March 22, 2004

Dr. John Bernard, Director
of Reactor Operations
Nuclear Reactor Laboratory
Massachusetts Institute of Technology
138 Albany Street
Cambridge, MA 02139

SUBJECT: INITIAL EXAMINATION REPORT NO. 50-20/OL-04-01, MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Dear Dr. Bernard:

During the week of February 2, 2004, the NRC administered an operator licensing examination at your Massachusetts Institute of Technology Reactor. The examination was 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 V. 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
New, Research and Test Reactors Program
Division of Regulatory Improvement Programs
Office of Nuclear Reactor Regulation

Docket No. 50-20

Enclosures:
1. Initial Examination Report No. 50-20/OL-04-01
2. Facility comments with NRC resolution
3. Examination and answer key (RO/SRO)

cc w/encls: Please see next page

Massachusetts Institute of
Technology

Docket No. 50-20

cc:

City Manager
City Hall
Cambridge, MA 02139

Department of Environmental
Quality Engineering
100 Cambridge Street
Boston, MA 02202

Test, Research, and Training
Reactor Newsletter
University of Florida
202 Nuclear Sciences Center
Gainesville, FL 32611

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AAdams	Facility File (EBarnhill) O6-F-2	

ADAMS EXAMINATION PACKAGE ACCESSION NO.: ML033230239
ADAMS REPORT LETTER ACCESSION NO.: ML040690691 **TEMPLATE #:NRR-074**

OFFICE	RNRP:CE		RNRP:E(U/I)		IROB:LA	E	RNRP:SC	
NAME	PDoyle:rdr		KWitt		EBarnhill		PMadden	
DATE	02/ 20 /2004		03/ 10 /2004		03/ 10 /2004		03/ 11 /2004	

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

REPORT NO.: 50-20/OL-04-01

FACILITY DOCKET NO.: 50-20

FACILITY LICENSE NO.: R-37

FACILITY: Massachusetts Institute of Technology

EXAMINATION DATES: February 2 – 4, 2004

SUBMITTED BY: ________*/RA/*___________________ 2/20/2004
Paul Doyle, Chief Examiner Date

SUMMARY:

During the week of February 2, 2004, the NRC administered operator licensing examinations to one Senior Reactor Operator (Upgrade) candidate and four Reactor Operator candidates. The Senior Operator Upgrade and two Reactor Operator candidates passed the examinations. Two Reactor Operator candidates failed section B of the written examination only.

REPORT DETAILS

1. Examiners:
Paul Doyle, Chief Examiner
Kevin Witt, Examiner (Under Instruction)

2. Results:

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

3. Exit Meeting:
Paul Doyle, NRC, Chief Examiner
Kevin Witt, NRC, Examiner (Under Instruction)
Frank Warmsley, NRL, Training Supervisor
Edward Lau, NRL, Superintendent

The NRC thanked the facility staff for their cooperation during the examination. The examiners noted that the candidates demonstrated a generic weakness in the areas of radiation hazards and detection. The facility staff presented the Chief Examiner with comments on the written examination.

ENCLOSURE 1

Facility Comments with NRC Resolution

Question B.03
With regard to the system lock out procedure, which ONE of the following situations would be unacceptable?

A. Installation of a primary coolant pump; not locking out the primary coolant inlet valve.

B. Moving fuel within the core; not locking out the motors to the control rod control system.

C. Changing the CO_2 bottles in the utility room; not locking out the isolation solenoid valve.

D. Replacing exhaust air fan blades; not locking out the power supply to the exhaust fan.

Facility Comment:

We suggest answers (a) and (d) both be acceptable because both conditions represent personnel safety hazards. In answer (a), loss of primary coolant through the valve could lower the core tank level, producing high radiation levels in the containment building.

NRC Resolution:
Agree with comment. Implementation of this comment has no impact on the grading of the examination, and the answer key will not be modified. However, the NRC will carefully review this question to ensure that in the future it contains only one correct answer.

Question B.14(c)
Identify the ***Quality Factor*** (1, 5, 10, 15, 20) for each of the types of radiation listed below.
NOTE: The quality factor is the constant specified in 10 CFR 20 that is used to derive dose equivalent from absorbed dose.

A. X-, gamma, or beta radiation

B. Alpha particles or fission fragments

C. Thermal neutrons ($2.5\text{x}10^{-8}$ MeV)

D. Fast neutrons (1 MeV)

Facility Comment:

We suggest this [part of the] question [c] be removed because there is no correct answer selection. The 10CFR20 Quality Factor for 2.5×10^{-8} MeV thermal neutron is 2.

NRC Resolution:
Agree with comment. This part of the question will be deleted and parts a, b and d will be modified to be worth ⅔ point each.

ENCLOSURE 2

Question B.15

Which ONE of the following situations would illustrate a time when the reactor is shutdown but not secured?

A. One of the control rods is removed for inspection while the other control rods are fully inserted and all fuel remains in the same configuration.

B. All control rods are fully inserted and fuel is being rearranged in the fuel storage pool.

C. The control rods are withdrawn to the subcritical position and the core is subcritical by 1% $\Delta K/K$.

D. All control rods are fully inserted and an experiment having a negative reactivity effect is installed in the reactor.

Facility Comment:

We suggest this question be removed because there is no correct answer selection. Answer (d) would have been correct if written as, … experiment having a negative reactivity effect is being installed in the reactor core."

NRC Resolution:

Agree with comment in part. A and C are obviously conditions where the reactor is not shutdown. However, either B or D could under certain conditions meet the criteria for reactor being shutdown but not secured. Therefore for the purposes of this examination either B or D will be considered correct answers for this question. In addition, this question will be modified to incorporate the facility staff's recommendation for rewording choice (d), and the NRC staff will rewrite choice (b) to better clarify the condition of the reactor.

Question B.16

How are the stack accumulators verified to be operable?

A. A signal is introduced into the detector and if the detector records readings, then it is operable.

B. The background signal is observed and compared to previously know background levels.

C. A check source is placed next to the detector and the value is compare to previous values.

D. The system is checked for the illumination of an error light.

Facility Comment:

We suggest answers (a) and (c) both be acceptable because either action can verify the operability of the stack accumulators.

NRC Resolution:

Agree with facility comment. The answer key has been modified to accept both "A" and "C" as correct.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

With Answer Key

UNITED STATES NUCLEAR REGULATORY COMMISSION

OPERATOR LICENSING EXAMINATION

February 2, 2004

Enclosure 3

QUESTION A.1 [1.0 point]
How does shim bank position relate to the reactivity worth of dumping the D_2O reflector?

A. For the highest shim bank position, the reactivity worth of a D_2O dump is at it's greatest.

B. For the lowest shim bank position, the reactivity worth of a D_2O dump is at it's greatest.

C. For the intermediate shim bank position, the reactivity worth of a D_2O dump is at it's minimum.

D. For the intermediate shim bank position, the reactivity worth of a D_2O dump is at it's greatest.

QUESTION A.2 [1.0 point]
Xenon and Samarium, have a marked effect on K_{eff} by decreasing which factor of the six factor formula?

A. L_T, the thermal non-leakage factor

B. h, the thermal reproductive factor

C. p, the resonance escape probability

D. f, the thermal utilization factor

QUESTION A.3 [1.0 point]
How will raising the temperature of the water in the core and the heavy water in the shield affect reactivity?

	Light Water	Heavy Water
A.	Positive	Negative
B.	Positive	Positive
C.	Negative	Negative
D.	Negative	Positive

QUESTION A.4 [1.0 point]
What is the definition of reactivity?

A. A measure of the number of neutrons being produced in the core.

B. A measure of the number of neutrons being absorbed by the fuel.

C. A measure of the reactor's multiplication factor.

D. A measure of the reactor's departure from critical.

QUESTION A.5 [1.0 point]
Which of the following power manipulations would take the longest to complete assuming the same period is maintained?

A. 1 MW to 2 MW

B. 2 MW to 3.5 MW

C. 3.5 MW to 4.5 MW

D. 4.5 MW to 5 MW

QUESTION A.6 [1.0 point]
When the reactor is shut down from full power, what is the main contributor to the steady -80 second period that is achieved?

A. The amount of negative reactivity introduced to the core.

B. The decay constant of the longest lived delayed neutron precursor.

C. The degree of neutron absorption by the fission products in the core.

D. The level of the prompt neutron population.

QUESTION A.7 [1.0 point]
If 100 millibeta of positive reactivity is suddenly introduced into a stable MITR-II core, what will be the steady period that is obtained? Assume the effective prompt neutron lifetime is 10^{-4} seconds and the effective delayed neutron decay constant is $0.08\ s^{-1}$.

A. 14.7 seconds

B. 53.5 seconds

C. 112.5 seconds

D. 147 seconds

QUESTION A.8 [1.0 point]
Suppose the source strength in the MITR-II core is 250 neutrons per second (N/sec) and the effective multiplication factor is 0.80. Select the closest stable neutron count rate from the list below:

A. 300 N/sec

B. 750 N/sec

C. 1250 N/sec

D. 1500 N/sec

QUESTION A.9 [1.0 point]
What will the regulating rod do in automatic control if a void is replaced with water in the core?

A. Drive out adding positive reactivity.

B. Drive in adding positive reactivity.

C. Drive out adding negative reactivity.

D. Drive in adding negative reactivity.

QUESTION A.10 [1.0 point]
The speed of the prompt drop occurring after a large amount of negative reactivity is suddenly inserted into the core is directly correlated to what factor?

A. Delayed neutron lifetime

B. Prompt neutron lifetime

C. Effective delayed neutron fraction

D. Effective prompt neutron fraction

QUESTION A.11 [1.0 point]
On average, how many neutrons will be emitted per fission from the MITR-II core?

A. 3

B. 2.5

C. 2

D. 1.5

QUESTION A.12 [1.0 point]
What is the kinetic energy range of a thermal neutron?

A. > 1 MeV

B. 100 KeV – 1 MeV

C. 1 eV – 100 KeV

D. < 1 eV

QUESTION A.13 [1.0 point]
What is the normal MITR-II neutron startup source for a startup when the reactor has only been shut down for a few hours?

A. Alpha produced from Po results in a neutron from Be^9

B. Spontaneous fission from Cf^{252}

C. Gamma produced from fuel results in a neutron from H^2

D. Beta produced from Ra results in a neutron from Li^8

QUESTION A.14 [1.0 point]
The term prompt critical refers to:

A. the instantaneous jump in power due to a rod withdrawal

B. a reactor which is supercritical using only prompt neutrons

C. a reactor which is critical using both prompt and delayed neutrons

D. a reactivity insertion which is less then b_{eff}

QUESTION A.15 [1.0 point]
What are the advantages/disadvantages of using light water as compared to heavy water as a moderator or reflector? Light water has a:

A. lower moderating power and a lower absorption cross-section

B. higher moderating power and a lower absorption cross-section

C. lower moderating power and a higher absorption cross-section

D. higher moderating power and a higher absorption cross-section

QUESTION A.16 [1.0 point]
Suppose the temperature coefficient of the MITR-II core is $-2.5\times10^{-4}\frac{\Delta K/K}{^oC}$ and the average control rod worth of the regulating control rod is $0.75\beta/_{inch}$. If the temperature increases by 50°C what will the automatic control command the regulating rod to do? ($\overline{\beta}_{eff} = 0.00786$) Select the answer that is closest to the calculated value.

A. 5.6 inches in

B. 2.1 inches out

C. 0.5 inches in

D. 4.3 inches out

QUESTION A.17 [1.0 point]
What is the approximate amount of time that it will take the MITR-II reactor operating at full power to reach a condition where the amount of Xenon being produced is equivalent to the amount of Xenon being destroyed? On the attached Xenon reactivity curve it is noted as the difference between time T_0 and T_{eq}.

A. 10 hours

B. 20 hours

C. 50 hours

D. 100 hours

QUESTION A.18 [1.0 point]
What is the approximate amount of time that it will take the amount of Xenon being produced to reach a peak after the reactor is shut down? On the attached Xenon reactivity curve it is noted as the difference between time T_{SD} and T_{Peak}.

A. 6 hours

B. 15 hours

C. 24 hours

D. 33 hours

QUESTION A.19 [1.0 point]
During a fuel loading of the MITR-II core, as the reactor approaches criticality, the value of 1/M:

A. Increases toward one

B. Decreases toward one

C. Increases toward infinity

D. Decreases toward zero

QUESTION A.20 [1.0 point]
Which ONE of the following is the major source of energy released during fission?

A. Prompt gamma rays

B. Fission fragments

C. Neutrinos

D. Fission neutrons

QUESTION B.1 [1.0 point]
What are the four (4) variables that constitute the safety limit?

A. Excess reactivity of the control system; height of water above the outlet end of the heated section; total reactor thermal power; reactor coolant outlet temperature.

B. Reactor coolant total flow rate; radiation level above the core tank; reactor coolant outlet temperature; height of water above the outlet end of the heated section.

C. Total reactor thermal power; reactor coolant total flow rate; reactor coolant outlet temperature; height of water above the outlet end of the heated section.

D. Height of water above the outlet end of the heated section; total reactor thermal power; reflector tank D_20 flow rate; reactor coolant total flow rate.

QUESTION B.2 [1.0 point]
Per Administrative Procedure 1.12, which ONE of the following is the lowest level of staff who may issue directives to an experimenter?

A. Any member of the operations staff.

B. Only designated management staff members.

C. All senior reactor operators on-site.

D. The experimenter's direct supervisor.

QUESTION B.3 [1.0 point]
With regard to the system lock out procedure, which ONE of the following situations would be unacceptable?

A. Installation of a primary coolant pump; not locking out the primary coolant inlet valve.

B. Moving fuel within the core; not locking out the motors to the control rod control system.

C. Changing the CO_2 bottles in the utility room; not locking out the isolation solenoid valve.

D. Replacing exhaust air fan blades; not locking out the power supply to the exhaust fan.

QUESTION B.4 [1.0 point]
What is the lowest level of supervision that can waive the daily surveillance check?

A. Operations coordinator.

B. Superintendent.

C. Shift supervisor.

D. Operator.

QUESTION B.5 [1.0 point]
All of the radiation monitor control units alarm at what radiation level? (Excluding the secondary hot cell monitor and medical room monitors)

A. 1 mR/hr

B. 5 mR/hr

C. 25 mR/hr

D. 100 mR/hr

QUESTION B.6 [1.0 point]
When starting the reactor using the One Loop Startup checklist, which of the following heat exchanger(s) must be placed on-line?

A. HE-1B

B. HE-1 & HE-1A

C. HE-1A

D. HE-1 & HE-1B

QUESTION B.7 [1.0 point]
What action should be taken if the shim bank exceeds the estimated critical position (ECP) by more than 0.5 inches and the reactor has not reached criticality?

A. Continue withdrawing rods until the reactor is critical and note new rod heights in log book.

B. Immediately scram the reactor and follow the appropriate emergency procedure.

C. Notify the SRO on duty and continue under careful scrutiny.

D. Lower rods by 1 inch or more and determine the cause of the discrepancy.

QUESTION B.8 [1.0 point]
The normal shutdown procedures instruct the operator to secure blowdown from the cooling towers. Why is this step included in the procedures?

A. There is no mechanism to detect a leak in the primary to secondary when the reactor is shutdown.

B. Conservation of energy that is used to operate the cooling tower fans.

C. Shutting down the secondary cooling system will reduce the run time on the secondary pumps.

D. It prevents damage to secondary coolant pumps since there will be no water makeup.

QUESTION B.9 [1.0 point]
What is the primary function of the "Weekend Open" selection on the intake damper control switch and when is it activated? When a high building vacuum alarm trips...

A. The ventilation will stop and the main intake damper will close; Done if the containment is to be secured and no personnel will be present.

B. The containment pressure relief system will be automatically activated; Done if the containment is to be secured and no personnel will be present.

C. The ventilation will stop and the main intake damper will close; Done if the containment is to be left unsecured and no personnel will be present.

D. The containment pressure relief system will be automatically activated; Done if the containment is to be left unsecured and no personnel will be present.

QUESTION B.10 [1.0 point]
What is the highest emergency classification level that can be implemented at the MITR-II?

A. Alert

B. General Emergency

C. Notification of Unusual Event

D. Site Area Emergency

QUESTION B.11 [1.0 point]
The SRO classifies an event as a ***"Notification of Unusual Event"***. The emergency procedure dictates that you (the reactor operator) are to coordinate emergency response from the control room. An example given is to have any available staff assist check the containment evacuated, escort experimenters out of the building to the machine shop, and to check that all core heat removal equipment is functioning. While performing these task the staff should limit their exposure to a maximum of …

A. 100 mrem

B. 500 mrem

C. 1000 mrem

D. 5000 mrem

QUESTION B.12 [1.0 point]
How is the emergency core cooling system (ECCS) prepared in case the system needs to be activated to prevent further tank level degradation? The ECCS needs to have its water supply connected to the …

A. primary coolant reactor inlet lines.

B. secondary coolant cooling towers outlet lines.

C. city water lines.

D. primary coolant storage tank.

QUESTION B.13 [1.0 point]
As a licensed reactor operator at the MITR-II, who is allowed to operate the controls of the reactor under your direction?

A. A local college newspaper reporter who wants to write a story on the safety of nuclear reactors.

B. A new student taking a reactor experiments class in the nuclear engineering department at MIT.

C. A health physicist who is trying to gain a certified health physicist (CHP) license.

D. An NRC inspector trying to make sure that all set points of the reactor are the same as those in the technical specifications.

QUESTION B.14 [0.5 point each]
Identify the ***Quality Factor*** (1, 5, 10, 15, 20) for each of the types of radiation listed below.
NOTE: The quality factor is the constant specified in 10 CFR 20 that is used to derive dose equivalent from absorbed dose.

Use these values for your answers:

A. X-, gamma, or beta radiation

B. Alpha particles or fission fragments

C. Thermal neutrons (2.5×10^{-8} MeV)

D. Fast neutrons (1 MeV)

QUESTION B.15 [1.0 point] Question changed to incorporate facility comments.
Which ONE of the following situations would illustrate a time when the reactor is shutdown but not secured? (Assume the only changing conditions in the facility are those listed in each choice listed below.)

A. One of the control rods is removed for inspection while the other control rods are fully inserted and all fuel remains in the same configuration.

B. ~~All control rods are fully inserted and~~ The console key is removed and in proper custody and fuel is being rearranged in the fuel storage pool.

C. The control rods are withdrawn to the subcritical position and the core is subcritical by 1% ΔK/K.

D. All control rods are fully inserted and an experiment having a negative reactivity effect is being installed in the reactor.

QUESTION B.16 [1.0 point]
How are the stack accumulators verified to be operable?

A. A signal is introduced into the detector and if the detector records readings, then it is operable.

B. The background signal is observed and compared to previously know background levels.

C. A check source is placed next to the detector and the value is compare to previous values.

D. The system is checked for the illumination of an error light.

QUESTION B.17 [1.0 point]
The technical specifications allow for the continued operation of the MITR-II under which ONE situation?

A. An inoperable control rod is fully inserted in the core.

B. A surveillance check shows emergency power can supply backup power for 45 minutes.

C. H_2 concentration in the air space above the core is 4 volume percent.

D. The malfunction of an in-core experiment results in a reactivity insertion of 1.5 % ΔK/K

QUESTION B.18 [1.0 point]
An unshielded Cs^{137} source reads 250 mrem/hr field at a distance of 30 cm. What thickness of lead shielding will be needed to lower the radiation level to values acceptable for a “Radiation Area”? The HVL (half-thickness) for Cs^{137} and lead is 6.5 mm.

A. 6.5 mm

B. 13 mm

C. 19.5 mm

D. 26 mm

QUESTION B.19 [1.0 point]
What is the definition of an emergency action level (EAL) in the emergency plan/procedures?

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

B. A class of accidents for which predetermined emergency measures should be taken or considered.

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

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

QUESTION C.1 [1.0 point]
Which one of the following gives the reason for the stepped design of the beam port sleeve and plug?

A. Precludes radiation streaming.

B. Prevents D_2O leakage if a break were to occur.

C. Maintains a negative pressure to inhibit activated air from leaking.

D. Facilitates ease of insertion and removal.

QUESTION C.2 [1.0 point]
What is the purpose of the coolant system for the lead thermal shields?

A. To maintain thermal equilibrium between the lead shields and the adjacent graphite reflector.

B. To maintain the thermal neutron shielding properties of the lead.

C. To prevent melting of the lead.

D. To prevent activation of lead by fast neutrons.

QUESTION C.3 [1.0 point]
If an Area Monitor detector is saturated, the the Detector Signal Conditioner LED will read …

A. All nines (9)

B. All zeros (0)

C. All dashes (-)

D. A blank screen

QUESTION C.4 [1.0 point]
With the reactor operating, a leak in one of the heat exchanges will be signaled by detection of which ONE of the following radionuclides?

A. Xe^{135}

B. H^3

C. Ar^{41}

D. F^{18}

QUESTION C.5 [1.0 point]
Which one of the following conditions is NOT a cause of the “trouble radiation monitor alarm” occurring?

A. Loss of flow to any plenum monitor

B. Saturation of secondary water monitor

C. Low level on any effluent monitor

D. Loss of flow to any stack effluent monitor

QUESTION C.6 [1.0 point]
Where are the plenum particulate monitors located in the ventilation system?

A. Before the main exhaust damper

B. In between the main exhaust damper and the exhaust filtering unit

C. In between the exhaust filtering unit and the stack exhaust fan

D. After the stack exhaust fan

QUESTION C.7 [1.0 point]
How do the airlocks maintain a gas tight seal?

A. Negative pressure applied to the inside of the airlock

B. Vacuum seals around all openings in the airlock

C. Solid metal construction that overlaps all penetrations in the airlock

D. Inflatable rubber gaskets around the seals of the doors in the airlock

QUESTION C.8 [1.0 point]
Why is Helium used to blanket the D_2O reflector system?

A. To prevent corrosion caused by nitrous oxide formation in air

B. To cool the empty spaces in the reflector above the D_2O level

C. To prevent activation of the Oxygen in CO_2 if CO_2 were used instead

D. To keep the D_2 and O_2 from being released into the atmosphere

QUESTION C.9 [1.0 point]
Which neutron flux monitoring channel controls the regulating control rod in automatic control mode?

A. Channel 3

B. Channel 5

C. Channel 7

D. Channel 9

QUESTION C.10 [1.0 point]
At what level in the core tank are the anti-syphon valves located?

A. At the top of the core tank (at the top of the pool level)

B. At the bottom of the core tank (below the reactor core level)

C. At the top of the core shroud (primary coolant inlet level)

D. At the bottom of the core shroud (natural convection valve level)

QUESTION C.11 [1.0 point]
What is one of the purposes for the subcritical interlock?

A. To prevent the reactor from being manipulated to a critical position before the startup channels are switched from fission chambers to uncompensated ion chambers.

B. To provide a reference point where all instruments undergo a check before the reactor is brought to a critical position.

C. To allow for all experiments to be installed before the reactor is critical.

D. To ensure that a steady rate of startup to the critical position is achieved.

QUESTION C.12 [1.0 point]
What prevents the fuel elements from being carried out of the core by the water flow during reactor operation?

A. The heavy weight of the fuel elements (~8 lbs).

B. Sleek aerodynamic fins, which reduce the amount of drag on the surface of the fuel elements.

C. The hold-down grid plate, which is locked in place during reactor operations.

D. Grooves in the upper and lower grid that increase the coefficient of friction between the element and the grids.

QUESTION C.13 [1.0 point]
Which one of the following scenarios would cause the reactor to automatically scram?

A. Deflation of both of the main personnel airlock door gaskets.

B. Opening of the shielded door to the fission converter medical therapy facility.

C. Unexplained loss of water resulting in a water level drop of 2" below the overflow point.

D. High plenum gaseous radiation level causing the exhaust fans to trip and isolation dampers to close.

QUESTION C.14 [1.0 point]
What is the purpose of the long hold up chamber, or plenum, in the exhaust air system?

A. To allow for the thorough measurement of the radiation levels in the exhaust air.

B. To enable the shorter lived activation products to decay before they are exhausted.

C. To filter out the particulates that would result in an airborne radiation release to the environment.

D. To delay the exhaust long enough for the butterfly dampers to close if the plenum monitor alarms.

QUESTION C.15 [1.0 point]
Which one of the following neutron flux monitoring channels provides a signal indicating the period of the reactor?

A. Channel 2

B. Channel 4

C. Channel 6

D. Channel 8

QUESTION C.16 [1.0 point]
What is indicated when an alarm on the annunciator alarm (SCAM) panel is silent, but is continuously brightly lit?

A. The alarm condition has been corrected but not acknowledged.

B. The alarm condition has been acknowledged but not corrected.

C. The alarm condition has neither been acknowledged nor corrected.

D. The alarm condition has been acknowledged and corrected and only serves as a reminder to the operator.

QUESTION C.17 [1.0 point]
What material is in the absorbing sections of the shim control rods? Boron impregnated …

A. graphite

B. aluminum

C. cadmium

D. stainless steel

QUESTION C.18 [0.25 point each]
List the order of placement of the following reactor components starting from the reactor core position moving outward.

A. Dense concrete shield

B. Graphite reflector

C. Lead thermal shield

D. D_2O reflector

QUESTION C.19 [1.0 point]
What is the purpose of heat exchanger #2 while the reactor is operating?

A. To provide additional cooling for the primary coolant, reducing the load on the other heat exchangers.

B. To reduce the volume fluctuations associated with temperature changes in the cleanup loop.

C. To maintain the purifying properties of the heat sensitive resin bed in the ion exchanger.

D. To prevent the water flow from becoming turbulent thus reducing the efficiency of the ion exchanger.

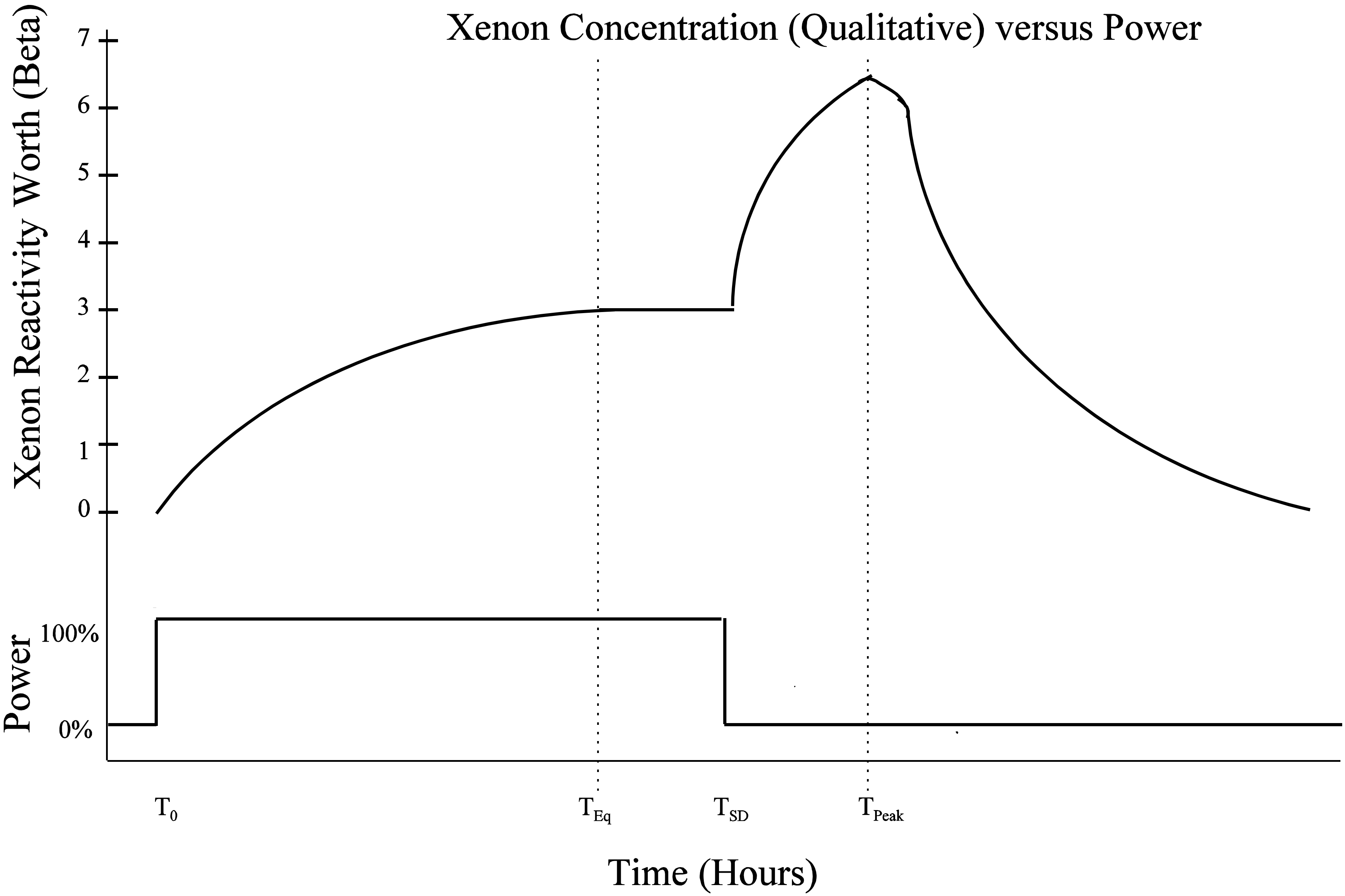
QUESTION C.20 [1.0 point]
Which three shutters in the fission convertor facility ensure the safety of the staff in the building?

A. Cadmium converter control shutter, water shutter, and lead shutter

B. Water converter control shutter, paraffin shutter, and cadmium shutter

C. Lead converter control shutter, paraffin shutter, and cadmium shutter

D. Paraffin converter control shutter, lead shutter, and water shutter



Xenon Concentration (Qualitative) versus Power
Xenon Reactivity Worth (Beta)
7
6
5
4
3
2
1
0
Power
100%
0%
T0
TEq
TSD
TPeak
Time (Hours)

A.1 A
REF: RSM 10-7

A.2 D
REF: RSM 10-7

A.3 C
REF: RSM 10-8

A.4 D
REF: MITR II Reactor Physics Notes - Reactor Kinetics

A.5 A
REF: MITR II Reactor Physics Notes - Reactor Kinetics Section (g) $P = P_0 e^{t/\tau}$

A.6 B
REF: MITR II Reactor Physics Notes - Reactor Kinetics Section (e)

A.7 C
REF: MITR II Reactor Physics Notes - Reactor Kinetics Section (d)

$$\tau = \frac{\ell^*}{\rho} + \frac{\bar{\beta} - \rho}{\lambda\rho + d\rho/dt} = \frac{10^{-4}}{0.1} + \frac{1 - .1}{(0.08)(0.1) + 0} = 112.5\ \text{sec}$$

A.8 C
REF: MITR II Reactor Physics Notes - Reactor Startup and Reactor Subcritical Multiplication

A.9 D
REF: RSM 10-9

$$Neutron\ Count\ Rate = \frac{S_0}{1-K} = \frac{250\ n/\text{sec}}{1-0.80} = 1250\ n/\text{sec}$$

A.10 B
REF: MITR II Reactor Physics Notes - Reactor Kinetics (e)

A.11 B
REF: MITR II Reactor Physics Notes - Reactor Startup and Subcritical Multiplication (2)

A.12 D
REF: Glasstone, S., *Nuclear Reactor Engineering*, Kreiger Publishing, Malabar: Florida, 1991. 3rd Edition. pg. 13

A.13 C
REF: MITR II Reactor Physics Notes - Reactor Startup and Subcritical Multiplication

A.14 B
REF: Glasstone, S., *Nuclear Reactor Engineering*, Kreiger Publishing, Malabar: Florida, 1991. 3rd Edition. pg. 248

A.15 D
REF: RSM 10-11

A.16 B
REF: MITR II Reactor Physics Notes - Table 4.1 - Reactivity Units

$$0.75\,\beta/inch \times 0.00786 = 5.895E-3\,\frac{\Delta K/K}{inch} \qquad -2.5\times10^{-4}\,\frac{\Delta K/K}{^oC} * 50^oC = -125\times10^{-2}\,\Delta K/K$$

Since the temperature rise results in a negative reactivity insertion, the control rod will need to drive out to add positive reactivity.

$$D = \frac{125\times10^{-2}\,\Delta K/K}{5.895\times10^{-3}\,\frac{\Delta K/K}{inch}} = 2.12\ inches$$

A.17 C
REF: RSM 10-7

A.18 A
REF: RSM 10-8

A.19 D
REF: Glasstone, S., *Nuclear Reactor Engineering*, Kreiger Publishing, Malabar: Florida, 1991. 3rd Edition. pg. 191

A.20 B
REF: Glasstone, S., *Nuclear Reactor Engineering*, Kreiger Publishing, Malabar: Florida, 1991. 3rd Edition. pg. 16

Section

B.1 C
REF: MITR-II TS 2.1

B.2 A
REF: Administrative Procedure 1.12

B.3 D
REF: Administrative Procedure 1.14.3

B.4 B
REF: PM 2.2 Pg. 9 of 11

B.5 B
REF: PM 3.1.1.1 Page 4 of 14

B.6 C
REF: PM 3.1.2.1 Page 1 of 14

B.7 D
REF: PM 2.3 Page 2 of 7; PM 3.1.7

B.8 A
REF: RSM 7-8

B.9.A
REF: PM 2.2 Pg. 9 of 11; RSM 9-20

B.10 D
REF: PM 4.4 Pg. 4 of 7

B.11 C
REF: PM 4.4.4.14 Pg. 5 of 14

B.12 C
REF: PM 5.2.3 Pg. 1&2

B.13 B
REF: 10 CFR 55.13; PM 1.14

B.14 A – 1; B – 20; C – 1; D – 10
REF: 10 CFR 20.1004

B.15 D or B, 2nd correct answer added per NRC review of question commented on by facility.

Section

C.1 A
REF: RSM 2-6

C.2 C
REF: RSM 3-16

C.3 C
REF: RSM 7-2

C.4 D
REF: RSM 7-8

C.5 B
REF: RSM 7-12; RSM 7-15 (Table 7.5-1)

C.6 A
REF: RSM 8-14

C.7 D
REF: RSM 8-8

C.8 A
REF: RSM 3-19

C.9 D
REF: RSM 5-11

C.10 C
REF: RSM 1-8

C.11 B
REF: RSM 4-3

C.12 C
REF: MITR-III SAR 4-21; RSM 1-5

C.13 A
REF: RSM 9-8; RSM 9-6; RSM 9-5

C.14 D
REF: RSM 8-14

C.15 A
REF: RSM 5-6

C.16 B
REF: RSM 9-2

C.17 D
REF: RSM 1-10

C.18 A – 4; B – 2; C – 3; D – 1
REF: RSM 1-2; 1-3

C.19 C
REF: RSM 3-3

C.20 A
REF: License Amendment #31 Safety Evaluation Pg. 11

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

Category Value: 60.00 | 20.00 | 20.00 | 20.00

% of Total: 33.3 | 33.3 | 33.3

CANDIDATE: REACTOR TYPE: DATE ADMINISTERED:

Candidates Score

% of

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FINAL GRADE

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U. S. NUCLEAR REG

MITR-II

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Category Value

2004/02/02

A. B. C. Category

Candidate's Signature

Radiological Controls Facility and Radiation Monitoring Systems Characteristics Normal and Emergency Operating Procedures and Reactor Theory, Thermodynamics and Facility Op

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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.

13. When you have completed and turned in you examination, leave the examination area. If you are observed in this area while the examination is still in progress, your license may be denied or revoked.

EQUATION SHEET

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

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

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

$$\lambda_{eff} = 0.08 \text{ seconds}^{-1}$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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.11	a	b	c	d	___
A.2	a	b	c	d	___	A.12	a	b	c	d	___
A.3	a	b	c	d	___	A.13	a	b	c	d	___
A.4	a	b	c	d	___	A.14	a	b	c	d	___
A.5	a	b	c	d	___	A.15	a	b	c	d	___
A.6	a	b	c	d	___	A.16	a	b	c	d	___
A.7	a	b	c	d	___	A.17	a	b	c	d	___
A.8	a	b	c	d	___	A.18	a	b	c	d	___
A.9	a	b	c	d	___	A.19	a	b	c	d	___
A.10	a	b	c	d	___	A.20	a	b	c	d	___

Section

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

Section

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.7 a b c d ___

C.8 a b c d ___

C.9 a b c d ___

C.10 a b c d ___

C.11 a b c d ___

C.12 a b c d ___

C.13 a b c d ___

C.14 a b c d ___

C.15 a b c d ___

C.16 a b c d ___

C.17 a b c d ___

C.18a 1 2 3 4 ___

C.18b 1 2 3 4 ___

C.18c 1 2 3 4 ___

C.18d 1 2 3 4 ___

C.19 a b c d ___

C.20 a b c d ___