UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

June 8, 2018

Dr. Ayman I. Hawari, Director
Nuclear Reactor Program
Department of Nuclear Engineering
North Carolina State University
Campus Box 7909
2500 Stinson Drive
Raleigh, NC 27695-7909

SUBJECT: EXAMINATION REPORT NO. 50-297/OL-18-01, NORTH CAROLINA STATE UNIVERSITY

Dear Dr. Hawari:

During the week of April 23, 2018, the U.S. Nuclear Regulatory Commission (NRC) administered operator licensing examinations at your North Carolina State University PULSTAR reactor. The examination was conducted according to NUREG-1478, "Operator Licensing Examiner Standards for Research and Test Reactors," Revision 2. Examination questions and preliminary findings were discussed with you and those members of your staff identified in the enclosed report at the conclusion of the examination.

In accordance with Title 10 of the *Code of Federal Regulations* Section 2.390, a copy of this letter and the enclosure will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records (PARS) component of NRC's Agencywide Documents Access and Management System (ADAMS). ADAMS is accessible from the NRC Web site at 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 Mrs. Paulette Torres at (301) 415-5656 or via e-mail Paulette.Torres@nrc.gov.

Sincerely,

/RA/

Anthony J. Mendiola, Chief
Research and Test Reactors Oversight Branch
Division of Licensing Projects
Office of Nuclear Reactor Regulation

Docket No. 50-297

Enclosures: 1. Examination Report No. 50-297/OL-18-01
2. Written Examination

cc: w/o enclosure: See next page

SUBJECT: EXAMINATION REPORT NO. 50-297/OL-18-01, NORTH CAROLINA STATE UNIVERSITY DATED JUNE 8, 2018

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Office of Intergovernmental Relations
116 West Jones Street
Raleigh, NC 27603

Dr. Kostadin Ivanov, Head
Department of Nuclear Engineering
North Carolina State University
Campus Box 7909
Raleigh, NC 27695-7909

W. Lee Cox, Section Chief
Department of Health and Human Services
Division of Health Service Regulation
Radiation Protection Section
1645 Mail Service Center
Raleigh, NC 27699-1645

Dr. Louis Martin-Vega, Dean
College of Engineering
North Carolina State University
113 Page Hall
Campus Box 7901
Raleigh, NC 27695-7901

Test, Research and Training
Reactor Newsletter
P.O. Box 118300
University of Florida
Gainesville, FL 32611

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

REPORT NO.: 50-297/OL-18-01

FACILITY DOCKET NO.: 50-297

FACILITY LICENSE NO.: R-120

FACILITY: North Carolina State University PULSTAR reactor

EXAMINATION DATE: April 23-25, 2018

SUBMITTED BY: ***/RA/*** **05/09/2018**
Paulette Torres, Chief Examiner Date

SUMMARY:

During the week of April 23, 2018 the NRC administered licensing examinations to three Reactor Operator (RO) applicants. All three RO applicants passed all portions of the examination.

REPORT DETAILS

1. Examiner: Paulette Torres, Chief Examiner, NRC

2. Results:

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

3. Exit Meeting:
   Paulette Torres, Chief Examiner, NRC
   Gregory Gibson, Senior Reactor Operator, NCSU
   Andrew T. Cook, Manager of Engineering and Operations, NCSU

   The NRC examiner found one area of common deficiency between all three candidates: 1) Types of dosimetry and how they measure exposure to radiation. The facility should consider strengthening this area for future examinations.

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

FACILITY: NCSU

REACTOR TYPE: PULSTAR

DATE ADMINISTERED: 04/25/2018

CANDIDATE: ____________________

INSTRUCTIONS TO CANDIDATE:
Answers are to be written on the Answer sheet provided. Attach all Answer sheets to the examination. Point values are indicated in parentheses for each question. A 70% in each category is required to pass the examination. Examinations will be picked up three (3) hours after the examination starts.

CATEGORY VALUE	% OF TOTAL	CANDIDATE'S SCORE	% OF CATEGORY VALUE	CATEGORY
20.00	33.3	________	_____	A. REACTOR THEORY, THERMODYNAMICS AND FACILITY OPERATING CHARACTERISTICS
20.00	33.3	________	_____	B. NORMAL AND EMERGENCY OPERATING PROCEDURES AND RADIOLOGICAL CONTROLS
20.00	33.3	________	_____	C. FACILITY AND RADIATION MONITORING SYSTEMS
60.00		________ FINAL GRADE	_____ %	TOTALS

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

____
Candidate's Signature

ENCLOSURE 2

A. Reactor Theory, Thermohydraulics & Facility Operating Characteristics

A N S W E R   S H E E T

Multiple Choice (Circle or X your choice)
If you change your Answer, write your selection in the blank.

A01 a ___ b ___ c ___ d ___

A02 a b c d ___

A03 a b c d ___

A04 a b c d ___

A05 a b c d ___

A06 a b c d ___

A07 a b c d ___

A08 a b c d ___

A09 a b c d ___

A10 a b c d ___

A11 a b c d ___

A12 a b c d ___

A13 a b c d ___

A14 a b c d ___

A15 a b c d ___

A16 a b c d ___

A17 a b c d ___

A18 a ___ b ___ c ___ d ___

A19 a b c d ___

A20 a b c d ___

(***** END OF SECTION A *****)

B. Normal/Emergency Procedures and Radiological Controls

A N S W E R   S H E E T

Multiple Choice (Circle or X your choice)
If you change your Answer, write your selection in the blank.

B01 a b c d ___

B02 a b c d ___

B03 a b c d ___

B04 a b c d ___

B05 a b c d ___

B06 a b c d ___

B07 a b c d ___

B08 a b c d ___

B09 a ___ b ___ c ___ d ___

B10 a b c d ___

B11 a b c d ___

B12 a b c d ___

B13 a b c d ___

B14 a b c d ___

B15 a b c d ___

B16 a b c d ___

B17 a b c d ___

B18 a b c d ___

B19 a b c d ___

B20 a b c d ___

(***** END OF SECTION B *****)

C. Facility and Radiation Monitoring Systems

A N S W E R   S H E E T

Multiple Choice (Circle or X your choice)
If you change your Answer, write your selection in the blank.

C01 a b c d ___

C02 a b c d ___

C03 a b c d ___

C04 a b c d ___

C05 a b c d ___

C06 a b c d ___

C07 a b c d ___

C08 a b c d ___

C09 a b c d ___

C10 a b c d ___

C11 a b c d ___

C12 a b c d ___

C13 a b c d ___

C14 a b c d ___

C15 a b c d ___

C16 a b c d ___

C17 a b c d ___

C18 a b c d ___

C19 a b c d ___

C20 a b c d ___

(***** END OF SECTION C *****)
(********** END OF EXAMINATION **********)

NRC RULES AND GUIDELINES FOR LICENSE EXAMINATIONS

During the administration of this examination the following rules apply:

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

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

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

4. Use black ink or dark pencil <u>only</u> to facilitate legible reproductions.

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

6. Mark your Answers on the Answer sheet provided. USE ONLY THE PAPER PROVIDED AND DO NOT WRITE ON THE BACK SIDE OF THE PAGE.

7. The point value for each question is indicated in [brackets] after the question.

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

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

10. Ensure all information you wish to have evaluated as part of your Answer is on your Answer sheet. Scrap paper will be disposed of immediately following the examination.

11. To pass the examination you must achieve a grade of 70 percent or greater in each category.

12. There is a time limit of three (3) hours for completion of the examination.

EQUATION SHEET

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

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

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

$$P = P_0\ e^{t/\mathrm{T}}$$

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

$$\lambda^* = 1\times10^{-4}\sec$$

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

$$CR_1\left(1-K_{eff_1}\right) = CR_2\left(1-K_{eff_2}\right)$$

$$CR_1(-\rho_1) = CR_2(-\rho_2)$$

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

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

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

$$M = \frac{1-K_{eff_1}}{1-K_{eff\,2}}$$

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

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

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

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

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

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

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

$$DR_1\,d_1^{\ 2} = DR_2 d_2^{\ 2}$$

$$DR = \frac{6\,Ci\,E(n)}{R^2}$$

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

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

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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 = 1.0 BTU/hr/lbm/°F

c_p = 1 cal/sec/gm/°C

North Carolina State University
Pulstar Reactor

Operator Licensing Examination

Week of April 23, 2018

QUESTION A.01 [1.0 point, 0.25 each]
Match the following neutron interactions with its net result. Answers can be used more than once.

Column A	Column B
a. Elastic Scattering	1. γ – Rays
b. Inelastic Scattering	2. Positive Ions
c. Nuclear Reactions	3. Protons
d. Capture	

QUESTION A.02 [1.0 point]
Which ONE of the following factors has a long term effect on K_{eff} but is of no consequence during short term and transient operation?

a. Fuel burnup

b. Increase in fuel temperature

c. Increase in moderator temperature

d. Xenon and Samarium fission products

QUESTION A.03 [1.0 point]
Shutdown Margin is defined as:

a. The negative reactivity inserted by an increase in moderator temperature within the core when the reactor is brought from zero to full power.

b. Provides a measure of excess reactivity available to overcome fission product buildup, fuel burnup, and power defect.

c. The amount of negative reactivity that would be added to a core if the rods in a critical, cold, clean reactor were fully inserted.

d. The amount of reactivity available above what is required to keep the reactor critical.

QUESTION A.04 [1.0 point]
The count rate is 100 cps. An experimenter inserts an experiment into the core, and the count rate decreases to 60 cps. Given the initial K_{eff} of the reactor was 0.92, what is the worth of the experiment?

a. $\Delta\rho$ = - 0.07

b. $\Delta\rho$ = + 0.07

c. $\Delta\rho$ = - 0.02

d. $\Delta\rho$ = + 0.02

QUESTION A.05 [1.0 point]
Xenon-135 is formed directly by decay of __________.

a. Antimony-135

b. Cesium -135

c. Iodine-135

d. Tellurium-135

QUESTION A.06 [1.0 point]
What happens to the mass number and the atomic number of an element when it undergoes beta decay?

a. The mass number decreases by 4 and the atomic number decreases by 2.

b. The mass number does not change and the atomic number decreases by 2.

c. The mass number increases by 2 and the atomic number increases by 1.

d. The mass number does not change and the atomic number increases by 1.

QUESTION A.07 [1.0 point]
The reactor is critical at 5 watts. Which ONE of the following correctly describes the reactor behavior when a reactivity worth of 0.50 % ΔK/K is IMMEDIATELY inserted to the reactor core?

a. Subcritical

b. Critical

c. Supercritical

d. Delayed Critical

QUESTION A.08 [1.0 point]
Which ONE of the following statements correctly describes the term neutron lifetime?

a. The mean time required for fission neutrons to slow down to thermal energies.

b. The average time that thermal neutrons diffuse before being lost in some way.

c. The time between succeeding neutron generations and is the sum of fission time, slowing down time, and diffusion time.

d. The average time between the release of a neutron in a fission reaction and its loss from the system by absorption or escape.

QUESTION A.09 [1.0 point]
Most text books list β for a U^{235} fueled reactor as 0.0065 ΔK/K and β_{eff} as being 0.0075 ΔK/K. Why is β_{eff} larger than β?

a. Delayed neutrons are born at lower energies than prompt neutrons resulting in a less loss due to leakage for these neutrons.

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

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

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

QUESTION A.10 [1.0 point]
The neutron microscopic cross-section for absorption σ_a generally:

a. Increases as neutron energy increases.

b. Decreases as neutron energy increases.

c. Increases as the mass of the target nucleus increases.

d. Decreases as the mass of the target nucleus increases.

QUESTION A.11 [1.0 point]
Which ONE is true about "subcritical multiplication"? As the reactor approaches criticality, the parameter:

a. k_{eff} approaches zero.

b. 1/M approaches zero.

c. M approaches one.

d. ρ approaches infinity.

QUESTION A.12 [1.0 point]
Which ONE defines an integral rod worth curve?

a. Conforms to an axial flux shape.

b. Any point on the curve represents the amount of reactivity that one inch of rod motion would insert at that position in the core.

c. Represents the cumulative area under the differential curve starting from the bottom of the core.

d. Reactivity is highest at the top of the core and lowest at bottom of the core.

QUESTION A.13 [1.0 point]
Which ONE of the following is the correct reason for the 80 second negative period following a reactor scram?

a. The fuel temperature coefficient adding positive reactivity due to the fuel temperature decrease following a scram.

b. The ability of U-235 to fission with source neutrons.

c. The decay constant for the longest lived precursor.

d. The amount of negative reactivity added on a scram being greater that the shutdown margin.

QUESTION A.14 [1.0 point]
A reactor is operating at a power of 10 W. If there is a reactivity insertion of ρ = 0.00065, how long is it before the reactor power reaches 10 kW? (Assume β_{eff} = 0.0065, λ = 0.07 sec^{-1} and T = 129 sec)

a. 2 min

b. 10 min

c. 15 min

d. 20 min

QUESTION A.15 [1.0 point]
The term ____________ defines the condition where no delay neutrons are required.

a. Prompt Jump

b. Prompt Drop

c. Asymptotic Period

d. Prompt Critical

QUESTION A.16 [1.0 point]
A subcritical reactor is being started up. A control blade is raised in four equal steps. Which ONE of the following statement most accurately describes the expected reactor response?

a. Power increases by the same amount for each withdrawal.

b. Each withdrawal will add the same amount of reactivity.

c. The time for power to stabilize after each successive withdrawal increases.

d. A lower critical rod height is attained by decreasing the time intervals between withdrawals.

QUESTION A.17 [1.0 point]
Which ONE of the following describes the characteristics of a good moderator?

a. Large scattering cross section and small absorption cross section.

b. Small scattering cross section and large absorption cross section.

c. Small scattering cross section and small absorption cross section.

d. Large scattering cross section and large absorption cross section.

QUESTION A.18 [1.0 point, 0.25 each]
The six factor formula is stated as $k_{eff} = \epsilon L_f \ p \ L_t \ f \eta$.
Match with the correct answer:

Column A	Column B
a. Thermal utilization factor (f)	1. Change as fertile material is converted to fissile material.
b. f and p factors	2. Can be changed, by inserting movable control rods in and out.
c. f, p, Reproduction (η) factors	3. Changes reactor power.
d. Resonance escape probability (p)	4. Change as fuel is burned.

QUESTION A.19 [1.0 point]
Reactor period is defined as ____________.

a. The time required for a reactor to change by a factor of *e.*

b. The time required for the reactor power to double.

c. The number of factors of ten that reactor power changes in one minute.

d. The fraction of all neutrons that are born as delayed neutrons.

QUESTION A.20 [1.0 point]
Which ONE of the following is the best approximation of the amount of energy released by the fission of one atom of U-235?

a. 5 - 10 MeV

b. 50 - 70 MeV

c. 100 - 120 MeV

d. 180 - 210 MeV

***************** End of Section A *****************

QUESTION B.01 [1.0 point]
All of the following materials shall be doubly encapsulated EXCEPT:

a. Corrosive

b. Explosives

c. Gases

d. Liquids

QUESTION B.02 [1.0 point]
To prevent an inadvertent reactor SCRAM due to moving an irradiated fuel assembly near the Linear Channel detector, the Linear Channel should be set to the __________ range.

a. 30 mW

b. 1 mW

c. 10 kW

d. 1 MW

QUESTION B.03 [1.0 point]
“The reactor shall not be operated unless the excess reactivity is not greater than 3970 pcm.” This is an example of a:

a. Safety Limit.

b. Limiting Safety System Setting.

c. Limiting Condition of Operation.

d. Surveillance Requirement.

QUESTION B.04 [1.0 point]
The nominal specifications of the reactor fuel shall be:

a. 6% enriched uranium clad with aluminum.

b. 94% enriched uranium clad with aluminum.

c. 96% enriched uranium clad with zircaloy.

d. 4% enriched uranium clad with zircaloy.

QUESTION B.05 [1.0 point]
Per Technical Specifications, the Control rod drop times shall be determined:

a. Daily

b. Monthly

c. Annually

d. Biennially

QUESTION B.06 [1.0 point]
The Quality Factor (Q) is used to convert:

a. Dose in rads to dose equivalent in rems.

b. Dose in rems to dose equivalent in rads.

c. Contamination in rads to contamination equivalent in rems.

d. Contamination in rems to contamination equivalent in rads.

QUESTION B.07 [1.0 point]
Reactor Operator works in a high radiation area for eight (8) hours a day. The dose rate in the area is 100 mR/hour. Which ONE of the following is the MAXIMUM number of days in which Reactor Operator may perform his duties WITHOUT exceeding 10 CFR 20 limits?

a. 5 days

b. 6 days

c. 7 days

d. 12 days

QUESTION B.08 [1.0 point]
Radiation dose to Emergency personnel is limited to __________ TEDE for lifesaving actions or for the protection of large populations by volunteers fully aware of risk involved.

a. > 25 rem

b. Up to 25 rem

c. Up to 10 rem

d. Up to 5 rem

QUESTION B.09 [1.0 point, 0.25 each]
Match the 10 CFR 55 requirements for maintaining an active operator license in column A with the corresponding time period from column B (answers can be used more than once).

Column A		Column B
a.	Medical Exam	1. 1 year
b.	Pass Requalification Operating Test	2. 2 years
c.	Renewal Application of Existing License	3. 4 years
d.	Pass Requalification Written Examination	4. 6 years

QUESTION B.10 [1.0 point]
Which ONE of the following terms defines the actions taken to avoid or reduce the potential dose to individuals and to prevent damage to property?

a. Assessment Actions

b. Corrective Actions

c. Protective Actions

d. Recovery Actions

QUESTION B.11 [1.0 point]
After a building evacuation, the reactor building re-entry point shall be determined by the __________ on the basis of available information.

a. Incident Commander

b. Reactor Health Physicist

c. Emergency Operations Manager

d. Emergency Coordinator

QUESTION B.12 [1.0 point]
Significant releases of radioactive materials as a result of experiment failures is a situation that can be classified as:

a. Notification of Unusual Event

b. Alert

c. Site Area Emergency

d. General Emergency

QUESTION B.13 [1.0 point]
Which ONE of the following is the 10 CFR 20 definition of Total Effective Dose Equivalent (TEDE)?

a. The sum of the deep dose equivalent and the committed effective dose equivalent.

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

c. The sum of the external deep dose and the organ dose.

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

QUESTION B.14 [1.0 point]
If a gamma source measures 425 mR/hr at one foot, what will it measure at three feet?

a. 0.021 mR/hr

b. 47 mR/hr

c. 142 mR/hr

d. 207 mR/hr

QUESTION B.15 [1.0 point]
An example of a record to be retained for the lifetime of the reactor facility is:

a. Audit summaries.

b. Reportable events.

c. Experiments performed with the reactor.

d. Gaseous and liquid radioactive waste released to the environs.

QUESTION B.16 [1.0 point]
The preferred way of approaching reactor criticality is by a series of doubling counts on the __________. After approximately 5 doublings the reactor will be close to critical.

a. Source Range Channel

b. Linear Channel

c. Log N Channel

d. Safety Channel

QUESTION B.17 [1.0 point]
Upon activation of the evacuation alarm, personnel in the Reactor Bay will assemble:

a. Outside the North entrance of the BEL

b. In the Control Room

c. In the Change Room

d. In the BEL Conference Room on the first floor

QUESTION B.18 [1.0 point]
__________ is an experiment which contains fissionable material with the exception of detectors.

a. Tried Experiment

b. Fueled Experiment

c. Movable Experiment

d. Secured Experiment

QUESTION B.19 [1.0 point]
Which ONE of the following systems is used primarily to fill the pool and beam tubes?

a. Service Water System

b. Secondary Coolant System

c. Primary Coolant Cleanup System

d. Primary Coolant Makeup Water System

QUESTION B.20 [1.0 point]
No console annunciation or external indicator lights are associated with this SCRAM.

a. Low Pool Level SCRAM

b. Low Primary Flow SCRAM

c. Ground Fault Detection SCRAM

d. Safety Flapper Not Closed SCRAM

****************************** End of Section B ********************************

QUESTION C.01 [1.0 point]
Which ONE of the following Control Rod Drive Mechanisms components can be de-energized in less than 50 milliseconds after a SCRAM demand?

a. Motor

b. Electromagnet

c. Lead Screw Drive

d. Gear Reduction System

QUESTION C.02 [1.0 point]
Which ONE of the following interlocks prevent the drive mechanisms from being moved in the down direction?

a. Magnet power.

b. Automatic power control.

c. Up-drive power for the individual control rod drive mechanisms.

d. There are no interlocks that prevent this action.

QUESTION C.03 [1.0 point]
The neutron startup source used in the NCSU PULSTAR reactor is:

a. Am-Be

b. Ra-Be

c. Sb-Be

d. Pu-Be

QUESTION C.04 [1.0 point]
The coolant system is designed to remove up to 1 MW of heat from the PULSTAR Reactor and maintain a _________ flow rate on the primary side.

a. 500 gpm

b. 700 gpm

c. 800 gpm

d. 1150 gpm

QUESTION C.05 [1.0 point]
Which ONE of the following locations shows the highest percentage measurement of routine Ar-41 production?

a. Air at the pool surface

b. Air dissolved in pool water

c. Pneumatic Transfer System

d. Beam Tubes and Thermal Column

QUESTION C.06 [1.0 point]
Which ONE of the following Required Radiation Area Monitors has an alarm setpoint of ≤ 5 mR/hr?

a. Control Room

b. Over-the-Pool

c. Stack Gas

d. West Wall

QUESTION C.07 [1.0 point]
What kind of detector feeds the Safety Channel?

a. Fission Chamber

b. Compensated Ion Chamber

c. Uncompensated Ion Chamber

d. Scintillation

QUESTION C.08 [1.0 point]
Which ONE of the following experimental facilities is considered an In-reflector facility?

a. Beam Ports

b. Rotating Exposure Ports

c. Pneumatic Transfer System

d. Thermal Column Enclosure

QUESTION C.09 [1.0 point]
The neutron absorbing blades are comprised of all of the following elements EXCEPT:

a. Cadmium

b. Boron

c. Silver

d. Indium

QUESTION C.10 [1.0 point]
__________ of the Linear Channel prevents an automatic channel operation when the demand potentiometer setting exceeds actual reactor power by more than ±9%.

a. Trip #1

b. Trip #2

c. Trip #3

d. Trip #4

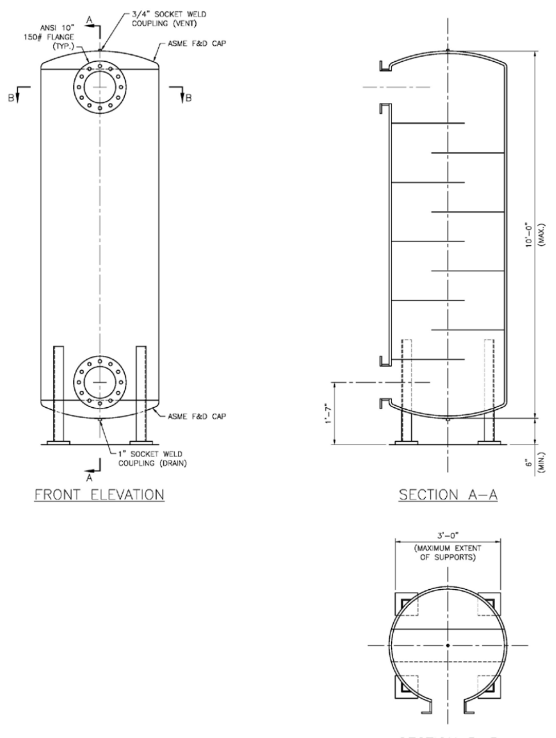
QUESTION C.11 [1.0 point]
The below picture show a “typical” detail of the:

a. Reactor Tank

b. Delay Tank

c. Waste Tank

d. Void Tank



QUESTION C.12 [1.0 point]
In support of ALARA, the PULSTAR goal for the typical occupational worker is established as the total effective dose equivalent equal to:

a. 2% of the NRC limit

b. 10% of the NRC limit

c. 20% of the NRC limit

d. Not applicable. Same as the NRC limit

QUESTION C.13 [1.0 point]
In accordance with Technical Specifications, the Reactor is SECURE when all of the following conditions exist EXCEPT:

a. The reactor key switch is in the OFF position and the key is removed from the lock

b. Power is unavailable to the control rod drive mechanism electromagnets.

c. No work is in progress involving core fuel, core structure, installed control rods, or control rod drives unless they are physically decoupled from the control rods.

d. No experiments are being moved or serviced that have, on movement, a reactivity worth exceeding one dollar (730 pcm).

QUESTION C.14 [1.0 point]
Two cylindrical fuel storage pits, 2 feet in diameter and 4 feet deep extend below the bottom of the pool liner. Each fuel storage pit has _________ locations in a subcritical configuration.

a. 7

b. 10

c. 13

d. 20

QUESTION C.15 [1.0 point]
The Auxiliary Generator Distribution Panel (AGDP), houses the feeder breakers that supply auxiliary power to:

a. Exhaust Fan

b. Confinement Fans #1 and #2

c. Reactor Bay Supply Fan

d. Control Room Supply Fan

QUESTION C.16 [1.0 point]
Following a loss of reactor building differential pressure (ΔP) it is assumed that the reactor is operating with the __________ operating when the loss of ΔP occurs.

a. Main HVAC System

b. Primary Coolant System

c. Radiation Monitoring System

d. Instrumentation and Control System

QUESTION C.17 [1.0 point]
There are four one-inch diameter holes in the zircaloy box just below the fuel pin support plate located in each fuel assembly box. These holes are provided as an Engineered Safety Feature design in order to:

a. Eliminate the blocked flow type of accident.

b. Ensure proper alignment of the core grid plate.

c. Ensure unimpeded coolant flow through the core.

d. Allow thermocouple leads from instrumented fuel elements to pass out of the core.

QUESTION C.18 [1.0 point]
The nuclear detector nitrogen purge pressure output is set at _________ psig.

a. 14

b. 16

c. 19

d. 21

QUESTION C.19 [1.0 point]
The fission chamber full out position is:

a. 0”

b. 12”

c. 24”

d. 36”

QUESTION C.20 [1.0 point]
Which ONE of the following is referred as the 12” square beam tube?

a. BP 3

b. BP 4

c. BP 5

d. BP 6

******************* End of Section C ****************************
****************** End of the Exam **************************

A.01
Answer: a,3 b,1 c,2 d,1
REF: Denaro and Jayson, Fundamentals of Radiation Chemistry, pg. 51

A.02
Answer: a
REF: Burns, Session 3.3.2, pg. 3-18

A.03
Answer: c
REF: Burns, example 6.2.3 (a), pg. 6-4

A.04
Answer: a
REF: $CR_1 / CR_2 = (1 - K_{eff2}) / (1 - K_{eff1})$
$100 / 60 = (1 - K_{eff2}) / (1 - 0.92)$
Therefore $K_{eff2} = 0.867$
$\Delta\rho = (K_{eff2} - K_{eff1}) / (K_{eff2} * K_{eff1})$
$\Delta\rho = (0.867 - 0.92) / (0.867 * 0.92)$
$\Delta\rho = - 0.0664$

A.05
Answer: c
REF: Burns, Figure 8.1, pg. 8-6

A.06
Answer: d
REF: DOE Handbook volume 1, NP-01, pg. 24, β decay = $ZX^A \rightarrow Z{+}1Y^A$ +e + v,
A = atomic mass = proton + neutrons
Z = # protons

A.07
Answer: c
REF: Burn, Section 4.2, Figure 4-1, pg. 4-2
0.5 % ΔK/K = 0.005 ΔK/K = ρ, ρ > 0
$\rho = (k_{eff} - 1) / k_{eff}$, then $k_{eff} = 1.005$
When k > 1, ρ > 0 and reactor is supercritical

A.08
Answer: d
REF: Burns, section 3.3.5, pg. 3-23

A.09
Answer: a
REF: Burns, Section 3.2.4, pg. 3-12

A.10
Answer: b
REF: Foster & Wright, "Basic Nuclear Engineering" 4th ed., Figure 8.3, pg. 202

A.11
Answer: b
REF: Burns, Table 5.5, pg. 5-15

A.12
Answer: c
REF: Burns, Section 7.3, pg. 7-5 to 7-7

A.13
Answer: c
REF: Lamarsh, 3rd ed., pg. 345

A.14
Answer: c
REF: Reactor power: $P(t) = P(0)\exp(t/T)$
Solving for t, we find $t = T \ln [P(t)/P(0)] = 129 \ln (10,000/10) = 891$ s = 14.9 min
Also,
$\rho = 0.00065$, then
$T = (\beta_{eff} - \rho)/(\rho\ \lambda) = (0.0065 - 0.00065)/(0.07)(0.00065) =$ 129 seconds

A.15
Answer: d
REF: Knief, Nuclear Engineering, 2nd ed., pg. 142

A.16
Answer: c
REF: Burns, Section 5.3, pg. 5-7

A.17
Answer: a
REF: DOE Handbook part 2, module 2, pg. 24

A.18
Answer: a,2 or B b,4 or D c,1 or A d,3 or C
REF: DOE Handbook part 2, module 3, pg. 10, 15

A.19
Answer: a
REF: DOE Handbook part 2, module 4, pg. 21

A.20

Answer: d

REF: Lamarsh, Table 3.6, pg. 88

Foster and Wright, Basic Nuclear Engineering, 4th ed., table 4.2, pg. 76, “The energy release per fission is approximately 200 MeV.”

B.01
Answer: b
REF: TS 3.7 a., pg. 23

B.02
Answer: c
REF: NRP-OP-301, Section 2.6, pg. 4 of 8

B.03
Answer: c
REF: TS 3.2 b, pg. 14

B.04
Answer: d
REF: TS 5.1 a., pg. 38

B.05
Answer: c
REF: TS 4.2 b., pg. 32

B.06
Answer: a
REF: 10 CFR 20.1004(b)

B.07
Answer: b
REF: 10 CFR 20.1201(a)(1)

$$5000mR * \frac{1hr}{100mR} * \frac{1day}{8hr} = 6.25days$$

B.08
Answer: a
REF: Emergency Procedure 1, Section 5.4 (10)(d), pg. 10
EP 7.5.7 b., pg. 32

B.09
Answer: a, 2 b, 1 c, 4 d, 2
REF: 10 CFR 55.53 “Conditions of Operator Licenses”
10 CFR 55.55 “Expiration”
10 CFR 55.59 “Requalification”

B.10
Answer: c
REF: EP Section 2, pg. 7

B.11
Answer: a
REF EP 7.5.4, pg. 31

B.12
Answer: b
REF: Emergency Procedure 4, Section 5.1 (b), pg. 2

B.13
Answer: a
REF: 10 CFR 20.1003, Definitions

B.14
Answer: b
REF: Given $DR_1(d_1)^2 = DR_2\,(d_2)^2$

Then $DR_2 = \dfrac{DR_1}{(d_2/d_1)^2}$

$DR_2 = \dfrac{425\text{ mR}}{(3/1)^2}$

$DR_2 = 47.2$ mR/hr

B.15
Answer: d
REF: TS 6.8.2 a., pg. 56

B.16
Answer: a
REF: NRP-OP-101, Section 2.12 NOTE, pg. 5 of 35

B.17
Answer: c
REF: EP 7.5.1, pg. 30
Emergency Procedure 1, Section 5.1 (2), pg. 3 and Section 5.1 (3), pg. 4

B.18
Answer: b
REF: NRP-OP-104, Section 1.2.3, pg. 3 of 20

B.19
Answer: a
REF: NRP-OP-202, Section 1.1, pg. 3 of 7

B.20
Answer: c
REF: NRP-OP-105, Section 2.3.8, pg. 5 of 18

C.01
Answer: b
REF: SAR 4.2.2, pg. 4-8

C.02
Answer: d
REF: SAR 7.3.3, pg. 7-2

C.03
Answer: d
REF: SAR Table 1-1, pg. 1-14 and SAR 4.2.4, pg. 4-10

C.04
Answer: a
REF: SAR Table 1-1, pg. 1-14, SAR Table 4-10, pg. 4-74, SAR 5.1, pg. 5-1
TS 2.1.1, pg. 7-9

C.05
Answer: c
REF: SAR 11.1.1.1, pg. 11-2

C.06
Answer: a
REF: TS Table 3.5-1, pg. 19

C.07
Answer: c
REF: SAR Figure 7.2, pg. 7-6, SAR 7.4.3.4, pg. 7-12

C.08
Answer: b
REF: SAR 10.2.2.1, pg. 10-8

C.09
Answer: b
REF: SAR 4.5.3.2.5, Section 5.4, pg. 4-61

C.10
Answer: d
REF: SAR 7.4.3.3, pg. 7-12

C.11
Answer: b
REF: SAR Figure 5-4, pg. 5-14

C.12
Answer: b
REF: HP 1 Radiation Protection Program, Section 4.3.4, pg. 6

C.13
Answer: b
REF: TS 1.2.22, pg. 4

C.14
Answer: c
REF: SAR Table 4-1, pg. 4-3, SAR 5.2, pg. 5-2

C.15
Answer: b
REF: TS 4.5.b, pg. 36
SAR Figure 8-2, pg. 8-5

C.16
Answer: a
REF: NRP-OP-105, Section 4.4, pg. 13 of 18
TS 3.6 c, NOTE (3), pg. 22

C.17
Answer: a
REF: SAR 6.2.5, pg. 6-11, SAR 13.2.5, pg. 13-21

C.18
Answer: b
REF: NRP-OP-101, Appendix A – Startup Checklist (pg. 1 of 5), Part C.4, pg. 14 of 35
NRP-OP-101, Appendix B – Startup Checklist Instructions (pg. 1 of 17), Part C.4, pg. 19 of 35
NRP-OP-103, Section 3.2.1.2, pg. 7 of 12

C.19
Answer: c
REF: NRP-OP-101, Section 2.18, pg. 5 of 35

C.20
Answer: d
REF: SAR Table 4-1, pg. 4-4
SAR Figure 4-7, pg. 4-12
SAR Table 4-2, pg. 4-28