October 24, 2003

Dr. Akira T. Tokuhiro, Reactor Director
Nuclear Reactor Facility
University of Missouri, Rolla
1870 Miner Circle
Rolla, MO 65409-0170

SUBJECT: INITIAL EXAMINATION REPORT NO. 50-123/OL-03-02, UNIVERSITY OF MISSOURI - ROLLA

Dear Dr. Tokuhiro:

During the week of September 22, 2003, the NRC administered initial examinations to employees of your facility who had applied for a license to operate your University of Missouri reactor. The examination was conducted in accordance with NUREG-1478, "Non-Power Reactor Operator Licensing Examiner Standards," Revision 1. At the conclusion of the examination, the examination questions and preliminary findings were discussed with those members of your staff identified in the enclosed report.

In accordance with 10 CFR 2.790 of the Commission's regulations, a copy of this letter and the enclosures will 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/index.html. The NRC is forwarding the individual grades to you in a separate letter which will not be released publicly. Should you have any questions concerning this examination, please contact Mr. Warren Eresian at 301-415-1833 or internet e-mail wje@nrc.gov.

Sincerely,

/RA/

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

Docket No. 50-123

Enclosures: 1. Initial Examination Report No. 50-123/OL-03-02
2. Examination and answer key

cc w/encls.: Please see next page

cc:

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Facility File (EBarnhill)

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RNRP\R&TR r/f
WEresian
PMadden

ADAMS PACKAGE ACCESSION NO.: ML032940279
ADAMS REPORT ACCESSION No. ML032940261 **TEMPLATE No.: NRR-074**

OFFICE	RNRP:CE		IROB:LA		RNRP:SC	
NAME	WEresian:rdr		EBarnhill		PMadden	
DATE	10/ 21 /2003		10/ 22 /2003		10/ 24 /2003	

C = COVER **E = COVER & ENCLOSURE** **N = NO COPY**

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

REPORT NO.: 50-123/OL-03-02

FACILITY DOCKET NO.: 50-123

FACILITY LICENSE NO.: R-79

FACILITY: University of Missouri

EXAMINATION DATES: September 24-25, 2003

EXAMINER: Warren Eresian, Chief Examiner

SUBMITTED BY: ***/RA/*** 10/ 21 /2003
Warren Eresian, Chief Examiner Date

SUMMARY:

During the week of September 22, 2003, the NRC administered operator licensing retake examinations to five Reactor Operator candidates, and an initial licensing examination to one Senior Reactor Operator (Upgrade) candidate. All candidates passed the examinations.

ENCLOSURE 1

REPORT DETAILS

1. Examiner: Warren Eresian, Chief Examiner

2. Results:

	RO PASS/FAIL	SRO PASS/FAIL	TOTAL PASS/FAIL
Written	**3/0**	**N/A**	**3/0**
Operating Tests	**2/0**	**1/0**	**3/0**
Overall	**5/0**	**1/0**	**6/0**

3. Exit Meeting:

Dr. Akira T. Tokuhiro, Reactor Director
Mr. Dan Estel, Training Coordinator
Mr. William Bonzer
Warren Eresian, NRC Chief Examiner

The NRC thanked the facility staff for their cooperation during the examination. No generic examination concerns were noted.

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

FACILITY: University of Missouri-Rolla

REACTOR TYPE: Pool

DATE ADMINISTERED: 09/24/2003

REGION: 3

CANDIDATE:_____

INSTRUCTIONS TO CANDIDATE:

Answers are to be written on the exam page itself, or the answer sheet provided. Write answers one side ONLY. Attach any answer sheets to the examination. Points for each question are indicated in parentheses for each question. A 70% in each category 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	33.3	_____	____	A. REACTOR THEORY, THERMODYNAMICS, AND FACILITY OPERATING CHARACTERISTICS
20	33.3	_____	____	B. NORMAL AND EMERGENCY OPERATING PROCEDURES AND RADIOLOGICAL CONTROLS
20	33.3	_____	____	C. FACILITY AND RADIATION MONITORING SYSTEMS
60		_____	____%	FINAL GRADE

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

_____
Candidate's Signature

ENCLOSURE 2

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. Print your name in the upper right-hand corner of the answer sheets.

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

8. Partial credit may be given. Therefore, ANSWER ALL PARTS OF THE QUESTION AND DO NOT LEAVE ANY ANSWER BLANK. NOTE: partial credit will NOT be given on multiple choice questions.

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

10. When turning in your examination, assemble the completed examination with examination questions, examination aids and answer sheets. In addition, turn in all scrap paper.

11. 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.

QUESTION: 001 (1.00)

Delayed neutron precursors decay by beta decay. Which ONE reaction below is an example of beta decay?

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

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

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

d. $_{35}Br^{87} \rightarrow {}_{33}Kr^{83}$

QUESTION: 002 (1.00)

Two different neutron sources were used during two reactor startups. The source used in the first startup emits ten times as many neutrons as the source used in the second startup. Assume all other factors are the same for the second startup. Which ONE of the following states the expected result at criticality?

a. Neutron flux will be higher for the first startup.

b. Neutron flux will be higher for the second startup.

c. The first startup will result in a higher rod position (rods further out of the core).

d. The second startup will result in a higher rod position (rods further out of the core).

QUESTION: 003 (1.00)

For the same constant reactor period, which ONE of the following transients requires the **SHORTEST** time to occur? A power increase 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.

(***** CATEGORY A CONTINUED ON NEXT PAGE *****)

QUESTION: 004 (1.00)

A reactor is subcritical with a K_{eff} of 0.955. A positive reactivity of 3.5% delta k/k is inserted into the core. At this point, the reactor is:

a. supercritical.

b. exactly critical.

c. subcritical.

d. prompt critical.

QUESTION: 005 (1.00)

During the time when reactor power increases, the delayed neutron fraction, β:

a. increases because delayed neutron precursors are being produced at a faster rate.

b. decreases because delayed neutrons are being produced from precursors that were formed at a lower power level.

c. increases because prompt neutrons are being produced at a faster rate.

d. remains unchanged.

QUESTION: 006 (1.00)

Which ONE of the following describes the term *prompt jump*?

a. The instantaneous change in power level due to withdrawing a control rod.

b. A reactor which has attained criticality on prompt neutrons alone.

c. A reactor which is critical using both prompt and delayed neutrons.

d. A negative reactivity insertion which is less than β_{eff}.

(***** CATEGORY A CONTINUED ON NEXT PAGE *****)

QUESTION: 007 (1.0)

Which ONE statement below describes a negative moderator temperature coefficient?

a. When moderator temperature decreases, negative reactivity is added.

b. When moderator temperature increases, positive reactivity is added.

c. When moderator temperature decreases, reactor power decreases.

d. When moderator temperature decreases, positive reactivity is added.

QUESTION: 008 (1.00)

A thermal neutron is a neutron which:

a. experiences no net change in its energy after several collisions with atoms of the diffusing medium.

b. has been produced several seconds after its initiating fission occurred.

c. is produced as a result of thermal fission.

d. possesses thermal rather than kinetic energy.

QUESTION: 009 (1.00)

Which ONE of the following describes the difference between a moderator and reflector?

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

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

c. A reflector decreases the thermal utilization factor and a moderator increases the fast fission factor.

d. A reflector decreases the neutron production factor and a moderator decreases the fast non-leakage factor.

(***** CATEGORY A CONTINUED ON NEXT PAGE *****)

QUESTION: 010 (1.00)

Which ONE statement describes why a reactor operates with thermal neutrons rather than fast neutrons.

a. Efficiency is increased since thermal neutrons are less likely to leak out of the core.

b. Neutron absorption in non-fuel materials increases exponentially as neutron energy increases.

c. The fission cross-section of U-235 is much higher for thermal neutrons.

d. The moderator temperature coefficient becomes positive as neutron energy increases.

QUESTION: 011 (1.00)

Which ONE of the following is the major source of energy released due to thermal fission of a U^{235} atom?

a. Gammas from fission product decay.

b. Kinetic energy of the fission neutrons.

c. Prompt gamma rays.

d. Kinetic energy of the fission fragments.

QUESTION: 012 (1.00)

Which ONE of the following factors in the six-factor formula is the simplest to vary by the operator?

a. reproduction factor.

b. resonance escape probability.

c. thermal non-leakage factor.

d. thermal utilization factor.

(***** CATEGORY A CONTINUED ON NEXT PAGE *****)

QUESTION: 013 (1.00)

Given: ρ_{excess} 0.50% delta k/k
Control Rod 1 0.25% delta k/k
Control Rod 2 0.45% delta k/k
Control Rod 3 0.55% delta k/k

What is the actual (NOT Tech. Spec. minimum) shutdown margin for this core?

a. 0.20% delta k/k

b. 0.75% delta k/k

c. 1.25% delta k/k

d. 1.75% delta k/k

QUESTION: 014 (1.00)

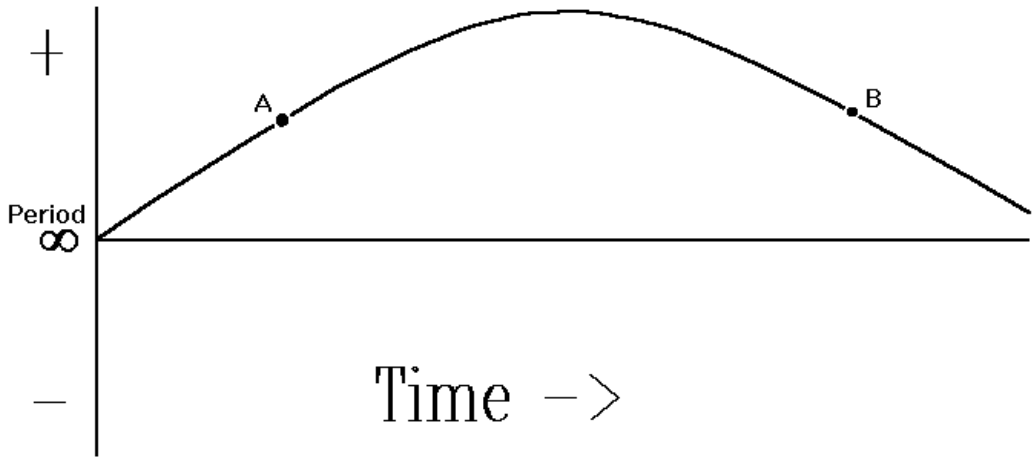
Shown below is a trace of reactor period as a function of time. Between points A and B **REACTOR POWER** is:

a. continually increasing.

b. increasing, then decreasing.

c. continually decreasing.

d. constant.



(***** CATEGORY A CONTINUED ON NEXT PAGE *****)

QUESTION: 015 (1.00)

Which ONE of the following statements describes the difference between Differential Rod Worth (DRW) and Integral Rod Worth (IRW)?

a. DRW relates the worth of the rod per increment of movement to rod position. IRW relates the total reactivity added by the rod to rod position.

b. DRW relates the time rate of reactivity change to rod position. IRW relates the total reactivity in the core to the time rate of reactivity change.

c. IRW relates the worth of the rod per increment of movement to rod position. DRW relates the total reactivity added by the rod to rod position.

d. IRW is the slope of the DRW at a given rod position.

QUESTION: 016 (1.00)

The effective neutron multiplication factor, K_{eff} is defined as:

a. absorption/(production + leakage)

b. (production + leakage)/absorption

c. (absorption + leakage)/production

d. production/(absorption + leakage)

QUESTION: 017 (1.00)

A critical reactor is operating at a steady-state power level of 1.000 kW. Reactor power is increased to a new steady-state power level of 1.004 kW. Neglecting any temperature effects, what reactivity insertion is required to accomplish this?

a. 0.004 delta k/k.

b. 0.4% delta k/k.

c. 1.004% delta k/k.

d. Indeterminant, since any amount of positive reactivity could have been used.

(***** CATEGORY A CONTINUED ON NEXT PAGE *****)

QUESTION: 018 (1.00)

Which ONE of the following factors is the most significant in determining the differential worth of a control rod?

a. Rod speed.

b. Reactor power.

c. Flux shape.

d. Enrichment of fuel.

QUESTION: 019 (1.00)

Which factor in the six-factor formula is described by the ratio:

$$\frac{\text{number of fast neutrons produced by thermal fission}}{\text{number of thermal neutrons absorbed in the fuel}}$$

a. fast fission factor.

b. resonance escape probability.

c. reproduction factor.

d. thermal utilization factor.

QUESTION: 020 (1.00)

Which ONE of the following conditions will DECREASE shutdown margin?

a. Adding an experiment which inserts negative reactivity.

b. Addition of uranium fuel.

c. Depletion of uranium fuel.

d. Increasing pool water temperature, if temperature coefficient is negative.

(***** END OF CATEGORY A *****)

QUESTION: 001 (1.00)

In accordance with Technical Specifications, which ONE of the following conditions is NOT permissible when the reactor is operating?

a. Primary coolant resistivity = 0.5 megaohm-cm.

b. Depth of water in pool = 16 feet.

c. A secured experiment worth 1.2% delta k/k in reactor.

d. Minimum shutdown margin = 1.5% delta k/k.

QUESTION: 002 (1.00)

Three visitors are to be allowed entry to the facility. In accordance with SOP 208:

a. three dosimeters may be placed in the bay area, and the maximum radiation value obtained will be credited to all visitors.

b. no dosimetry is required as long as the escort is wearing dosimetry.

c. each visitor is issued a dosimeter.

d. one visitor is issued a dosimeter, and the radiation value obtained will be credited to the other two visitors.

QUESTION: 003 (1.00)

In accordance with the Emergency Plan, the site boundary is:

a. the outside walls of the reactor confinement building.

b. the UMR campus boundary.

c. a 500 meter radius from the reactor building.

d. the Emergency Support Center.

(***** CATEGORY B CONTINUED ON NEXT PAGE *****)

QUESTION: 004 (1.00)

In accordance with SOP 101, who is the only person authorized to use an interlock bypass key?

a. The licensed reactor operator at the console.

b. The Senior Operator on duty.

c. Reactor Manager.

d. Reactor Director.

QUESTION: 005 (1.00)

The reactor parameter which is protected by a Safety Limit is:

a. fuel element temperature.

b. reactor power level.

c. primary coolant flow rate.

d. fuel element cladding temperature.

QUESTION: 006 (1.00)

In accordance with 10 CFR 20, the "Annual Limit on Intake (ALI)" refers to:

a. the amount of radioactive material taken into the body by inhalation or ingestion in one (1) year which would result in a committed effective dose equivalent of five (5) rems.

b. the concentration of a given radionuclide in air which, if breathed for a working year of 2000 hours, would result in a committed effective dose equivalent of 5 rems.

c. the dose equivalent to organs that will be received from an intake of radioactive material by an individual during the 50-year period following the intake.

d. limits on the release of effluents to an unrestricted environment.

(***** CATEGORY B CONTINUED ON NEXT PAGE *****)

QUESTION: 007 (1.00)

A radiation survey instrument is used to measure an gamma-beta irradiated experiment. The results are 100 mrem/hour with the window open and 60 mrem/hour with the window closed. The beta dose rate is:

a. 40 mrem/hour.

b. 60 mrem/hour.

c. 100 mrem/hour.

d. 140 mrem/hour.

QUESTION: 008 (1.00)

The reactor is operating when a rabbit is withdrawn from the core. The dose rate outside the glovebox is 100 mR/hour. In accordance with SOP-710, the reactor operator should:

a. shoot the rabbit back into the core and notify the SRO on duty.

b. shoot the rabbit back into the core, turn the rabbit system off, shut down the reactor and notify the SRO on duty.

c. manually scram the reactor, leave the rabbit in its present position and notify the SRO on duty.

d. manually scram the reactor, leave the rabbit in its present position and turn the rabbit system off.

QUESTION: 009 (1.00)

A radioactive sample is to be removed from the reactor pool. The sample is surveyed and the dose rate is found to be 60 mR/hr at 1 foot. In accordance with SOP-601, the sample may be handled:

a. only with permission from the Health Physicist.

b. by students under the direct supervision of the reactor staff.

c. by the reactor staff.

d. by students with the permission of the reactor staff.

(***** CATEGORY B CONTINUED ON NEXT PAGE *****)

QUESTION: 010 (1.00)

The Technical Specifications require that experimental verification of calculated values of airborne radioactive effluents be performed annually. The purpose of this requirement is to measure the airborne radioactivity associated with:

a. Nitrogen-16.

b. Argon-41.

c. Iodine-131.

d. Cesium-137.

QUESTION: 011 (1.00)

In accordance with 10CFR20, which ONE of the following defines "Total Effective Dose Equivalent (TEDE)?"

a. It is the sum of Internal Whole Body Dose and the External Whole Body Dose.

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

c. It is the sum of the External Whole Body Dose and the Organ Dose.

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

QUESTION: 012 (1.00)

"A channel test of each of the reactor safety system channels shall be performed before each day's operation or before each operation expected to extend more than one day, except for the bridge motion monitor which shall be done weekly." This is an example of a"

a. safety limit.

b. limiting safety system setting.

c. limiting condition for operation.

d. surveillance requirement.

(***** CATEGORY B CONTINUED ON NEXT PAGE *****)

QUESTION: 013 (1.00)

A power calibration has been done in accordance with SOP-816. It is found that the power indicated on the linear recorder is 10% higher than calculated power. As a result:

a. the high voltage to the detector is adjusted so that the recorder reads the calculated power.

b. the recorder is adjusted so that it reads the calculated power.

c. the compensating voltage on the detector is adjusted so that the recorder reads the calculated power.

d. the position of the detector is adjusted so that the recorder reads the calculated power.

QUESTION: 014 (1.00)

A radiation survey of an area reveals a general radiation reading of 1 mrem/hr. There is, however, a small section of pipe (point source) which reads 10 mrem/hr at one (1) meter. Which ONE of the following defines the posting requirements for the area in accordance with 10CFR20?

a. "CAUTION RADIATION AREA."

b. "CAUTION RADIOACTIVE MATERIAL."

c. "CAUTION HIGH RADIATION AREA."

d. "GRAVE DANGER, VERY HIGH RADIATION AREA."

QUESTION: 015 (1.00)

A Rundown Alarm signal has been received and control rods are inserting. The alarm condition clears and the operator stops the Rundown. In accordance with SOP-150, the reactor may be restarted (rods withdrawn):

a. after the operator has determined the cause of the rundown.

b. after the operator has taken corrective action.

c. after notifying the SRO on Duty.

d. only with the permission of the SRO on Duty.

(***** CATEGORY B CONTINUED ON NEXT PAGE *****)

QUESTION: 016 (1.00)

Which ONE of the operations below does NOT require the authorization or supervision of the Senior Reactor Operator on Duty?

a. Bypass High Radiation Area alarm.

b. Power increase on a 35-second period.

c. Place reactor in automatic control.

d. Operation at greater than 20 kW with no nitrogen diffuser on.

QUESTION: 017 (1.00)

"Emergency Action Levels" are:

a. specific instrument readings, observations, dose rates, etc. which provide thresholds for establishing emergency classes.

b. projected dose equivalents to individuals in the general population which warrants protective actions following a nuclear incident.

c. dose equivalents that are projected to be received by individuals in a population group from a contaminating event if no protective actions were taken.

d. instructions that detail the implementation actions and methods required to achieve the objectives of the emergency plan.

QUESTION: 018 (1.00)

In accordance with Technical Specifications, which ONE of the following conditions is permissible when the reactor is operating at 20 kW?

a. Regulating rod worth = 1.0% delta k/k.

b. Free drop time for shim-safety rod = 800 msec.

c. One ventilation fan inoperable.

d. Pool water temperature Rod Withdrawal Prohibit key bypassed.

(***** CATEGORY B CONTINUED ON NEXT PAGE *****)

QUESTION: 019 (1.00)

To maintain an active Reactor Operator or Senior Reactor Operator license, the functions of an operator or senior operator must be actively performed for at least:

a. one hour per month.

b. three hours per calendar quarter.

c. four hours per calendar quarter.

d. twelve hours per year.

QUESTION: 020 (1.00)

Match the definition in Column II with the correct term in Column I. Each definition is only used once.

	Column I		Column II
a.	Channel Check	1.	The introduction of an input signal into the channel to verify that it is operable.
b.	Channel Test	2.	The qualitative verification of acceptable performance by observation of channel behavior.
c.	Channel Calibration	3.	The adjustment of a channel such that its output corresponds with acceptable accuracy to known values of the parameter which the channel measures.

(***** END OF CATEGORY B *****)

QUESTION: 001 (1.00)

Which ONE (1) of the following conditions would activate an interlock preventing Shim-Safety Rod withdrawal?

a. Radiation Area Monitor = 25 mr/hour.

b. Reactor period = 15 seconds.

c. Log power recorder is out of service.

d. Period amplifier not operable.

QUESTION: 002 (1.00)

WHICH ONE of the following parameters can initiate a reactor scram, a rundown, and rod withdrawal prohibit?

a. Recorders not operating.

b. Radiation dose rate.

c. Reactor power.

d. Reactor period.

QUESTION: 003 (1.00)

Which ONE of the following types of detector is utilized in the continuous air monitoring system?

a. Geiger-Mueller tube.

b. Scintillation detector.

c. Ionization chamber.

d. Proportional counter.

(***** CATEGORY C CONTINUED ON NEXT PAGE *****)

QUESTION: 004 (1.00)

Which ONE accident below is designated as the Maximum Hypothetical Accident for the UMRR?

a. Failure of a fueled experiment.

b. Fuel element handling accident.

c. Loss of coolant accident.

d. Failure of a movable experiment.

QUESTION: 005 (1.00)

In order to reduce the buildup of radioisotopes in the reactor bay, the facility has three fans in the ventilation system. These fans have the capability to replace the air in the reactor bay approximately:

a. every 1.4 minutes, or about forty changes per hour.

b. every 14 minutes, or about four changes per hour.

c. every 140 minutes, or about one-half change per hour.

d. every 1400 minutes, or about one change per day.

QUESTION: 006 (1.00)

The radiation area monitor located near the thermal column and beam port can automatically initiate:

a. a rundown only.

b. a reactor scram only.

c. a rod withdrawal prohibit only.

d. a reactor scram and building evacuation.

(***** CATEGORY C CONTINUED ON NEXT PAGE *****)

QUESTION: 007 (1.00)

Nitrogen gas is used as the transport medium for the pneumatic sample transfer system because:

a. it is more compressible than air.

b. it minimizes the production of Ar-41.

c. it is non-combustible.

d. it minimizes the production of N-16.

QUESTION: 008 (1.00)

A minimum depth of water between the top of the core and the pool surface is maintained in order to provide:

a. the proper amount of cooling of the core.

b. shielding against radiation at the pool surface.

c. sufficient suction head for the purification pump.

d. sufficient cooling for the fuel element storage space.

QUESTION: 009 (1.00)

Core inlet temperature is measured by two thermocouples located below the core. A trip is provided:

a. when either thermocouple reads 135 deg. F.

b. only when both thermocouples read 135 deg. F.

c. only when the average of both thermocouples is 135 deg. F.

d. only when both thermocouples read 57 deg. C.

(***** CATEGORY C CONTINUED ON NEXT PAGE *****)

QUESTION: 010 (1.00)

Compensating voltage to the compensated ion chambers is lost while the reactor is operating. As a result, the power level indication will:

a. increase

b. decrease

c. increase or decrease, depending on the power level

d. remain unchanged

QUESTION: 011 (1.00)

Match the detector type in Column II with the correct Nuclear Instrument Channel in Column I. Detector types may be used more than once.

	Column I		Column II
a.	Linear Power	1.	Fission Chamber
b.	Period	2.	Uncompensated Ion Chamber
c.	Log Power	3.	Compensated Ion Chamber
d.	Power Range (Safety)		
e.	Startup		

QUESTION: 012 (1.00)

Following a loss of building electrical power:

a. power to reactor instrumentation will not be lost due to a fast transfer (less than 50 msec) to the reserve supply.

b. power to reactor instrumentation will be restored following a 5 second time delay as transfer to the reserve supply occurs.

c. power will be lost to reactor instrumentation but will be automatically restored when building power returns.

d. power will be lost to reactor instrumentation and will not return until building power returns and the power supplies are manually reset.

(***** CATEGORY C CONTINUED ON NEXT PAGE *****)

QUESTION: 013 (1.00)

The purpose of the two water retention tanks is to:

a. provide a sump from which water may be pumped directly into the sanitary sewer.

b. allow the activity of overflow water from the reactor pool to decay prior to pumping the water back into the pool.

c. provide a source of water for the HCl and NaOH tanks.

d. hold the liquids resulting from regeneration of the ion exchanger.

QUESTION: 014 (1.00)

Which ONE of the following describes the operation of the building ventilation system exhaust duct and intake louvers?

a. The louvers automatically close when the ventilation fans are turned off.

b. The louvers automatically close when the building evacuation alarm sounds.

c. When the louvers reach their fully-closed position, the ventilation fans automatically turn off.

d. The louvers automatically close when any radiation area monitor alarms.

QUESTION: 015 (1.00)

The equations which describe the operation of the neutron source are:

a. Pu-239 -> alpha + U-235
B-10 + alpha -> N-13 + neutron

b. Pu-239 -> beta + Am-239
B-10 + beta -> Be-9 + neutron

c. Pu-239 -> alpha + U-235
Be-9 + alpha -> C-12 + neutron

d. Pu-239 -> beta + Am-239
Be-9 + beta -> Li-8 + neutron

(***** CATEGORY C CONTINUED ON NEXT PAGE *****)

QUESTION: 016 (1.00)

For a shim-safety rod, the "withdraw limit" light is ON, the "insert limit" light is OFF, and the "contact" light is OFF. This means that:

a. The rod and drive are not in contact, the rod is full out and the drive is full in.

b. The rod and drive are both full out.

c. The rod and drive are both full in.

d. The rod and drive are not in contact, the drive is full out and the rod is full in.

QUESTION: 017 (1.00)

The standard fuel elements are about:

a. 20% enriched uranium with stainless steel clad.

b. 20% enriched uranium with aluminum clad.

c. 12.5% enriched uranium with stainless steel clad.

d. 12.5% enriched uranium with aluminum steel clad.

QUESTION: 018 (1.00)

Two safety channels, a master and slave sensing circuit, are part of the reactor protection system which provides the mechanism for scramming the reactor. In order to have a reactor scram:

a. a scram signal must be present in each of the circuits.

b. a scram signal must be present in the master circuit; the slave circuit need not have a scram signal.

c. a scram signal must be present in the slave circuit; the master circuit need not have a scram signal.

d. a scram signal can be present in either circuit.

(***** CATEGORY C CONTINUED ON NEXT PAGE *****)

QUESTION: 019 (1.00)

Which ONE of the following describes the action of the shim-safety rod drive system following a reactor scram?

a. The magnet remains in its present position until driven in.

b. Deactivation of the contact-actuated microswitch initiates the down motion of the magnet.

c. Activation of the INSERT LIMIT microswitch initiates the down motion of the magnet.

d. The scram signal automatically causes the magnet to be driven in.

QUESTION: 020 (1.00)

At a power level of 200 kW, the core average thermal neutron flux is approximately 1.5×10^{12} neutrons/cm^2/sec. The average fast neutron flux is approximately:

a. 3 times greater.

b. 100 times greater.

c. 10 times smaller.

d. 3 times smaller.

(***** END OF CATEGORY C *****)
(***** END OF EXAMINATION *****)

A. REACTOR THEORY, THERMODYNAMICS AND FACILITY OPERATING CHARACTERISTICS

ANSWER: 001 (1.00)
B.
REFERENCE:
Burn, Introduction to Nuclear Reactor Operations, Page 2-30.

ANSWER: 002 (1.00)
A.
REFERENCE:
Burn, Introduction to Nuclear Reactor Operations, Pages 5-14 thru 5-19.

ANSWER: 003 (1.00)
D.
REFERENCE:
Burn, Introduction to Nuclear Reactor Operations, Page 4-4.

ANSWER: 004 (1.00)
C.
REFERENCE:
Burn, Introduction to Nuclear Reactor Operations, Page 3-20.
Initial Reactivity = (K-1)/K = (0.955 -1)/0.955 = - 0.047 delta k/k
After reactivity insertion, net reactivity = - 0.047 + 0.035 = - 0.012 delta k/k

ANSWER: 005 (1.00)
B.
REFERENCE:
Burn, Introduction to Nuclear Reactor Operations, Page 4-8.

ANSWER: 006 (1.00)
A.
REFERENCE:
Burn, Introduction to Nuclear Reactor Operations, Page 4-21.

ANSWER: 007 (1.00)
D.
REFERENCE:
Burn, Introduction to Nuclear Reactor Operations, Page 6-5.

ANSWER: 008 (1.00)
A.
REFERENCE:
Burn, Introduction to Nuclear Reactor Operations, Pages 2-36, 2-45.

ANSWER: 009 (1.00)
A.
REFERENCE:
Burn, Introduction to Nuclear Reactor Operations, Page 3-16.

ANSWER: 010 (1.00)
C.
REFERENCE:
Burn, Introduction to Nuclear Reactor Operations, Page 2-36.

ANSWER: 011 (1.00)
D.
REFERENCE:
Burn, Introduction to Nuclear Reactor Operations, Page 3-5.

ANSWER: 012 (1.00)
D.
REFERENCE:
Burn, Introduction to Nuclear Reactor Operations, Page 3-19.

ANSWER: 013 (1.00)
B.
REFERENCE:
Burn, Introduction to Nuclear Reactor Operations, Page 6-2.
Shutdown Margin = Total Rod Worth - Excess Reactivity
SDM = 1.25% - 0.50% = 0.75% delta k/k

ANSWER: 014 (1.00)
A.
REFERENCE:
Since the period is always positive, power continually increases (but at different rates).

ANSWER: 015 (1.00)
A.
REFERENCE:
Burn, Introduction to Nuclear Reactor Operations, Pages 7-1 thru 7-5.

ANSWER: 016 (1.00)
D.
REFERENCE:
Burn, Introduction to Nuclear Reactor Operations, Page 3-16.

ANSWER: 017 (1.00)
D.
REFERENCE:
The amount of positive reactivity only affects the rate at which the transient occurs. Since no time is specified for the change, any amount will do.

ANSWER: 018 (1.00)
C.
REFERENCE:
Burn, Introduction to Nuclear Reactor Operations, Page 7-4.

ANSWER: 019 (1.00)
C.
REFERENCE:
Burn, Introduction to Nuclear Reactor Operations, Page 3-16

ANSWER: 020 (1.00)
B.
REFERENCE:
Anything which adds positive reactivity will decrease the shutdown margin.

B. NORMAL/EMERGENCY PROCEDURES & RADIOLOGICAL CONTROLS

ANSWER: 001 (1.00)
B.
REFERENCE:
University of Missouri-Rolla Technical Specifications, Section 3.3.

ANSWER: 002 (1.00)
C.
REFERENCE:
SOP 208, Reactor Security.

ANSWER: 003 (1.00)
B.
REFERENCE:
University of Missouri-Rolla Emergency Plan, Page 4.

ANSWER: 004 (1.00)
B.
REFERENCE:
SOP 101, General Operational Procedures.

ANSWER: 005 (1.00)
D.
REFERENCE:
University of Missouri-Rolla Technical Specifications, Section 2.1.

ANSWER: 006 (1.00)
A.
REFERENCE:
10 CFR 20.1003.

ANSWER: 007 (1.00)
A.
REFERENCE:
Instrument reads only gamma dose rate with window closed. Instrument read both gamma and beta dose rate with window open. Beta dose rate is window open dose rate minus window closed dose rate.

ANSWER: 008 (1.00)
B.
REFERENCE:
SOP 710, Insertion and Removal of Experiments.

ANSWER: 009 (1.00)
C.
REFERENCE:
SOP 601, Handling of Radioactive Samples.

ANSWER: 010 (1.00)
B.
REFERENCE:
SAR, Section 7.6.1.

ANSWER: 011 (1.00)
A.
REFERENCE:
10 CFR 20.1003.

ANSWER: 012 (1.00)
D.
REFERENCE:
University of Missouri-Rolla Technical Specifications, Section 4.2.2.

ANSWER: 013 (1.00)
D.
REFERENCE:
SOP 816, UMRR Power Calibration.

ANSWER: 014 (1.00)
C.
REFERENCE:
10 CFR 20.1003
$DR_1D_1^2 = DR_2D_2^2$
10 mR/hr at 1 meter = 111 mR/hr at 30 cm.

ANSWER: 015 (1.00)
D.
REFERENCE:
SOP 150, Response to Alarms.

ANSWER: 016 (1.00)
C.
REFERENCE:
SOP 104, Reactor Power Changes and Stable Operations.

ANSWER: 017 (1.00)
A.
REFERENCE:
University of Missouri-Rolla Emergency Plan, Page 12.

ANSWER: 018 (1.00)
C.
REFERENCE:
University of Missouri-Rolla Technical Specifications, Section 3.5.

ANSWER: 019 (1.00)
C.
REFERENCE:
10 CFR 55.53.

ANSWER: 020 (1.00)
A,2; B,1; C,3.
REFERENCE:
University of Missouri-Rolla Technical Specifications, Section 1.3.

C. FACILITY AND RADIATION MONITORING SYSTEMS

ANSWER: 001 (1.00)
C.
REFERENCE:
University of Missouri-Rolla SAR, Table IX, page 3-41.

ANSWER: 002 (1.00)
D.
REFERENCE:
University of Missouri-Rolla Technical Specifications, Tables 3.1, 3.2.

ANSWER: 003 (1.00)
A.
REFERENCE:
University of Missouri-Rolla SAR, page 3-47.

ANSWER: 004 (1.00)
A.
REFERENCE:
University of Missouri-Rolla SAR, page 9-19.

ANSWER: 005 (1.00)
A.
REFERENCE:
University of Missouri-Rolla SAR, page 5-5.

ANSWER: 006 (1.00)
A.
REFERENCE:
University of Missouri-Rolla SAR, page 3-47.

ANSWER: 007 (1.00)
B.
REFERENCE:
University of Missouri-Rolla SAR, page 4-5.

ANSWER: 008 (1.00)
B.
REFERENCE:
University of Missouri-Rolla SAR, page 3-45.

ANSWER: 009 (1.00)
A.
REFERENCE:
University of Missouri-Rolla SAR, page 3-36.

ANSWER: 010 (1.00)
A.
REFERENCE:
When compensation voltage is lost, the detector reads both the neutron and gamma signals.

C. FACILITY AND RADIATION MONITORING SYSTEMS

ANSWER: 011 (1.00)
A,3; B,3; C,3; D,2; E,1.
REFERENCE:
University of Missouri-Rolla SAR, page 3-31.

ANSWER: 012 (1.00)
D.
REFERENCE:
SOP-308

ANSWER: 013 (1.00)
D.
REFERENCE:
University of Missouri-Rolla SAR, page 5-5.

ANSWER: 014 (1.00)
A.
REFERENCE:
University of Missouri-Rolla SAR, page 5-7.

ANSWER: 015 (1.00)
C.
REFERENCE:
SOP-653

ANSWER: 016 (1.00)
D.
REFERENCE:
University of Missouri-Rolla SAR, page 3-37.

ANSWER: 017 (1.00)
B.
REFERENCE:
University of Missouri-Rolla SAR, page 3-10.

ANSWER: 018 (1.00)
D.
REFERENCE:
University of Missouri-Rolla SAR, page 3-38.

ANSWER: 019 (1.00)
A.
REFERENCE:
University of Missouri-Rolla SAR, page 3-11.

ANSWER: 020 (1.00)
A.
REFERENCE:
University of Missouri-Rolla SAR, page 3-3.

A. REACTOR THEORY, THERMODYNAMICS AND FACILITY OPERATING CHARACTERISTICS

ANSWER SHEET

MULTIPLE CHOICE (Circle or X your choice)
If you change your answer, write your selection in the blank.

001	a	b	c	d _____
002	a	b	c	d _____
003	a	b	c	d _____
004	a	b	c	d _____
005	a	b	c	d _____
006	a	b	c	d _____
007	a	b	c	d _____
008	a	b	c	d _____
009	a	b	c	d _____
010	a	b	c	d _____
011	a	b	c	d _____
012	a	b	c	d _____
013	a	b	c	d _____
014	a	b	c	d _____
015	a	b	c	d _____
016	a	b	c	d _____
017	a	b	c	d _____
018	a	b	c	d _____
019	a	b	c	d _____
020	a	b	c	d _____

(***** END OF CATEGORY A *****)

B. NORMAL/EMERGENCY PROCEDURES & RADIOLOGICAL CONTROLS

ANSWER SHEET

MULTIPLE CHOICE (Circle or X your choice)
If you change your answer, write your selection in the blank.

001 a b c d _____

002 a b c d _____

003 a b c d _____

004 a b c d _____

005 a b c d _____

006 a b c d _____

007 a b c d _____

008 a b c d _____

009 a b c d _____

010 a b c d _____

011 a b c d _____

012 a b c d _____

013 a b c d _____

014 a b c d _____

015 a b c d _____

016 a b c d _____

017 a b c d _____

018 a b c d _____

019 a b c d _____

020 a_____b_____ c_____

(***** END OF CATEGORY B *****)

C. FACILITY AND RADIATION MONITORING SYSTEMS

ANSWER SHEET

MULTIPLE CHOICE (Circle or X your choice)
If you change your answer, write your selection in the blank.

001 a b c d _____

002 a b c d _____

003 a b c d _____

004 a b c d _____

005 a b c d _____

006 a b c d _____

007 a b c d _____

008 a b c d _____

009 a b c d _____

010 a b c d _____

011 a____ b____ c____ d____ e____

012 a b c d _____

013 a b c d _____

014 a b c d _____

015 a b c d _____

016 a b c d _____

017 a b c d _____

018 a b c d _____

019 a b c d _____

020 a b c d _____

(***** END OF CATEGORY C *****)

EQUATION SHEET

$Q = m\ c_p\ \Delta T$	$CR_1\ (1\text{-}Keff)_1 = CR_2\ (1\text{-}Keff)_2$
$SUR = 26.06/\tau$	$P = P_0\ 10^{SUR(t)}$
$P = P_0\ e^{(t/\tau)}$	$\tau = (\ell^*/\rho) + [(\beta-\rho)/\lambda_{eff}\rho]$
$\lambda_{eff} = 0.1\ seconds^{-1}$	$DR_1D_1^2 = DR_2D_2^2$
$DR = DR_o e^{-\lambda t}$	$DR = 6CiE/D^2$
$\rho = (Keff-1)/Keff$	
$1\ Curie = 3.7x10^{10}\ dps$	1 gallon water = 8.34 pounds
1 Btu = 778 ft-lbf	$°F = 9/5°C + 32$
$1\ Mw = 3.41x10^6\ BTU/hr$	$°C = 5/9\ (°F - 32)$