October 20, 2006

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-06-01, MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Dear Dr. Bernard:

During the week of September 4, 2006, 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 2.390 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 Agencywide Documents Access and Management System (ADAMS). ADAMS is accessible from the NRC Web site at (the Public Electronic Reading Room) http://www.nrc.gov/reading-rm/adams.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. Paul V. Doyle Jr. at (301) 415-1058 or via internet e-mail pvd@nrc.gov.

Sincerely,

/RA/

Johnny Eads, Chief
Research and Test Reactors Branch B
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Docket No. 50-20

Enclosures: 1. Initial Examination Report No. 50-20/OL-06-01
2. Examination and answer key

cc w/encls:
Please see next page

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ADAMS ACCESSION #: ML062910219 **TEMPLATE #:NRR-074**

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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

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: September 5 – 8, 2006

SUBMITTED BY: ________/RA/____________________ 10/17/2006
Paul V. Doyle Jr., Chief Examiner Date

SUMMARY:

During the week of September 4, 2006, the NRC administered operator licencing examinations to six Reactor Operator (RO) candidates, one Senior Reactor Operator (Instant) (SRO-I) candidate and four Senior Reactor Operator (Upgrade) (SRO-U) candidates. One RO candidate failed sections A and C of the written examination and the operating test, due to withdrawal by the facility management. One RO candidate failed Section C of the written examination and overall (less than 70% overall). The SRO-I candidate failed sections B and C of the written examination. One SRO-U candidate failed the operating test. The other four RO candidates and the other three SRO-U candidates passed all portions of their examinations.

REPORT DETAILS

1. Examiners: Paul V. Doyle Jr., Chief Examiner, Phillip Young, Examiner

2. Results:

	RO PASS/FAIL	SRO PASS/FAIL	TOTAL PASS/FAIL
Written	4/2	0/1	4/3
Operating Tests	4/2	3/2	7/4
Overall	4/2	3/2	7/4

3. Exit Meeting:
Paul V. Doyle Jr., NRC, Examiner
Edward Lau, Reactor Superintendent, MIT
Frank Warmsley, Training Manager, MIT

The examiner thanked the facility for their support in the administration of the examinations. However, he also noted that there was a generic weakness on the part of the candidates, not in any one system, but rather, in their “in the plant” familiarity with the systems. The candidates seemed to have sufficient to good knowledge of the purpose of systems, but had a hard time pointing out system components, flow paths, and describing the actual methods used to perform different procedures.

OPERATOR LICENSING EXAMINATION
With Answer Key

UNITED STATES NUCLEAR REGULATORY COMMISSION

MASSACHUSETTS INSTITUTE
OF TECHNOLOGY

Week of September 4, 2006

Enclosure 2

QUESTION A.01 [2.0 points, 0.4 each]

The listed isotopes are all potential daughter products due to the radioactive decay of ${}_{35}Br^{87}$. Identify the type of decay necessary [Alpha (α), Beta plus (β^+), Beta minus (β^-), Gamma (γ) or Neutron (ℕ) emission) to produce each of the isotopes.

a. ${}_{33}As^{83}$

b. ${}_{35}Br^{86}$

c. ${}_{35}Br^{87}$

d. ${}_{36}Kr^{87}$

e. ${}_{34}Se^{87}$

QUESTION A.02 [1.0 point]

Which ONE of the following statements is the definition of **REACTIVITY**?

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

b. A measure of the core's deviation from criticality.

c. Equal to 1.00 ΔK/K when the reactor is critical.

d. Equal to 1.00 ΔK/K when the reactor is prompt critical.

QUESTION A.03 [1.0 point]

Suppose the temperature coefficient of a core is -2.5×10^{-4} ΔK/K/°C and the average control rod worth of the regulating control rod is 5.895×10^{-3} ΔK/K/inch. If the temperature INCREASES by 50°C what will the automatic control command the regulating rod to do? 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.04 [1.0 point]

During a reactor startup, criticality occurred at a lower rod height than the last startup. Which ONE of the following reasons could be the cause?

a. Adding an experiment with positive reactivity.

b. Xe^{135} peaked.

c. Moderator temperature increased.

d. Maintenance on the control rods resulted in a slightly faster rod speed.

QUESTION A.05 [1.0 point]

Which one of the following is the definition of the ***FAST FISSION FACTOR***?

a. The ratio of the number of neutrons produced by fast fission to the number produced by thermal fission

b. The ratio of the number of neutrons produced by thermal fission to the number produced by fast fission

c. The ratio of the number of neutrons produced by fast and thermal fission to the number produced by thermal fission

d. The ratio of the number of neutrons produced by fast fission to the number produced by fast and thermal fission

QUESTION A.06 [1.0 point]

In a reactor at full power, the thermal neutron flux (φ) is 2.5×10^{12} neutrons/cm^2/sec. and the macroscopic fission cross-section Σ_f is 0.1 cm^{-1}. The fission reaction rate is:

a. 2.5×10^{11} fissions/sec.

b. 2.5×10^{13} fissions/sec.

c. 2.5×10^{11} fissions/cm^3/sec.

d. 2.5×10^{13} fissions/cm^3/sec.

QUESTION A.07 [1.0 point]
Which ONE of the following explains the response of a ***SUBCRITICAL*** reactor to equal insertions of positive reactivity as the reactor approaches criticality? Each insertion causes a …

a. ***SMALLER*** increase in the neutron flux resulting in a ***LONGER*** time to stabilize.

b. ***LARGER*** increase in the neutron flux resulting in a ***LONGER*** time to stabilize.

c. ***SMALLER*** increase in the neutron flux resulting in a ***SHORTER*** time to stabilize.

d. ***LARGER*** increase in the neutron flux resulting in a ***SHORTER*** time to stabilize.

QUESTION A.08 [1.0 point]
Which ONE of the following atoms will cause a neutron to lose the most energy in an elastic collision?

a. Uranium^{238}

b. Carbon^{12}

c. Hydrogen^{2}

d. Hydrogen^{1}

QUESTION A.09 [1.0 point]
A thin foil target of 10% copper and 90% aluminum is in a thermal neutron beam. Given $\sigma_{a\,Cu}$ = 3.79 barns, $\sigma_{a\,Al}$ = 0.23 barns, $\sigma_{s\,Cu}$ = 7.90 barns, and $\sigma_{s\,Al}$ =1.49 barns, which ONE of the following reactions has the highest probability of occurring? A neutron …

a. scattering reaction with aluminum

b. scattering reaction with copper

c. absorption in aluminum

d. absorption in copper

QUESTION A.10 [1.0 point]
Core excess reactivity changes with …

a. fuel element buildup

b. control rod height

c. neutron energy level

d. reactor power level

QUESTION A.11 [1.0 point]

The delayed neutron precursor β for U^{235} is 0.0065. However, when calculating reactor parameters you use the *effective* delayed neutron precursor β_{eff} with a value of ~0.0070. Which ONE of the following is the correct reason that β_{eff} is larger than β?

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

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

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

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

QUESTION A.12 [2.0 points, 0.5 each]

Match each term in column A with the correct definition in column B.

	Column A		Column B
a.	Prompt Neutron	1.	A neutron in equilibrium with its surroundings.
b.	Fast Neutron	2.	A neutron born directly from fission.
c.	Thermal Neutron	3.	A neutron born due to decay of a fission product.
d.	Delayed Neutron	4.	A neutron at an energy level greater than its surroundings.

QUESTION A.13 [1.0 point] Note: Original question was identical to A.08. This question was substituted during the administration of the examination.

Moving the control blades, primarily changes reactivity in the reactor by changing which ONE of the four factors?

a. Fast Fission Factor (ε)

b. Reproduction Factor (η)

c. Resonance Escape Probability (p)

d. Thermal Utilization Factor (f)

QUESTION A.14 [1.0 point]

Which ONE of the following describes the ***MAJOR*** contributors to the production and depletion of Xenon respectively in the core shortly (less than an hour) after ***SHUTDOWN***

	Production	***Depletion***
a.	Radioactive decay of Iodine	Radioactive Decay
b.	Radioactive decay of Iodine	Neutron Absorption
c.	Directly from fission due to delayed neutrons	Radioactive Decay
d.	Directly from fission due to delayed neutrons	Neutron Absorption

QUESTION A.15 [1.0 point]

Several processes within the core increase or decrease the number of neutrons in a generation. Which ONE of the following six-factor terms describes a process which results in an INCREASE in the number of neutrons during the cycle?

a. Thermal Utilization Factor (f)

b. Resonance Escape Probability (p)

c. Thermal Non-Leakage Probability ($\mathcal{L}_{TH}$)

d. Reproduction Factor (η)

~~QUESTION A.16 [1.0 point]~~ Question deleted per facility comment (MIT does NOT add burnable poison to its core.)

~~Which **ONE** of the following is the correct reason burnable poison is added to the core?~~

~~a. To minimize the effects of a rod withdrawal accident.~~

~~b. To increase the power achievable for a given core size.~~

~~c. To allow addition of additional fuel to compensate for burnup.~~

~~d. To decrease the effects of Xenon and Samarium on the core~~.

QUESTION A.17 [1.0 point]
Initially Nuclear Instrumentation is reading 30 CPS and the reactor has a K_{eff} of 0.90. You add an experiment which causes the Nuclear instrumentation reading to increase to 60 CPS. Which ONE of the following is the new K_{eff}?

a. 0.91

b. 0.925

c. 0.95

d. 0.975

QUESTION A.18 [1.0 point]
You enter the control room and note that all nuclear instrumentation show a steady neutron level, and no rods are in motion. Which ONE of the following conditions **CANNOT** be true?

a. The reactor is critical.

b. The reactor is subcritical.

c. The reactor is supercritical.

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

QUESTION B.01 [1.0 point]
You note that 1 cm of a material (used as a shield) reduces the radiation level from a given source by a factor of 2. If you add another nine cm of the material (for a total of 10 cm), you would expect the radiation level to be reduced by a factor of approximately ____ over no shielding. (Note: Ignore dose decrease due to distance, and decay.)

a. 20

b. 100

c. 200

d. 1,000

QUESTION B.02 [1.0 point]
The air purge above the reactor is secured. If H^2 concentration increases to above 1.0% Technical Specifications require you to …

a. insert a Major Scram.

b. insert a Minor Scram.

c. reduce power to less than 200 Kw.

d. perform a normal reactor shutdown.

QUESTION B.03 [2.0 points, ⅓ each]
Match the experiment type listed in column A with the corresponding Technical Specification limit listed in column B. (Notes: Only one answer for each item in column A. Items in column B, may be used more than once, or not at all.)

Column A	Column B
a. Single movable	1. 0.2% ΔK/K
b. Total movable	2. 0.5% ΔK/K
c. Single Non-secured	3. 1.0% ΔK/K
d. Total Non-secured	4. 1.5% ΔK/K
e. Single secured	5. 1.8% ΔK/K
f. Total secured	

QUESTION B.04 [1.0 point]
Which ONE of the following classifications for an emergency is not credible for the MIT reactor? (Note: Items are listed alphabetically, **NOT** in order of severity!)

a. Alert

b. General Emergency

c. Notification of Unusual Event

d. Site Area Emergency

QUESTION B.05 [1.0 point]
While working on an experiment, you receive the following radiation doses: 100 mrem (β), 25 mrem (γ), and 5 mrem (thermal neutrons). Which ONE of the following is your total dose?

a. 175 mrem

b. 155 mrem

c. 145 mrem

d. 130 mrem

QUESTION B.06 [1.0 point]
Pump MM-1 is **LOCKED OUT** to support corrective maintenance on the pump (replace packing). During performance of the work the key will remain in the custody of the …

a. person performing the work.

b. Operator-in-Charge.

c. Senior Reactor Operator.

d. Reactor Supervisor or his designee.

QUESTION B.07 [1.0 point]
Following a change in fuel configuration, measurements must be made to determine the conditions of Technical Specification 3.1 are met prior to exceeding …

a. 1 kilowatt

b. 10 kilowatts

c. 100 kilowatts

d. 1 Megawatt

QUESTION B.08 [1.0 point]
During the performance of an Abnormal Operating Procedure, a temporary change to the procedure is required. Select the minimum complement of personnel required to approve this temporary change.

a. Two members of the reactor staff, at least one of whom holds a Senior Reactor Operator License.

b. The Duty Shift Supervisor and an appropriate group Supervisor.

c. A licensed Senior Reactor Operator and a member of the Reactor Safeguards Committee.

d. Two licensed Senior Reactor Operators and the Director of Reactor Operations.

QUESTION B.09 [2.0 points, 0.5 each]
Identify whether each of the following experiments has no special requirements (NR), requires Double encapsulation (DBL), requires Pressure Test (PT) or is Not Authorized (NA). (Note choices may be used more than once or not at all.)

a. Corrosive Materials

b. Metastable Materials

c. contains 3 milligrams of explosive material, and will not cause rearrangement or damage to the reactor.

d. the calculated surface temperature of a submerged experiment will be high enough to cause nucleate boiling within the coolant, but not cause bulk boiling.

QUESTION B.10 [1.0 points, 0.25 each]
Identify the source for the listed radioisotopes. Irradiation of air, water, structural material or fission product.

a. N^{16}

b. Na^{24}

c. Ar^{41}

d. Xe^{188}

QUESTION B.11 [1.0 point]

The CURIE content of a radioactive source is a measure of

a. the number of radioactive atoms in the source.

b. the amount of energy emitted per unit time by the source

c. the amount of damage to soft body tissue per unit time.

d. the number of nuclear disintegrations per unit time.

QUESTION B.12 [1.0 point]

Consider two point sources, each having the SAME curie strength. Source A's gammas have an energy of 0.5 MeV, while Source B's gammas have an energy of 1.0 MeV. Using a Geiger-Müller detector the reading from source B will be … (NOTE: Ignore detector efficiency.)

a. four times that of source A.

b. twice that of source A.

c. the same.

d. half that of source A.

QUESTION B.13 [1.0 point]

Which **ONE** of the following conditions is an Reportable Occurrence per the Technical Specification definition?

a. Five shim blades are operable. The inoperable blade is fully out.

b. Operation of the reactor with one shield coolant flow rate scram channel failed. It has been out of service for five hours. Personnel working on it anticipate having it repaired within 2 hours.

c. During operation at full power you find both Emergency cooling jumper hoses sabotaged.

d. Operation of the reactor with a height of water above the core 2" below the overflow pipe.

QUESTION B.14 [1.0 point]

The MITR Emergency Plan defines ***<u>"Emergency Planning Zone (EPZ)"</u>*** as …

a. the reactor floor area which is bounded by walls and airlocks.

b. the area within a 100 meter radius of the reactor containment.

c. the MIT campus.

d. the area within a one mile radius of the MIT Research Reactor.

QUESTION B.15 [1.0 point]

Which **ONE** of the following is the definition of a **CHANNEL TEST**?

a. the combination of sensor, line, amplifier, and output devices which are connected for the purpose of measuring the value of a parameter.

b. an adjustment of the channel such that it output corresponds with acceptable accuracy to known values of the parameter which the channel measures.

c. a qualitative verification of acceptable performance by observation of channel behavior.

d. the introduction of a signal into the channel for verification that It Is operable.

QUESTION B.16 [1.0 point]

During continuous power operation with the automatic control system, it may be necessary for the operator to reshim the control blades to maintain the regulating rod within its useful range. Which ONE of the following describes a requirement associated with this reshim of the control blades?

a. Reactor power must be maintained within 2.5% of the desired level while reshimming.

b. All shim blades must be maintained within 2.5 inches of each other during the reshim and within 1.0 inch following the reshim.

c. The first motion of any control absorber during a reshim should be inward so as to lower reactor power.

d. The duty supervisor must approve all reshims prior to performance.

QUESTION B.17 [1.0 point]

Note: Original question was identical to B.08. This question was substituted during the administration of the examination.

During refueling operations the D_2O reflector would NOT be dumped if this would result in a decrease in …

a. radiation shielding by 100 mr/hr

b. radiation shielding by 10 mr/hr

c. count rate below 100 cpm

d. count rate below 10 cpm

QUESTION B.18 [1.0 point]

Federal Regulations [10CFR50.54(x)] allows the operator to deviate from the Technical Specifications to ensure the health and safety of the public. Per 10CFR50.54(y) the minimum level of authorization to do this is …

a. any NRC duty officer.

b. the Reactor Superintendent.

c. any licensed Senior Reactor Operator.

d. any License Reactor Operator.

QUESTION C.01 [1.0 point]
During startup, after channel 3 starts reading you must shift channels 1 and 2 from their fission chamber inputs to their ion chamber inputs. How do you do this? For the channel you _____ the overall gain and for the fission chamber you ____ the discriminator setting.

a. Increase, Increase

b. Increase, Decrease

c. Decrease, Increase

d. Decrease, Decrease

QUESTION C.02 [1.0 point]
Which one of the following loads on Electrical Panel #1 will shift to emergency power on a loss of normal power?

a. Startup Channels

b. Recombiner Heaters

c. Medical Therapy Control Panel

d. Recorders, Clock and Front Panel Outlets

QUESTION C.03 [1.0 point]
A gas purge is maintained on the vertical sample thimbles while the reactor is operating. Which one of the following gases is used for this purge and why?

a. He, to reduce the production of Ar^{41} and N^{16}.

b. N_2, to reduce the production of Ar^{41} and N^{16}.

c. CO_2, to reduce the production of Ar^{41} and Nitrous Oxide.

d. Ar^{40}, to aid in the production of Ar^{41} for gamma production.

QUESTION C.04 [1.0 point]
The surveillance system is activated. An alarm on the center scam panel will cause an audible alarm at all of the below listed areas except …

a. the Reactor floor.

b. the Utility room.

c. the Reception desk.

d. the Operations Office.

QUESTION   C.05 [1.0 point]
Which one of the following is the correct type of detector used for Nuclear Instrumentation Channel 9 (used as input to the regulating rod automatic control circuit)?

a. Fission Chamber

b. Boron Lined Compensated Ion Chamber

c. Boron Lined Uncompensated Ion Chamber

d. Unlined Ion Chamber

QUESTION   C.06 [1.0 point]
Which one of the following is the correct value for the alarm setpoint for the high temperature D_2O reflector cleanup system?

a. 40°C

b. 50°C

c. 60°C

d. 70°C

QUESTION   C.07 [1.0 point]
Which one of the following is correct with respect to maintaining the D_2O reflector dump valve closed when air compressor CM-2 is tagged out for maintenance?

a. As long as solenoid valves CV-90 and CV-91 remain as is, the dump valve will remain shut.

b. A dedicated air receiver just upstream of CV-90 and CV-91, contains sufficient air volume to maintain the dump valve shut for eight hours.

c. On a low pressure signal a solenoid valve will automatically shift the dump valve air supply to a bank of air cylinders.

d. When air in the header decreases below 95 psig, a check valve will open supplying air from the backup air receiver.

QUESTION C.08 [1.0 point]
A trainee accidentally depresses the **ALL-ABSORBERS-IN** pushbutton. Which one of the following actions will stop the inward motion of the control blades?

a. Going to the out position on the regulating rod.

b. Depressing the Alarm Acknowledge pushbutton.

c. Depressing the Alarm Acknowledge pushbutton followed by the Alarm Reset pushbutton.

d. Depressing the Reactor Start pushbutton

QUESTION C.09 [1.0 point]
The secondary system is sampled every 24 hours while the reactor is operating. Which one of the following isotopes is used to detect a very small leak from either the D_2O reflector system or the H_2O primary system?

a. H^3

b. N^{16}

c. F^{18}

d. Kr^{88}

QUESTION C.10 [1.0 point]
Which **ONE** of the following statements concerning interlocks associated with the Liquid Waste System is **INCORRECT**?

a. On a high sump level signal a second parallel sump pump will automatically start.

b. On a high Waste Tank level in one tank, the inlet city water solenoid valve will close.

c. On a high sump level signal, the inlet city water solenoid valve will close.

d. On a high Waste Tank level in one tank, both sump pumps will be shut off.

QUESTION C.11 [1.0 point]
Which **ONE** of the following describes the decay heat removal capability while on Emergency Power?

a. Primary coolant system auxiliary pump MM2 can be restarted after resetting the low-voltage protection.

b. Primary coolant system pump MM1 can be restarted after resetting the low-voltage protection.

c. Standby transfer pump DM-2 will automatically start on high temperature.

d. Natural circulation provides cooling since pumping power is not available.

QUESTION C.12 [1.0 point]
On a loss of both eternal electrical power feeders the emergency system batteries will supply a nominal load of 72 amps to selected instruments and pumps on the Emergency Power Distribution system for approximately …

a. 2 hours.

b. 8 hours.

c. 24 hours.

d. 72 hours.

QUESTION C.13 [1.0 point] Question deleted per facility comment – No current reference.
~~Which **ONE** of the following is the correct reason that only one vertical thimble may contain a level and period channel detector?~~

~~a. Neutron flux is not usable for power detection in all but one thimble.~~

~~b. Only one cable tray supplies the top of the reactor.~~

~~c. Interference with the pneumatic tube system.~~

~~d. The thimble are not large enough to contain the double detectors of channels 1 and 2.~~

QUESTION C.14 [1.0 point] Question deleted per facility comment – No such system currently in use.
~~Which **ONE** of the following actions (along with reason) would you take on a loss of the Multichannel Radiation Monitoring System while people were on the Main Reactor Floor? (Note: All individual monitors are operating normally.)~~

~~a. Immediately evacuate all personnel due to a loss of all area radiation monitors on the reactor floor.~~

~~b. None, required. One of the three area radiation monitors is individually powered so that the requirement for one monitor available is met.~~

~~c. None required. Two of the three area radiation monitors are individually powered so that the requirement for one monitor available is met.~~

~~d. None required. All three area radiation monitors are individually powered so that the requirement for one monitor is met.~~

QUESTION C.15 [1.0 point]
The Exhaust Air Effluent Monitor picks up radiation levels in excess of operating limits. Which **ONE** of the following actions will NOT occur immediately as a result?

a. Intake Backup Damper will close

b. Exhaust Fans will stop.

c. Intake Butterfly Damper will close.

d. Intake Fans will stop.

QUESTION C.16 [1.0 point]
A radiation survey performed 2 hours after the reactor has been shutdown has a contact reading of 2,000 mr/hr on the main heat exchangers. Is this reading normal or abnormal and what is the most likely cause?

a. Normal, N^{16}.

b. Normal, F^{18}.

c. Abnormal, H^3

d. Abnormal, Fission Products

QUESTION C.17 [1.0 point]
The fuel element dummies are constructed of …

a. Titanium

b. Stainless-Steel

c. Aluminum

d. Hafnium

QUESTION C.18 [1.0 point]
Which ONE of the following is **NOT** a function of the primary cleanup system?

a. Provide emergency core cooling spray.

b. Maintain level with the core tank.

c. Remove decay heat during reactor shutdown.

d. Supply cooling for the lead thermal doors.

QUESTION C.19 [1.0 point]
The ventilation system filtering unit (coarse and absolute filters) is located …

a. at the entrance to the plenum.

b. before the fast-closing exhaust butterfly damper.

c. before the two inlet bleeder ducts for the stack exhaust fan.

d. after the stack exhaust fans.

QUESTION C.20 [1.0 point]
Which ONE of the following indication is NOT provided in the Emergency Support Center?

a. Reactor Power.

b. Reactor Floor Radiation Level.

c. Wind Direction and Speed.

d. Core Tank Level.

A.01 a, α; b, ℕ; c, γ; d, β^-; e, β^+
Ref: Standard NRC question

A.02 b
Ref: Standard NRC question

A.03 b
REF: The temperature increase will result in a change in reactivity of: -2.5×10^{-4} ΔK/K/°C × 50°C = -1.25×10^{-2} ΔK/K. Since the temperature rise results in a negative reactivity insertion, the control rod will need to drive out to add positive reactivity. D = (1.25×10^{-2} ΔK/K) ÷ (5.895×10^{-3} ΔK/K/inch) = 2.12 inches

A.04 a
Ref:

A.05 c
Ref:

A.06 c
Ref:

A.07 b
Ref:

A.08 d
Ref:

A.09 a 0.1 × 3.79 = 0.379 0.9 × 0.23 = 0.207 0.1 × 7.9 = 0.79 0.9 × 1.49 = 1.34
Ref:

A.10 a or b second correct answer added per facility comment.
Ref:

A.11 b
Ref:

A.12 a, 2; b, 4; c, 1; d, 3 a
Ref:

A.13 d
Ref:

A.14 a
Ref:

A.15 d
Ref:

A.16 c
Ref:

A.17 c
Ref: Doubling the Count Rate results in halving the shutdown margin.
$CR_2/CR_1) = (1 - K_{eff1})/(1 - K_{eff2})$ $60/30 = (1 - 0.900)/(1 - K_{eff2})$
$1 - K_{eff2} = ½ \times 0.1 = 0.05$ $K_{eff2} = 1 - 0.05 = 0.95$

A.18 c
Ref:

B.1 d
REF: $2^{10} = 1{,}024 \approx 1{,}000$

B.2 c
REF: MITR-II Tech. Spec. § 3.4, p. 3-14

B.3 a, 1; b, 2; c, 2; d, 3; e, 5; f, 5
REF: MITR-II Tech. Spec. § 6.1, Table within specification 1, p. 6-1.

B.4 b
REF: Emergency Plan §§ 4.4.1.1 through 4.4.1.4.

B.5 d
REF: A rem is a rem is a rem.

B.9 a
REF: MITR-II PROCEDURE MANUAL Chapter 1 Administrative Procedures § 1.14.3 Equipment Tagout and Lockout Procedure.

B.15 a
REF: MITR-II, PM 1.15 ¶3, pg. 1 of 5

B.8 a
REF: PM 1.5

B.9 a, DBL; b, PT; c, PT; d, NA
REF: Technical Specifications § 6, *Limitations on Experiments*

B.10 a, water; b, structural material; c, air; d, fission product
REF:

B.11 d
REF: Standard Health Physics Definition.

B.12 c
REF: Standard NRC Health Physics Question. G-M detector is not sensitive to incident energy levels.

B.13 c
REF: Technical Specification 3.9, 3.7, 3.6, 2.2.

B.14 b
REF: PM 4.6

B.15 d
REF: Technical Specifications § 1.13

B.16 c
REF: PM 2.4, Step 3(a), p. 3

B.17 d
REF: PM 1.5

B.18 c
REF: 10CFR50.54(y)

C.1 c
REF: MITR-II Reactor Systems Manual, § 5.3.1, p 5.5

C.2 d
REF: MITR-II Reactor Systems Manual Table 8-8B, p. 8.34

C.3 c
REF: MITR-II Reactor Systems Manual § 2.4, p. 2.7

C.4 d
REF: MITR-II Reactor Systems Manual, § 9.5, p. 17

C.5 d
REF: MITR-II Reactor Systems Manual § 5.6.3, p. 5.9.

C.6 b
REF: MITR-II, Reactor Systems Manual, § 9.2.1, p, 9.4

C.7 d
REF: MITR-II, Reactor Systems Manual, § 8.6.2, p. 8-27.

C.8 d
REF: MITR-II, Reactor System Manual, Chapter 4, p. 4.5, first paragraph.

C.9 a
REF: MITR-II, Reactor System Manual § 7.4.1, p, 7-6.

C.10 d
REF: MITR-II Reactor Systems Manual, § 8.5 p. 8.24.

C.11 a
REF: MITR-II, Reactor Systems Manual § 8.37

C.12 b
REF: MITR-II Reactor Systems Manual, § 8.35

~~C.13 b~~ Question Deleted per facility comment
~~REF: MITR-II Reactor Systems Manual § 5.1, p. 5.1~~

~~C.14 c~~ Question Deleted per facility comment
~~REF: MITR-II Reactor Systems Manual, §§7.2 and 7.2.1, pp. 7-1 through 7-3.~~

C.15 a
REF: MITR-II, Training Program Sample Questions § C question 2, also Reactor Systems Manual § 7.4.2.

C.16 d
REF: MITR-II Training Program Sample Question C.25, also AOP, PM 5.0

C.17 c
REF: PM 3.3.1

C.18 d
REF: MITR-II RSM pg. 6-35

C.19	c
REF:	MITR-II RSM pg. 9-21

C.20	a
REF:	MITR-II SRM pg. 2-31

U. S. NUCLEAR REGULATORY COMMISSION
RESEARCH AND TEST REACTOR
INITIAL OPERATOR LICENSE EXAMINATION

FACILITY: Massachusetts Institute of Technology

REACTOR TYPE: MITR-II

DATE ADMINISTERED: September 04, 2006

CANDIDATE: ___________________________

INSTRUCTIONS TO CANDIDATE:
Answers are to be written on the answer sheet provided. Attach the answer sheets to the examination. Points for each question are indicated in brackets for each question. A 70% is required to pass the examination. Examinations will be picked up one (1) hour after the examination starts.

Total Points	% of Total	Candidate's Points	Category Score (%)	Category Title
20.0	0.333	______	______	A. Reactor Theory, Thermodynamics & Facility Operating Characteristics
20.0	0.333	______	______	B. Normal & Abnormal Operating, Emergency and Radiological Controls Procedures
20.0	0.333	______	______	C. Plant and Radiation Monitoring Systems
60.0		______	______	

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

____
Candidate's Signature

NRC RULES AND GUIDELINES FOR LICENSE EXAMINATIONS

During the administration of this examination the following rules apply:

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

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

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

4. Use black ink or dark pencil <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.

12. There is a time limit of one (1) hour 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.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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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)

$c_{P\,(H2O)}$ = 1.0 BTU/hr/lbm/°F

$c_{p\,(H2O)}$ = 1 cal/sec/gm/°C

A.01a α β^- β^+ γ ℕ ___

A.01b α β^- β^+ γ ℕ ___

A.01c α β^- β^+ γ ℕ ___

A.01d α β^- β^+ γ ℕ ___

A.01e α β^- β^+ γ ℕ ___

A.02 a b c d ___

A.03 a b c d ___

A.04 a b c d ___

A.05 a b c d ___

A.06 a b c d ___

A.07 a b c d ___

A.08 a b c d ___

A.09 a b c d ___

A.09 a b c d ___ (A.10)

A.10 a b c d ___ (A.11)

A.12a 1 2 3 4 ___

A.12b 1 2 3 4 ___

A.12c 1 2 3 4 ___

A.12d 1 2 3 4 ___

A.13 a b c d ___

A.14 a b c d ___

A.15 a b c d ___

A.16 a b c d ___

A.17 a b c d ___

A.18 a b c d ___

B.01 a b c d ___

B.02 a b c d ___

%ΔK/K

B.03a 0.2 0.5 1.0 1.5 1.8 ___

B.03b 0.2 0.5 1.0 1.5 1.8 ___

B.03c 0.2 0.5 1.0 1.5 1.8 ___

B.03d 0.2 0.5 1.0 1.5 1.8 ___

B.03e 0.2 0.5 1.0 1.5 1.8 ___

B.03f 0.2 0.5 1.0 1.5 1.8 ___

B.04 a b c d ___

B.05 a b c d ___

B.06 a b c d ___

B.07 a b c d ___

B.08 a b c d ___

B.9a DBL NA NR PT ___

B.9b DBL NA NR PT ___

B.9c DBL NA NR PT ___

B.9d DBL NA NR PT ___

B.10a air water F.P. S.M. ___

B.10b air water F.P. S.M. ___

B.10c air water F.P. S.M. ___

B.10d air water F.P. S.M. ___

B.11 a b c d ___

B.12 a b c d ___

B.13 a b c d ___

B.14 a b c d ___

B.15 a b c d ___

B.16 a b c d ___

B.17 a b c d ___

B.18 a b c d ___

C.01 a b c d ___	C.11 a b c d ___
C.02 a b c d ___	C.12 a b c d ___
C.03 a b c d ___	C.13 a b c d ___
C.04 a b c d ___	C.14 a b c d ___
C.05 a b c d ___	C.15 a b c d ___
C.06 a b c d ___	C.16 a b c d ___
C.07 a b c d ___	C.17 a b c d ___
C.08 a b c d ___	C.18 a b c d ___
C.09 a b c d ___	C.19 a b c d ___
C.10 a b c d ___	C.20 a b c d ___