March 11, 2005

Mr. Stephen LaFlamme, Director
Nuclear Reactor Facility
Worcester Polytechnic Institute
100 Institute Rd.
Worcester, MA 01609-2280

SUBJECT: INITIAL EXAMINATION REPORT NO. 50-134/OL-05-01, WORCESTER POLYTECHNIC INSTITUTE

Dear Mr. LaFlamme:

During the week of February 7, 2005, the NRC administered initial examinations to employees of your facility who had applied for a license to operate your Worcester Polytechnic Institute 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 2.390 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 document 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. Warren Eresian at 301-415-1833 or internet e-mail wje@nrc.gov.

Sincerely,

/RA/

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

Docket No. 50-134

Enclosures: 1. Initial Examination Report No. 50-134/OL-05-01
2. Examination and answer key

cc w/encls: Please see next page

cc:

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PIsaac, PM	WEresian	PMadden

EXAMINATION PACKAGE ACCESSION #: ML042510205
EXAMINATION REPORT ACCESSION #: ML050480498 **TEMPLATE #: NRR-074**

OFFICE	RNRP:CE	IROB:LA	RNRP:SC
NAME	WEresian	EBarnhill	PMadden
DATE	02/28/2005	03/10/2005	03/10/2005

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<u>U. S. NUCLEAR REGULATORY COMMISSION</u>
<u>OPERATOR LICENSING INITIAL EXAMINATION REPORT</u>

REPORT NO.:	50-134/OL-05-01
FACILITY DOCKET NO.:	50-134
FACILITY LICENSE NO.:	R-61
FACILITY:	Worcester Polytechnic Institute
EXAMINATION DATES:	February 8-9, 2005
EXAMINERS:	Warren Arisen, Chief Examiner

SUBMITTED BY: **/RA/** 03/ 11 /2005
Warren Arisen, Chief Examiner Date

SUMMARY:

During the week of February 7, 2005, the NRC administered operator licensing examinations to one Reactor Operator candidate and one Senior Reactor Operator (Instant) candidate. Both candidates passed the examination.

ENCLOSURE 1

REPORT DETAILS

1. Examiners: Warren Arisen, Chief Examiner

2. Results:

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

3. Exit Meeting:

Warren Arisen, NRC Chief Examiner
Stephen J. LaFlamme, Facility Director

The NRC thanked the facility staff for their cooperation during the examinations. No generic concerns were noted. The facility reviewed the written examination and as a result Category B Question 1 was deleted, no longer applicable to the facility.

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

FACILITY: Worcester Polytechnic Institute

REACTOR TYPE: Pool

DATE ADMINISTERED: 02/08/2005

REGION: 1

CANDIDATE:____________________________

INSTRUCTIONS TO CANDIDATE:

Answers are to be written on the exam page itself, or the answer sheet provided. Write answers one side ONLY. Attach any answer sheets to the examination. Points for each question are indicated in parentheses for each question. A 70% in each category is required to pass the examination.

Examinations will be picked up three (3) hours after the examination starts.

CATEGORY VALUE	% OF TOTAL	CANDIDATE'S SCORE	% OF CATEGORY VALUE	CATEGORY
20	35	______	____	A. REACTOR THEORY, THERMODYNAMICS, AND FACILITY OPERATING CHARACTERISTICS
19	35	______	____	B. NORMAL AND EMERGENCY OPERATING PROCEDURES AND RADIOLOGICAL CONTROLS
16	30	______	____	C. FACILITY AND RADIATION MONITORING SYSTEMS
55		______	_____% FINAL GRADE	

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 not received or given assistance in completing the examination. This must be done after you complete the examination.

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

4. Use black ink or dark pencil only to facilitate legible reproductions.

5. Print your name in the blank provided in the upper right-hand corner of the examination cover sheet.

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

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

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

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

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

11. When you are done and have turned in your examination, leave the examination area as defined by the examiner. If you are found in this area while the examination is still in progress, your license may be denied or revoked.

QUESTION: 001 (1.00)

Element “X” is a 1/v absorber. The absorption cross section σ_a for element “X” for 0.0253 eV neutrons is 100 barns. Which ONE of the following is the absorption cross section of element “X” for 0.0506 eV neutrons?

a. 50.0 barns

b. 70.7 barns

c. 100.0 barns

d. 200.0 barns

QUESTION: 002

Which ONE of the following conditions would increase shutdown margin?

a. An experiment that added positive reactivity.

b. Depletion of uranium fuel.

c. Removal of a void from the core.

d. Decreasing fuel temperature.

QUESTION: 003 (1.00)

A reactor is exactly critical when a 100 cc void is introduced into the core. As a result, a control rod with an average rod worth of 0.1% delta k/k/inch must be withdrawn 10 inches in order to make the reactor critical again. The void coefficient is:

a. + 0.01% delta k/k/cc

b. + 0.10% delta k/k/cc

c. - 0.01% delta k/k/cc

d. -0.10% delta k/k/cc

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

QUESTION: 004 (1.00)

During a reactor startup, the count rate is increasing linearly with time, with no rod motion. (The Y-axis is a linear scale.) This means that:

a. the reactor is subcritical and the count rate increase is due to the buildup of delayed neutron precursors.

b. the reactor is critical and the count rate increase is due to source neutrons.

c. the reactor is subcritical and the count rate increase is due to source neutrons.

d. the reactor is critical and the count rate increase is due to the buildup of delayed neutron precursors.

QUESTION: 005 (1.00)

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

a. supercritical.

b. exactly critical.

c. prompt critical.

d. subcritical.

QUESTION: 006 (1.00)

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

a. 0.004 delta k/k.

b. 0.4% delta k/k.

c. 1.004% delta k/k.

d. Indeterminate, since any amount of positive reactivity could be used.

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

QUESTION: 007 (1.00)

A reactor is operating at criticality. Instantaneously, all of the delayed neutrons are suddenly removed from the reactor. The K_{eff} of the reactor in this state would be approximately:

a. 1.007

b. 1.000

c. 0.000

d. 0.993

QUESTION: 008 (1.00)

Reactor power level is determined by irradiating a gold foil. If the actual irradiation time is longer than the irradiation time used in the equation for the determination of power level, the calculated power level will be:

a. greater than the actual power level.

b. Less than the actual power level.

c. The same as the actual power level.

d. Greater or less than the actual power level, depending on whether the irradiation was performed at a high or low power level.

QUESTION: 009 (1.00)

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

a. decreases because delayed neutron precursors are being produced at a slower rate.

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

c. decreases because prompt neutrons are being produced at a slower rate.

d. remains unchanged.

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

QUESTION: 010 (1.00)

Fuel is being loaded into the core. The operator is using a 1/M plot to monitor core loading. Which ONE of the following conditions would result in a non-conservative prediction of core critical mass, i.e., the reactor would reach criticality prior to the predicted critical mass?

a. The detector is too far away from the source and the fuel.

b. The detector is too close to the source and the fuel.

c. Excessive time is allowed between fuel elements being loaded.

d. A fuel element is placed between the source and the detector.

QUESTION: 011 (1.00)

Inelastic scattering is the process whereby a neutron collides with a nucleus and:

a. recoils with the same kinetic energy it had prior to the collision.

b. recoils with a lower kinetic energy, with the nucleus emitting a gamma ray.

c. is absorbed by the nucleus, with the nucleus emitting a gamma ray.

d. recoils with a higher kinetic energy, with the nucleus emitting a gamma ray.

QUESTION: 012 (1.00)

Which ONE of the following describes the difference between reflectors and moderators?

a. Reflector decrease core leakage while moderators thermalize neutrons.

b. Reflectors shield against neutrons while moderators decrease core leakage.

c. Reflectors decrease thermal leakage while moderators decrease fast leakage.

d. Reflectors thermalize neutrons while moderators decrease core leakage.

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

QUESTION: 013 (1.00)

A hypothetical fuel produces 20% of its power from the fission of element X and 80% of its power from the fission of element Y. The beta fraction of element X is 0.006 and the beta fraction of element Y is 0.008. The beta fraction of the fuel as a whole is:

a. 0.0064

b. 0.0070

c. 0.0076

d. 0.0140

QUESTION: 014 (1.00)

Which ONE of the following factors in the six-factor formula can be varied by the reactor operator?

a. Fast fission factor.

b. Reproduction factor.

c. Fast non-leakage factor.

d. Thermal utilization factor.

QUESTION: 015 (1.00)

In a critical reactor, 100 fast neutrons are produced from fission and start to slow down. Twenty neutrons are captured in resonance peaks and 10 leak out of the core after they have reached thermal energy. The remaining neutrons are absorbed in fuel and other materials. Each fission produces 2.5 neutrons and 85% of the neutrons absorbed in fuel result in fission. For this reactor, the thermal utilization factor is:

a. 0.47

b. 0.62

c. 0.67

d. 1.61

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

QUESTION: 016   (1.00)

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

a. Count rate will be lower for the first startup.

b. Count rate will be higher for the first startup.

c. Rod position will be lower for the first startup (rods will be further into the core.)

d. Rod position will be higher for the first startup (rods will be further out of the core.)

QUESTION: 017   (1.00)

Reactor A increases power from 1% to 2% with a period of 50 seconds. Reactor B increases power from 2% to 3%, also with a period of 50 seconds. Compared to reactor A, the time required for the power increase of reactor B is:

a. longer than A.

b. the same as A.

c. shorter than A.

d. longer or shorter, depending on the amount of reactivity inserted.

QUESTION: 018   (1.00)

Which ONE of the following would result in a determination of the excess reactivity of a reactor?

a. The reactor is critical at a low power level, with two control rods full out and a regulating rod at some position. The reactivity remaining in the regulating rod (i.e., its rod worth from its present position to full out) is the excess reactivity.

b. All rods are full in. The two control rods and the regulating rod are withdrawn until the reactor becomes critical. The total rod worth withdrawn is the excess reactivity.

c. The reactor is at full power. The total rod worth withdrawn is the excess reactivity.

d. The reactor is at full power. The regulating rod is moved from its present position to full in. The negative reactivity inserted by the regulating rod is the excess reactivity.

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

QUESTION: 019 (1.00)

An equal amount of positive reactivity is added to two identical reactors, Reactor A at a power level of 10 watts and Reactor B at a power level of 100 watts. Compared to Reactor A, the magnitude of the prompt jump in Reactor B will be:

a. larger, because power level is higher.

b. The same, because the magnitude depends only on how much reactivity was added.

c. Smaller, because at higher power levels the same reactivity addition has a smaller effect.

d. The same, unless the reactivity addition is equal to the beta fraction.

QUESTION: 020 (1.00)

A reactor with a negative fuel temperature reactivity coefficient is critical at full power. A control rod is inserted and the power decreases to a lower steady-state value. The reactivity of the reactor at the lower power level is zero because:

a. the positive reactivity due to the fuel temperature decrease balances the negative reactivity due to the control rod insertion.

b. the negative reactivity due to the fuel temperature decrease balances the negative reactivity due to the control rod insertion.

c. the positive reactivity due to the fuel temperature increase balances the negative reactivity due to the control rod insertion.

d. the negative reactivity due to the fuel temperature increase balances the negative reactivity due to the control rod insertion.

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

QUESTION: 001 (1.00) QUESTION DELETED

When verifying Period Meter performance during a startup, if indicated period does not fall within calculated limits:

a. a second measurement must be made before the startup can continue.

b. rod withdrawal must stop and the SRO notified.

c. the reactor must be immediately shut down.

d. the startup can continue only under the direct supervision of the SRO.

QUESTION: 002 (1.00)

In accordance with the Fuel Loading Procedure, fuel element transfers require:

a. a licensed operator at the console, a licensed operator on the bridge, and a senior reactor operator present.

b. a licensed operator at the console and a senior operator on the bridge.

c. a senior operator at the console and a licensed operator on the bridge.

d. a licensed operator at the console and a licensed operator on the bridge.

QUESTION: 003 (1.00)

In accordance with the Technical Specifications, which ONE situation below is permissible?

a. An experiment with a moving component having a reactivity worth of $0.50.

b. An excess reactivity above cold, clean critical of 1% delta k/k.

c. A depth of water in the reactor pool 9 feet above the top of the end box of the fuel elements.

d. Pool water resistivity = $5x10^6$ ohm-cm.

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

QUESTION: 004 (1.00)

The primary source of radiation release to the environment through the ventilation system during reactor operation is:

a. gamma emission from activated structural members.

b. argon-41 from the beam port and thermal column.

c. nitrogen-16 from pool water evaporation.

d. alpha-beta radiation from activation of air.

QUESTION: 005 (1.00)

In accordance with the Technical Specifications, which ONE situation below is NOT permissible?

a. Storage of a fuel element outside the reactor pool with a radiation level of 90 mRem/hour at the storage container surface.

b. Pool water activity = 10^{-4} µCi/ml.

c. Temperature coefficient of reactivity = - 5×10^{-5} delta k/k/deg F with an average core water temperature of 100 degrees F.

d. Reactor subcritical with all blades withdrawn.

QUESTION: 006 (1.00)

In accordance with the Technical Specifications, the reactor will be in a <u>shutdown</u> condition if:

a. the shutdown margin with the highest worth control blade fully withdrawn is greater than 1% delta k/k.

b. the reactor key is removed.

c. there are less than 12 fuel elements loaded on the grid plate.

d. the three control blades are fully inserted.

QUESTION: 007 (1.00)

The term “cold, clean, critical condition” means that:

a. the reactor is critical and is free of xenon and samarium.

b. the reactor core is at the ambient pool water temperature of between 70 and 75 degrees F.

c. the reactor core is less than 60 degrees F and is free of xenon and samarium.

d. the reactor is critical and free of any experiments.

QUESTION: 008 (1.00)

An area is established in a room for an experiment and has been posted as a High Radiation Area. Which ONE of the following additional actions must be taken?

a. Equip the area with a surveillance camera.

b. Place portable radiation monitors in the area.

c. Equip the door with an audible or visual alarm.

d. Place a lock on the door.

QUESTION: 009 (1.00)

A sample has been removed from the core and measures 110 mR/hour at 6 inches. In accordance with the “Routine Experiments and Samples Irradiation” procedure:

a. the sample must be reinserted in the pool until it measures less than 100 mR/hr.

b. the sample must be doubly encapsulated.

c. the sample may only be handled by a reactor staff member.

d. the area must be posted as a “Caution-High Radiation” area.

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

QUESTION: 010 (1.00)

The actual cold, clean core excess reactivity is 0.3% delta k/k. An unsecured (moving) experiment with a reactivity worth of + 0.15% delta k/k is being irradiated in the reactor. It is desired to add another experiment also having positive reactivity. The reactivity of the additional experiment cannot exceed:

a. +0.05% delta k/k.

b. +0.15% delta k/k.

c. +0.35% delta k/k.

d. +0.50% delta k/k.

QUESTION: 011 (1.00)

A licensed operator who fails to actively perform the functions of an operator for a minimum of four hours per quarter:

a. cannot operate the reactor until he/she has successfully completed an oral or written examination on console operation.

b. can continue to operate the reactor only under the direction of an operator or senior operator until ten startups are completed.

c. must operate the reactor for a sufficient number of hours in the next calendar quarter so that at least eight hours of operation have occurred in the two quarters.

d. cannot operate the reactor unless he/she has performed a minimum of six hours of licensed functions under the direction of an operator or senior operator.

QUESTION: 012 (1.00)

A portable radiation monitor may temporarily replace one of the fixed area radiation monitors provided that:

a. the required alarms are operational.

b. The portable monitor is capable of measuring neutron dose rates.

c. The portable monitor is used for a maximum time of one (1) week.

d. The portable monitor is calibrated (not a source check) before each startup.

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

QUESTION: 013 (1.00)

“The minimum shutdown margin under any condition with the highest worth control blade fully withdrawn shall be no less than 1% delta k/k.” This is an example of a(n):

a. general operating limitation.

b. procedural requirement.

c. safety limit.

d. surveillance requirement.

QUESTION: 014 (1.00)

The limit for minimum water level above the core is based on providing:

a. adequate neutron shielding during operation.

b. the proper amount of core cooling.

c. sufficient suction head for the purification pump.

d. adequate gamma radiation shielding during operation.

QUESTION: 015 (1.00)

During critical operation of the reactor, the safety system functions that are required to be operable at ALL times are:

a. reactor period, reactor power, pool radiation monitor.

b. reactor period, reactor power, manual scram.

c. reactor power, neutron count rate, pool water level.

d. reactor power, manual scram, pool water level.

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

QUESTION: 016 (1.00)

An Emergency Action Level is:

a. a condition that 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 procedure that details the implementation actions and methods required to achieve the objectives of the Emergency Plan.

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

QUESTION: 017 (1.00)

Which ONE of the following activities may be performed by a licensed operator without the permission or supervision of a senior licensed operator?

a. Maintenance of the regulating rod drive.

b. Movement of fuel from the core to a fuel rack.

c. Placing the pool water level safety switch in the BYPASS condition.

d. Measurement of rod drop times.

QUESTION: 018 (1.00)

As part of the reactor checkout procedure prior to operation, the regulating blade is withdrawn from beyond its “in” limit, and then it is checked that no control blade can be withdrawn. The purpose of this check is to:

a. ensure that the reactor can only be taken critical using the regulating blade.

b. verify that a control blade cannot be moved if the Startup count rate meter shows less than 50 counts per second.

c. verify that the regulating blade will scram when the source bottle is used to obtain a period of about six seconds.

d. verify that the regulating blade position indicator is operating properly.

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

QUESTION: 019 (1.00)

In accordance with 10 CFR 20, which ONE of the following defines “Total Effective Dose Equivalent (TEDE)?”

a. The sum of the Internal Dose and External Dose.

b. The dose that the whole body receives from sources outside the body.

c. The sum of External Dose and Organ Dose.

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

QUESTION: 020 (1.00)

In accordance with the Emergency Plan, the term “on-site” means:

a. within the operations boundary.

b. within the Emergency Planning Zone.

c. the area within the site boundary.

d. the WPI campus.

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

QUESTION: 001 (1.00)

The shrouds which surround each safety blade have small holes at the bottom. The purpose of these holes is to:

a. minimize the effect of viscous damping on scram times.

b. provide a cooling water path through the shrouds.

c. provide points where a shroud lifting tool can be attached.

d. smooth out the thermal neutron flux distribution at the bottom of the core.

QUESTION: 002 (1.00)

When normal electrical power is lost, emergency power is provided by batteries to:

a. area radiation monitors, evacuation alarms, and facility emergency lighting.

b. area radiation monitors, control rod drive system, and evacuation alarms.

c. neutron detectors, evacuation alarms, and facility emergency lighting.

d. neutron detectors, control rod drive system, and evacuation alarms.

QUESTION: 003 (1.00)

Pool water purity is measured by a resistivity probe located at:

a. the outlet of the demineralizer.

b. the inlet to the demineralizer.

c. the outlet of the purification pump.

d. the outlet of the reactor pool.

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

QUESTION: 004 (1.00)

When reactor power is raised above 1 kW, the thermal column and beamport exhaust fans:

a. will automatically start.

b. will automatically start and will automatically stop when power is reduced below 1 kW.

c. will automatically start, but must be manually stopped when power is reduced below 1 kW.

d. must be manually started and manually stopped when power is reduced below 1 kW.

QUESTION: 005 (1.00)

During a reactor startup, safety blades cannot be withdrawn unless:

a. the B-10 counter is fully inserted and the Log N channel is above 3000 cpm.

b. the regulating blade is fully inserted and the Log N channel is above 3000 cpm.

c. the B-10 counter is fully inserted and the Startup channel is above 3000 cpm.

d. the regulating blade is fully inserted and the Startup channel is above 3000 cpm.

QUESTION: 006 (1.00)

The “TEST” position of the Master Switch allows:

a. insertion of scram signals without de-energizing the scram magnets.

b. control power and lamp indication operability testing.

c. control blade drive motion without energizing the magnets.

d. control blade drive motion with energized magnets.

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

QUESTION: 007 (1.00)

In case of a radioactive spill, the ventilation system:

a. exhaust duct must be closed.

b. supply and exhaust ducts must be closed.

c. fans must be tripped.

d. remains operating.

QUESTION: 008 (1.00)

Which ONE condition below will NOT result in a reactor scram?

a. Fast reactor period.

b. High pool monitor radiation.

c. Safety channel high voltage failure.

d. High neutron flux.

QUESTION: 009 (1.00)

During periodic leak testing of the neutron source, filter paper wipes are counted for the detection of:

a. alpha radiation.

b. beta radiation.

c. gamma radiation.

d. neutrons.

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

QUESTION: 010 (1.00)

Which ONE of the following will cause a building evacuation alarm?

a. Loss of electrical power.

b. High pool temperature.

c. High radiation level at fuel storage container surface.

d. Low pool water level.

QUESTION: 011 (1.00)

During full power operation, the B-10 proportional counter is fully withdrawn to its uppermost position so that the:

a. high count rate interlock will not prevent blade withdrawal.

b. high count rate will not initiate a period scram.

c. “Startup channel full-in” annunciator will not alarm.

d. high count rate will not initiate a reactor scram.

QUESTION: 012 (1.00)

Period information is supplied from:

a. safety channel #1.

b. safety channel #2.

c. Log N channel.

d. startup channel.

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

QUESTION: 013 (1.00)

Reactor fuel consists of:

a. 20% enriched alloy with aluminum cladding.

b. 20% enriched alloy with stainless steel cladding.

c. 93% enriched alloy with aluminum cladding.

d. 93% enriched alloy with stainless steel cladding.

QUESTION: 014 (1.00)

For a safety blade, the “IN” light if OFF, the “OUT” light is ON, and the “MAGNET ENGAGED” light is OFF. This indicates that:

a. the blade and drive are not in contact, the blade is full up and the drive is full down.

b. The blade and drive are both full up.

c. The blade and drive are both full down.

d. The blade and drive are not in contact, the drive is full up and the blade is full down.

QUESTION: 015 (1.00)

Which ONE of the following safety blade withdrawal interlocks provides protection against an abnormally high reactivity insertion?

a. Log N count below 3000 cpm.

b. 5-second delay subsequent to reactor startup.

c. Regulating blade is withdrawn from its lowest position.

d. Flux rises above a preset level before the safety blades are completely withdrawn.

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

QUESTION: 016 (1.00)

The poison section of a safety blade is constructed from:

a. stainless steel.

b. boron carbide and aluminum, sandwiched between aluminum plates.

c. boron carbide and aluminum, sandwiched between stainless steel plates.

d. aluminum.

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

A. REACTOR THEORY, THERMODYNAMICS & FACILITY OPERATING CHARACTERISTICS

ANSWER: 001 (1.00)
B.
REFERENCE:
Lamarsh, Introduction to Nuclear Engineering, 2^{nd}. Edition, page 57.

ANSWER: 002 (1.00)
B.
REFERENCE:
Any condition that adds negative reactivity increases shutdown margin.

ANSWER: 003 (1.00)
C.
REFERENCE:
Lamarsh, Introduction to Nuclear Engineering, 2^{nd}. Edition, page 315.
Reactivity due to voids + reactivity due to control rod = 0
(100 cc)x(Void coefficient) + (0.1% delta k/k/inch)x(10 inches) = 0
Void coefficient = - (1% delta k/k)/100cc = -0.01% delta k/k/cc

ANSWER: 004 (1.00)
B.
REFERENCE:
A linear increase means that a constant number of neutrons are being added each generation, which can only be due to source neutrons.

ANSWER: 005 (1.00)
D.
REFERENCE:
Lamarsh, Introduction to Nuclear Engineering, 2^{nd}. Edition, page 282.
Reactivity = (K-1)/K = -4.7% delta K/K. If + 3.5% delta K/K is added, the new reactivity will be
-1.2%, i.e., subcritical.

ANSWER: 006 (1.00)
D.
REFERENCE:
Lamarsh, Introduction to Nuclear Engineering, 2^{nd}. Edition, page 285.

ANSWER: 007 (1.00)
D.
REFERENCE:
Lamarsh, Introduction to Nuclear Engineering, 2^{nd}. Edition, page 286.

ANSWER: 008 (1.00)
A.
REFERENCE:
Power Level Calibration Procedure.

ANSWER: 009 (1.00)
B.
REFERENCE:
Lamarsh, Introduction to Nuclear Engineering, 2^{nd}. Edition, page 281.

ANSWER: 010 (1.00)
A.
REFERENCE:
A detector that is too far from the source and fuel will underestimate the effects of adding fuel, since the measured counts will not appreciably increase with each fuel element addition.

ANSWER: 011 (1.00)
B.
REFERENCE:
Lamarsh, Introduction to Nuclear Engineering, 2^{nd}. Edition, page 57.

ANSWER: 012 (1.00)
A.
REFERENCE:
Lamarsh, Introduction to Nuclear Engineering, 2^{nd}. Edition, page 117.

ANSWER: 013 (1.00)
C.
REFERENCE:
Lamarsh, Introduction to Nuclear Engineering, 2^{nd}. Edition, page 74.
The beta fraction for the fuel is the power (fission) weighted average of the beta fractions for each component.
Beta = (0.2)(0.006) + (0.8)(0.008) = 0.0076

ANSWER: 014 (1.00)
D.
REFERENCE:
Lamarsh, Introduction to Nuclear Engineering, 2^{nd}. Edition, page 222.

ANSWER: 015 (1.00)
C.
REFERENCE:
Lamarsh, Introduction to Nuclear Engineering, 2^{nd}. Edition, page 262.
A total of 70 thermal neutrons (100-20-10) are absorbed in the fuel plus other materials. Since the reactor is critical, there were 40 fissions (40x2.5 = 100). Since 85% of the absorptions result in fission, there were 40/0.85 = 47 neutrons absorbed in fuel. The thermal utilization is 47/70 = 0.67.

ANSWER: 016 (1.00)
B.
REFERENCE:
Count Rate is proportional to (Source Strength)/(1 - K)

ANSWER: 017 (1.00)
C.
REFERENCE:
Lamarsh, Introduction to Nuclear Engineering, 2^{nd}. Edition, page 279.
The power for reactor A increases by a factor of 2, while the power for reactor B increases by a factor of 1.5. Since the periods are the same, power increase B takes a shorter time.

ANSWER: 018 (1.00)
A.
REFERENCE:
Regulating Blade Worth and Excess Reactivity Measurement Procedure.

ANSWER: 019 (1.00)
A.
REFERENCE:
Lamarsh, Introduction to Nuclear Engineering, 2nd. Edition, page 288.
$\varphi/\varphi_o = \beta(1-\rho)/(\beta-\rho)$. Since the ratio of the magnitude of the prompt jump to the initial power is the same for each reactor, the prompt jump is higher in Reactor B.

ANSWER: 020 (1.00)
A.
REFERENCE:
Lamarsh, Introduction to Nuclear Engineering, 2nd. Edition, page 307.

B. NORMAL/EMERGENCY PROCEDURES & RADIOLOGICAL CONTROLS

ANSWER: 001 (1.00) QUESTION DELETED
C.
REFERENCE:
WPI Standing Order 2.

ANSWER: 002 (1.00)
A.
REFERENCE:
WPI Fuel Loading Procedure.

ANSWER: 003 (1.00)
D.
REFERENCE:
WPI Technical Specifications, Section 2.1.

ANSWER: 004 (1.00)
B.
REFERENCE:
WPI RHSC, Regulations and Argon Release Calculations.

ANSWER: 005 (1.00)
B.
REFERENCE:
WPI Technical Specifications, Section 2.1.

ANSWER: 006 (1.00)
C.
REFERENCE:
WPI Technical Specifications, Section 1.0.

ANSWER: 007 (1.00)
B.
REFERENCE:
WPI Technical Specifications, Section 1.0.

ANSWER: 008 (1.00)
C.
REFERENCE:
WPI RHSC, page 2.

ANSWER: 009 (1.00)
C.
REFERENCE:
OP-02, Routine Experiments and Sample Irradiation, Section 5.7.

ANSWER: 010 (1.00)
A.
REFERENCE:
WPI Technical Specifications, Section 2.3(4).

ANSWER: 011 (1.00)
D.

REFERENCE:
WPI Requalification Program.
ANSWER: 012 (1.00)
A.
REFERENCE:
WPI Technical Specifications, Section 3.3.

ANSWER: 013 (1.00)
C.
REFERENCE:
WPI Technical Specifications, Section 2.1.

ANSWER: 014 (1.00)
D.
REFERENCE:
SAR, Section 4.5.

ANSWER: 015 (1.00)
B.
REFERENCE:
WPI Technical Specifications, Table 4.1.

ANSWER: 016 (1.00)
D.
REFERENCE:
Emergency Plan, Definitions.

ANSWER: 017 (1.00)
D.
REFERENCE:
OP-7, Rod Drop Measurement Procedures.

ANSWER: 018 (1.00)
A.
REFERENCE:
OP-1, Reactor Startup, Section I.12.

ANSWER: 019 (1.00)
A.
REFERENCE:
10 CFR 20.

ANSWER: 020 (1.00)
C.
REFERENCE:
Emergency Plan, Definitions.

C. FACILITY AND RADIATION MONITORING SYSTEMS

ANSWER: 001 (1.00)
A.
REFERENCE:
SAR, Section 4.2.2.1.

ANSWER: 002 (1.00)
A.
REFERENCE:
SAR, Section 8.2.

ANSWER: 003 (1.00)
A.
REFERENCE:
MP-01.

ANSWER: 004 (1.00)
D.
REFERENCE:
OP-01.

ANSWER: 005 (1.00)
D.
REFERENCE:
SAR, Section 7.7.

ANSWER: 006 (1.00)
C.
REFERENCE:
SAR, Section 8.1.

ANSWER: 007 (1.00)
D.
REFERENCE:
SAR, Section 9.1.

ANSWER: 008 (1.00)
B.
REFERENCE:
SAR, Section 7.9.

ANSWER: 009 (1.00)
A.
REFERENCE:
SAR, Section 4.2.4.

ANSWER: 010 (1.00)
D.
REFERENCE:
Technical Specifications, Table 4.1.

ANSWER: 011 (1.00)
A.

REFERENCE:
SAR, Section 7.4.

ANSWER: 012 (1.00)
C.
REFERENCE:
SAR, Section 7.6.

ANSWER: 013 (1.00)
A.
REFERENCE:
SAR, Section 4.2.1.

ANSWER: 014 (1.00)
D.
REFERENCE:
Reactor Facility Data, Figure 19.

ANSWER: 015 (1.00)
D.
REFERENCE:
SAR, Section 7.7.

ANSWER: 016 (1.00)
B.
REFERENCE:
SAR, Section 4.2.2.1.

A. REACTOR THEORY, THERMODYNAMICS AND FACILITY OPERATING CHARACTERISTICS

ANSWER SHEET

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

001 a b c d ______

002 a b c d ______

003 a b c d ______

004 a b c d ______

005 a b c d ______

006 a b c d ______

007 a b c d ______

008 a b c d ______

009 a b c d ______

010 a b c d ______

011 a b c d ______

012 a b c d ______

013 a b c d ______

014 a b c d ______

015 a b c d ______

016 a b c d ______

017 a b c d ______

018 a b c d ______

019 a b c d ______

020 a b c d ______

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

B. NORMAL/EMERGENCY PROCEDURES & RADIOLOGICAL CONTROLS

ANSWER SHEET

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

001 a b c d ______ QUESTION DELETED

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 *****)

C. FACILITY AND RADIATION MONITORING SYSTEMS

ANSWER SHEET

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

001 a b c d ______

002 a b c d ______

003 a b c d ______

004 a b c d ______

005 a b c d ______

006 a b c d ______

007 a b c d ______

008 a b c d ______

009 a b c d ______

010 a b c d ______

011 a b c d ______

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 ______

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

EQUATION SHEET

$Q = m\ c_p\ \Delta T$

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

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

$DR_1D_1^2 = DR_2D_2^2$

$DR = 6CiE/D^2$

1 Curie = $3.7x10^{10}$ dps

EF = 9/5EC + 32

EC = 5/9 (EF - 32)

$N = S/(1-K)$

$CR_1\ (1-K_1) = CR_2\ (1-K_2)$

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

λ_{eff} = 0.1 seconds^{-1}

$DR = DR_oe^{-\lambda t}$

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

1 gallon water = 8.34 pounds

1 Mw = $3.41x10^6$ BTU/hr

1 Mev = $1.6x10^{-13}$ watt-sec