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

REPORT NO.:	50-186/OL-99-01
FACILITY DOCKET NO.:	50-186
FACILITY LICENSE NO.:	R-103
FACILITY:	University of Missouri — Columbia
EXAMINATION DATES:	August 16–17, 1999
EXAMINER:	Paul Doyle, Chief Examiner
SUBMITTED BY:	Paul Doyle, Chief Examiner — 9/16/99 Date

SUMMARY:

The NRC administered Operator Licensing Examinations to two Reactor Operator (RO) and three Senior Reactor Operator (SRO) candidates. One of the SRO candidates was previously licensed at another facility and received an SRO-Instant examination. One SRO was previously licensed on the facility and was granted a waiver allowing him to take an SRO-Upgrade examination. One SRO candidate was licensed as an RO and took an SRO-Upgrade examination. All candidates passed all sections of all examinations they were administered with the exception of one Reactor Operator who failed Section A of the written examination.

REPORT DETAILS

1. Examiners:
   Paul Doyle, Chief Examiner

2. Results:

	RO PASS/FAIL	SRO PASS/FAIL	TOTAL PASS/FAIL
Written	1/1	1/0	2/1
Operating Tests	2/0	3/0	5/0
Overall	1/1	3/0	4/1

3. Exit Meeting:
   Paul Doyle, NRC, Examiner
   Charles McKibben, University of Missouri
   Anthony Schoone, University of Missouri

   The NRC examiner thanked the facility for their assistance in coordinating the examinations. The facility reviewed the examination prior to administration and found some discrepancies related to incorrect data in the training material. The examiner and the facility reactor manager worked together to rewrite some questions making them correct with respect to changes made to the facility. All changes were made prior to examination administration. The facility had no post administration comments on the written examination. The examination included as Enclosure 2 to this letter is as administered.

UNIVERSITY OF MISSOURI-COLUMBIA
With Answer Key
August 17, 1999

UNITED STATES NUCLEAR REGULATORY COMMISSION

OPERATOR LICENSING EXAMINATION

Enclosure 2

QUESTION (A.1) [1.0 point]
Core excess reactivity changes with ...

a. fuel element burnup

b. control rod height

c. neutron energy level

d. reactor power level

QUESTION (A.2) [1.0 point]
Inserting a control rod predominantly affects K_{eff} by changing the ...

a. fast fission factor

b. thermal utilization factor

c. neutron reproduction factor

d. resonance escape probability.

QUESTION (A.3) [2.0 points, ½ point 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.

QUESTION (A.4) [1.0 point]
K_{eff} (the neutron multiplication factor) is defined as ...

a. absorption/production + leakage

b. production + leakage/absorption

c. absorption + leakage/production

d. production/absorbtion + leakage

QUESTION (A.5) [1.0 point]
You enter the control room and note that all nuclear instrumentation show a steady neutron level, and no rods are in motion. Which ONE of the following conditions **CANNOT** be true?

a. The reactor is critical.

b. The reactor is subcritical.

c. The reactor is supercritical.

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

QUESTION (A.6) [1.0 point]
Which ONE of the following is an example of (β) decay?

a. ${}_{35}Br^{87} \rightarrow {}_{33}As^{83}$

b. ${}_{35}Br^{87} \rightarrow {}_{35}Br^{86}$

c. ${}_{35}Br^{87} \rightarrow {}_{34}Se^{86}$

d. ${}_{35}Br^{87} \rightarrow {}_{36}Kr^{87}$

QUESTION (A.7) [1.0 point]
The delayed neutron precursor (β) for U^{235} is 0.0065. However, when calculating reactor parameters you use β_{eff} with a value of ~0.0070. Why is β_{eff} larger than β?

a. Delayed neutrons are born at higher energies than prompt neutrons resulting in a greater worth for the neutrons.

b. Delayed neutrons are born at lower energies than prompt neutrons resulting in less leakage during slowdown to thermal energies.

c. The fuel also contains U^{238} which has a relatively large β for fast fission.

d. U^{238} in the core becomes Pu^{239} (by neutron absorption), which has a higher β for fission.

QUESTION (A.8) [1.0 point]
The difference between a moderator and a reflector is that a reflector ...

a. increases the fast non-leakage factor and a moderator increases the thermal utilization factor.

b. increases the neutron production factor and a moderator increases the fast fission factor.

c. increases the neutron production factor and a moderator decreases the thermal utilization factor.

d. decreases the fast non-leakage factor and a moderator increases the thermal utilization factor.

QUESTION (A.9) [1.0 point]
Which of the following atoms will cause a neutron to lose the most energy during an elastic scattering reaction?

a. O^{16}

b. C^{12}

c. U^{235}

d. H^{1}

QUESTION (A.10) [1.0 point]
The reactor is critical at a milliwatt with the regulating blade at position X. You withdraw the reg rod to increase power to a watt. To stabilize power at this level you must insert the reg rod to ...

a. a position lower than X.

b. position X.

c. a position slightly higher than X.

d. all the way into the core.

QUESTION (A.11) [1.0 point]
Which ONE of the following statements correctly describes the concentration of Xenon in the core following a scram from extended operation at 10 Megawatts? Xenon concentration ...

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

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

c. increases to maximum in approximately 10 hours due to the reduction in burnup.

d. remains at equilibrium, because without fission no new Xenon is being produced.

QUESTION (A.12) [1.0 point]
Which ONE of the following is the MAJOR source of energy released during fission? Kinetic Energy of ...

a. prompt gamma rays.

b. capture gammas.

c. Beta particle-

d. fission fragments.

QUESTION (A.13) [1.0 point]
Five minutes following a reactor shutdown, the source range monitor is reading 3×10^6 counts/minute. Which ONE of the following is the count rate you would expect to see three minutes later

a. 10^6 counts/minute

b. 8×10^5 counts/minute

c. 5×10^5 counts/minute

d. 3×10^5 counts/minute

QUESTION (A.14) [1.0 point]
The reactor is on a **CONSTANT** positive period. Which ONE of the following power changes will take the **LONGEST** time to complete?

a. 5%, from 95% to 100%

b. 10%, from 80% to 90%

c. 15%, from 15% to 30%

d. 20%, from 60% to 80%

QUESTION (A.15) [1.0 point]
The reactor is shutdown with a shutdown margin of 12%. An experimenter inserts an experiment into the center flux trap, and Source Range Monitor indication increases from 100 CPM to 200 CPM. What is the worth of the experiment?

a. 0.2% ΔK/K

b. 3.2% ΔK/K

c. 6.4% ΔK/K

d. 9.6% ΔK/K

QUESTION (A.16) [1.0 point]
The term ***PROMPT JUMP*** refers to ...

a. the instantaneous change in power due to raising a control blade.

b. a reactor which is critical due to both prompt and delayed neutrons.

c. a reactor which has attained criticality on prompt neutrons alone.

d. a negative reactivity insertion which is greater than β_{eff}.

QUESTION (A.17) [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. recoils with less kinetic energy than it had prior to the collision with the nucleus emitting a gamma ray.

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

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

QUESTION (A.18) [1.0 point]
The **PRIMARY** reason that a neutron source is installed in the reactor is to ...

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

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

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

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

QUESTION (A.19) [1.0 point]
Which one of the following figures most closely depicts the reactivity versus time plot for xenon for the following series of evolutions: (See attached figures on last page of handout for choice selections.)

TIME	EVOLUTION
1/2	10 MW startup, clean core;
3	Shutdown for 15 hours;
4	5 Mw for 12 hours.

a. a

b. b

c. c

d. d

QUESTION (B.1) [2.0 points, ½ point each]
Identify each of the actions listed below as either a Channel Check (Check), a Channel Test (Test), or a Channel Calibration (Cal).

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

b. During startup you compare all of your nuclear instrument channels ensuring they track together.

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

d. During reactor shutdown you note -80 second period on nuclear instrumentation.

QUESTION (B.2) [1.0 point]
How long (by standard practice) must the reactor be secured prior to venting a beam port containing Ar^{41}?

a. 1 hour

b. 12 hours

c. 1 day

d. 2 days

QUESTION (B.3) [1.0 point]
A radioactive source gives a dose rate of 50 mR/hr. Adding a thin lead shield reduces the dose rate to 25 mR/hr. If you **ADD** two more thin lead shields of the same thickness as the first the new dose rate will be ...

a. 12½

b. 6¼

c. 3⅛

d. 1⅞

QUESTION (B.4) [2.0 points, ½ point each]
Identify each of the following as either a Safety Limit (SL), Limiting Safety System Setting (LSSS), or a Limiting Condition for Operation (LCO)

a. During startup all six (6) nuclear instrumentation channels are required.

b. During operation in Modes I and II, a minimum of 1625 gpm primary coolant flow is required, either loop.

c. In Mode III do not exceed 150 Kilowatts (maximum)

d. During operation the maximum reactivity insertion rate for the regulating blade is 2.5×10^{-4} ΔK/second.

QUESTION (B.5) [2.0 points, ½ point each]
The appropriate federal regulation contains many requirements for Operator Licenses, match each of the requirements listed in column A with it's appropriate time period in column B. (Note: Periods from column B may be used more than once or not at all.)

Column A (Requirements)	Column B (Years)
a. License Renewal	1
b. Requalification Written Examination	2
c. Requalification Operating Test	4
d. Medical Examination	6

QUESTION (B.6) [1.0 points, ¼ point each]
Identify each of the radioisotopes in column A with its PRIMARY source (irradiation of air or water, or fission product).

a. ${}_{1}H^{3}$

b. ${}_{18}Ar^{41}$

c. ${}_{7}N^{16}$

d. ${}_{54}Xe^{135}$

QUESTION (B.7) [2.0 points, ½ point each]
Match the type of radiation in column A with its associated Quality Factor (10CFR20) from column B.

Column A	Column B
a. alpha	1
b. beta	2
c. gamma	5
d. neutron (unknown energy)	10
	20

QUESTION (B.8) [1.0.]
Which ONE of the following is the MINIMUM reactor period for placing the regulating blade in automatic mode?

a. 30 seconds

b. 35 seconds

c. 50 seconds

d. 100 seconds

QUESTION (B.9) [1.0 point]
Which ONE of the following methods is the **PREFERRED** method for reducing activity prior to disposing of radioactive liquid waste?

a. Transfer the water to a distillation unit for evaporation of the liquid. The solid distillate is disposed of as solid waste.

b. Chemically treat the waste so that the radionuclides will form a precipitate. Then pump the water through filters to lower the activity.

c. Maintain the liquid in tank(s) until the radioactivity has decayed low enough for normal liquid waste tank pumping.

d. Add domestic cold water (DCW) to the tank to reduce the concentration low enough to allow pumping.

QUESTION (B.10) [1.0 point]
During normal operation of the reactor, you take a complete set of process data every ...

a. ½ hour

b. hour

c. 2 hours

d. 4 hours

QUESTION (B.11) [1.0 point]
The MAXIMUM K_{eff} for fuel stored at MURR is ...

a. 0.80

b. 0.85

c. 0.90

d. 0.95

QUESTION (B.12) [1.0 points, ¼ point each]
Match the Federal regulation in column A with the requirements it covers.

Column A	Column B
a. 10 CFR 20	1. Operator Licenses
b. 10 CFR 50	2. Facility Licenses
c. 10 CFR 55	3. Radiation Protection
d. 10 CFR 73	4. Special Nuclear Material

QUESTION (B.13) [1.0 point]
You've detected a stuck rod. Which ONE of the following is your immediate action(s) according to REP-8?

a. Attempt to drive the affected rod in until power decreases by 2%.

b. Drive all shim rods in verifying the stuck rod fails to move.

c. Scram the reactor, noting the position of the stuck rod.

d. Stop all rod movement, and notify the Shift Supervisor.

QUESTION (B.14) [1.0 point]
When pumping the Liquid Waste tanks to the sanitary sewer, the maximum accumulated activity for H^3 is 10 millicuries for the Shift Supervisor to authorize the procedure. The maximum accumulated activity for other nuclides is ...

a. 1 millicurie

b. 2 millicuries

c. 4 millicuries

d. 20 millicuries

QUESTION (B.15) [1.0 point]
Per the definition in the Emergency Plan, Protective Action Guide(s) is (are) ...

a. The person or persons appointed by the Emergency Coordinator to ensure that all personnel have evacuated the facility or a specific part of the facility.

b. a condition or conditions which call(s) for immediate action, beyond the scope of normal operating procedures, to avoid an accident or to mitigate the consequences of one.

c. Projected radiological dose or dose commitment values to individuals that warrant protective action following a release of radioactive material.

d. Specific instrument readings, or observations; radiological dose or dose rates; or specific contamination levels of airborne, waterborne, or surface- deposited radioactive materials that may be used as thresholds for establishing emergency classes and initiating appropriate emergency measures.

QUESTION (B.16) [1.0 point]
Annual maintenance was last performed on a system on July 31, 1998. The last date annual maintenance may be performed on the system without being late is ...

a. July 31, 1999

b. August 31, 1999

c. September 30, 1999

d. October 31, 1999

QUESTION (C.1) [1.0 point]
How is Reactor Coolant temperature controlled?

a. Varying reactor loop flow by varying speed of pumps P501A/B.

b. Varying reactor loop flow by varying the position of butterfly valve 901.

c. Varying secondary loop flow by varying speed of pumps P1, P2 and P3.

d. Varying secondary loop flow by varying the position of butterfly valve S-1.

QUESTION (C.2) [1.0 point]
Which ONE of the following is the reason for the 100 gallon holdup tank in the purification system? This tank

a. is part of the regeneration system.

b. allows N^{16} gamma activity to decay off.

c. contains spent resin from the demineralizer units.

d. provides water hammer protection for the purification system.

QUESTION (C.3) [1.0 point]
The corrosion inhibitors require a pH range between 7 and 8 to work correctly. Which ONE of the following is added to the secondary to maintain the pH?

a. Carbonic Acid

b. Sulfuric Acid

c. Phosphates

d. Potassium-Tetraborate-Tetrahydrate.

QUESTION (C.4) [2.0 points, 0.286 point each]
Match each of the channels listed in column A with the appropriate type of Detector listed in column B.

Column A (NI Channel)	Column B (Neutron Detector)
a. Channel 1	1. Fission Chamber
b. Channel 2	2. Compensated Ion Chamber
c. Channel 3	3. BF_3 Proportional Counter
d. Channel 4	4. Uncompensated Ion Chamber
e. Channel 5	
f. Channel 6	
g. Wide Range Monitor	

QUESTION (C.5) [1.0 point]
Which ONE of the following Area Radiation Monitoring System (ARMS) channels does ***NOT*** cause a building isolation?

a. Air Plenum 2

b. Bridge ALARA

c. Room 114

d. Bridge

QUESTION (C.6) [1.0 point]
What is the purpose of the ventilation ducts built into the pool wall? These ducts are designed to remove ...

a. H^3

b. N^{16}

c. Ar^{41}

d. I^{131}

QUESTION (C.7) [1.0 point]
Which ONE of the following is the correct (temporary) method for maintaining power to critical reactor instrumentation when performing maintenance on the Uninterruptible Power Supply?

a. Close the bypass switch, allowing the batteries to feed a backup UPS.

b. Close the static switch, allowing the batteries to feed a backup UPS.

c. Close the bypass switch, allowing site power to feed the instrumentation.

d. Close the static switch, allowing site power to feed the instrumentation.

QUESTION (C.8) [1.0 point]
The AUTO SHIM CIRCUIT ...

a. drives the shim safety blades in, until the regulating blade reaches 20% withdrawn

b. drives the shim safety blades out, until the regulating blade reaches 20% withdrawn

c. drives the shim safety blades in, until the regulating blade reaches 60% withdrawn

d. drives the shim safety blades out, until the regulating blade reaches 60% withdrawn

QUESTION (C.9) [1.0 point]
Which ONE of the following Nuclear Instrument Channels has an input into the regulating blade auto control circuit.

a. Channel 1 (Source Range Monitor)

b. Channel 2 (Intermediate Range (Log-N))

c. Channel 4 (Wide Range Monitor)

d. Channel 6 (Power Range Monitor)

QUESTION (C.10) [1.0 point]
The N_2 bank on service to supply the pressurizer will automatically isolate, and the standby bank will come on line when line pressure reaches ...

a. 250 psig

b. 185 psig

c. 120 psig

d. 55 psig

QUESTION (C.11) [1.0 point]
The ventilation system has two backup doors located in the ventilation supply and return plenums which shut on containment isolation. Which ONE of the following is the method used to shut these doors? The doors are ...

a. air motor operated, with their own emergency air supply tanks.

b. motor operated, with air supplied from the emergency air supply system.

c. held open by solenoid, which when deenergized, the door closes via gravity.

d. held open by air pistons, which when vented, the doors close via gravity.

QUESTION (C.12) [1.0 point]
Which ONE of the following is NOT cooled by the Secondary system?

a. Reactor Loop System.

b. Pool Loop System.

c. Facility Air Conditioning System.

d. Emergency Air Compressors.

QUESTION (C.13) [1.0 point]
The purification system contains a fission product monitor. This monitor detects radiation from fission products collected in ...

a. the filter

b. the holdup tank

c. the cation column

d. the anion column

QUESTION (C.14) [2.0 points, ⅓ point each]
Match each of the beamports in column A with the correct characteristics in Column B

	Column A Beamport	Column B Characteristic
a.	A	6" radial
b.	B	6" tangential
c.	C	4" radial
d.	D	4" tangential
e.	E	
f.	F	

QUESTION (C.15) [1.0 point]
The Rabbit in the reactor indication is generated by ...

a. a magnetic pickup

b. a photocell

c. a limit switch

d. a pushbutton

QUESTION (C.16) [1.0 point]
During normal operation a thermal column door open alarm will ...

a. have no effect on the operation of the reactor.

b. cause a rod run-in.

c. cause a reactor scram.

d. prevent withdrawal of control rods.

QUESTION (C.17) [2.0, ½ point each]
Identify whether each of the following valves fails OPEN or SHUT.

a. Pressurizer Drain Valve (527A)

b. Vent Tank Vent Valve (552A)

c. Pressurizer Isolation Valve (527C)

d. Demin Inlet Isolation Valve (527E)

A.1 a
REF: Burn, R., *Introduction to Nuclear Reactor Operations*, © 1988, § 6.2.1, & 6.2.2 p. 6-2.

A.2 b
REF: Burn, R., *Introduction to Nuclear Reactor Operations*, © 1988, § 3.3.2, ¶ 2, p. 3-18.

A.3 a, 2; b, 4; c, 1; d, 3
REF: Burn, R., *Introduction to Nuclear Reactor Operations*, © 1988, §§ 3.2.2, p. 3-7 and 2.5.3, p 2-45.

A.4 d
REF: Burn, R., *Introduction to Nuclear Reactor Operations*, © 1988, § 3.3.1, P. 3-16.

A.5 c
REF: Burn, R., *Introduction to Nuclear Reactor Operations*, © 1988, §

A.6 d
REF: Burn, R., *Introduction to Nuclear Reactor Operations*, © 1988, § 2.4.6, p. 2-30.

A.7 b
REF: Burn, R., *Introduction to Nuclear Reactor Operations*, © 1988, § 3,2,4m p. 3-12.

A.8 a
REF: Standard NRC question.

A.9 d
REF: Burn, R., *Introduction to Nuclear Reactor Operations*, © 1988, § 2.5.3, p. 2-45

A.10 b
REF: Burn, R., *Introduction to Nuclear Reactor Operations*, © 1988, § 6.2, p. 6-2. (No moderator heatup ∴ no power defect.

A.11 c
REF: Burn, R., *Introduction to Nuclear Reactor Operations*, © 1988, § 8.4.1, p. 8-9.

A.12 d
REF: Burn, R., *Introduction to Nuclear Reactor Operations*, © 1988, Table 3.2, p-3-5.

A.13 d
REF: Burn, R., *Introduction to Nuclear Reactor Operations*, © 1988, § 4.6, p. 4-16

A.14 c
REF: Burn, R., *Introduction to Nuclear Reactor Operations*, © 1988, § 4.3, p. 4-4.

A.15 c
REF: See Calculation attached to end of this section.

A.16 a
REF: Burn, R., *Introduction to Nuclear Reactor Operations*, © 1988, § 4.7, p.4-21

A.17 b
REF: Burn, R., *Introduction to Nuclear Reactor Operations*, © 1988, § 2.4.5, p. 2-28.

A.18 c
REF: Burn, R., *Introduction to Nuclear Reactor Operations*, © 1988, § 5.2, p. 5-1.

A.19 a
REF: Burn, R., *Introduction to Nuclear Reactor Operations*, © 1988, § 8.4.3, p. 8-13.

B.1 a, Test; b, Check; c, Cal; d, Check
REF: T.S. § 1.0 Definitions

B.2 b
REF: Reactor Operator Training Manual, § I.11 5th ¶.

B.3 b
REF:

$$I = I_0\left(\tfrac{1}{2}\right)^3 = I_0\left(\tfrac{1}{8}\right) = \frac{50}{8} = 6\tfrac{1}{4}$$

B.4 a, LCO; b, LSSS; c, SL; d, LCO
REF: T.S. §§ a-3.3.a and 3.4.a, b-2.2.a/b, c-2.1.c, d-3.1

B.5 a, 6; b, 2; c, 1; d, 2
REF: 10CFR55

B.6 a, water ; b, air; c, water; d, fission product
REF:

B.7 a, 20; b, 1; c, 1; d, 10
REF: 10CFR20.100x

B.8 b
REF: SOPII § II.1.3.

B.9 c
REF: SOP VII, § VII.8.3.b

B.10 c
REF: SOP I.4.4.F

B.11 c
REF: T.S. 3.8.d

B.12 a, 3; b, 2; c, 1; d, 4.
REF: Title 10 to the Code of federal Regulations.

B.13 c
REF: Reactor Emergency Procedure 8

B.14 b
REF: Reactor Operator Training Manual, § I.10.2, p. 2, 1st ¶.

B.15 c
REF: Emergency Plan, § 9.0 Definitions.

B.16 c
REF: T.S. 1.2 Calibration or Testing Interval.

C.1 d
REF: Reactor Operator Training Manual, § I.2.E *Reactor Loop Coolant Temperature Measurement and Control*, p. I.2.11. 3rd ¶.

C.2 b
REF: Reactor Operator Training Manual, § I.4 Clean-up Systems, p. I.4.1 3rd ¶.

C.3 b
REF: Reactor Operator Training Manual, § IV.5, *Secondary Chemistry Control*, p. IV.5.1 2nd ¶.

C.4 a, 1; b, 1; c, 1; d, 1; e, 1; f, 4; g, 2
REF: Reactor Operator Training Manual, Figure on page II.1.8.

C.5 c
REF: Reactor Operator Training Manual §II.10, *Reactor Isolation, Facility Evacuation and Components*, p. II.10.1 B.2 Reactor Isolation, p. II.10.3.

C.6 a
REF: Reactor Operator Training Manual, § I.11, *Containment Building Exhaust System* p. I.11.1, 2nd ¶.

C.7 c
REF: Reactor Operator Training Manual § III.3.C.1.3, page II.3.3,

C.8 c
REF: Reactor Operator training Manual § II.15, ¶¶ 2 & 3.

C.9 c
REF: Reactor Operator Training Manual, § II.14, p. II.14.3

C.10 c
REF: Reactor Operator Training Manual, § IV.1.A.

C.11 d
REF: Reactor Operator Training Manual, § II.10.A.4; Page II.10.2.

C.12 d
REF: Reactor Operator Training Manual, § IV.3. 1st ¶

C.13 d
REF: Rewrite of facility supplied question, *Plant and Radiation monitoring Systems*, #28.

C.14 a, 4R; b, 6R; c, 6T; d, 4T; e, 6R; f, 4R
REF: Rewrite of facility supplied question, *Plant and Radiation Monitoring Systems*, #32.

C.15 b
REF: Rewrite of facility supplied question, *Plant and Radiation Monitoring Systems*, #70

C.16 d
REF: Rewrite of facility supplied question, *Plant and Radiation Monitoring Systems*, #86

C.17 a, S; b, S; c, S; d, S
REF: Reactor Operator Training Manual, § I.5, *Valve Operating System*, ¶¶ B.6, 8, , 12

Calculation for Question A.15

$$K_{eff_1} = \frac{1}{1+SDM} = \frac{1}{1+0.12} = \frac{1}{1.12} = 0.892857$$

$$CR_1\left(1-K_{eff_1}\right) = CR_2\left(1-K_{eff_2}\right) \qquad 1-K_{eff_2} = \left(1-K_{eff_1}\right)\left(\frac{CR_1}{CR_2}\right)$$

$$1-K_{eff_2} = \frac{100}{200}(1-0.892857) = \frac{1}{2}(0.107143) = 0.0535715$$

$$K_{eff_2} = 1-0.0535715 = 0.9464286$$

$$\Delta\rho = \frac{K_{eff_2}-K_{eff_1}}{K_{eff_2}\ K_{eff_1}} = \frac{0.9464284-0.892857}{(0.9464284)\ (0.892857)} = 0.063964$$

or about 6.4% ΔK/K

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

FACILITY:	University of Missouri-Columbia
REACTOR TYPE:	TANK
DATE ADMINISTERED:	1999/08/17
REGION:	III
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 brackets for each question. A 70% in each section is required to pass the examination. Examinations will be picked up three (3) hours after the examination starts.

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

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

____
Candidate's Signature

NRC RULES AND GUIDELINES FOR LICENSE EXAMINATIONS

During the administration of this examination the following rules apply:

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

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

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

4. Use black ink or dark pencil 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

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

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

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

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

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

$$CR_1(1-K_{eff_1}) = CR_2(1-K_{eff_2})$$
$$CR_1(-\rho_1) = CR_2(-\rho_2)$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

1 Curie = 3.7 x 10^{10} dis/sec

1 Horsepower = 2.54 x 10^3 BTU/hr

1 BTU = 778 ft-lbf

1 gal (H_2O) ≈ 8 lbm

c_p = 1.0 BTU/hr/lbm/°F

1 kg = 2.21 lbm

1 Mw = 3.41 x 10^6 BTU/hr

°F = 9/5 °C + 32

°C = 5/9 (°F - 32)

c_p = 1 cal/sec/gm/°C

A.1 a b c d ___

A.2 a b c d ___

A.3a 1 2 3 4 ___

A.3b 1 2 3 4 ___

A.3c 1 2 3 4 ___

A.3d 1 2 3 4 ___

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 1 2 3 4 ___

A.11 1 2 3 4 ___

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 ___

B.1a Check Test Cal ___

B.1b Check Test Cal ___

B1c Check Test Cal ___

B.1d Check Test Cal ___

B.2 a b c d ___

B.3 a b c d ___

B.4a SL LSSS LCO ___

B.4b SL LSSS LCO ___

B.4c SL LSSS LCO ___

B.4d SL LSSS LCO ___

B.5a 1 2 4 6 ___

B.5b 1 2 4 6 ___

B.5c 1 2 4 6 ___

B.5d 1 2 4 6 ___

B.6a air water fission ___

B.6b air water fission ___

B.6c air water fission ___

B.6d air water fission ___

B.7a 1 2 5 10 20 ___

B.7b 1 2 5 10 20 ___

B.7c 1 2 5 10 20 ___

B.7d 1 2 5 10 20 ___

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.12a 1 2 3 4 ___

B.12b 1 2 3 4 ___

B.12c 1 2 3 4 ___

B.12d 1 2 3 4 ___

B.13 a b c d ___

B.14 a b c d ___

B.15 a b c d ___

B.16 a b c d ___

C.1 a b c d ___

C.2 a b c d ___

C.3 a b c d ___

C.4a 1 2 3 4 ___

C.4b 1 2 3 4 ___

C.4c 1 2 3 4 ___

C.4d 1 2 3 4 ___

C.5 a b c d ___

C.6 a b c d ___

C.7 a b c d ___

C.8 a b c d ___

C.9 a b c d ___

C.10 a b c d ___

C.11 a b c d ___

C.12 a b c d ___

C.13 a b c d ___

C.14a 6R 6T 4R 4T ___

C.14b 6R 6T 4R 4T ___

C.14c 6R 6T 4R 4T ___

C.14d 6R 6T 4R 4T ___

C.14e 6R 6T 4R 4T ___

C.14f 6R 6T 4R 4T ___

C.15 a b c d ___

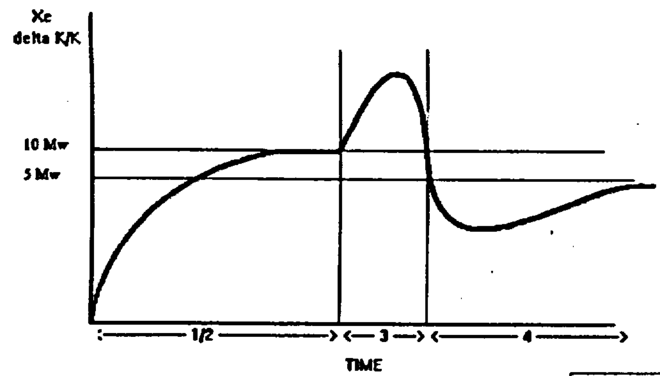
C.16 a b c d ___

C.17a OPEN SHUT ___

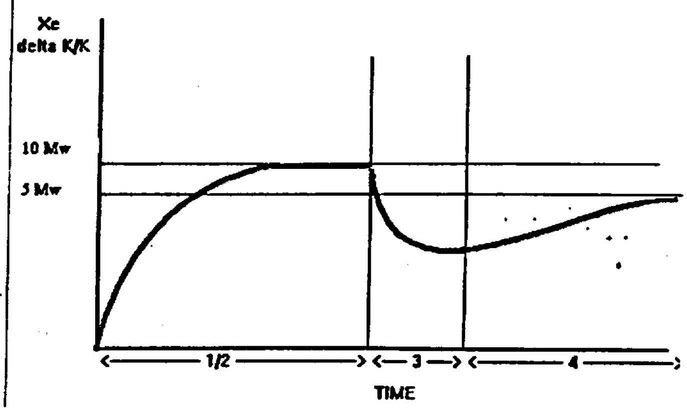
C.17b OPEN SHUT ___

C.17c OPEN SHUT ___

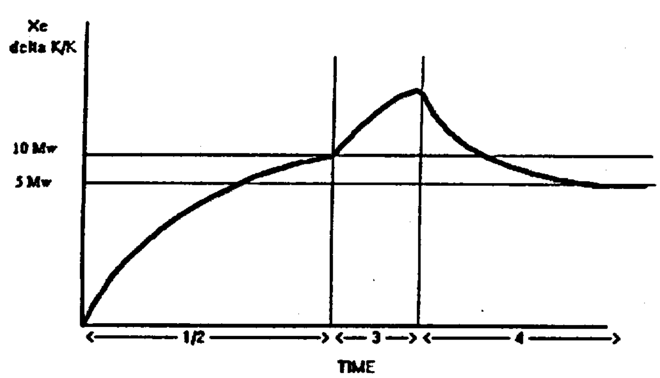
C.17d OPEN SHUT ___


Xe
delta K/K
10 Mw
5 Mw
1/2
3
4
TIME

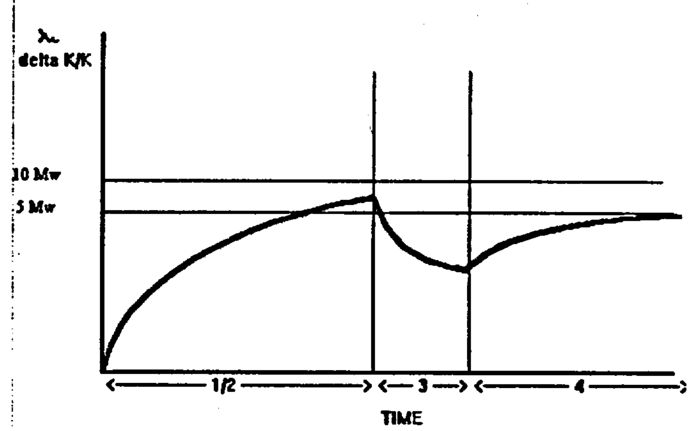
a


Xe
delta K/K
10 Mw
5 Mw
1/2
3
4
TIME

b


Xe
delta K/K
10 Mw
5 Mw
1/2
3
4
TIME

c


delta K/K
10 Mw
5 Mw
1/2
3
4
TIME

d