ...

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b. + 0.0113

c. - 0,0006

d. - 0.0113

QUESTION (A.10) [1.0]
Which ONE of the following is the reason that R power stabilizes several hours after shutdown? (Assume source inserted in core, nuclear instrumentation is operable and reading on-scale, and no reactivity changes are in progress.)

a. Continuing decay of the shortest lived neutron precursor.

b. Gamma saturation of the fission chamber.

c. Subcritical multiplication of source neutrons.

d. Neutron activation of the fission chamber.

QUESTION (A.11) [1.0]
The book *Nuclear Reactor Engineering*, by Glasstone & Sesonske states that the delayed neutron fraction (β) for ^{U235} is 0.0065. However your Safety Analysis report states the $\beta_{effective}$ is approximately 0.0075. Why is $\beta_{effective}$ larger than β?

a. The fuel contains U^{238} which has a large β for fast fissions.

b. The fuel contains Pu^{239} which has a large β for thermal fissioning.

c. Delayed neutrons are born at a higher energy level than fission neutrons resulting in a greater amount of neutrons from fast fissions.

d. Delayed neutrons are born at a lower energy level than fission neutrons resulting in fewer being lost to fast leakage.

QUESTION (A.12) [1.0]
You've shutdown the reactor and power is decreasing at a steady negative period. The fission chamber output reads 100 cpm. What would you expect reactor power to read 3 minutes later?

a. 50 cpm

b. 25 cpm

c. 10 cpm

d. 5 cpm

QUESTION (A.13) [1.0]
Which ONE of the four factors listed that is MOST affected by an increase in poison level in the reactor?

a. Fast fission factor (ε)

b. Thermal Utilization factor (f)

c. Resonance Escape probability (p)

d. Reproduction Factor (η)

QUESTION (A.14) [1.0]
Which ONE would be the resultant K_{eff} for an exactly critical reactor where all of the delayed neutrons were instantaneously removed?

a. 1.007

b. 1.000

c. 0.993

d. 0.000

QUESTION (A.15) [1.0]
K_{eff} for the reactor is 0.85, when you place an experiment worth +16% $\Delta K/K$ into the core. The new K_{eff} is ...

a. 1.01

b. 0.98

c. 0.93

d. 0.90

QUESTION (A.16) [1.0]
With the reactor on a constant period which transient will take the **LONGEST** time to complete? A reactor power change of ...

a. 5% of rated power, going from 1% to 6% of rated power.

b. 10% of rated power, going from 10% to 20% of rated power.

c. 15% of rated power, going from 20% to 35% of rated power.

d. 20% of rated power, going from 40% to 60% of rated power.

QUESTION (A.17) [1.0]
Regulating rod worth for a reactor is 0.001 ΔK/K/inch. The moderator temperature coefficient (α_{Tmod}) for the same reactor is 0.0005 ΔK/K/°F. If moderator temperature increases by 9°F. By how much, and in which direction must the regulating rod move to compensate?

a. 4½ inches, outward

b. 9 inches, outward

c. 4½ inches, inward

d. 9 inches, inward

QUESTION (A.18) [1.0]
In a **CRITICAL** reactor, of 100 fast neutrons produced from fission, 20 neutrons are captured in resonance peaks, and 10 leak out. The remainder are absorbed in the core (fuel and other materials). Each fission produces 2.5 neutrons, and 85% of the neutrons absorbed in the fuel result in fissions. For this reactor the thermal utilization factor (f) is: **(SHOW ALL WORK)**

a. 0.47

b. 0.62

c. 0.67

d. 1.61

QUESTION (A.19) [1.0]
Which ONE of the following conditions would **INCREASE** the shutdown margin of a reactor?

a. Inserting an experiment adding positive reactivity.

b. Lowering moderator temperature if the moderator temperature coefficient is negative.

c. Depletion of a burnable poison.

d. Depletion of uranium fuel.

***** END OF SECTION A *****

QUESTION (B.1) [1.0]
Two sheets of ¼ inch thick lead reduces a radiation beam from 200 mR/hr to 100 mR/hr, at one foot. What will be the radiation measurement at 1 foot if you add another (for a total of 3) ¼ inch lead sheet?

a. 71 mR/hr

b. 50 mR/hr

c. 35 mR/hr

d. 17 mR/hr

QUESTION (B.2) [1.0]
In the process of saving someone's life you receive 6 Rem. How is this radiation dose tracked?

a. Tracked by the facility as "occupational dose"

b. Tracked by the facility as a "planned special exposure"

c. Exempt from tracking per Emergency Plan

d. Tracked by the NRC as a "planned special exposure"

QUESTION (B.3) [2.0, 0.5 each]
Match the actions listed in column A with its appropriate technical specification definition of Channel Check, Channel Test or Channel Calibration.

a. Observe overlap between Nuclear Instrument channels.

b. Replace resistance temperature detector with a precision resistance bridge to check proper temperature circuit operation.

c. Monitor Nuclear Instrumentation after shutdown verifying power decreases by a factor of 10 in three minutes.

d. Based on a flux measurement using gold foils, adjust Nuclear Instrumentation.

QUESTION (B.4) [2.0, 0.5 each]
Match the requirements associated with your individual licensed listed in column A with the correct frequency in column B.

	Column A	Column B
a.	Requalification Written	6 years
b.	Requalification Operating Test	4 years
c.	Medical Examination	2 years
d.	License Expiration	1 years

QUESTION (B.5) [1.0]
Which ONE of the following is the 10 CFR 20 definition of **TOTAL EFFECTIVE DOES EQUIVALENT (TEDE)**?

a. The sum of the deep does equivalent and the committed effective dose equivalent.

b. The dose that your whole body receives from sources outside the body.

c. The sum of the external deep dose and the organ dose.

d. The dose to a specific organ or tissue resulting from an intake of radioactive material.

QUESTION (B.6) [2.0, 0.4 each]
Match the Technical Specifications experiment categories listed in column A with their respective maximum reactivity worths in column B. (Values from column B be may be used more than once, or not at all.)

	Column A		Column B
a.	Single movable	1.	0.001 $\Delta K/K$
b.	Single unsecured	2.	0.002 $\Delta K/K$
c.	Single secured	3.	0.003 $\Delta K/K$
d.	Total moveable and unsecured	4.	0.004 $\Delta K/K$
e.	Total secured	5.	0.005 $\Delta K/K$
		6.	0.006 $\Delta K/K$

QUESTION (B.7) [2.0, 0.5 each]
Match the general radiation area levels in column A with the corresponding 10 CFR 20 definitions listed in column B. (Items in column B may be used more than once or not at all.)

	Column A		Column B
a.	1.5 mRem/hr	1.	Unrestricted Area
b.	15 mRem/hr	2.	Radiation Area
c.	210 mRem/hr	3.	High Radiation Area
d.	900 mRem/hr	4.	Very High Radiation Area

QUESTION (B.8) [1.0]
You are part of a team cleaning up an accident. You have received 1.3 Rem (whole body dose) so far this calendar year. You have no committed dose. Which one of the following is the longest you can work in the accident field of 4.7 Rem/hr, without exceeding your annual 10 CFR 20 TEDE limit? (Emergency Dose is NOT authorized.)

a. 47 minutes

b. 1 hour 3 minutes

c. 1 hour 16 minutes

d. 1 hour 20 minutes

QUESTION (B.9) [1.0]
Which ONE of the below is the lowest level of Purdue Reactor Staff who may authorize restart following a scram?

a. Licensed Reactor Operator on the console.

b. Licensed Senior Reactor Operator on Call.

c. Reactor Supervisor.

d. Facility Director

QUESTION (B.10) [1.0]
An Emergency Action Level is:

a. a condition which calls for immediate action, beyond the scope of normal operating procedures, to avoid an accident or to mitigate the consequences of one.

b. a class of accidents for which predetermined emergency measures should be taken or considered.

c. a procedure that details the implementation actions and methods required to achieve the objectives of the emergency plan.

d. a specific instrument reading or observation which may be used as a threshold for initiating appropriate emergency procedures.

QUESTION (B.11) [1.0]
Which ONE of the following is the maximum reading (at one foot) for which a sample holder may be removed from the pool?

a. 1 mR/hr

b. 7½ mR/hr

c. 100 mR/hr

d. 1 R/hr

QUESTION (B.12) [1.0]
Which ONE of the following conditions is a violation of a Technical Specification Limiting Condition of Operation?

a. Primary coolant pH at 4.6

b. Primary coolant resistivity at 400,000 ohm-cm.

c. An experiment at 95°C

d. Pool water level at 12½ feet above the core.

QUESTION (B.13) [1.0]
Which ONE of the following conditions is a *REPORTABLE OCCURRENCE*?

a. Dropping material into the shutdown core, with a reactivity worth of 0.4%ΔK/K.

b. A core excess reactivity of 0.5%ΔK/K.

c. An unexpected short-term reactivity change causing a period of 19 seconds

d. Discovering the scram setpoint for the safety channel was set at 125% power.

QUESTION (B.14) [1.0]
Which ONE of the following Setbacks is not required by Technical Specifications?

a. Linear Channel Low Level

b. Linear Channel High Level

c. Log Count Rate Low Level Period

d. Log N Channel High Level Period

QUESTION (B.15) [1.0]
Which ONE of the following the scrams is NOT required by Technical Specifications?

a. 7½ mR/hr on console monitor

b. 7 second period on Log Count Rate Channel

c. Manual scram in hall

d. CSA Trouble

*** END OF SECTION B ***

QUESTION (C.1) [1.0]
Which ONE of the following correctly identifies the result of a loss of compensation to a Compensation Ion chamber at low power levels?

a. Unchanged

b. Higher than actual

c. Lower than actual

d. Higher or lower than actual depending on power level.

QUESTION (C.2) [2.0, 0.5 each]
Match the Nuclear Instrumentation channels with their correct functions. (Protection refers to scrams and setbacks, while control relates to input to the automatic circuit for the servo control system.)

	Column A		Column B
a.	Startup Channel	1.	Setback and Slow Scram
b.	Log-N Period Channel	2.	Setback and Fast Scram
c.	Pool Top Radiation Area Monitor	3.	Slow Scram Only
d.	Safety Channel	4.	None
e.	Continuous Air Monitor		

QUESTION (C.3) [1.0]
Which ONE of the following is the Neutron startup source used at Purdue?

a. Pu-Be

b. Am-Be

c. Sb-Be

d. Ra-Be

QUESTION (C.4) [1.0]
Which ONE of the following components within the purification system is responsible for maintaining primary conductivity low?

a. Heat exchanger

b. Cuno Filter

c. Freon compressor

d. Cartridge type Demineralizer

QUESTION (C.5) [1.0]
Which ONE of the following is the method used to reduce mechanical shock to the shim-safety rods when scramming?

a. Small spring located at bottom of rod.

b. A Piston moves into a dashpot as the rod nears the bottom of travel.

c. An electrical-mechanical brake energizes when the lower limit is reached.

d. There is no method for absorbing mechanical shock.

QUESTION (C.6) [1.0]
Which ONE of the following is the correct method used to determine fine control rod position indication? A ratiometer is connected to ...

a. a series of limit switches located every 0.1 inch or rod travel

b. a precision potentiometer mechanically connected to the drive unit.

c. a series of limit switches located every 0.5 inch of rod travel.

d. a precision coil electrically coupled to the rod.

QUESTION (C.7) [1.0]
Which ONE of the following elements is used as the neutron absorber in the Shim-Safety rods?

a. Hafnium

b. Aluminum

c. Borated Stainless Steel

d. Cadmium

QUESTION (C.8) [1.0]
An experimenter drops a sample while preparing to count it. He exits the room and closes the door. Which meter would you hold up to the closed door to determine the extent of the problem prior to entering to clean up the spill.

a. Geiger Muller, to detect a radiation field

b. Geiger Muller, to detect radiation contamination

c. Ion Chamber, to detect a radiation field

d. Ion Chamber, to detect radiation contamination

QUESTION (C.9) [1.0]
Which ONE of the following is the shim-safety rod speed?

a. 17.7 inch/minute

b. 13.2 inch/minute

c. 8.8 inch/minute

d. 4.4 inch/minute

QUESTION (C.10) [1.0]
Which ONE of the following is the correct method to be used to emergency shut down the reactor if the rods do not scram?

a. Remove Fuel assembly H-2.

b. Remove Reflector assembly H-1

c. Insert a cadmium bar into Isotope Production assembly H-6

d. Dump boric acid into pool.

QUESTION (C.11) [1.0]
A visitor inadvertently hits the gang-lower switch. How may the operator stop the rods from inserting?

a. Reenergizing the Log Count Rate Channel.

b. Ranging UP on the Linear Level Channel.

c. Momentarily placing the Raise-Lower switch in either the raise or lower position.

d. Not required. Rod insertion will stop when the gang lower switch is released.

QUESTION (C.12) [1.0]
Which ONE of the following is the detector type used in the Radiation Area Monitors?

a. Scintillation Detector

b. Ion Chamber

c. Geiger Muller

d. Proportional Counter

QUESTION (C.13) [1.0]
What is the purpose of the Startup channel drive mechanism?

a. To maintain the instrument on-scale.

b. To prevent burnout of the U^{235} coating on the detector during high power.

c. To maintain coupling between the fission chamber and the neutron source as they are both withdrawn from the core.

d. To prevent shorting out the preamplifier due to detector saturation.

QUESTION (C.14) [1.0]
Maximum design flow rate for the Ion Exchanger (Demineralizer) is 20 gpm, but the design flow rate of the pump is 30 gallons per minute. How is the system setup to prevent too much flow to the Demineralizer?

a. A pipe with an orifice bypasses some flow around the Demineralizer.

b. A throttle valve in the system is adjusted to supply proper flow.

c. Cavitation due to inadequate Net Positive Suction Head (NPSH) is used to derate the pump flow rate.

d. Differential pressure across the cartridge type filters is kept high to reduce flow.

QUESTION (C.15) [1.0]
Which ONE of the following is the name of the console light which indicates that the shim-safety rods are at the proper height for a critical experiment fuel movement (⅔ out)?

a. SHIM

b. SAFETY

c. TEST

d. SOURCE

QUESTION (C.16) [1.0]
Which ONE of the following channels supplies input to the Regulating Rod SERVO system?

a. Start-up Channel (1)

b. Log N & Period Channel (2)

c. Linear Power Channel (3)

d. Safety Channel (4)

QUESTION (C.17) [1.0]
Which ONE of the following conditions will NOT prohibit withdrawal of the shim-safety rods?

a. Reactor period at 12 seconds.

b. Linear channel reading 112% range.

c. Startup channel Count Rate at 1 cps.

d. Log Count Rate Selector in USE position.

*** END OF SECTION C ***

***** END OF EXAMINATION *****

ANSWER (B.1)
a
REFERENCE (B.1)
A half-thickness is two sheets. $I = I_0 (½)^{1.5}$ = 0.3535 * 200 mR/hr = 70.71 mR/hr

ANSWER (B.2)
b
REFERENCE (B.2)
10 CFR 20.1206

ANSWER (B.3)
a, check; b, test; c, check; d, cal
REFERENCE (B.3)
Technical Specifications § 1.0 Definitions

ANSWER (B.4)
a, 3; b, 4; c, 3; d, 1
REFERENCE (B.4)
10 CFR 55 §§ 21, 55, & 59 (2)

ANSWER (B.5)
a
REFERENCE (B.5)
10 CFR 20.1003, *Definitions*

ANSWER (B.6)
a, 3; b, 3; c, 4; d, 3; e, 6
REFERENCE (B.6)
Technical Specifications § 3.1 *Reactivity Limits*

ANSWER (B.7)
a, 1; b, 2; c, 3; d, 4
REFERENCE (B.7)
10 CFR 20.1003, *Definitions*

ANSWER (B.8)
a
REFERENCE (B.8)
First calculate can get: 5 - 1.3 = 3.7 Rem.
Time = Can get ÷ rate: (3.7 Rem)/(4.7 Rem/hr) × 60 = 47.2 min

ANSWER (B.9)
a
REFERENCE (B.9)
Emergency Procedure located behind the Emergency Plan. Also pp. 13 – 15 in PUR-1 Operating Manual (1965). **NOTE: This violates 10 CFR 50.54.m(1)**

ANSWER (A.1)
d
REFERENCE (A.1)
Glasstone, S. And Sesonske, A, *Nuclear Reactor Engineering,* Kreiger Publishing, Malabar, Florida, 1991, § 3.154, p. 188

~~ANSWER (A.2)~~ **Question Deleted.**
~~b~~
~~REFERENCE (A.2)~~
~~Glasstone, S. And Sesonske, A, *Nuclear Reactor Engineering,* Kreiger Publishing, Malabar, Florida, 1991, § 5.9, p. 231~~

ANSWER (A.3)
c
REFERENCE (A.3)
Glasstone, S. And Sesonske, A, *Nuclear Reactor Engineering,* Kreiger Publishing, Malabar, Florida, 1991, §§ 2.108 – 2.1.114, pp. 77 – 80

ANSWER (A.4)
d
REFERENCE (A.4)
Glasstone, S. And Sesonske, A, *Nuclear Reactor Engineering,* Kreiger Publishing, Malabar, Florida, 1991, §§ 1.50 – 1.55, Table 1.2, pp. 16, 17

ANSWER (A.5)
a
REFERENCE (A.5)
Glasstone, S. And Sesonske, A, *Nuclear Reactor Engineering,* Kreiger Publishing, Malabar, Florida, 1991, §§ 3.81 – 3.85, Table 3.3, pp. 164, 165

ANSWER (A.6)
c
REFERENCE (A.6)
Glasstone, S. And Sesonske, A, *Nuclear Reactor Engineering,* Kreiger Publishing, Malabar, Florida, 1991, § 2.183, p. 107

ANSWER (A.7)
c
REFERENCE (A.7)
Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 6.2.2, pp. 6-2 & 6-3.

ANSWER (A.8)
d
REFERENCE (A.8)
Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 5.2, p. 5-1.

ANSWER (A.9)
b
REFERENCE (A.9)
Reactivity (ρ) = -0.015ΔK/K $K_{eff} = 1/(1 - \rho) = 1/[1-(-0.015)] = 1/1.015 = 0.9852$
$CR_1/CR_2 = (1 - K_{eff2})/(1 - K_{eff1})$ $1 - K_{eff2} = [CR_1 (1 - K_{eff1})]/CR_2$ $K_{eff2} = 1 - [CR_1(1 - K_{eff1})/CR_2]$
$K_{eff2} = 1 - [15/60(1 - 0.9852) = 1 - (1 - 0.9852)/4 = 1 - 0.01478/4 = 1 - 0.003695 = 0.9963$
Worth = $(K_{eff1} - K_{eff2})/K_{eff1}K_{eff2} = (0.9963 - 0.9852)/(0.9852 \times 0.9963) = +0.0113\ \Delta K/K$

ANSWER (A.10)
c
REFERENCE (A.10)
Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, Chapt. 5 § 5.3, pp. 5-5 – 5-13.

ANSWER (A.11)
d
REFERENCE (A.11)
Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 3.2.4, p. 3-12.

ANSWER (A.12)
c
REFERENCE (A.12)
Glasstone, S. And Sesonske, A, *Nuclear Reactor Engineering,* Kreiger Publishing, Malabar, Florida, 1991, § 5.45, p. 246 $P = P_0 e^{t/T}$ $100 (e^{-180/80}) = 10.54$

ANSWER (A.13)
b
REFERENCE (A.13)
Glasstone, S. And Sesonske, A, *Nuclear Reactor Engineering,* Kreiger Publishing, Malabar, Florida, 1991, § 3.157, p. 189

ANSWER (A.14)
c
REFERENCE (A.14)
Glasstone, S. And Sesonske, A, *Nuclear Reactor Engineering,* Kreiger Publishing, Malabar, Florida, 1991, § 5.9, p. 321

ANSWER (A.15)
b
REFERENCE (A.15)
Reactivity (ρ) = $(K_{eff} - 1)/K_{eff}$ = 0.1765 = -17.65% ΔK/K.
-17.65% ΔK/K + 16.0% ΔK/K = -1.65% ΔK/K
Final $K_{eff} = 1/(1 - \rho) = 1/[1 - (-0.0165)] = 0.9838$

ANSWER (A.16)
a
REFERENCE (A.16)
Glasstone, S. And Sesonske, A, *Nuclear Reactor Engineering,* Kreiger Publishing, Malabar, Florida, 1991, § 5.18, p. 234

ANSWER (A.17) **Answer changed per facility comment.**
~~a~~ c
REFERENCE (A.17)
A 9°F HEATUP, will add 9°F × -0.0005 ΔK/K/°F = -0.0045 ΔK/K. To compensate, the regulating rod must add 0.0045 positive reactivity, which implies move out.
+0.0045 ΔK/K ÷ 0.001 ΔK/K/inch = 4.5 inches

ANSWER (A.18)
c
REFERENCE (A.18)
100 - 20 - 10 = 70 neutrons are absorbed in the core (fuel, clad, etc.). Since the reactor is critical the number of fission = 100 neutrons ÷ 2.5 neutrons/fission = 40 fissions. Since 85% of neutrons absorbed in the U^{235} result in a fission, there were 40 fissions /0.85 fissions/neutrons absorbed by fuel = 47 neutrons. The thermal utilization = 47/70 = 0.67.
Glasstone, S. And Sesonske, A, *Nuclear Reactor Engineering,* Kreiger Publishing, Malabar, Florida, 1991, § 2.156, p. 189

ANSWER (A.19)
d
REFERENCE (A.19)
Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 6.2.3, p. 6-4.

***** END OF SECTION A *****

ANSWER (B.1)
a
REFERENCE (B.1)
A half-thickness is two sheets. $I = I_0 (½)^{1.5} =$ 0.3535 * 200 mR/hr = 70.71 mR/hr

ANSWER (B.2)
b
REFERENCE (B.2)
10 CFR 20.1206

ANSWER (B.3)
a, check; b, test; c, check; d, cal
REFERENCE (B.3)
Technical Specifications § 1.0 Definitions

ANSWER (B.4)
a, 2; b, 1; c, 2; d, 6
REFERENCE (B.4)
10 CFR 55 §§ 21, 55, & 59 (2)

ANSWER (B.5)
a
REFERENCE (B.5)
10 CFR 20.1003, *Definitions*

ANSWER (B.6)
a, 3; b, 3; c, 4; d, 3; e, 6
REFERENCE (B.6)
Technical Specifications § 3.1 *Reactivity Limits*

ANSWER (B.7)
a, 1; b, 2; c, 3; d, 4
REFERENCE (B.7)
10 CFR 20.1003, *Definitions*

ANSWER (B.8)
a
REFERENCE (B.8)
First calculate can get: 5 - 1.3 = 3.7 Rem.
Time = Can get ÷ rate: (3.7 Rem)/(4.7 Rem/hr) × 60 = 47.2 min

ANSWER (B.9)
a
REFERENCE (B.9)
Emergency Procedure located behind the Emergency Plan. Also pp. 13 – 15 in PUR-1 Operating Manual (1965). **NOTE: This violates 10 CFR 50.54.m(1)**

ANSWER (B.10)
d
REFERENCE (B.10)
Emergency Plan, § 2.0 *Definitions*

ANSWER (B.11)
d
REFERENCE (B.11)
PUR procedure 91-2 *Sample Irradiation*, procedure steps 2 and 7.

ANSWER (B.12)
d
REFERENCE (B.12)
Technical Specifications §§ 3.3 and 3.5

ANSWER (B.13)
d
REFERENCE (B.13)
Technical Specifications §§ 3.2 & 1.27

ANSWER (B.14)
a
REFERENCE (B.14)
PUR-1 Procedure M-1 *Procedure for Checking Meter-Contact Switches*, Channel 3 and Technical Specifications Table 1.

ANSWER (B.15)
d
REFERENCE (B.15)
Technical Specifications Table I *Safety Channels Required for Operation*, also 12/80 Requalification Examination Question E.1

***** END OF SECTION B *****

ANSWER (C.1)
b
REFERENCE (C.1)
NRC administered examination August 1992.

ANSWER (C.2)
a, 1; b, 2; c, 3; d, 2; e, 4
REFERENCE (C.2)
Instrumentation Block Diagram

ANSWER (C.3)
a
REFERENCE (C.3)
Old Requal Exam administered December, 1977

ANSWER (C.4)
d
REFERENCE (C.4)
PUR-1 Operating Reactor, Lockheed Nuclear Products, § 1.6 *Process System*

ANSWER (C.5)
b
REFERENCE (C.5)
Supplied drawing for Shim-Safety Rod.

ANSWER (C.6)
b
REFERENCE (C.6)
PUR-1 Operations Manual 1962, Lockheed Nuclear Products, § 1.5.6.6

ANSWER (C.7)
c
REFERENCE (C.7)
PUR-1 Operating Manual, Lockheed Nuclear Products, § 1.1, *General Specifications*

ANSWER (C.8)
c
REFERENCE (C.8)
Standard NRC question

ANSWER (C.9)
d
REFERENCE (C.9)
PUR-1 Operations Manual, 1962, Lockheed Nuclear Products, § 1.1 General Specifications

ANSWER (C.10)
d
REFERENCE (C.10)
Old Requalification question 12/77, question E.2

ANSWER (C.11)
c
REFERENCE (C.11)
PUR-1 Operating Manual 1962, Lockheed Nuclear Products, § 1.5.6.5.

ANSWER (C.12)
a
REFERENCE (C.12)
PUR-1 Operating Procedure M-5, *Procedure for Radiation Area Monitor*, figure 1

ANSWER (C.13)
a
REFERENCE (C.13)
PUR-1 Operation Manual 1962, Lockheed Nuclear Products, § 1.5.6.3 *Fission Chamber Drive System*

ANSWER (C.14)
b
REFERENCE (C.14)
PUR-1 Operations Manual 1962, Lockheed Nuclear Products, § 1.6 *Process System*

ANSWER (C.15)
a
REFERENCE (C.15)
PUR-1 Operations Manual 1962, § 1.5.6.1, *Shim Safety Rod Drive System*

ANSWER (C.16)
c
REFERENCE (C.16)
Supplied drawings

ANSWER (C.17)
d
REFERENCE (C.17)
PURDUE Requalification Examination 12/78, question E.2.

***** END OF SECTION C *****
******* END OF EXAMINATION *******

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

FACILITY: Purdue University

REACTOR TYPE: Pool

DATE ADMINISTERED: 1997/06/01

REGION: 3

CANDIDATE: ______________________

INSTRUCTIONS TO CANDIDATE:
Answers are to be written on the answer sheet provided. Attach the answer sheets to the examination. Points for each question are indicated in paren-theses for each question. A 70% overall is required to pass the examination. Examinations will be picked up three (3) hours after the examination starts.

CATEGORY VALUE	% OF TOTAL	CANDIDATE'S SCORE	% OF CATEGORY VALUE		CATEGORY
20.00	35.1	_____	_____	A.	REACTOR THEORY, THERMODYNAMICS AND FACILITY OPERATING CHARACTERISTICS
19.00	33.3	_____	_____	B.	NORMAL AND EMERGENCY OPERATING PROCEDURES AND RADIOLOGICAL CONTROLS
18.00	31.6	_____	_____	C.	PLANT AND RADIATION MONITORING SYSTEMS
57.00		_____	_____%		TOTALS
		FINA'. GRADE			

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

____
Candidate's Signature

NRC RULES AND GUIDELINES
FOR LICENSE EXAMINATIONS

During the administration of this examination the following rules apply:

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

2. After the examination has been completed, you must sign the statement on the cover sheet indicating that the work is your own and you have not received or 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.

6. Fill in the date on the cover sheet of the examination (if necessary).

7. Print your name in the upper right-hand corner of the first page of each section of your answer sheets.

8. Before you turn in your examination, consecutively number each answer sheet, including any additional pages inserted when writing your answers on the examination question page.

9. The point value for each question is indicated in parentheses after the question.

10. Partial credit will NOT be given.

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

12. When you are done and have turned in your examination, leave the examination area as defined by the examiner. If you are found in this area while the examination is still in progress, your license may be denied or revoked.

EQUATION SHEET

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

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

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

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

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

$$CR_1(1 - K_{eff_1}) = CR_2(1 - K_{eff_2})$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

---

1 Curie = 3.7×10^{10} dis/sec

1 kg = 2.21 lbm

1 Horsepower = 2.54×10^3 BTU/hr

1 Mw = 3.41×10^6 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

ANSWER SHEET

A.1 a b c d ___

A.2 a b c d ___

A.3 a b c d ___

A.4 a b c d ___

A.5 a b c d ___

A.6 a b c d ___

A.7 a b c d ___

A.8 a b c d ___

A.9 a b c d ___

A.10 a b c d ___

A.11 a b c d ___

A.12 a b c d ___

A.13 a b c d ___

A.14 a b c d ___

A.15 a b c d ___

A.16 a b c d ___

A.17 a b c d ___

A.18 a b c d ___

A.19 a b c d ___

ANSWER SHEET

B.1 a b c d ___

B.2 a b c d ___

B.3a check cal test ___

B.3b check cal test ___

B.3c check cal test ___

B.3d check cal test ___

Years
B.4a 6 4 2 1 ___

Years
B.4b 6 4 2 1 ___

Years
B.4c 6 4 2 1 ___

Years
B.4d 6 4 2 1 ___

B.5 a b c d ___

B.6a 1 2 3 4 5 6 ___

B.6b 1 2 3 4 5 6 ___

B.6c 1 2 3 4 5 6 ___

B.6d 1 2 3 4 5 6 ___

B.6e 1 2 3 4 5 6 ___

B.7a 1 2 3 4 ___

B.7b 1 2 3 4 ___

B.7c 1 2 3 4 ___

B.7d 1 2 3 4 ___

B.8 a b c d ___

B.9 a b c d ___

B.10 a b c d ___

B.11 a b c d ___

B.12 a b c d ___

B.13 a b c d ___

B.14 a b c d ___

B.15 a b c d ___

ANSWER SHEET

C.1	a b c d ___	C.8	a b c d ___
C.2a	1 2 3 4 ___	C.9	a b c d ___
C.2b	1 2 3 4 ___	C.10	a b c d ___
C.2c	1 2 3 4 ___	C.11	a b c d ___
C.2d	a b c d ___	C.12	a b c d ___
C.3	a b c d ___	C.13	a b c d ___
C.4	a b c d ___	C.14	a b c d ___
C.5	a b c d ___	C.15	a b c d ___
C.6	a b c d ___	C.16	a b c d ___
C.7	a b c d ___	C.17	a b c d ___