August 15, 2000

Dr. John C. Lee, Interim Director
Phoenix Memorial Laboratory
Ford Nuclear Reactor
University of Michigan
2301 Bonisteel Boulevard
Ann Arbor, Michigan 48109-2100

Dear Dr. Lee:

SUBJECT: INITIAL EXAMINATION REPORT NO. 50-002/OL-00-02

During the week of July 17, 2000, the NRC administered initial examinations to employees of your facility who had applied for a license to operate your University of Michigan 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 NRC's "Rules of Practice," a copy of this letter and its enclosure 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/index.html. The NRC is forwarding the individual grades to you in a separate letter which will not be released publicly. If you have any questions concerning the examination, please contact Patrick Isaac at 301-415-1019.

Sincerely,

/RA/

Ledyard B. Marsh, Chief
Events Assessment, Generic Communications
and Non-Power Reactors Branch
Division of Regulatory Improvement Programs
Office of Nuclear Reactor Regulation

Docket No. 50-002

Enclosures:
1. Initial Examination Report No. 50-002/OL-00-02
2. Examination and answer key (SRO)

cc w/encls:
Please see next page

cc:

Special Assistant to the Governor
Office of the Governor
Room 1 - State Capitol
Lansing, MI 48909

Mr. Christopher Becker
Phoenix Memorial Laboratory
University of Michigan - North Campus
Ann Arbor, MI 48109

Michigan Department of Environmental Quality
Drinking Water and Radiological
Protection Division
P.O. Box 30630
Lansing, MI 48909-8130

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DISTRIBUTION w/ encls.:
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TMichaels
Facility File (EBarnhill)

DISTRIBUTION w/o encls.
REXB r/f
DMatthews
LMarsh/LHowell
PIsaac

ACCESSION NO: ML003737713 **TEMPLATE #: NRR-074**

OFFICE	DIPM:IOLB		REXB:CE		REXB:BCADBC	
NAME	EBarnhill:rdr		PIsaac		LMarsh/LHowell	
DATE	08/14/2000		08/10/2000		08/15/2000	

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

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

REPORT NO.: 50-002/OL-00-02

FACILITY DOCKET NO.: 50-002

FACILITY LICENSE NO.: R-28

FACILITY: University of Michigan

EXAMINATION DATES: July 18-19, 2000

EXAMINER: Patrick Isaac, Chief Examiner

SUBMITTED BY: **/RA/** 08/01/2000
Patrick Isaac, Chief Examiner Date

SUMMARY:

During the week of July 17, 2000, NRC administered Operator Licensing Examinations to one Senior Reactor Operator Instant (SROI) candidate and one Senior Reactor Operator Upgrade (SROU) candidate. Both candidates passed the examinations.

REPORT DETAILS

1. Examiners: Patrick Isaac, Chief Examiner

2. Results:

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

3. Exit Meeting: N/A

ENCLOSURE 1

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

FACILITY: University of Michigan

REACTOR TYPE: POOL

DATE ADMINISTERED: 2000/07/17

REGION: III

CANDIDATE: ______________________

INSTRUCTIONS TO CANDIDATE:
Answers are to be written on the answer sheet provided. Attach all answer sheets to the examination. Point values 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
20.00	**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.**	**FACILITY 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

ENCLOSURE 2

A. RX THEORY, THERMO & FAC OP CHARS

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/EMERG PROCEDURES & RAD CON

A N S W E R   S H E E T

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 B *****)

A N S W E R   S H E E T

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 ___

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

EQUATION SHEET

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

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

$\dot{Q} = \dot{m} \Delta h$

$SCR = S/(1\text{-}Keff)$

$\dot{Q} = UA \Delta T$

$CR_1 (1\text{-}Keff)_1 = CR_2 (1\text{-}Keff)_2$

$$SUR = \frac{26.06 (\lambda_{eff}\rho)}{(\beta - \rho)}$$

$$M = \frac{(1\text{-}Keff)_0}{(1\text{-}Keff)_1}$$

$SUR = 26.06/\tau$

$M = 1/(1\text{-}Keff) = CR_1/CR_0$

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

$SDM = (1\text{-}Keff)/Keff$

$P = P_0 \, e^{(t/\tau)}$

$Pwr = W_f \dot{m}$

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

$\ell^* = 1 \times 10^{-5}$ seconds

$\tau = (\ell^*/\rho) + [(\bar{\beta}-\rho)/\lambda_{eff}\rho]$

$\tau = \ell^*/(\rho-\bar{\beta})$

$\rho = (Keff-1)/Keff$

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

$\rho = \Delta Keff/Keff$

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

$\bar{\beta} = 0.0075$

$DR_1 D_1^2 = DR_2 D_2^2$

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

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

DR ≡ R/hr, Ci ≡ Curies, E ≡ Mev, R ≡ feet

1 Curie = 3.7×10^{10} dps

1 kg = 2.21 lbm

1 hp = 2.54×10^3 BTU/hr

1 Mw = 3.41×10^6 BTU/hr

1 BTU = 778 ft-lbf

°F = 9/5°C + 32

1 gal H_2O ≈ 8 lbm

°C = 5/9 (°F - 32)

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 <u>only</u> 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.

QUESTION (A.1) [1.0]
An experiment requires that power be ramped from 15 watts to 500 kilowatts on a 45 second period. Which one of the following will be the elapsed time to reach 500 kilowatts for this ramp?

a. 157.6 seconds

b. 243.0 seconds

c. 365.0 seconds

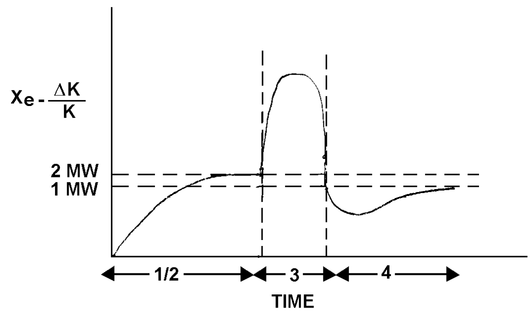
d. 468.6 seconds

*QUESTION (A.2) [1.0]
Which one of the following figures most closely depicts the reactivity versus time plot for xenon for the following sequence of evolutions:

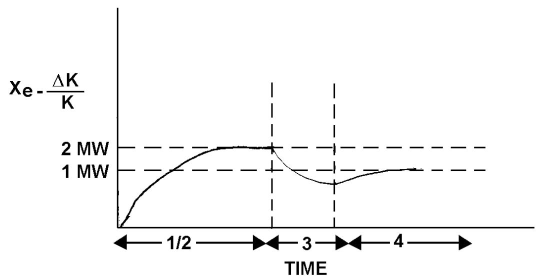
TIME	EVOLUTION
1	2 MW startup, clean core;
2	Operation at 2 MW for four days;
3	Shutdown for 15 hours;
4	1 MW for 29 hours.

(See next page for choice selections.)

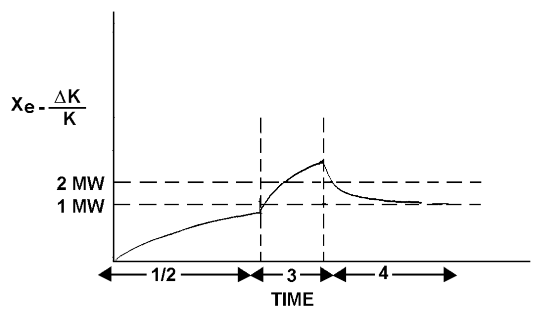
1.


Xe - ΔK/K
2 MW
1 MW
1/2
3
4
TIME

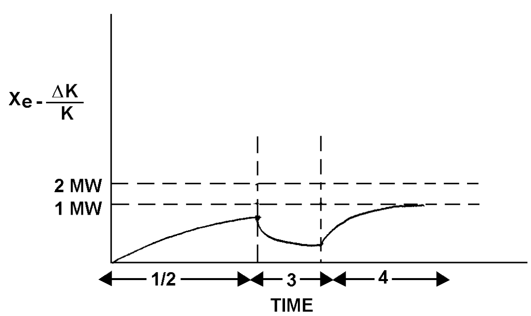
2.


Xe - ΔK/K
2 MW
1 MW
1/2
3
4
TIME

3.


Xe - ΔK/K
2 MW
1 MW
1/2
3
4
TIME

4.


Xe - ΔK/K
2 MW
1 MW
1/2
3
4
TIME

*QUESTION (A.3) [1.0]

Given the following: Moderator temperature coefficient: -1.0×10^{-4} ΔK/K/°F
Control rod worth: 0.003 ΔK/K/inch

The reactor is operating in automatic at 300 KW. The moderator temperature decreases slowly by 18°F. Which one of the following is the direction and distance that the control rod will move to compensate for the change in temperature?

a. The control rod moves in 0.3 inches.

b. The control rod moves out 0.3 inches.

c. The control rod moves in 0.6 inches.

d. The control rod moves out 0.6 inches.

*QUESTION (A.4) [1.0]

During reactor operation at 2 MW, one shim rod with a total worth of 3% scrams into the reactor. Which one of the following is the reactor power level immediately after the transient?

a. 388 KW

b. 412 KW

c. 647 KW

d. 689 KW

*QUESTION (A.5) [1.0]

With the reactor on a constant period, which transient requires the longest time to occur?

a. 5% power -- going from 1% to 6% power

b. 10% power -- going from 10% to 20% power

c. 15% power -- going from 20% to 35% power

d. 20% power -- going from 40% to 60% power

*QUESTION (A.6) [1.0]
The operator is approaching criticality by a pull and wait procedure. Each consecutive pull adds the same amount of reactivity. Which one of the following describes the time required for the startup instrumentation to level out at each subcritical level?

a. Longer periods of time with each successive pull due to larger subcritical multiplication factors at higher neutron levels

b. Shorter periods of time with each successive pull due to larger subcritical multiplication factors at higher neutron levels

c. Longer periods of time with each successive pull due to smaller subcritical multiplication factors at higher neutron levels

d. Shorter periods of time with each successive pull due to smaller subcritical multiplication factors at higher neutron levels

*QUESTION (A.7) [1.0]
The reactor is operating at 500 kilowatts. With a temperature coefficient of reactivity of -1.5×10^{-4} $\Delta K/K/^{\circ}F$, which one of the following is the INITIAL reactor period which would result from a 10°F decrease in moderator temperature?

a. 25 seconds

b. 30 seconds

c. 35 seconds

d. 40 seconds

*QUESTION (A.8) [1.0]
The reactor is subcritical with a reactor startup in progress. The reactor operator notices a significant change in neutron count rate while withdrawing a peripheral control rod. The operator next withdraws a center control rod and observes a very small increase in neutron count rate. Which one of the following would explain these observations?

a. The rod at the center of the core is in an area of higher neutron flux as compared with the periphery of the core, resulting in greater rod worth for the center control rod.

b. The rod at the periphery of the core is in an area of higher neutron flux as compared with the center of the core, resulting in greater rod worth for the peripheral control rod.

c. The rod at the center of the core is in an area of higher neutron flux as compared with the periphery of the core, resulting in greater rod worth for the peripheral control rod.

d. The rod at the periphery of the core is in an area of higher neutron flux as compared with the center of the core, resulting in greater rod worth for the center control rod.

*QUESTION (A.9) [1.0]
The reactor is shutdown by 5%Δk/k with a count rate of 100 cps on the startup channel. Rods are withdrawn until the count rate is 2000 cps. After the rods are withdrawn, the reactor is ________.

a. supercritical with K_{eff} = 1.05

b. supercritical with K_{eff} = 1.002

c. subcritical with K_{eff} equal to 0.998

d. subcritical with K_{eff} equal to 0.952

*QUESTION (A.10) [1.0]
Which one of the following is a correct statement concerning the factors affecting control rod worth? Assume constant reactor power.

a. Moderator temperature increase causes rod worth to decrease.

b. Fuel burnup causes the rod worth to decrease in the center of the core.

c. Samarium concentration increases over core life causing the rod worth to decrease in the periphery rods.

d. The withdrawal of an adjacent rod causes the rod worth of the stationary control rod to decrease.

*QUESTION (A.11) [1.0]
An experiment is loaded into the core while the reactor is operating at 2 Mw. After loading the experiment, the reactor power decreased to 500 Kw. Which one of the following is the magnitude of the reactivity added by the experiment? (Neglect any change due to heat gain or loss)

a. 1.23×10^{-4} ΔK/K

b. 6.25×10^{-4} ΔK/K

c. 12.50×10^{-4} ΔK/K

d. 18.75×10^{-4} ΔK/K

*QUESTION (A.12) [1.0]
Reactor power decreases on a stable negative period after a reactor scram, following an initial prompt drop. Which ONE (1) of the following is the reason for this?

a. All prompt neutrons decay during the prompt drop, and the subsequent rate of power change is dependent **ONLY** on the half-life of the longest lived prompt gamma emitter.

b. This rate of power change is dependent on the **MEAN** lifetime of the shortest lived delayed neutron precursor.

c. This rate of power change is dependent on the **MEAN** lifetime of the longest lived delayed neutron precursor.

d. This rate of power change is dependent on the **CONSTANT** decay rate of prompt neutrons following a scram.

*QUESTION (A.13) [1.0]
Which ONE of the following describes "CORE EXCESS"?

a. Extra reactivity into the core due to the presence of the source neutrons.

b. A measure of the resultant reactivity if all of the control rods and other poisons were removed.

c. The combined reactivity worth of control rods and chemical poison needed to keep the reactor shutdown.

d. The maximum reactivity insertion with the reactor shutdown with control rods fully inserted under peak Xenon conditions.

*QUESTION (A.14) [1.0]
The following data was obtained during a reactor fuel load.

No. of Elements	Detector A (cps)
0	20
8	30
16	40
22	60
24	90
26	155

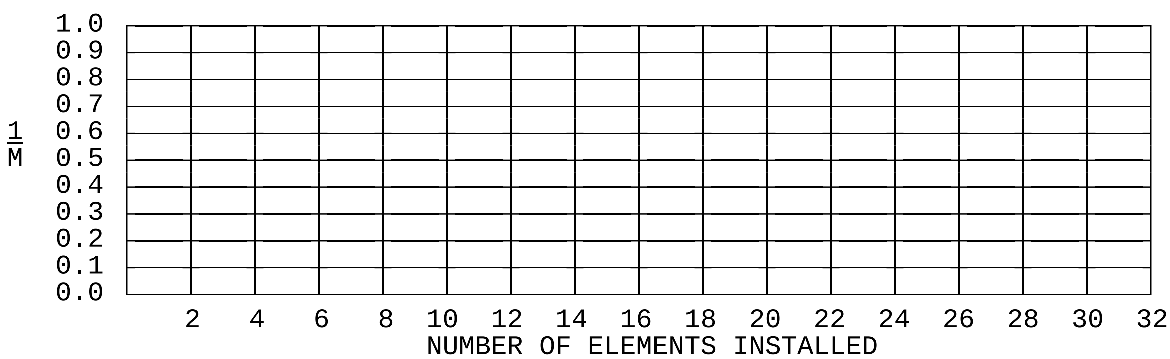
Which one of the following is the number of fuel elements required to make the reactor critical? (The attached figure may be used to determine the correct response.)

a. 16

b. 24

c. 28

d. 32



*QUESTION (A.15) [1.0]
Which one of the following could result from an attempt to start up the reactor with NO installed neutron source?

a. The reactor could not be started up because there would be no source of neutrons to start the chain reaction.

b. It is possible that reactor power would not be indicated on the nuclear instrumentation until after the reactor has reached a very high power level.

c. Subcritical multiplication would result in a stable count rate on the nuclear instrumentation even though power was increasing.

d. Startup of the reactor would require increasing the voltage on the source range detectors to establish a count rate from photo-neutrons.

*QUESTION (A.16) [1.0]
In accordance with Technical Specifications, the basis for the regulating rod reactivity is:

a. Reactor will remain subcritical after cool down and xenon decay even if the regulating rod should be in the fully withdrawn position.

b. Regulating rod reactivity adequate to overcome the negative reactivity effect of moveable experiments

c. Regulating rod will not introduce enough reactivity to produce a prompt critical condition.

d. Regulating rod reactivity sufficient to overcome the negative reactivity effect of fission product xenon and samarium buildup in a clean core.

*QUESTION (A.17) [1.0]
Which one of the following describes the location in the core where the peak fuel temperature is observed?

a. At the core mid-plane because this is where the maximum peak heat generation is found.

b. At the top of the core because this is where the worst combination of heat generation and coolant temperature occurs.

c. Between the core mid-plane and the bottom of the core because this is where the worst combination of heat generation and coolant temperature occurs.

d. At the bottom of the core because this is the area where coolant temperature is the greatest.

*QUESTION (A.18) [1.0]
Assume reactor power is held steady at 2 MW. Which one of the following describes the change in radial flux pattern over core life?

a. The flux pattern becomes more peaked in the center due to the withdrawal of control rods from the core.

b. The flux pattern becomes more peaked in the center due to fuel depletion near the periphery of the core.

c. The flux pattern becomes flatter due to the withdrawal of control rods from the core.

d. The flux pattern becomes flatter due to fuel burn-up near the center of the core.

*QUESTION (A.19) [1.0]
The shutdown margin (SDM), upon full insertion of all control rods following a reactor scram from full power, is _________________ the SDM immediately prior to the scram.

a. Equal to

b. Less than

c. Greater than

d. Independent of

*QUESTION (A.20) [1.0]
The reactor has been operating at 100% power for the past 20 days. Which one of the following is the primary source of heat generation in the core 30 seconds following a reactor scram from 100% power?

a. Fission from the longest lived delayed neutron precursors.

b. Fission resulting from installed source neutrons.

c. Beta and gamma heating from fission decay products.

d. Beta and gamma heating from fission generated by installed neutron sources.

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

QUESTION (B.1) [1.0]
A radioactive sample was removed from the reactor core, reading 40 Rem/hour. Four (4) hours later, the sample reads 4 Rem/hour. Which one of the following is the time required for the sample to decay from 4 Rem/hr to 100 mrem/hour?

a. 1.9 hours

b. 5.6 hours

c. 6.4 hours

d. 10.4 hours

*QUESTION (B.2) [1.0]
Which one of the following would be posted on an entry to an area with a dose rate of 17 mrem/hr.

a. CAUTION - RADIATION AREA

b. CAUTION - HIGH RADIATION AREA

c. CAUTION - AIRBORNE RADIATION AREA

d. CAUTION - RADIOACTIVE MATERIALS

*QUESTION (B.3) [1.0]
You have been assigned to decrease the dose rate being emitted by a point source. The dose rate is due to 1.5 Mev gamma. What thickness of lead will be required to decrease the dose rate by a factor of 10?

Given: Mass attenuation coefficient for lead @ 1.5 Mev = 0.5814 cm^{-1}

a. 0.2 cm

b. 2 cm

c. 4 cm

d. 8 cm

*QUESTION (B.4) [1.0]

Reactor conditions are as follows:

Natural convection mode	
Reactor power	400 KW
Reactor coolant inlet temperature	138°F
Pool water height (above core)	18.5 feet

Which one of the following lists the fuel cladding integrity safety limits that have been exceeded?

a. Reactor power and reactor coolant inlet temperature

b. Reactor power and water height

c. Water height ONLY

d. Reactor coolant inlet temperature ONLY

*QUESTION (B.5) [1.0]

Which one of the following describes the reason why shutdown margin is measured with the reactor critical at low power?

a. To minimize the negative reactivity contribution from temperature coefficient effects.

b. To minimize xenon burnout at higher neutron fluxes.

c. To ensure that the entire shutdown margin is due to the shim-safety rods alone.

d. To minimize the effects of the installed neutron source.

*QUESTION (B.6) [1.0]

An area radiation monitor and a MAP monitor are both alarming. Which one of the following describes the reactor operator's first required action?

a. Shut the reactor down by running in all control rods.

b. Notify the Nuclear Reactor Laboratory Manager.

c. Scram the reactor when either a second area radiation monitor or MAP alarm is received.

d. Notify the On-call Supervisor.

*QUESTION (B.7) [1.0]
A fire has occurred at the FNR and a building evacuation is in progress in accordance with EP-101, Reactor Building Emergency. The control room operator has arrived in the lobby and notes that the plant operator has not arrived in the lobby within a reasonable amount of time. Which one of the following actions should the control room operator take?

a. Proceed to the south side entrance door and await the fire department.

b. Attempt to locate the plant operator by retracing the plant operator's prescribed route.

c. Dial 911 and report to Public Safety and Security that the plant operator has not yet reported to the lobby.

d. Await the fire department in the lobby and inform them that the plant operator has not yet reported.

*QUESTION (B.8) [1.0]
It has just been brought to your attention that a release of I-131 at the reactor stack discharge of $2x10^{-8}$ uCi/ml has been detected. 10CFR20 lists 10^{-10} uCi/ml as permissible. What do you do?

a. Scram the reactor. A T.S. limit has been exceeded. This constitutes a Reportable Occurrence.

b. Shutdown the reactor. The Nuclear Reactor Laboratory Manager shall be notified of the occurrence.

c. Notify the on-call supervisor. The discharge is below 10CFR20 limits.

d. Secure the reactor. Initiate evacuation. Close the stack 2 exhaust damper.

*QUESTION (B.9) [1.0]
The reactor is in steady-state power at 90% when you, the operator, notice that the Reactor Bridge area radiation monitor is inoperable. Which one of the following describes the correct action you should take?

a. Shutdown the reactor. Technical Specifications (T.S.) do not allow operations of the reactor without a fully operating Reactor Bridge radiation monitor.

b. Continue operation. T.S. allow the unit to be out of service for up to 7 days.

c. Continue operation. Within 24 hours of recognition of failure, replace the unit with a portable gamma-sensitive instrument with alarm.

d. Continue operation as long as a minimum of three other area radiation monitors are operating.

*QUESTION (B.10) [2.0]
Which one of the following statements is TRUE concerning experiments?

a. An experiment approved for control fuel element irradiation may be irradiated in a polyethylene container if the irradiation is for six hours or less.

b. The reactivity worth of any moveable experiment shall not exceed 0.01 ΔK/K.

c. Experiments approved for the sample stringer can be loaded or unloaded from the reactor only during reactor shutdown periods.

d. The total reactivity worth of moveable and secured experiments shall not exceed 0.0436 ΔK/K.

*QUESTION (B.11) [1.0]
Limiting Safety System Settings (LSSS) are …

a. limits on very important process variables which are found to be necessary to reasonably protect the integrity of certain physical barriers which guard against the uncontrolled release of radioactivity.

b. settings for automatic protective devices related to those variable having significant safety functions.

c. settings for ANSI 15.8 suggested reactor scrams and/or alarms which form the protective system for the reactor or provide information which requires manual protective action to be initiated.

d. the lowest functional capability or performance levels of equipment required for safe operation of the reactor.

*QUESTION (B.12) [1.0]
During reactor operation, which one of the following conditions violates confinement integrity?

a. The reactor building ventilation supply fan is off.

b. The access hatch from grade level to the beamport floor is temporarily opened for the passage of personnel.

c. The beamport exhaust damper to Stack 2 is tagged shut.

d. The beamport floor door to the Phoenix Memorial Laboratory is clamped closed.

*QUESTION (B.13) [1.0]
Which one of the following is the basis for maintaining the pool level within Technical Specification Safety Limits?

a. To maintain the maximum cladding temperature in the hot channel in the core below the boiling point of the coolant.

b. To maintain the dose rate in the pool area as low as reasonably achievable.

c. To “Scrub out” radionuclides that are released from the reactor core.

d. To provide adequate reactor core moderation.

*QUESTION (B.14) [1.0]
Which one of the following is NOT a prerequisite for fuel movement?

a. Establish communications between the control room and the bridge.

b. Verify that the Linear Level system is operating.

c. Establish a count rate of 100 cps on an operating Log Count Rate channel.

d. Tag out the operating Log Count Rate channel fission chamber positioning switch

*QUESTION (B.15) [1.0]
Which one of the following does NOT require specific permission from the console operator during fuel movements?

a. Unlock the fuel tool.

b. Remove fuel elements from the core.

c. Insert fuel elements into the core,

d. Unlatch the fuel tool from elements inserted into the core,

*QUESTION (B.16) [1.0]
Which one of the following is an unauthorized Secondary System condition?

a. Operating the cooling tower fans in reverse to de-ice the cooling tower.

b. Operating the Secondary System with a pH of 9.2.

c. Adding Sodium hypochlorite to the Secondary System to control microbiological material.

d. Adding Sulfuric acid to the Secondary System to control pH.

*QUESTION (B.17) [1.0]
For which one of the following operating conditions is the recommended action NOT to insert all rods?

a. Inability to exercise control over primary water system components.

b. Loss of FNR exhaust radiation monitor.

c. Malfunction of auto-rundown circuit.

d. Loss of shim safety rod magnet contact light.

*QUESTION (B.18) [1.0]
Which one of the following is TRUE?

a. If a “duress” alarm is received at the control room , the operator on duty should initiate the building alarm.

b. Work scheduled on the Shutdown Maintenance Schedule is considered approved.

c. The magnet power keys are normally in the custody of the SRO on duty.

d. If the reactor is shutdown, the minimum control room staffing is a licensed reactor operator.

*QUESTION (B.19) [1.0]
The T.S. require a minimum Shutdown Margin (SDM) of 0.0045 ΔK/K for a specific core and control rods configuration. Assuming Xenon free conditions and the following worths, which one of the following is the calculated SDM?

	worth %ΔK/K
Shim-Safety rod #1:	2.41
Shim-Safety rod #2:	2.32
Shim-Safety rod #3:	2.49
Control rod (Reg.)	0.084
Excess Reactivity:	1.42
Experiments (Max Worth)	0.60

a. 7.96%

b. 5.28%

c 5.20%

d. 2.71%

*QUESTION (B.20) [1.0]
When performing OP-201 “Building Checklist” for reactor operation, which one of the following would be an ABNORMAL line up for the emergency generator?

a. Voltage regulator is in automatic with the field switch on.

b. Generator output breaker is shut.

c. Battery electrolyte level is at the base of the split rings in each cell.

d. Control power is on and run switch is off.

(*** End of Section B ***)

QUESTION (C.1) [1.0]
Which one of the following systems is NOT classified as Class I system?

a. Primary Coolant

b. 5 area radiation monitors

c. Pool level rundown

d. Shim safety rods

QUESTION (C.2) [1.0]
What does a green beamport door status light signify when is illuminated?

a. The door is closed.

b. The door is open.

c. The door is interlocked to the scram system.

d. The door is interlocked to the auto run down system.

QUESTION (C.3) [2.0]
What approximate reactivity change (magnitude and direction) is introduced by or associated with:

a. Removing a standard fuel element from the edge of the core.

b. Raising the reactor power from 1 Kw to 1 Mw.

c. Inserting a standard fuel element into an empty position at the center of the core.

d. Draining the heavy water tank and replacing with H_2O

1. +3% ΔK/K

2. -3% ΔK/K

3. +2% ΔK/K

4. -2% ΔK/K

5. +1% ΔK/K

6. -1% ΔK/K

7. +0.25% ΔK/K

8. -0.25% ΔK/K

QUESTION (C.4) [1.0]
Which of the following is not a control rod automatic permit requirement?

a. Linear level indication greater than setpoint minus 5%.

b. Control rod in upper limit.

c. Control rod drive switch in neutral.

d. Linear Level range selector switch unchanged.

QUESTION (C.5) [1.0]
Which of the following radiation monitors actuates the stack alarm?

a. Stack 2 MAPP

b. Pool Floor MAPP

c. Beamport Floor MAPP

d, FNR GAD

QUESTION (C.6) [1.0]
The servo deviation that will revert the reactor from auto to manual is:

a. 10% above setpoint.

b. 5% above setpoint.

c. 5% below the setpoint.

d. 10% below the setpoint.

QUESTION (C.7) [1.0]
Which one of the following sets of conditions would be most normal for 2 Mw operations?

	PRIMARY FLOW RATE	SECONDARY FLOW RATE
a.	1150 gpm	750 gpm
b.	1500 gpm	850 gpm
c.	1000 gpm	1000 gpm
d.	850 gpm	1050 gpm

QUESTION (C.8) [1.0]
Which one of the following radiation monitoring detectors is NOT required safety related instrumentation per Technical Specifications?

a. Reactor bridge monitor.

b. Fuel vault monitor.

c. Northeast column (beamport floor) monitor.

d. Northwest column (beamport floor) monitor.

QUESTION (C.9) [1.0]

Which one of the following loads would NOT have emergency power on a loss of normal power?

a. Radiation monitoring equipment.

b. Reactor air compressor.

c. Standby air compressor.

d. Emergency generator vent fan.

QUESTION (C.10) [1.0]
Which one of the following is correct about the log count rate (LCR) system?

a. LCR will cause an inhibit interlock to prevent shim-safety rod motion if the LCR recorder is greater than 2 cps.

b. To overcome the shim-safety rod inhibit interlock, the LCR fission chamber must be raised to the upper limit.

c. If compensating voltage applied to the LCR fission chamber is lost, the indicated power level will increase.

d. At the bottom limit of travel, the LCR fission chamber is approximately level with the top of the reactor core,

QUESTION (C.11) [1.0]
Which one of the following describes the N-16 Power Level Monitor detector?

a. Geiger-Mueller

b. Fission chamber

c. Gamma ion chamber

d. Compensated ion chamber

QUESTION (C.12) [1.0]
Which one of the following is generated by the Log N Recorder?

a. Reactor scram on Hdr Up/No Flow.

b. Control rod inhibit.

c. Reactor On clock.

d. Reactor at full power light.

QUESTION (C.13 [1.0]
Waste water is being transferred from RT2 to RT1 using the centrifugal pump. Which one of the following is the reason the breaker for the positive displacement pump must be verified OPEN?

a. The positive displacement pump may over pressurize RT1.

b. The positive displacement pump has no suction from RT2.

c. One START pushbutton controls the start of both the centrifugal pump and the positive displacement pump.

d. The positive displacement pump will automatically start if tank level decreases to 200 gallons.

QUESTION (C.14) [1.0]
Which one of the following would indicate that a leak had developed between the heavy water tank and the reactor pool?

a. Positive reactivity addition as light water dilutes the heavy water in the heavy water tank.

b. Increase in beamport thermal flux due to greater moderation of fast neutrons.

c. Increase in the gross beta analysis due to tritium in the pool water.

d. Abnormal rod insertions due to greater reflection of neutrons from the heavy water tank into the core.

QUESTION (C.15) [1.0]
Which one of the following will result in a reactor scram and a ventilation system isolation?

a. 5.2 mrem/hr in the fuel vault

b. 1.6 mrem/hr in PML exhaust stack 2

c. 0.5 mrem/hr in the building supply header

d. Deenergizing the FNR main exhaust fan

QUESTION (C.16) [1.0]
Select the choice that completes the following statement.

In the event of a rupture in the Hot Demineralizer system, system isolation is accomplished by a flow switch that:

a. signals the inlet and outlet pump motor controllers to stop both pumps. The flow signal also deenergizes the auto-shut off valve.

b. deenergizes the auto-shut off valve. The closure of the auto-shut off valve causes the inlet and outlet pump motor controllers to stop both pumps.

c. signals the inlet and outlet pump motor controllers to stop both pumps. The inlet pump motor controller also deenergizes the auto-shut off valve.

d. signals the inlet and outlet pump motor controllers to stop both pumps. The auto-shut off valve closes upon sensing a low water pressure.

QUESTION (C.17) [1.0]
Which one of the following will cause an auto rundown?

a. Control rod full in (in auto).

b. Period is 20 seconds.

c. Temperature is 125°F.

d. Pool level is 10 inches low.

QUESTION (C.18) [1.0]
Which one of the following beamports cannot be drained?

a. J port

b. E port

c. H port

d. C port

QUESTION (C.19) [1.0]
Which one of the following will limit the loss of coolant in the event of a coolant leak due to rupture of a beamtube while the beamport is being used for an experiment?

a. Beamport shield door.

b. Flanges at each end of beamport.

c. Damage control plugs.

d. Collimator.

(*** End of Examination ***)

*ANSWER (A.1)
d
*REFERENCE (A.1)
Introduction to Nuclear Reactor Operations, p. 4-4

*ANSWER (A.2)
a
*REFERENCE (A.2)
Introduction to Nuclear Reactor Operations, Chapter 8.

*ANSWER (A.3)
c
*REFERENCE (A.3)
UM: Introduction to Nuclear Reactor Operations, p. 6-5, LO 2. (Moderator Temperature Coefficient)*(Change in Temperature)/(Control Rod Worth per Inch) = (Control Rod Movement) a positive sign would be rod insertion and negative sign would be rod withdrawal. $(-1.0 \times 10^{-4})*(-18)/(.003)= +0.6$ inches

*ANSWER (A.4)
b
*REFERENCE (A.4)
1. UM: Introduction to Nuclear Reactor Operation, p 4-21, LO 2.
   $P_1 = [ß*(1 - χ)/(ß - χ)]*P_0$
   $P_1 = [(0.0075*1.03)/(0.0075+0.03)] \times 2000$ KW = 412 KW

*ANSWER (A.5)
a
*REFERENCE (A.5)
Introduction to Nuclear Reactor Theory, pg. 4-35
$P_f=P_0\, e^{(t/χ)} \Rightarrow t = [\ln (P_f/P_0)]\cdot χ$
$\ln(6/1) > \ln(20/10) > \ln(35/20) > \ln(60/40)$

*ANSWER (A.6)
a
*REFERENCE (A.6)
Introduction Nuclear Reactor Operations, p. 5-7.

*ANSWER (A.7)
d
*REFERENCE (A.7)
Introduction to Nuclear Reactor Operations, Chapter 6, p. 6-15
Period (T) = (ß - χ)/(decay constant (χ) • χ)
T = (0.0075 - 0.0015) / (0.1 ● 0.0015) ==> 0.006/0.00015 = 40 seconds

*ANSWER (A.8)
b
*REFERENCE (A.8)
Introduction to Nuclear Reactor Operations, Chapter 7, p. 7-15.

*ANSWER (A.9)
c
*REFERENCE (A.9)
Introduction to Nuclear Reactor Operations, p. 5-5
$χ = -0.05\ Δk/k$

$K_{eff} = 1/(1-\chi) = 0.952$

$CR_1(1-K_1) = CR_2(1-K_2)$ with $CR_1 = 100$ and $CR_2 = 2000$
$(1-K_2) = CR_1/CR_2 \bullet (1-K_1) = (100/2000) \bullet (1 - 0.9524)$
$1 - K_2 = 1/20\ (0.0476) = 0.00238$
$K_2 = 0.998$

*ANSWER (A.10)
b
*REFERENCE (A.10)
Introduction to Nuclear Reactor Operations, p. 7-15 to 7-18.

*ANSWER (A.11)
d
*REFERENCE (A.11)
FNR Examination Question Bank pg. A-405

*ANSWER (A.12)
c
*REFERENCE (A.12)
Introduction to Nuclear Reactor Operations, p. 4-33

*ANSWER (A.13)
b
*REFERENCE (A.13)
Introduction to Nuclear Reactor Operations, © 1982, § 6.2, pp. 6-1 — 6-4.

*ANSWER (A.14)
c
*REFERENCE (A.14)
Introduction to Nuclear Reactor Operations, p. 5-33.

*ANSWER (A.15)
b
*REFERENCE (A.15)
Introduction to Nuclear Reactor Operations, p. 5-5.

*ANSWER (A.16)
c
*REFERENCE (A.16)
FNR Technical Specifications 3.1.7 Basis.

*ANSWER (A.17)
c
*REFERENCE (A.17)
Introduction to Nuclear Reactor Operations, p. 9-14.

*ANSWER (A.18)
d
*REFERENCE (A.18)
Introduction to Nuclear Reactor Operations, p. 9-12

*ANSWER (A.19)

a
*REFERENCE (A.19)
Introduction to Nuclear Reactor Operations, p. 6-4
Definition of SDM and Shutdown Reactivity

*ANSWER (A.20)
c
*REFERENCE (A.20)
Introduction to Nuclear Reactor Operations, p. 4-23

(*** End of Section A ***)

*ANSWER (B.1)
c
*REFERENCE (B.1)
Nuclear Power Plant Health Physics and Radiation Protection, p. 4-10

decay const.= ln(4 Rem per hour / 40 Rem per hour)/ 4 hours =- 0.58 hr-1
t=ln(100 mrem per hour / 4000 mrem per hour) /(- 0.58 hr(-1)) = 6.36 hr.

*ANSWER (B.2)
a
*REFERENCE (B.2)
Nuclear Power Plant Health Physics and Radiation Protection, 8-7 to 8-14

*ANSWER (B.3)
c
*REFERENCE (B.3)
$I = I_o e^{-ux}$ ==> ln (0.1) = -(0.5814)χ

χ= 2.3026/0.5814 = 3.9672 ≈ 4

*ANSWER (B.4)
a
*REFERENCE (B.4)
FNR Technical Specifications, p. 7

*ANSWER (B.5)
a
*REFERENCE (B.5)
OP-105 Core Excess Reactivity and Shutdown Margin § 4.3.3.2

*ANSWER (B.6)
a
*REFERENCE (B.6)
EP-101, Reactor Building Emergency, § 3.2.2

*ANSWER (B.7)
b
*REFERENCE (B.7)
EP-101, Reactor Building Emergency, Sect. 5.1

*ANSWER (B.8)
c
*REFERENCE (B.8)
10CFR20
FNR T.S. section 3.6
Exam. Question section B pg. B-592

*ANSWER (B.9)
a
*REFERENCE (B.9)
T.S. Table 3.2, pg. 13

*ANSWER (B.10)
c
*REFERENCE (B.10)
OP-104 Reactor Experiments and Cobalt-60 Irradiations. § 4.7.1
T.S. 3.1

*ANSWER (B.11)
b
*REFERENCE (B.11)
FNR T.S. Definition Pg. 1

*ANSWER (B.12)
b
*REFERENCE (B.12)
T.S. 3.3 2.d

*ANSWER (B.13)
a
*REFERENCE (B.13)
T.S. 2.1.1 and 2.1.2

*ANSWER (B.14)
b
*REFERENCE (B.14)
AP-301, Section 6

*ANSWER (B.15)
a
*REFERENCE (B.15)
AP-301 Section 6.15

*ANSWER (B.16)
b
*REFERENCE (B.16)
OP-103, Reactor Operation, Maintenance, Systems and Components; Section 10.11
FNR Supplied Question Bank Section B

*ANSWER (B.17)
d
*REFERENCE (B.17)
Exam Question Bank Section B, pg. B-138
OP-109, Response to Scrams, Alarms, and Abnormal Conditions

*ANSWER (B.18)
b
*REFERENCE (B.18)
EP-101, OP-101, OP-103

*ANSWER (B.19)
d
*REFERENCE (B.19)
OP-105 Core Excess, SDM and Control Rod Reactivity
Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 6.2.3 p. 6-4.

SDM (cold/clean) = Total Rod worth - K_{excess} - Most reactive rod - Reg Rod - Experiments worth
SDM = (2.41 + 2.32 + 2.49 + 0.084) - 1.42 - 2.49 - 0.084 - 0.60 = 2.71%

*ANSWER (B.20)
d
*REFERENCE (B.20)
OP-201 “Building Checklist” Sect. 4.15

(*** End of Section B ***)

*ANSWER (C.1)
b
*REFERENCE (C.1)
FNR System Descriptions, Ch. 1
Question Bank C-258

*ANSWER (C.2)
c
*REFERENCE (C.2)
FNR System Description Ch. 13
Question Bank C-204

*ANSWER (C.3)
a 6 - b 8 - c 1 - d 4
*REFERENCE (C.3)
FNR System Descriptions. Ch. 2
Question Bank C-153

*ANSWER (C.4)
b
*REFERENCE (C.4)
FNR System Descriptions. Ch. 13.11
Question Bank C-88

*ANSWER (C.5)
a
*REFERENCE (C.5)
FNR System Descriptions. Ch. 13.9
Question Bank C-85

*ANSWER (C.6)
c
*REFERENCE (C.6)
FNR System Descriptions. Ch. 13
Question Bank C-22

*ANSWER (C.7)
c
*REFERENCE (C.7)
FNR System Descriptions. Ch. 4 and 5
Question Bank C-17

*ANSWER (C.8)
b
*REFERENCE (C.8)
FNR T.S. Table 3.2
Question Bank C-12

*ANSWER (C.9)
b
*REFERENCE (C.9)
FNR System Descriptions. Ch. 13
Question Bank C-9

*ANSWER (C.10)
d
*REFERENCE (C.10)
FNR System Descriptions. Ch. 13
Question Bank C-3

*ANSWER (C.11)
c
*REFERENCE (C.11)
System Descriptions Ch. 13 Sect. 13.12.1

*ANSWER (C.12)
d
*REFERENCE (C.12)
System Descriptions Ch. 13 Sect. 13.2.3.7

*ANSWER (C.13)
c
*REFERENCE (C.13)
Question Bank B-717
Op-208, pg. 2

*ANSWER (C.14)
c
*REFERENCE (C.14)
FNR System Descriptions Ch. 3
Question Bank C-248

*ANSWER (C.15)
a
*REFERENCE (C.15)
System descriptions p. 12-1

*ANSWER (C.16)
c
*REFERENCE (C.16)
FNR System Descriptions Ch. 7 pg. 7-1 and 7-2

*ANSWER (C.17)
a
*REFERENCE (C.17)
FNR System Descriptions, Ch. 13

*ANSWER (C.18)
d
*REFERENCE (C.18)
OP-108

*ANSWER (C.19)
d
*REFERENCE (C.19)
SAR; 14.2.4 Beamports

(*** End of Section C ***)
(***** End of Examination *****)