July 21, 2004

Dr. C. Frederick Sears, Director
Penn State Breazeale Reactor
Pennsylvania State University
University Park, PA 16802-1504

SUBJECT: INITIAL EXAMINATION REPORT NO. 50-005/OL-04-01, PENNSYLVANIA STATE UNIVERSITY

Dear Dr. Sears:

During the week of June 21, 2004, the NRC administered initial examinations to employees of your facility who had applied for a license to operate your Pennsylvania State University reactor. The examination was conducted in accordance with 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/NRC/ADAMS/index.html. The NRC is forwarding the individual grades to you in a separate letter which will not be released publicly. Should you have any questions concerning this examination, please contact Mr. Kevin Witt at 301-415-4075 or internet e-mail kmw@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. 50-005

Enclosures: 1. Initial Examination Report No. 50-005/OL-04-01
2. Facility comments with NRC resolution
3. Examination and answer key

cc w/encls:
Please see next page

cc:

Mr. Eric J. Boeldt, Manager of
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The Pennsylvania State University
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Mr. William P. Dornsife, Director
Bureau of Radiation Protection
Department of Environmental Protection
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Office of Nuclear Reactor Regulation

Docket No. 50-005

Enclosures: 1. Initial Examination Report No. 50-005/OL-04-01
2. Facility comments with NRC resolution
3. Examination and answer key

cc w/encls:
Please see next page

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Facility File (EBarnhill)

DISTRIBUTION w/o encls.:
RNRP/R&TR r/f
KWitt
PMadden

ADAMS PACKAGE ACCESSION NO.: ML040560204
ADAMS REPORT ACCESSION NO.: ML041900224 **TEMPLATE #: NRR-074**

OFFICE	RORP:CE		IROB:LA		RORP:SC	
NAME	KWitt:vmj		EBarnhill		PMadden	
DATE	07/ 8 /2004		07/ 9 /2004		07/ 12 /2004	

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

REPORT NO.: 50-005/OL-04-01

FACILITY DOCKET NO.: 50-005

FACILITY LICENSE NO.: R-2

FACILITY: Pennsylvania State University

EXAMINATION DATES: June 23-25, 2004

SUBMITTED BY: _____ 7 / / 2004
Kevin Witt, Chief Examiner Date

SUMMARY:

During the week of June 21, 2004, the NRC administered operator licensing examinations to two Senior Reactor Operator (Instant) candidates, one Senior Reactor Operator (Upgrade) candidates, and one Reactor Operator candidate. All candidates passed the examinations.

REPORT DETAILS

1. Examiners:
   Kevin Witt, Chief Examiner

2. Results:

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

3. Exit Meeting:
   Kevin Witt, NRC, Chief Examiner
   Terry Flinchbaugh, PSBR, Associate Director for Operations

   The NRC thanked the facility staff for their assistance and cooperation during the examination. The facility staff presented the Chief Examiner with comments on the written examination. Generic weaknesses noted were minor, and included confusion about the gamma ion chamber, shut down checks, and 10 CFR 55. The facility staff agreed to put a stronger emphasis on these items before the next examinations are administered.

ENCLOSURE 1

Facility Comments with NRC Resolution

Question A.16:
The reactor is operating in the automatic mode at 50% power. The prompt negative power coefficient of the PSBR is $-1.4\times10^{-4}\ \frac{\Delta K/K}{^{o}C}$ and the **average** control rod worth of the regulating control rod is $1.85\times10^{-3}\ \$/inch$. An external event causes the primary coolant temperature to increase from 200°C to 225°C. How much will the operator pull the regulating rod out to compensate for power? ($\bar{\beta}_{eff} = 0.007\ \Delta K/K$)

A. 155 units

B. 270 units

C. 540 units

D. 765 units

Facility Comment:
The word "fuel" was substituted for "primary coolant" during the exam.

NRC Resolution:
Comment accepted. The question will be modified accordingly.

Question A.20:
What type of reaction forms the Ar^{41} that is formed from reactor operations?

A. $_{16}S^{38}$ (α, n) $_{18}Ar^{41}$

B. $_{18}Ar^{40}$ (n, γ) $_{18}Ar^{41}$

C. $_{19}K^{42}$ (γ, p) $_{18}Ar^{41}$

D. $_{19}K^{41}$ (n, p) $_{18}Ar^{41}$

Facility Comment:
Answer key error. Key has D as the answer but the answer is B as indicated in the reference.

NRC Resolution:
Comment accepted. The answer key will be modified to accept "b" as the correct answer.

ENCLOSURE 2

Question B.1:
For a loss of pool water through a beam port in the neutron beam laboratory, which ONE of the following beam ports can NOT be repaired using an inflatable test plug?

A. # 1

B. # 3

C. # 4

D. # 7

Facility Comment:
The answer key has D. which is correct, however, B would also be a correct answer.

NRC Resolution:
Comment accepted. The answer key will be modified to accept “b” and “d” as correct answers.

Question B.10:
Which ONE of the following conditions requires immediate actions during reactor operations as specified in the technical specifications?

A. Bulk pool water temperature is 122^{o}F (50^{o}C).

B. A single in-core experiment has a reactivity worth of 1.5%Δk/k ($2.14).

C. The shim control rod drop time is 0.5 seconds.

D. Pool water level is 19 feet above the bottom grid plate of the core.

Facility Comment:
The word “movable” was added after the word “single” during the exam.

NRC Resolution:
Comment accepted. The question will be modified accordingly.

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

FACILITY: Pennsylvania State University

REACTOR TYPE: TRIGA MARK-III

DATE ADMINISTERED: 06/23/04

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% in each section is required to pass the examination. Examinations will be picked up three (3) hours after the examination starts.

Category Value	% of Total	Candidates Score	% of Category Value	Category
20.00	33.3	_____	____	A. Reactor Theory, Thermodynamics and Facility Operating Characteristics
20.00	33.3	_____	____	B. Normal and Emergency Operating Procedures and Radiological Controls
20.00	33.3	_____	____	C. Facility and Radiation Monitoring Systems
60.00		_____	____% FINAL GRADE	TOTALS

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

_____
Candidate's Signature

ENCLOSURE 3

QUESTION A.1 [1.0 point]
Which of the following best describes the fission product masses?

A. $1<A<70$

B. $70<A<160$

C. $160<A<200$

D. $200<A<300$

QUESTION A.2 [1.0 point]
Reactivity is a measure of the:

A. Number of neutrons being produced in the core.

B. Number of neutrons being absorbed by the fuel.

C. Reactor's deviation from critical.

D. Reactor's multiplication factor.

QUESTION A.3 [1.0 point]
Which ONE 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.4 [1.0 point]
How is the macroscopic cross section different than the microscopic cross section?

A. It never changes with energy level.

B. It always is a total for all reactions.

C. It is only applicable to one type of reaction.

D. It considers the atom density.

(*** Category A continued on next page *****)**

QUESTION A.5 [1.0 point]
Which ONE of the following has the highest probability of occurring for a thermal neutron with E = 0.025 eV?

A. Fission with ^{235}U

B. Absorption by ^{235}U

C. Fission with ^{238}U

D. Absorption by ^{238}U

QUESTION A.6 [1.0 point]
What is the primary reason delayed neutrons are so effective at controlling reactor power changes?

A. A very large fraction of the fission neutrons in the core are delayed.

B. Prompt neutrons have a much shorter mean lifetime than delayed neutrons.

C. Prompt neutrons are born at higher energies than delayed neutrons.

D. Delayed neutrons are born at thermal energies.

QUESTION A.7 [1.0 point]
Where is the hottest part of a fuel element during a pulse?

A. The center of the element.

B. Half the distance from the center of the fuel to the outside of the fuel portion.

C. In the gap between the fuel and the cladding.

D. On the outside of the element.

QUESTION A.8 [1.0 point]
Which ONE of the following is the STRONGEST contributor to the prompt negative temperature coefficient at the PSBR? (Assuming steady state operations)

A. Zirconium Hydride cell effects

B. Doppler broadening of the U-238 resonances

C. Density changes in the poison material in the control rods

D. Core leakage

(*** Category A continued on next page *****)**

QUESTION A.9 [1.0 point]
A reactor has scrammed resulting in a negative reactivity insertion of 0.003 δk/k. Which ONE of the following is the stable negative reactor period resulting from the scram?
($\ell^* = 10^{-3}$ seconds)

A. -3 seconds

B. -57 seconds

C. -80 seconds

D. -112 seconds

QUESTION A.10 [1.0 point]
Which ONE of the following is the direct source of delayed neutrons in the fission process?

A. Fissioning of ^{235}U

B. Spontaneous fissioning of the fission products

C. Absorption by ^{238}U

D. Decay of the fission product daughters

QUESTION A.11 [1.0 point]
A control rod is withdrawn from the core. Which ONE of the following explains the reactivity addition from the rod?

A. Reactivity added will be equal for each inch of withdrawal.

B. Reactivity addition per inch will be greatest from 40% to 60% withdrawn.

C. Reactivity addition per inch will be greatest in the bottom fourth of the core.

D. Reactivity added will be at a maximum for the first inch of withdrawal.

(*** Category A continued on next page *****)**

QUESTION A.12 [1.0 point]
Assume that the total worth of the Transient, Safety, Shim, and Regulating rods are, respectively, $2.86, $4.24, $2.73, and $2.77. The reactor is exactly critical at 50 W with the following control rod worth remaining in the core: Transient $1.08, Safety $1.54, Shim $1.00, Reg $1.00. What is the shutdown margin calculated according to the technical specification definition?

A. $3.74

B. $4.62

C. $7.98

D. $12.60

QUESTION A.13 [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?

A. 9 hours

B. 15 hours

C. 24 hours

D. 33 hours

QUESTION A.14 [1.0 point]
Which ONE of the following reactivity insertions will cause the reactor to become prompt critical?

A. $0.07

B. $0.99

C. 0.8% δk/k

D. 0.0035 δk/k

(*** Category A continued on next page *****)**

QUESTION A.15 [1.0 point]
Which ONE of the following is a factor which is included in the effective multiplication factor but is not part of the infinite multiplication factor?

A. Fast fission factor

B. Resonance escape probability

C. Fast non-leakage probability

D. Thermal utilization factor

QUESTION A.16 [1.0 point] Question changed to incorporate facility comments.
The reactor is operating in the automatic mode at 50% power. The prompt negative power coefficient of the PSBR is $-1.4\times10^{-4}\ \frac{\Delta K/K}{^oC}$ and the **average** control rod worth of the regulating control rod is $1.85\times10^{-3}\ \$/inch$. An external event causes the ~~primary coolant~~ fuel temperature to increase from 200°C to 225°C. How much will the operator pull the regulating rod out to compensate for power? ($\bar{\beta}_{eff} = 0.007\ \Delta K/K$)

A. 155 units

B. 270 units

C. 540 units

D. 765 units

QUESTION A.17 [1.0 point]
Fill in the blanks:
As k_{eff} approaches unity for a subcritical reactor, the neutron population _____ as k_{eff} increases for a given generation and a _____ period of time is required to reach the equilibrium neutron level.

A. Increases; shorter

B. Increases; longer

C. Decreases; shorter

D. Decreases; longer

(*** Category A continued on next page *****)**

QUESTION A.18 [1.0 point]
On average, how many neutrons will be emitted per fission from the PSBR core?

A. 3

B. 2.5

C. 2

D. 1.5

QUESTION A.19 [1.0 point]
Before the reactor is started up, k_{eff} is 0.8 and the count rate meter is reading 250 counts per minute. After pulling the control rods for a short time, you notice that the count rate has doubled to 500 counts per minute. What is the new k_{eff}?

A. 0.6

B. 0.7

C. 0.8

D. 0.9

QUESTION A.20 [1.0 point]
What type of reaction forms the Ar^{41} that is formed from reactor operations?

A. $_{16}S^{38}(\alpha, n)\ _{18}Ar^{41}$

B. $_{18}Ar^{40}(n, \gamma)\ _{18}Ar^{41}$

C. $_{19}K^{42}(\gamma, p)\ _{18}Ar^{41}$

D. $_{19}K^{41}(n, p)\ _{18}Ar^{41}$

QUESTION B.1 [1.0 point]
For a loss of pool water through a beam port in the neutron beam laboratory, which ONE of the following beam ports can NOT be repaired using an inflatable test plug?

A. # 1

B. # 3

C. # 4

D. # 7

QUESTION B.2 [1.0 point]
Which ONE of the following is a MAJOR concern in qualifying a new reactor pool reactor operating position?

A. Flexing of the reactor tower that could affect control rod scram times.

B. Higher possibility of damage due to bridge stress for positions never occupied before.

C. Increased heating of the pool water, resulting in corrosion of reactor components.

D. Different positions may not be able to accommodate some experimental facilities.

QUESTION B.3 [1.0 point]
There are no experiments installed in the core with a reactivity effect. If you want to conduct a pulse, what is the minimum pulse reactivity allowable per procedures?

A. $0.50

B. $1.00

C. $1.50

D. $2.00

QUESTION B.4 [1.0 point]
Which ONE of the following emergency classifications would be used in the event of a loss of pool water exceeding the makeup capacity?

A. No classification

B. Non-reactor specific

C. Unusual event

D. Alert

(*** Category B continued on next page *****)**

QUESTION B.5 [1.0 point]
What is the purpose of removing the source from the core during the daily checkout procedure?

A. To reduce any unnecessary contributors when checking the power channel scrams.

B. To verify that the source level interlock message is received on the DCC-X.

C. To keep the reactor from reaching criticality while performing the checkout.

D. To check the response of the power channels when the source is moved near them.

QUESTION B.6 [1.0 point]
What is the definition of Total Effective Dose Equivalent (TEDE)?

A. Sum of external and internal dose.

B. Dose equivalent at tissue depth of 1 cm.

C. Dose equivalent to organs or tissues.

D. Sum of dose multiplied by weighting factors.

QUESTION B.7 [1.0 point]
When counting the daily smears prior to reactor operation, one of the smears comes out greater than the background count rate plus the critical level on the calibration tag, yet the gross count rate is less than 100 cpm. Which ONE of the following should be done?

A. Notify the RPO and proceed to start up the reactor.

B. Inform the duty SRO, clean the area, and repeat the smears for that area.

C. Clean the area with a wet paper towel and proceed to start up the reactor.

D. Ensure that the contaminated area is defined and cancel reactor operations.

QUESTION B.8 [1.0 point]
You are the reactor operator for a pneumatic transfer system experiment. Which ONE of the following must be done after flushing the rabbit system with CO_2 and before going to the desired power level?

A. A blank sample is sent into the core while the reactor is shutdown.

B. A representative sample is sent into the core while the reactor is shutdown.

C. A blank sample is sent into the core while the reactor is at stand-by.

D. A representative sample is sent into the core while the reactor is at stand-by.

(*** Category B continued on next page *****)**

QUESTION B.9 [½ point each]
Match the following situations with the proper type of tag-out to be used:
(Each choice to be used ONCE)

A.	East facility exhaust system out of service.	1. Administrative (Yellow) - AD
B.	Fuel element temperature malfunction.	2. White with danger insignia - EN
C.	Power limit of 100kW due to maintenance.	3. Do Not Operate (Red) - DNO
D.	Closing the inlet valve when performing a resin change.	4. Equipment (Manila) - EQ

QUESTION B.10 [1.0 point] Question changed to incorporate facility comments.
Which ONE of the following conditions requires immediate actions during reactor operations as specified in the technical specifications?

A. Bulk pool water temperature is 122°F (50°C).

B. A single movable in-core experiment has a reactivity worth of 1.5%Δk/k ($2.14).

C. The shim control rod drop time is 0.5 seconds.

D. Pool water level is 19 feet above the bottom grid plate of the core.

QUESTION B.11 [1.0 point]
How often do the radiation monitor checks in the “Radiation, Evacuation, and Alarm Checks” procedure, SOP-4, have to be completed?

A. Daily

B. Weekly

C. Monthly

D. Quarterly

QUESTION B.12 [1.0 point]
Who is the lowest level of authority that can make minor procedural changes to <u>experimental procedures</u> that do not change the intent of the procedure?

A. Reactor Operator

B. Senior Reactor Operator

C. Associate Director for Operations

D. Facility Director

(*** Category B continued on next page *****)**

QUESTION B.13 [1.0 point]
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 already out of the core 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 racks.

C. The control rods are withdrawn to a subcritical position and the core is subcritical by greater than $1.00.

D. All control rods are fully inserted and an experiment having a negative reactivity effect of $0.50 is installed in the reactor.

QUESTION B.14 [1.0 point]
If there is a fission product release while you are operating the reactor, what would be your immediate response after scramming the reactor and notifying the SRO?

A. Cover the pool with a tarp to reduce the amount of radiation leaking from the pool.

B. Move fuel from inner ring to storage racks to prevent any further releases.

C. Place lead shielding above the pool deck plates in order to lower radiation dose rates.

D. Evacuate the reactor bay to impede unnecessary exposure to radiation.

QUESTION B.15 [⅓ point each]
Select the MODE from Column II when the Safety Channels from Column I are required to be operable. Modes may be used once, more than once, or not at all.

Column I (Safety Channel)	Column II (Mode)
a. Fuel Element Temperature	1. Steady State only
b. Preset timer	2. Steady State and Square Wave only
c. Log Power	3. Pulse only
	4. All modes

(*** Category B continued on next page *****)**

QUESTION B.16 [1.0 point]
The radiation from an unshielded Cs-137 source is 250 mrem/hr at a distance of 30 cm. What thickness of lead shielding will be needed to lower the radiation level to values below those acceptable for a “Radiation Area”? The HVL (half-thickness) for Cs-137 and lead is 6.5 mm.

A. 6.5 mm

B. 19.5 mm

C. 26 mm

D. 39 mm

QUESTION B.17 [1.0 point]
Which ONE of the following items will ALLOW a reactor operator to continue to operate the reactor? (Assume today is the three year anniversary of receiving your RO license)

A. Last physical was 3 years ago.

B. Written exam administered by supervisor was 16 months ago.

C. 2 hours on the console last quarter performing the functions of a licensed operator.

D. Performing a power change using square wave mode 15 months ago.

QUESTION B.18 [1.0 point]
Which ONE of the following shall be used as the primary indicator of reactor power during normal steady-state operations?

A. Wide range monitor bar graph readout

B. Power range monitor bar graph readout

C. Wide range monitor DCC-X digital readout

D. Power range monitor DCC-X digital readout

QUESTION B.19 [1.0 point]
Nitrogen-16 is produced by neutron absorption in Oxygen-16. A majority of the Nitrogen-16 decays by:

A. a 1.3 Mev gamma with a half-life of 1.8 hours.

B. a 6.1 Mev gamma with a half-life of 7 seconds.

C. neutron emission with a half-life of 1.8 hours.

D. a 1.3 Mev beta with a half-life of 7 seconds.

(*** End of Category B *****)**

QUESTION C.1 [1.0 point]
Which ONE of the following is NOT a control rod limit switch?

A. Motor in the up position

B. Motor in the down position

C. Rod in the up position

D. Rod in the down position

QUESTION C.2 [1.0 point]
What is the purpose of the containment box in the pneumatic transfer system?

A. Maintains a negative pressure on the system to automatically remove samples.

B. Prevents workers from being exposed to Argon-41.

C. Serves as a reservoir allowing samples to be sent through the system.

D. Retains samples that are too radioactive to be handled.

QUESTION C.3 [1.0 point]
Which ONE of the following is NOT an element of the emergency exhaust system?

A. Cuno filter

B. Pre-filter

C. Absolute filter

D. Activated charcoal filter

QUESTION C.4 [1.0 point]
When an evacuation alarm occurs:

A. The Emergency Exhaust System activates and the Facility Exhaust System continues to operate.

B. The Emergency Exhaust System activates and the Facility Exhaust System is secured.

C. The Facility Exhaust System fans turn off but the louvers remain open.

D. The Facility Exhaust System fans turn off, and will restart when the evacuation is cleared.

(*** Category C continued on next page *****)**

QUESTION C.5 [1.0 point]
What will happen if the RM-25 monitor for the pneumatic transfer system exceeds the alarm setpoint?

A. The reactor will automatically scram.

B. The system fan will increase the negative pressure in the containment box.

C. The laboratory terminus will lock shut in order to prevent access to the sample.

D. The pressure in the system will be relieved by an electrically operated valve.

QUESTION C.6 [1.0 point]
Which ONE of the following control rods can NOT be manipulated by the DCC-X in the auto mode of operation?

A. Safety

B. Shim

C. Regulating

D. Transient

QUESTION C.7 [1.0 point]
Which ONE of the following describes an RSS operational interlock function while in the PULSE mode of operation?

A. Prevents manual withdrawal of more than one rod.

B. Prevents application of air to the transient rod if the drive is not fully down.

C. Prevents manual withdrawal of any rod.

D. Prevents withdrawal of all rods except the transient rod.

QUESTION C.8 [1.0 point]
In the PSBR Water Handling System, one of the pool water conductivity meters is located:

A. at the suction of the recirculation pump

B. downstream of the skimmer

C. at the inlet of the demineralizer

D. between the filter and recirculation pump

(*** Category C continued on next page *****)**

QUESTION C.9 [1.0 point]
What type of detectors are used in the reactor bay east and west air monitors?

A. Geiger-Mueller

B. Proportional counter

C. Ionization chamber

D. β^- Scintillation

QUESTION C.10 [1.0 point]
Where is the N-16 diffuser pump located?

A. In the mechanical equipment room.

B. Next to the beam ports in the beam hole lab.

C. Suspended beneath the reactor bridge.

D. On the bottom of the pool floor.

QUESTION C.11 [1.0 point]
Which ONE of the following neutron flux detectors provides a signal indicating the period of the reactor?

A. Uncompensated ion chamber

B. Gamma ion chamber

C. Fission chamber

D. Boron-trifluoride detector

QUESTION C.12 [1.0 point]
All operational interlocks and safety trips required by technical specifications are performed by the:

A. Digital Control Computer (DCC-Z)

B. Digital Control Computer (DCC-X)

C. protection, control and monitoring system (PCMS)

D. reactor safety system (RSS)

(*** Category C continued on next page *****)**

QUESTION C.13 [0.5 point each]
Where are the primary and secondary pressure sensors located for the heat exchanger differential pressure alarm? (In relation to the heat exchanger)

Primary and Secondary:
A. Inlet and inlet

B. Inlet and outlet

C. Outlet and inlet

D. Outlet and outlet

QUESTION C.14 [1.0 point]
What prevents reactor pool water from being accidently released into the environment through the pool drain lines ?

A. Water detection systems that stop all flow of water in the pipes.

B. Pneumatically controlled valves that can only be manipulated through the DCC-X.

C. Locks on the valves prevents manipulation by anyone except for those with “A” keys.

D. Anti-syphon valves that prevent water from flowing in the absence of water.

QUESTION C.15 [1.0 point]
Which ONE of the following materials could cause a fission product release if introduced into the reactor pool?

A. D_2O

B. Mercury

C. Iodine

D. Sodium

QUESTION C.16 [1.0 point]
What AUTOMATIC action is associated with a pool level low alarm?

A. Notification will be sent to the University police.

B. The reactor will scram immediately.

C. The primary coolant pump will stop running.

D. The evacuation alarm will be initiated.

(*** Category C continued on next page *****)**

QUESTION C.17 [1.0 point]
What is located below the boron carbide impregnated graphite section of the transient control rod?

A. Graphite reflector

B. Uranium zirconium hydride fuel

C. Air filled cavity

D. Nothing

QUESTION C.18 [1.0 point]
What will happen if the D_2O tank over pressurizes to >15 psi?

A. Nothing, since the D_2O tank is designed to handle pressures up to 50 psi.

B. The cover gas will absorb varying pressures in the D_2O tank.

C. The D_2O tank will burst open spilling its contents into the reactor pool water.

D. The pressure relief valve will release the appropriate amount of D_2O.

QUESTION C.19 [1.0 point]
Which ONE of the following is the main reason for having the small air compressor in the building compressed air supply system?

A. To provide a back-up for the large air compressor.

B. To prevent minor fluctuations in building compressed air pressure.

C. To supply air to the non-essential compressed air lines.

D. To contribute to the building compressed air pressure in addition to the large air compressor.

QUESTION C.20 [1.0 point]
Which ONE of the following detectors will NOT activate the emergency evacuation alarm upon receipt of a high radiation alarm?

A. Beam laboratory

B. Co-60 bay

C. Reactor bay/bridge south

D. Reactor bay air west

(*** End of Category C *****)**

Section A: Rx Theory, Thermodynamics & Facility Operating Characteristics ANSWERS

A.1 B
REF: PSBR Training Manual Chapter 2 Pg. 4

A.2 C
REF: PSBR Training Manual Chapter 2 Pg. 17

A.3 A
REF: PSBR Training Manual Chapter 2 Pg. 19

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

A.4 D
REF: PSBR Training Manual Chapter 2 Pg. 32

A.5 A
REF: Standard NRC Question (refer to cross section graph of U-235)
PSBR Training Manual Chapter 2 Pg. 7 (absorption cross section graph of U-238)

A.6 B
REF: PSBR Training Manual Chapter 2 Pg. 22

A.7 C
REF: PSBR SAR Chapter 9 Pg. 3

A.8 A
REF: PSBR Training Manual Chapter 2 Pg. 42-43

A.9 C
REF: PSBR Training Manual Chapter 2 Pg. 22
(Standard NRC Question)

A.10 D
REF: PSBR Training Manual Chapter 2 Pg. 20

A.11 B
REF: Standard NRC Question

A.12 A
REF: PSBR CCP-11 Page A-1 (Core Reactivity Evaluation)

$$S/D\ M\arg in = (\$2.86 + 4.24 + 2.73 + 2.77) - (\$1.08 + 1.54 + 1.00 + 1.00)$$
$$= \$7.98 - 4.24 = \$3.74$$

A.13 A
REF: PSBR Training Manual Chapter 2 Pg. 38

A.14 C
REF: PSBR Training Manual Chapter 2 Pg. 24

A.15 C
REF: PSBR Training Manual Chapter 2 Pg. 10

Section A: ~~R~~ **Theory, Thermodynamics & Facility Operating Characteristics** ANSWERS

A.16 B
REF: Standard NRC Question

$$1.85E-3\,{}^{\$}\!/_{unit}\times 0.007 = 1.295E-5\,\frac{{}^{\Delta K}\!/_{K}}{unit}$$

$$-1.4E-4\,\frac{{}^{\Delta K}\!/_{K}}{{}^{o}C} * 25^{o}C = -3.5E-3\,{}^{\Delta K}\!/_{K}$$

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

$$D = \frac{3.5E-3\,{}^{\Delta K}\!/_{K}}{1.295E-5\,\frac{{}^{\Delta K}\!/_{K}}{unit}} = 270\ units$$

A.17 B
REF: PSBR Training Manual Chapter 2 Pg. 29

A.18 B
REF: PSBR Training Manual Chapter 2 Pg. 5

A.19 D
REF: Standard NRC Question

$$CR_1\left(1-k_{eff\,1}\right) = CR_2\left(1-k_{eff\,2}\right) \rightarrow k_{eff\,2} = 1-\frac{CR_1\left(1-k_{eff\,1}\right)}{CR_2} = 1-\frac{250cpm(1-0.8)}{500cpm} = 0.9$$

A.20 ~~D~~ B (Answer changed to incorporate facility comments.)
REF: Standard NRC Question

$${}_{18}Ar^{40} + {}_{0}n^{1} \rightarrow {}_{18}Ar^{41} + \gamma$$

Section B: Normal / Emergency Procedures & Radiological Controls ANSWERS

B.1 D or B, 2nd correct answer added per NRC review of question commented on by facility.
REF: PSBR EP-4 Pg. 3 of 7 §V.D.3

B.2 A
REF: PSBR SOP-7 Pg. 1 of 5 §V.A.2

B.3 C
REF: PSBR SOP-1 Pg. 12 of 15 §V.E.2.a

B.4 D
REF: PSBR EP-1 Pg. 15 of 27 §A-6

B.5 B
REF: PSBR SOP-2 Pg. 3 of 16 §V.E.1.b

B.6 A
REF: 10 CFR 20.1003

B.7 B
REF: PSBR AOP-4 Pg. 2 of 3 §V.C.1

B.8 C
REF: PSBR SOP-9 Pg. 2 of 8 §V.A.7

B.9 A 4; B 3; C 1; D 2
REF: PSBR AP-10 Pgs. 1-3 of 3 §V.A-D

B.10 B
REF: PSBR TS 3.7.a (Pg. 25)

B.11 C
REF: PSBR TS 4.6.1 (Pg. 35)

B.12 B
REF: PSBR SOP-5 Pg. 4 of 8 §V.B

B.13 C
REF: PSBR TS 1.1.29&30 (Pg. 4)

B.14 D
REF: PSBR EP-5 Pg. 3 of 4 §V.F

B.15 A 4; B 3; C 2
REF: PSBR TS 3.2.4 (Pg. 16)

B.16 D
REF: 10 CFR 20.1003

B.17 B
REF: PSBR AP-3 Pgs. 1-7 of 8 §V.B-I

B.18 C
REF: PSBR SOP-1 Pg. 1 of 15 §II.J

B.19 B
REF: Chart of The Nuclides: http://www2.bnl.gov/ton

Section C: Facility and Radiation Monitoring Systems ANSWERS

C.1 C
REF: PSBR Training Manual Chapter 4 Pg. 40

C.2 C
REF: PSBR Training Manual Chapter 3 Pg. 30

C.3 A
REF: PSBR Training Manual Chapter 3 Pg. 26

C.4 B
REF: PSBR Training Manual Chapter 3 Pg. 24

C.5 D
REF: PSBR Training Manual Chapter 3 Pg. 30

C.6 D
REF: PSBR SAR VII-14

C.7 D
REF: PSBR Training Manual Chapter 4 Pg. 20

C.8 C
REF: PSBR Training Manual Chapter 3 Pg. 13

C.9 A
REF: PSBR Training Manual Chapter 4 Pg. 13

C.10 C
REF: PSBR Training Manual Chapter 3 Pg. 19

C.11 C
REF: PSBR Training Manual Chapter 4 Pg. 23

C.12 D
REF: PSBR Training Manual Chapter 4 Pg. 15

C.13 B
REF: PSBR Training Manual Chapter 3 Pg. 18

C.14 C
REF: PSBR Training Manual Chapter 3 Pg. 16

C.15 B
REF: PSBR Training Manual Chapter 3 Pg. 5

C.16 A
REF: PSBR SOP-4 Pg. 7 of 15 §V.I.2.b

C.17 C
REF: PSBR Training Manual Chapter 3 Pg. 8

C.18 D
REF: PSBR Training Manual Chapter 3 Pg. 33

Section C: Facility and Radiation Monitoring Systems ANSWERS

C.19 A
REF: PSBR Training Manual Chapter 3 Pg. 19

C.20 C
REF: PSBR SAR VII-52

Section A ℞ Theory, Thermo, and Facility Characteristics

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

A.1 a b c d ___

A.2 a b c d ___

A.3 a b c d ___

A.4 a b c d ___

A.5 a b c d ___

A.6 a b c d ___

A.7 a b c d ___

A.8 a b c d ___

A.9 a b c d ___

A.10 a b c d ___

A.11 a b c d ___

A.12 a b c d ___

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 ___

A.19 a b c d ___

A.20 a b c d ___

Section B Normal/Emerg. Procedures & Rad Con

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

B.1 a b c d ___

B.2 a b c d ___

B.3 a b c d ___

B.4 a b c d ___

B.5 a b c d ___

B.6 a b c d ___

B.7 a b c d ___

B.8 a b c d ___

B.9 a__ b__ c__ d__

B.10 a b c d ___

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__

B.16 a b c d ___

B.17 a b c d ___

B.18 a b c d ___

B.19 a b c d ___

Section C Facility and Radiation Monitoring Systems

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

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.18 a b c d ___

C.19 a b c d ___

C.20 a b c d ___

EQUATION SHEET

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

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

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

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

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

$$R_1(1-K_{eff_1}) = CR_2(1-K_{eff_2})$$
$$CR_1(-\rho_1) = CR_2(-\rho_2)$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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**