October 9, 2002

Mr. Ralph A. Butler, Chief Operating Officer
Research Reactor Facility
University of Missouri
Columbia, MO 65211

SUBJECT: INITIAL EXAMINATION REPORT NO. 50-186/OL-02-03, UNIVERSITY OF MISSOURI – COLUMBIA

Dear Mr. Butler:

During the week of September 16, 2002, the NRC administered operator licensing examinations at your University of Missouri – Columbia Reactor. The examinations were 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 2.790 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 document system (ADAMS). ADAMS is accessible from the NRC Web site at (the Public Electronic Reading Room) http://www.nrc.gov/NRC/ADAMS/indesx.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 Paul Doyle at (301) 415-1058 or via internet E-mail at pvd@nrc.gov.

Sincerely,

/RA/

Patrick M. Madden, Section Chief
Research and Test Reactors Section
Operating Reactor Improvements Program
Division of Regulatory Improvement Programs
Office of Nuclear Reactor Regulation

Docket No. 50-186

Enclosures: 1. Initial Examination Report No. 50-186/OL-02-03
2. Examination and answer key with facility comments incorporated

cc w/encls:
Please see next page

cc:

University of Missouri
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DISTRIBUTION w/ encls.:

PUBLIC	RORP R&TR r/f	PMadden
AAdams	Facility File (EBarnhill) O-6 D-17	

ADAMS ACCESSION #: ML022730393 TEMPLATE #:NRR-074

OFFICE	RORP:CE		IEHB:LA	E	RORP:SC	
NAME	PDoyle:rdr		EBarnhill		PMadden	
DATE	10/ 07/2002		10/ 07/2002		10/ 09 /2002	

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

REPORT NO.: 50-186/OL-02-03

FACILITY DOCKET NO.: 50-186

FACILITY LICENSE NO.: R-103

FACILITY: University of Missouri – Columbia

EXAMINATION DATES: September 16-18, 2002

SUBMITTED BY: ***/RA/*** 10/01/2002
Paul Doyle, Chief Examiner Date

SUMMARY:

The NRC administered Operator Licensing examinations to five Reactor Operator and one Senior Reactor Operator (Upgrade) candidates. All six license candidates passed all portions of their respective examinations.

REPORT DETAILS

1. Examiners:
   Paul Doyle, Chief Examiner

2. Results:

	RO PASS/FAIL	SRO PASS/FAIL	TOTAL PASS/FAIL
Written	5/0	0/0	5/0
Operating Tests	5/0	1/0	6/0
Overall	5/0	1/0	6/0

3. Exit Meeting:
   Paul Doyle, NRC, Examiner
   Michael Dixon, University of Missouri-Columbia, Assistant Reactor Manager-Operations

   During the exit meeting Mr. Doyle thanked Mr. Dixon, for the support of the facility staff in administering the examinations. The examiner did not note any generic weaknesses, but overall noted that the candidates were well prepared.

ENCLOSURE 1

UNIVERSITY OF MISSOURI–COLUMBIA

With Answer Key

OPERATOR LICENSING EXAMINATION

September 18, 2002

Enclosure 2

QUESTION A.1 [1.0 point]
Which one of the following statements correctly describes the property of a **GOOD MODERATOR**?

a. It slows down fast neutrons to thermal energy levels via a large number of collisions.

b. It reduces gamma radiation to thermal energy levels via a small number of collisions.

c. It slows down fast neutrons to thermal energy levels via a small number of collisions.

d. It reduces gamma radiation to thermal energy levels via a large number of collisions.

QUESTION A.2 [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. $_{35}Br^{87} \rightarrow {}_{34}Se^{87}$

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

QUESTION A.3 [1.0 point]
The reactor is at a power of 1 watt, with a 30 second stable period. How long will it take for power to reach 500 watts?

a. 186 seconds

b. 140 seconds

c. 124 seconds

d. 81 seconds

QUESTION A.4 [1.0 point]
The reactor is subcritical with a K_{eff} of 0.96 and 30 counts per second indicated. After a fuel element is removed the count rate drops to 10 counts per second. No other changes have occurred. What is the K_{eff} of the core with the fuel element removed?

a. 0.9733

b. 0.8800

c. 0.8400

d. 0.8000

QUESTION A.5 [1.0 point]
Which of the following statements correctly describe the influence of ***DELAYED NEUTRONS*** on the neutron life cycle? Delayed neutrons …

a. increase the time required for PU^{239} to moderate the fission process.

b. decrease the time required for the neutron population to change between generations.

c. increase the time required for the neutron population to change between generations.

d. decrease the amount of reflection possible with a steel reflector.

QUESTION A.6 [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.

QUESTION A.7 [1.0 point]
Why is the stable negative period following a scram always the same value, regardless of initial power level? The rate of power change is dependent on the …

a. mean lifetime of the longest lived delayed precursor.

b. constant decay rate of prompt neutrons.

c. mean lifetime of the shortest lived delayed neutron precursor.

d. constant decay rate of prompt gamma emitters.

QUESTION A.8 [1.0 point]
During a Critical Experiment "1/M" data is required to be taken. What does the 1/M represent?

a. The inverse of the moderator coefficient of reactivity.

b. The inverse of core total U^{235} mass.

c. The inverse migration length of neutrons of varying energies.

d. The inverse multiplication of the count rate between generations.

QUESTION A.9 [1.0 point]
Which one of the following correctly describes the relationship between differential rod worth (DRW) and integral rod worth (IRW)?

a. DRW is the slope of the IRW curve at a given location.

b. DRW is the area under the IRW curve at a given location.

c. DRW is the square root of the IRW curve at a given location.

d. There is no relationship between DRW and IRW.

QUESTION A.10 [1.0 point]
What is the period that would cause reactor power to double in 40 seconds?

a. 3.7 seconds

b. 27.7 seconds

c. 57.7 seconds

d. 80.0 seconds

QUESTION A.11 [1.0 point]
Which one of the following accurately details a factor contributing to Xenon balance within the reactor?

a. Most Xe^{135} is formed by fission.

b. Te^{135} is a fission product which quickly decays to I^{135}.

c. Within approximately 8 hours after startup, Xe^{135} has reached its equilibrium value.

d. Several minutes following a reactor shutdown, Xe level is increasing because I^{135} is not being produced.

QUESTION A.12 [1.0 point]
The term "reactivity" may be described as …

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

b. negative when K_{eff} is greater than 1.0.

c. a measure of the core's deviation from criticality.

d. being equal to 0.0050 $\Delta K/K$ when the reactor is prompt critical.

QUESTION A.13 [1.0 point]
Delayed neutrons comprise approximately what percent of all neutrons produced in the reactor?

a. 0.65%

b. 1.3%

c. 6.5%

d. 13%

QUESTION A.14 [1.0 point]
Which of the following factors has the LEAST effect on rod worth?

a. number and location of adjacent rods.

b. temperature of the moderator.

c. temperature of the fuel.

d. core age.

QUESTION A.15 [1.0 point]
Given the following data, which ONE of the following is the closest to the half life of the material?

TIME	***ACTIVITY***
0	2400 cps
10 min.	1757 cps
20 min.	1286 cps
30 min.	941 cps
60 min.	369 cps

a. 11 minutes

b. 22 minutes

c. 44 minutes

d. 51 minutes

QUESTION A.16 [1.0 point]
Which ONE of the following is correct with regard to criticality?

a. Critical rod height does NOT depend on how fast control rods are withdrawn.

b. Critical rod height dictates the reactor power level when criticality is first achieved.

c. The slower the approach to criticality, the lower the reactor power level will be when reaching criticality.

d. The reactivity of the reactor increases towards infinity during the approach to criticality.

QUESTION A.17 [1.0 point]
What is the ***PRINCIPAL*** source of heat in the reactor after shutdown?

a. Cosmic radiation causing fission

b. Decay of fission products

c. Spontaneous fission within the core

d. Stored energy from the reactor and core materials

QUESTION A.18 [1.0 point]
Which one of the following factors is most easily varied by the reactor operator?

a. reproduction factor

b. fast fission factor

c. fast non-leakage probability

d. thermal utilization factor

QUESTION A.19 [1.0 point]
β and β_{eff} both describe the total fraction of delayed neutrons. The difference between the two is that β_{eff} is …

a. smaller than β since delayed neutrons are born at lower energy levels than prompt neutrons.

b. larger than β since delayed neutrons are born at lower energy levels than prompt neutrons.

c. smaller than β since delayed neutrons are born at higher energy levels than prompt neutrons.

d. larger than β since delayed neutrons are born at higher energy levels than prompt neutrons.

QUESTION (B.1) [1.0 point]
During startup of the Primary coolant system, per procedure you start the pumps at 63 psig. After starting the second pump, the pumps cycle off then on. Per procedure you should …

a. continue the system startup.

b. stop both pumps, and inform the Lead Senior Reactor Operator.

c. stop both pumps, wait for primary pressure to increase greater than 66 psig, then restart the pumps.

d. continue the system startup, after informing the Lead Senior Reactor Operator.

QUESTION (B.2) [2.0 points, ½ each]
Identify each of the following reactor plant limitations as a Safety Limit (SL), Limiting Safety System Setting (LSSS) or a Limiting Condition for Operation (LCO). (Choices may be used more than once or not at all.)

a. Primary Coolant Pressure (minimum) 75 psia

b. 1" (maximum) distance between highest and lowest shim arms above 100 Kilowatts

c. 1625 gpm (minimum) either loop.

d. A minimum of one decade of overlap shall exist between adjacent ranges of nuclear instrument channels.

QUESTION B.3 [1.0 point]
Which ONE of the following is NOT a requirement of OP-RO-531 *Primary and Pool Sample Station*?

a. The primary must be sampled daily for H^3.

b. If the primary system fuel failure detector is out of service the primary must be sampled every 4 hours.

c. Do not operate if I^{131} concentration exceeds 5×10^{-3} μCi/ml

d. HP coverage is required if abnormal fission product activity is present.

QUESTION (B.4) [2.0 points, ½ each]
Match the 10CFR20 values for Quality Factor in Column B with their respective types of radiation in Column A. (Note: Values in column B may be used more than once or not at all.)

Column A	Column B
a. Alpha (α)	1
b. Beta (β)	2
c. Gamma (γ)	5
d. Neutron (unknown energy)	10
	20

QUESTION (B.5) [2.0 points, ½ each]
Identify the correct number (1 through 20) 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

QUESTION (B.6) [1.0 point]
Which one of the following describes the Emergency Planning Zone (EPZ) for the MURR? The EPZ …

a. is the geographical area that is beyond the site boundary.

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

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

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

QUESTION (B.7) [1.0 point, ¼ each]
Common radioisotopes associated with research reactors are N^{16}, Ar^{4l}, H^3 and Na^{24}. The half-life for each is (seconds (sec), minutes (min) hours (hr) or years (yr)).

a. N^{16} is 7 _____.

b. Ar^{41} is 1.9 _____.

c. H^3 is 12 _____.

d. Na^{24} is 15 _____.

QUESTION (B.8) [2.0 points, ½ 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

QUESTION (B.9) [1.0 point]
An experiment is removed from the reactor with a radiation level of **10R/hr** at **1 foot**. The radioisotope has a half-life of 120 seconds. Approximately how long must you let the experiment decay before the radiation level has decreased by a factor of 1000?

a. 600 seconds (ten minutes)

b. 1200 seconds (twenty minutes)

c. 6000 seconds (1hour 40 minutes)

d. 12000 seconds (3 hours 20 minutes)

QUESTION (B.10) [1.0 point]
Monday morning maintenance has been completed. A full power pre-startup checksheet was completed at 09:00 am. The new trainees have been performing startups and shutdowns all day for NRC examinations. All equipment has been operating properly. Following the completion of exams, a cooling tower fan failed. It was a loose wire which was quickly corrected. Due to the late hour (19:30) the startup following the examinations will start after shift change at 20:00 pm. Which ONE of the following statements is correct? Because the …

a. cooling tower equipment is not part of a short form pre-startup checksheet, and it is less than 12 hours since the last full power startup checksheet, you may startup after successfully completing a short form pre-startup checksheet.

b. cooling tower equipment is part of a short form pre-startup checksheet, regardless of the time you must perform a full power startup checksheet prior to startup.

c. time since the last full power startup checksheet is greater than 8 hours regardless of wether the cooling tower equipment is part of a short form pre-startup checksheet, you must perform a full power startup checksheet prior to startup.

d. last full power startup checksheet was preformed during a different shift a new full power check sheet must be performed regardless of time or equipment malfunctions.

QUESTION (B.11) [1.0 point]
The fastest reactor period which may be used to raise power to 50 KW according to procedure is …

a. 10 seconds

b. 30 seconds

c. 50 seconds

d. 100 seconds

QUESTION (B.12) [1.0 point]
Which one of the following is ***NOT*** a class of emergency at the MURR?

a. Alert

b. General Emergency

c. Notification of Unusual Events

d. Site Area Emergency

QUESTION (B.13) [1.0 point]
Which one of the following conditions satisfies the requirements for containment integrity?

a. Truck door capable is operable and capable of being closed.

b. Containment building ventilation system automatically closing doors and automatically closing valves are closed.

c. The emergency electrical generator is operable.

d. seal trench has enough water to maintain a seal of 47 inches.

QUESTION (B.14) [1.0 point]
An accessible area with a radiation level of 50 mR/hr should be posted as a:

a. restricted area

b. radiation area

c. high radiation area

d. very high radiation area

QUESTION (B.15) [1.0 point]
Which ONE of the following is the exposure you would expect (approximately) two feet from a point source containing 5 curies of Co^{60}.

a. 190 mR/hr

b. 1.9 R/hr

c. 19 R/hr

d. 190 R/hr

QUESTION (B.16) [1.0 point]
When pumping the Liquid Waste tanks to the sanitary sewer, the maximum accumulated activity for nuclides other than H^3 is 2 millicuries for the Lead Senior Reactor Operator to authorize the procedure. The maximum accumulated activity for H^3 is …

a. 5 millicuries

b. 10 millicuries

c. 15 millicuries

d. 20 millicuries

QUESTION C.1 [1.0 point]
The Building Exhaust System is operating normally, one fan in fast speed, both fan controllers in the auto position. Upon loss of power to the running fan the stand-by fan will …

a. start in fast speed.

b. start in slow speed, the operator must push a button to shift it to fast speed.

c. start in slow speed, after 15 seconds it will automatically shift to fast speed.

d. remain off, the operator must push a button to start the standby pump in either slow or fast speed.

QUESTION C.2 [1.0 point]
In order to minimize check valve slam …

a. start both secondary coolant pumps simultaneously.

b. start the first secondary coolant pump, then wait at least 5 minutes before starting the second pump.

c. secure both secondary coolant pumps simultaneously.

d. secure the first secondary coolant pump, then wait at least 5 minutes before securing the second pump.

QUESTION C.3 [1.0 point] Changes made during examination administration.
You going to lower pool level lower than the surface block intake level. Prior to starting the evolution you must …

a. do nothing, both suctions (upper and lower) are normally open.

b. close the ~~lower~~ upper and open the ~~upper~~ lower using the handwheels on the valves.

c. close the ~~lower~~ upper and open the ~~upper~~ lower the switches in the control room (solenoid controlled air valves).

d. close the ~~lower~~ upper and open the ~~upper~~ lower using the “T” wrench.

QUESTION C.4 [1.0 point]
The SAR (Draft) discusses a neutron source in the pool. Which ONE of the following is not normally performed using the source?

a. To take subcriticality measurements of fuel in the spent fuel storage racks.

b. To take subcriticality measurements of fuel in shipping casks.

c. To perform response checks (“bug”) new Nuclear Instrumentation detectors.

d. To ensure high enough counts for startup of the reactor.

QUESTION C.5 [1.0 point]
In order to reduce N^{16} radiation when taking a sample from the primary, the water is first sent through a

a. 100 gallon holdup tank upstream of the primary pumps

b. 100 gallon holdup tank upstream of the Rx demineralizer pump

c. 6000 gallon holdup tank upstream of the primary pumps

d. 6000 gallon holdup tank upstream of the Rx demineralizer pump

QUESTION C.6 [1.0 point]
Which ONE of the following is the reason that the pool DI system water returns to the pool about 2 feet below the pool surface? In order to …

a. aid in the mixing of the water, which results in a more even temperature distribution.

b. create a blanket of warmer water at the top of the pool to reduce mixing, and therefore reduce the dose rate at the surface of the pool.

c. reduce pool surface temperature, since DI water is cooler than pool water.

d. reduce interference between the pool cooling system and the pool skimmer, which takes its suction at the pool surface.

QUESTION C.7 [1.0 point, ⅓ each]
Common radioisotopes associated with research reactors are Ar^{4l}, H^3 and Na^{24}. How is the radiological effect of each of these isotopes decreased for MURR workers.

a. Ar^{41} 1. Vents at top of pool

b. H^3 2. Containment Ventilation

c. Na^{24} 3. Purification System (Demineralizer)

QUESTION C.8 [1.0 point]
Which ONE of the following prevents structural damage to the containment building if the design limit of 2 PSI over-pressure is exceeded?

a. Electrical Entry penetration plates

b. Door 101

c. Utility Entry Water Trap

d. 16" valves

QUESTION C.9 [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. Sodium Hydroxide

d. Potassium-Tetraborate-Tetrahydrate.

QUESTION C.10 [1.0 point]
Which ONE of the following electrical loads CANNOT be supplied by the Emergency Generator?

a. Pool Cooling Pumps

b. Exhaust Fan EF-13

c. Intercom System

d. ~~Pool Pump P508A~~ Deleted during examination administration (same as choice “a”).

QUESTION C.11 [1.0 point]
What type of sensor is used to detect the position of the "rabbit" in the core?

a. photo-electric cell

b. magnetic switch

c. micro switch

d. reed switch

QUESTION C.12 [1.0 point]
Which of the following conditions will result in an automatic rod run-in?

a. High Power

b. Low Pressurizer Pressure

c. Anti-Siphon System Pressure High

d. Thermal Column Door Open

QUESTION C.13 [1.0 point]
Given the following, choose the correct reason that the regulating blade will not go into automatic mode.

Wide Range	10 Kilowatt range with black pen reading higher than red.
Annunciator Panel Status	All lights deenergized except “Reg Blade out of Auto”
IRM 2&3 Period	45 Seconds

a. Wide range meter range selected is too low.

b. Power is too low on selected range.

c. Regulating blade position is too low.

d. Intermediate range period is too short.

QUESTION C.14 [1.0 point]
Which ONE of the following signals does NOT feed into the digital power meter?

a. Pool ΔT

b. Pool Flow

c. Primary Demin Flow

d. Channel 4 Power Level

QUESTION C.15 [2.0 points, $^2/_5$ each]
Indicate whether each of the following reactivity coefficients are positive or negative for the indicated locations.

a. Void Coefficient of the Flux Trap

b. Void Coefficient of the Core

c. Temperature Coefficient of the Core

d. Temperature Coefficient of the Pool

e. Temperature Coefficient of the Flux Trap

QUESTION C.16 [1.0 point]
Which ONE of the following correctly describes the actions of the automatic shim control circuit? Shim rods will automatically insert when the regulating rod reaches the ____ withdrawn position. The insertion will be enough to drive the regulating rod to ____ withdrawn.

a. 20% 60%

b. 20% 70%

c. 30% 70%

d. 30% 70%

QUESTION C.17 [1.0 point]
Which ONE of the following alarms on the control panel is NOT associated with the startup interlock?

a. Channel 1 Low Count rate

b. Nuclear Instrument Anomaly

c. Thermal Column Door Open

d. Jumper Board in Use

QUESTION C.18 [2.0 points, ⅓ 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 (6R)
b.	B	6" tangential (6T)
c.	C	4" radial (4R)
d.	D	4" tangential (4T)
e.	E	
f.	F	

A.1 c
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, Volume X, Module Y, Enabling Objective Z.Z

A.2 c
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, Volume X, Module Y, Enabling Objective Z.Z

A.3 a $N/N_0 = e^{t/T}$ $500 = e^{t/T}$ $\ln 500 = t/30$ $t = 6.21 \times 30 = 186$ seconds
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, Volume X, Module Y, Enabling Objective Z.Z

A.4 b $CR_1/CR_2 = [1 - K_{eff2}]/[1 - K_{eff1}]$ $30/10 = [1 - K_{eff}]/[1 - 0.96]$ $1 - K_{eff} = 3 \times 0.04 = 0.12$ $K_{eff} = 0.88$
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, Volume X, Module Y, Enabling Objective Z.Z

A.5 c.
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, Volume X, Module Y, Enabling Objective Z.Z

A.6 a, 2; b, 4; c, 1; d, 3
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, Volume X, Module Y, Enabling Objective Z.Z

A.7 a.
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, Volume X, Module Y, Enabling Objective Z.Z

A.8 d
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, Volume X, Module Y, Enabling Objective Z.Z

A.9 a
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, Volume X, Module Y, Enabling Objective Z.Z

A.10 c $P = P^0 e^{t/T}$ $\ln(P/P_0) = t/T$ $T = t/\ln(P/P_0)$ $T = 30 \text{ sec}/(\ln(2)) = 30/0.693 = 57.7$ sec
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, Volume X, Module Y, Enabling Objective Z.Z

A.11 b
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, Volume X, Module Y, Enabling Objective Z.Z

A.12 c
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, Volume X, Module Y, Enabling Objective Z.Z

A.13 a
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, Volume X, Module Y, Enabling Objective Z.Z

A.14 c
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, Volume X, Module Y, Enabling Objective Z.Z

A.15 b
1285 is close to ½ activity, so time should be close. Also, $A = A_0 e^{-\lambda t}$ so: $\ln (1286/2400) = -\lambda(20 \text{ min})$
$\lambda = -(\ln(1286/2400))/20\text{min} = -0.0312$ min $t = \ln(½)/-0.0312 = 22.19$
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, Volume X, Module Y, Enabling Objective Z.Z

A.16 a
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, Volume X, Module Y, Enabling Objective Z.Z

A.17 b
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, Volume X, Module Y, Enabling Objective Z.Z

A.18 d
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, Volume X, Module Y, Enabling Objective Z.Z

A.19 b
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, Volume X, Module Y, Enabling Objective Z.Z

B.1 c
REF: OP-RO-410, *Primary Coolant System.*

B.2 a, LSSS; b, LCO; c, LSSS; d, LCO
REF:

B.3 a
REF: OP-RO-531, Primary and Pool Sample Station.

B.4 a, 20; b, 1; c, 1; d, 10
REF: 10CFR20.

B.5 a, 9; b, 6; c, 4; d, 14
REF: Technical Specifications § 1.0 Definitions

B.6 d
REF: E-Plan Definitions 9.8, also NRC examination administered January 1997

B.7 a, sec, b, hr; c, yr; d, hr;
REF: Rewrite of NRC question administered April, 1984

B.8 a. 4 b. 2 c. 1 d. 3
REF: Standard NRC Question

B.9 b
REF: Standard NRC question $1/1000 \approx ½^{10}$

B.10 c
REF: Rewrite of NRC examination question administered January 1989. Also SOP/I-5

B.11 c.
REF: SOP Manual II

B.12 b
REF: E-Plan § 3.0

B.13 b
REF: T.S. 1.15

B.14 b
REF: 10CFR20.1003

B.15 c $R/hr = 6CiE/d^2$ $R/hr = (6 \times 5 \text{ curies} \times 2.5MeV)/(2 \text{ feet})^2 = 75/4 = 18.75 R/hr \approx 19 R/hr$
REF: Standard NRC question.

B.16 b
REF: Reactor Operator Training Manual, § I.10.2, p. 2, 1st ¶.

C.1 b
REF: OP-RO-730, *Building Exhaust System Fans*

C.2 c
REF: OP-RO-480, *Secondary Coolant System*

C.3 d
REF: OP-RO-465 *Pool Level Control - Skimmer System*

C.4 d
REF: Draft SAR §

C.5 b
REF: Hazards Summary Report Figure A.2,

C.6 b
REF: MURR HSR, § 7.1.10 p. 7-20.

C.7 a, Ventilation System; b, vents at top of pool; c, demineralizer
REF: Rewrite of NRC question administered April 1984.

C.8 ~~b~~ c, answer changed per facility comment (typographic error).
REF: MURR Hazard Summary Report pg. 3-1.

C.9 b
REF: Reactor Operator Training Manual, § IV.5, Secondary Chemistry Control, p. IV.5.1 2nd ¶.

C.10 a
REF: Training Manual for Reactor Operators, § III.1 Electrical Power Distribution and § III.3 Emergency Electrical System

C.11 a
REF: Facility Requalification Examination (11/17/93)

C.12 a
REF: Rewrite of NRC examination question administered January 1989.

C.13 c
REF: RO Training Manual § II.14, Rod Control System, also SOP II Reactor Operating Procedures § II.1,3 Assuming Automatic Reactor Control.

C.14 d
REF: Facility Requalification Examination (11/17/93).

C.15 a. positive b. negative c. negative d. positive e. positive
REF: MURR Hazards Summary Report, p. 4-14.,SOP/VIII-7 Critical Parameters List

C.16 a
REF: MURR Training Manual, p. II, also rewrite of NRC question administered July, 1986.

C.17 d
REF: Drawing # 79, HSR § 9.5 Startup Interlocks, Training Manual for ROs § II.14.A Rod Control System/Shim-Safety Rod Control, p. II.14.2

C.18 a, 4R; b, 6R; c, 6T; d, 4T; e, 6R; f, 4R
REF: Rewrite of facility supplied question, Plant and Radiation Monitoring Systems, #32.

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

FACILITY: University of Missouri-Columbia

REACTOR TYPE: TANK

DATE ADMINISTERED: 2002/03/12

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

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

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

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

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

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

$$R_1(1-K_{eff_1}) = CR_2(1-K_{eff_2})$$
$$CR_1(-\rho_1) = CR_2(-\rho_2)$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$DR_1 d_1^{\,2} = DR_2 d_2^{\,2}$$

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 kg = 2.21 lbm

1 Horsepower = 2.54 x 10^3 BTU/hr

1 Mw = 3.41 x 10^6 BTU/hr

1 BTU = 778 ft-lbf

°F = 9/5 °C + 32

1 gal (H_2O) ≈ 8 lbm

°C = 5/9 (°F - 32)

c_P = 1.0 BTU/hr/lbm/°F

c_p = 1 cal/sec/gm/°C

A.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.6a 1 2 3 4 ___

A.6b 1 2 3 4 ___

A.6c 1 2 3 4 ___

A.6d 1 2 3 4 ___

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 ___

B.1 a b c d ___

B.2a SL LSSS LCO ___

B.2b SL LSSS LCO ___

B.2c SL LSSS LCO ___

B.2d SL LSSS LCO ___

B.3 a b c d ___

B.4a 1 2 5 10 20 ___

B.4b 1 2 5 10 20 ___

B.4c 1 2 5 10 20 ___

B.4d 1 2 5 10 20 ___

B.5a 1 2 3 4 5 6 7 8 9 10 11 ___
12 13 14 15 16 17 18 19 20

B.5b 1 2 3 4 5 6 7 8 9 10 11 ___
12 13 14 15 16 17 18 19 20

B.5c 1 2 3 4 5 6 7 8 9 10 11 ___
12 13 14 15 16 17 18 19 20

B.5d 1 2 3 4 5 6 7 8 9 10 11 ___
12 13 14 15 16 17 18 19 20

B.6 a b c d ___

B.7a sec min hr yr ___

B.7b sec min hr yr ___

B.7c sec min hr yr ___

B.7d sec min hr yr ___

B.8a 1 2 3 4 ___

B.8b 1 2 3 4 ___

B.8c 1 2 3 4 ___

B.8d 1 2 3 4 ___

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 ___

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.4 a b c d ___

C.5 a b c d ___

C.6 a b c d ___

C.7a 1 2 3 ___

C.7b 1 2 3 ___

C.7c 1 2 3 ___

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.14 a b c d ___

C.15a Positive Negative ___

C.15b Positive Negative ___

C.15c Positive Negative ___

C.15d Positive Negative ___

C.15e Positive Negative ___

C.16 a b c d ___

C.17 a b c d ___

C.18a 4R 4T 6R 6T ___

C.18b 4R 4T 6R 6T ___

C.18c 4R 4T 6R 6T ___

C.18d 4R 4T 6R 6T ___

C.18e 4R 4T 6R 6T ___

C.18f 4R 4T 6R 6T ___