April 14, 2015

Dr. Paul Brand, Manager of Operations and Engineering
NIST Center for Neutron Research
National Institute of Standards and Technology
U. S. Department of Commerce
100 Bureau Drive, Mail Stop 8561
Gaithersburg, MD 20899-8561

SUBJECT: EXAMINATION REPORT NO. 50-184/OL-15-02, NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY REACTOR

Dear Dr. Brand:

During the week of March 23, 2015, the NRC administered operator licensing examinations at your NIST reactor. The examinations were conducted according to NUREG-1478, "Operator Licensing Examiner Standards for Research and Test Reactors," Revision 2. 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 Title 10 of the *Code of Federal Regulations* Section 2.390, 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 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. Phillip T. Young at (301) 415-4094 or via internet e-mail Phillip.Young@nrc.gov.

Sincerely,

/RA/

Kevin Hsueh, Chief
Research and Test Reactors Oversight Branch
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Docket No. 50-184

Enclosures:
1. Examination Report No. 50-184/OL-15-02
2. Facility comments with resolution
3. Written examination with facility
   comments incorporated

cc: See next page w/o enclosures

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ADAMS Accession No.: ML15098A610 **NRR-074**

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NAME	PYoung	CRevelle	KHseuh
DATE	04/02/2015	04/09/2015	04/14/2015

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cc:

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Test, Research, and Training
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U. S. NUCLEAR REGULATORY COMMISSION
OPERATOR LICENSING INITIAL EXAMINATION REPORT

REPORT NO.: 50-184/OL-15-02

FACILITY DOCKET NO.: 50-184

FACILITY LICENSE NO.: TR-5

FACILITY: NSBR

EXAMINATION DATES: March 24 to 25, 2015

SUBMITTED BY: ***/RA/*** **04/02/2015**
Phillip T. Young, Chief Examiner Date

SUMMARY:

During the week of March 23, 2015, the NRC administered licensing examinations to two Senior Reactor Operator-Instant (SROI) applicants. The applicant passed all portions of the examination.

REPORT DETAILS

1. Examiner: Phillip T. Young, Chief Examiner, NRC

2. Results:

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

3. Exit Meeting:

Phillip T. Young, Chief Examiner, NRC
Daniel E. Hughes, Chief of Reactor Operations, NIST
Majeed Kahn, Nuclear Engineering Technician, NIST

ENCLOSURE 1

FACILITY COMMENTS WITH NRC RESOLUTION

Question: A.07
The reactor is operating at 10mW in steady-state and in automatic mode. Which one of the following describes the stable reactor period if the control rods drop fully into the core?

a. -34 seconds due to the rapid decrease in prompt neutrons
b. -34 seconds due to the rapid decay of the short lived delayed neutron precursors
c. -80 seconds due to the slowing down length of prompt neutrons
d. -80 seconds due to the decay half-life of the long lived delayed neutrons precursors

Comment: According to Lamarsh, J.R., Introduction to Nuclear Engineering, Addison-Wesley Publishing, Reading, Massachusetts, .2001. § 7.2 , p. 345
When the Reactivity equation for the actual case of six delayed neutron groups is plotted, the value of ω_1 approaches λ_1, the decay constant for the *longest lived* precursor – namely, the precursor with a mean life of about - 80 sec.
The NBSR Reactor uses 14 groups of delayed neutrons. Eight of the groups come from photo-neutron production in D_2O caused by gamma rays from the decay of fission products. The neutrons from these groups contribute to a -120 sec period for the NBSR, U235 fueled, D_2O moderated reactor vs. the -80 sec period for a U235 fueled light water reactor.

Justification: See comments above.

NRC Resolution: Facility comment accepted, the question is deleted from this examination with the grading changed accordingly.

Question: C.18
Identify each of the following conditions as a **S**cram, **R**undown or **N**either.

a. Period on NC-6 at 5 sec (currently <10% of full power)
b. Thermal power at 22 MW
c. Reactor outlet temperature at 135^0F
d. Reactor level at 142”

Answer: C.18 a. = RD; b. = N; c. = RD; d. = RD
Reference:AP 6.1 – Scram and AP 6.2 – Rundown

Comment:
Dispute: AP 6.1 Scram, Section 1.A.4., states: “Period scram NC-3, NC-4 or NC-6 (is) 5 sec when (the reactor power is) < 10% of full power.” AP 6.2, Section 1.A.3 states: “Reactor Rundown NC-3, NC-4 or NC-6 (is) 10 sec when (the reactor power is) < 10% of full power.” Therefore, the answer for part a. of Question C.018 is Scram, not Rundown.

Justification: See comments above.

NRC Resolution: Facility comment accepted, answer “S” will be accepted as the correct answer with the grading changed accordingly.

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

FACILITY: National Institute of Standards and Technology

REACTOR TYPE: TEST

DATE ADMINISTERED: 3/25/2015

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	% of Candidates Score	Category Value	Category
20.00	33.3	______	____	A. Reactor Theory, Thermodynamics and Facility Operating Characteristics
22.00	33.3	______	____	B. Normal and Emergency Operating Procedures and Radiological Controls
20.00	33.3	______	____	C. Facility and Radiation Monitoring Systems
62.00		______	____% FINAL GRADE	TOTALS

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

____
Candidate's Signature

ENCLOSURE 2

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.

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

Section A   Reactor Theory, Thermo, and Facility Characteristics

EQUATION SHEET's

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

1 Curie = 3.7×10^{10} dis/sec

1 Horsepower = 2.54×10^3 BTU/hr

1 BTU = 778 ft/lbf

1 gal (H_2O) ≈ 8 lbm

c_P = 1.0 BTU/hr/lbm/ºF

1 kg = 2.21 lbm

1 Mw = 3.41×10^6 BTU/hr

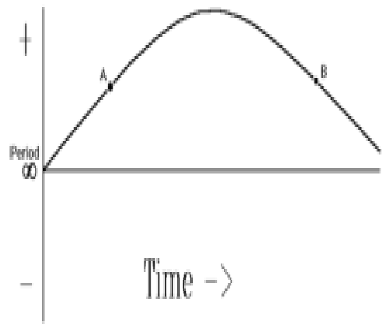
ºF = 9/5 °C + 32

ºC = 5/9 (°F - 32)

c_p = 1 cal/sec/gm/ºC

Section A Reactor Theory, Thermo, and Facility Characteristics

Question A.001 [1.0 point] (1.0)
Shown below is a trace of reactor period as a function of time. Between points A and B reactor power is:



a. continually increasing.
b. continually decreasing.
c. increasing, then decreasing.
d. constant.

Answer: A.01 a.
Reference: Standard NRC Question

Question: A.002 [1.0 point] (2.0)
Which ONE of the following is true concerning the differences between prompt and delayed neutrons?

a. Prompt neutrons account for less than 1% of the neutron population while delayed neutrons account for approximately 99% of the neutron population.

b. Prompt neutrons are released during fast fissions while delayed neutrons are released during thermal fissions.

c. Prompt neutrons are released during the fission process while delayed neutrons are released during the decay process.

d. Prompt neutrons are the dominating factor in determining the reactor period while delayed neutrons have little effect on the reactor period.

Answer: A.02 c.
Reference: Intro to Nuc Eng, John R. Lamarsh © 1983, § 3.7 pp. 73 – 75.

Section A Reactor Theory, Thermo, and Facility Characteristics

Question A.003 [2.0 points, 0.5 each] (4.0)
Match the neutron terms in column A with their corresponding description in Column B.

Column A	Column B
a. Fast neutrons	1. Neutrons released within 10^{-5} sec of fission
b. Prompt neutrons	2. High energy neutrons
c. Slow neutrons	3. Neutrons released by decay of fission products
d. Delayed neutrons	4. Low energy neutrons

Answer: A.03 a. = 2; b. = 1; c. = 4; d. = 3
Reference: Standard NRC Reactor Theory

Question: A.0 4 [1.0 point] (5.0)
Which condition below describes a critical reactor?

a. K = 1, ΔK/K = 1

b. K = 1, ΔK/K = 0

c. K = 0, ΔK/K = 1

d. K = 0, ΔK/K = 0

Answer: A.04 b.
Reference: Intro to Nuc Eng, John R. Lamarsh © 1983, § 7.1, p. 282.

Question A.005 [1.0 point] (6.0)
You are performing a startup from a very low reactor power level. If you establish a 26 second period, approximately how long will it take to increase reactor power by a factor of 1000?

a. 1 minutes

b. 3 minutes

c. 10 minutes

d. 30 minutes

Answer: A.05 b.
Reference: Standard NRC Question: SUR = 26/τ 26/26 = 1 SUR = time in[1.0] minutes to increase power by a factor of 10. 1000 = three decades 3 × 1 = 3 minutes.

Section A Reactor Theory, Thermo, and Facility Characteristics

Question: A.006 [1.0 point] (7.0)

The reactor is shutdown by 0.05 ΔK/K, this would correspond to K_{eff} of:

a. 0.9995.

b. 0.9524.

c. 0.7750.

d. 0.0500.

Answer: A.06 b.

Reference: Lamarsh, J.R., Introduction to Nuclear Engineering, Addison-Wesley Publishing, Reading, Massachusetts, 1983. § 4,1, p. 102 & § 7.1, p. 282. p=(k-1)/k; p= -0.05; -0.05k = k-1; 1 = k-(-0.05k) = k(1+0.05); k=1/1.05; k=0.9524

~~**Question** A.007 [1.0 point] (8.0)~~ Deleted per facility comment

~~The reactor is operating at 10 mW in steady-state and in automatic mode. Which one of the following describes the stable reactor period if the control rods drop fully into the core?~~

~~a. -34 seconds due to the rapid decrease in prompt neutrons~~

~~b. -34 seconds due to the rapid decay of the short lived delayed neutron precursors~~

~~c. -80 seconds due to the slowing down length of prompt neutrons~~

~~d. -80 seconds due to the decay half life of the long lived delayed neutron precursors~~

~~Answer: A.07 d.~~

~~Reference: The amount of reactivity inserted by the blades much larger than beta; therefore, maximum stable negative period of -80 seconds results.~~

Question: A.008 [1.0 point] (9.0)

An initial count rate of 100 is doubled five times during startup. Assuming an initial K_{eff} = 0.950, what is the new K_{eff}?

a. 0.957

b. 0.979

c. 0.988

d. 0.998

Answer: A.08 d.

Reference: $CR1/CR2 = (1 - K_{eff2})/(1 - K_{eff1})$ $1/32\ (1 - 0.95) = 1 - K_{eff2}$

$1 - 0.05/32 = Keff2$ $K_{eff2} = 0.9984$

Section A Reactor Theory, Thermo, and Facility Characteristics

Question A.009 [1.0 point] (10.0)
Which ONE of the following reactor changes requires a control rod INSERTION to return reactor power to its initial level following the change?

a. Buildup of Xe^{135}

b. Formation of N^{16} in the coolant.

c. Removal of an experiment with positive reactivity from the reactor.

d. A fault in the automatic system resulting in a primary coolant temperature decrease.

Answer: A.09 d.
Reference: Standard NRC Question

Question: A.010 [1.0 point] (11.0)
K_{eff} is K_{∞} times the

a. fast fission factor (ε)

b. reproduction factor (η)

c. total non-leakage factor ($\mathcal{L}_f \times \mathcal{L}_{th}$)

d. resonance escape probability (p)

Answer: A.10 c.
Reference: Standard NRC Question

Question A.011 [1.0 point] {12.0}
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.

Answer: A.11 b.
Reference: Standard NRC Question

Question: A.012 [1.0 point] (13.0)
Which ONE of the following is the reason for an installed neutron source within the reactor? A startup without a neutron source …

a. is impossible as there would be no neutrons available to start the fission process.

b. would be very slow due to the long time to build up neutron population from so low a level.

c. could result in a very short period due to the reactor going critical before neutron population can build up high enough to be read on nuclear instrumentation.

d. can be compensated for by adjusting the compensating voltage on the source range detector.

Answer: A.12 c.
Reference: Standard NRC Reactor Theory

Question: A.013 [1.0 point] (14.0)
Which ONE of the following describes "EXCESS REACTIVITY"?

a. Extra reactivity into the core due to the presence of the source neutrons.

b. A measure of the resultant reactivity if all of the control elements were withdrawn.

c. The combined reactivity worth of control rods and other poisons needed to keep the reactor shutdown.

d. The maximum reactivity insertion with the reactor shutdown with control rods fully inserted under peak Xenon conditions.

Answer: A.13 b.
Reference: Standard NRC Reactor Theory Question

Question: A.014 [1.0 point] (15.0)
Which ONE of the following is an example of beta (β) decay?

a. ${}_{35}Br^{87}$ —> ${}_{33}As^{83}$

b. ${}_{35}Br^{87}$ —> ${}_{35}Br^{86}$

c. ${}_{35}Br^{87}$ —> ${}_{34}Se^{86}$

d. ${}_{35}Br^{87}$ —> ${}_{36}Kr^{87}$

Answer: A.14 d.
Reference: Standard NRC Reactor Theory Question, Chart of the Nuclides

Question: A.015 [1.0 point] (16.0)
Which statement best describes Xe-135 behavior following a Reactor Scram?

a. Xenon concentration decreases due to production rate from fission stops.

b. Xenon concentration decreases due to production rate from I-135 decay increasing.

c. Xenon concentration increases due to production rate from Pm-149 increasing.

d. Xenon concentration increases due to I-135 decay exceeding Xe-135 decay.

Answer: A.15 d.
Reference: Standard NRC Reactor Theory Question

Question: A.016 [1.0 point] (17.0)
Which ONE of the following conditions would increase shutdown margin?

a. An experiment which added positive reactivity.

b. Depletion of the burnable poison added to the uranium fuel.

c. Depletion of uranium fuel.

d. Decreasing fuel temperature.

Answer: A.16 c.
Reference: Adding negative reactivity increases the shutdown margin.

Question: A.017 [1.0 point] (18.0)
Which ONE of the following statements describes the difference between Differential (DRW) and Integral (IRW) rod worth curves?

a. DRW relates the worth of the rod per increment of movement to rod position. IRW relates the total reactivity added by the rod to the rod position.

b. DRW relates the time rate of reactivity change to rod position. IRW relates the total reactivity in the core to the time rate of reactivity change.

c. IRW relates the worth of the rod per increment of movement to rod position. DRW relates the total reactivity added by the rod to the rod position.

d. IRW is the slope of the DRW at a given rod position

Answer: A.17 a.
Reference: Lamarsh, Introduction to Nuclear Engineering, 1975, Page 270

Question: A.018 [1.0 point] (19.0)
The fuel temperature coefficient of reactivity is -1.25×10^{-4} ΔK/K/°C. When a control rod with an average rod worth of 0.1 % ΔK/K/inch is withdrawn 10 inches, reactor power increases and becomes stable at a higher level. At this point, the fuel temperature has:

a. increased by 80°C

b. decreased by 80°C

c. increased by 8°C

d. decreased by 8°C

Answer: A.18 a.
Reference: Lamarsh, Introduction to Nuclear Engineering, 2nd Edition, Page 306
Reactivity added by control rod = +(0.001 Δk/k/inch)(10 inches) = 0.01 Δk/k.
Fuel temperature change = -Reactivity added by rod / fuel temperature coefficient
Fuel temperature change = (-0.01 Δk/k) / (-1.25×10^{-4} Δk/k/□C) = 80□C.

Question: A.019 [1.0 point] (20.0)
Which factor in the six factor formula is represented by the ratio:

$$\frac{\text{number of neutrons that reach thermal energy}}{\text{number of neutrons that start to slow down}}$$

a. fast non-leakage probability (L_f)

b. resonance escape probability (p)

c. reproduction factor (η)

d. thermal utilization factor (f)

Answer: A.19 b.
Reference: *Intro to Nuc Eng,* John R. Lamarsh © 1983, § 6.5 p. 239.

Question: A.020 [1.0 point] (21.0)
In a reactor at full power, the thermal neutron flux is 2.5×10^{12} neutrons/cm^2/sec., and the macroscopic fission cross-section Σ_f is 0.1 cm^{-1}. The fission rate is:

a. 2.5×10^{11} fissions/cm/sec.

b. 2.5×10^{13} fissions/cm/sec.

c. 2.5×10^{11} fissions/cm^3/sec.

d. 2.5×10^{13} fissions/cm^3/sec.

Answer: A.20 c.
Reference: Standard EQB question. R = □ Σ_f = (2.5×10^{12}) x 0.1 = 2.5×10^{11}

Section B Normal/Emergency Procedures & Radiological Controls

Question B.001 [2.0 points ½ each] (2.0)
When using a meter, to convert from rad to Rem you must convert using the appropriate Quality Factor. Match the type of radiation in column A with it's Quality Factor in column B

Column A	Column B
a. Thermal Neutrons	1
b. Gamma, X-rays, Beta	2
c. Fast Neutrons, Protons	5
d. Alpha particles, heavy recoil nuclei	10
	20

Answer: B.01 a. = 2; b. = 1; c. = 10; d. = 20
Reference: 10 CFR 20.xxxx

Question B.002 [2.0 points, 0.5 each] (4.0)
Identify each of the following Technical Specification Requirements as being either a Safety Limit (SL) Limiting Safety System Setting (LSSS) or a Limiting Condition for Operation (LCO).

a. Minimum Coolant Flow (inner plenum) 60 gpm/MW

b. The reactor shall not be operated unless all four shim safety arms are operable.

c. The reactor shall not be operated unless at least one shutdown cooling pump is operable.

d. The reactor may be operated at power levels of up to 10 kW with reduced flow (including no flow) if decay heat is insufficient to cause significant heating of the reactor coolant.

Answer: B.02 a. = LSSS b. = LCO c. = LCO; d. = SL
Reference: Technical Specifications, 2.1 2nd specification, 3.2 1st specification, 3.4 1st specification and 2.2 3rd specification.

Question: B.003 [1.0 point] (5.0)
Which **ONE** of the following statements correctly defines the term "Channel Test?"

a. The introduction of a signal into a channel and observation of the proper channel response.

b. The qualitative verification of acceptable performance by observation of channel behavior.

c. An arrangement of sensors, components and modules as required to provide a single trip or other output signal relating to a reactor or system operating parameter.

d. The adjustment of a channel such that its output corresponds with acceptable accuracy to known values of the parameter which the channel measures.

Answer: B.03 a.
Reference: TS, § 1.3.2.3

Question B.004 [1.0 point] (6.0)
Per Annunciator Procedure 0.1 *“D_2O System Rupture”*, Immediate Action, you would stop and isolate the shutdown cooling pumps and initiate top feed if vessel level falls below …

a. 60 inches.

b. 100 inches.

c. 140 inches.

d. 180 inches.

Answer: B.04 c.
Reference: Annunciator Procedures, A.P. 01 § III.A.

Question: B.005 [1.0 point, 0.25 each] (7.0)
Match the allowable voluntary radiation exposure limit authorized during an emergency listed in column B with the correct condition from column A.

Column A	Column B
a. Lifesaving; without approval of Emergency Director	5 REM
b. Other Serious Events; without approval of Emergency Director	10 REM
c. Lifesaving; with approval of Emergency Director	25 REM
d. Other Serious Events; with approval of Emergency Director	50 REM
	100 REM

Answer B.05 a. = 25; b. = 5; c. = 100; d. = 25
Reference: Emergency Instruction 3.6, Essential Personnel Evacuation, IV. Voluntary Exposure Limits

Question B.006 [1.0 point] (8.0)
Given a failure in the Secondary System, the operator is instructed to maintain primary temperature less than:

a. 110°F

b. 112°F

c. 120°F

d. 125°F

Answer: B.06 b.
Reference: A.P.0.9 - SECONDARY SYSTEM FAILURE

Question: B.007 [1.0 point] (9.0)
Per 10CFR55.53, an SRO who has not maintained active status must have an authorized representative of the facility licensee certify the following:

a. a minimum of **six** hours of shift functions under the direction of an operator or senior operator as appropriate and in the position to which the individual will be assigned has been completed.

b. a minimum of **four** hours of shift functions under the direction of an operator or senior operator as appropriate and in the position to which the individual will be assigned has been completed.

c. a minimum of **six** hours of shift functions under the direction of an operator or senior operator as appropriate and in the position to which the individual will be assigned has been completed and, that in part, the individual is current in all of the facility requalification program requirements.

d. a minimum of **four** hours of shift functions under the direction of an operator or senior operator as appropriate and in the position to which the individual will be assigned has been completed and, that in part, the individual has completed a requalification program written examination and operating test within the current calendar quarter.

Answer: B.07 c.
Reference: 10CFR55.53 and 10CFR55.59

Question B.008 [1.0 point] (10.0)
Operator "A" works a standard forty (40) hour work week. His duties require him to work in a radiation area for (4) hours a day. The dose rate in the area is 10 mR/hour. Which one of the following is the MAXIMUM number of days Operator "A" may perform his duties without exceeding 10CFR20 limits?

a. 12 days

b. 25 days

c. 31 days

d. 125 days

Answer: B.08 d.
Reference: 10CFR20.1201(a)(1) $5000 \text{ mr} \times \frac{1 \text{ hr}}{10 \text{ mr}} \times \frac{\text{day}}{4 \text{ hr}} = 125 \text{ days}$

Question: B.009 [1.0 point] (11.0)
A gamma source reads 125 mR/hr @ 1 foot. How far from the source must you post a barrier for a radiation area?

a. 35 feet

b. 25 feet

c. 15 feet

d. 5 feet

Answer: B.09 d.
Reference: $A_f = A_0 (d_0/d_f)^2 \Rightarrow d_f^2 = A_0/A_f \times d_0^2 = 125/5 \times 1^2 = 25$ $d_0 = 5$

Question B.010 [1.0 point] (12.0)
The dose rate from a mixed beta-gamma point source is 100 mrem/hour at a distance of one (1) foot, and is 0.1 mrem/hour at a distance of twenty (20) feet. What percentage of the source consists of beta radiation?

a. 20%

b. 40%

c. 60%

d. 80%

Answer: B.10 c.
Reference: 10CFR20.
At 20 feet, there is no beta radiation. Gamma at 20 feet = 0.1 mrem/hour, gamma at 1 foot = 40 mrem/hour. Therefore beta at 1 foot = 60 mrem/hour = 60%.

Question: B.011 [1.0 point] (13.0)
Which ONE of the following is the ***LOWEST*** level of NIST management who may authorize reactor startup (to previous shim position) following a scram, where the cause of the scram remains unknown?

a. Reactor Operator

b. Senior Reactor Operator

c. Reactor Supervisor

d. Deputy Chief Engineer

Answer: B.11 b.
Reference: O.I. 1.1B (Checklist B) step I.B.

Section B Normal/Emergency Procedures & Radiological Controls

Question B.012 {1.0 point} (14.0)
A radioactive sample which initially was reading 50 R/hr has decayed over 8 hours to 25 R/hr. What will the sample read in another 4 hours?

a. 12.5 R/hr

b. 17.8 R/hr

c. 18.8 R/hr

d. 22.9 R/hr

Answer: B.12 b.
Reference: A = AO * e exp(-lambda * time) 25 = 50 * e exp(-lambda * 8 * 3600);
lambda = 2.4 exp-5/sec A = 25 * e exp(-2.4 exp-5 * 4 * 3600); A = 17.7

Question: B.013 [1.0 point, 0.25 point each] (15.0)
For Research and Test reactors we primarily worry about two isotopes N^{16} and Ar^{41}. Identify the approximate half-life and gamma energy for each. (Each item has only one answer.)

Isotope	Radiological Parameters			
a. Ar^{41} half-life	1) 1.8 sec	2) 1.8 min	3) 1.8 hour	4) 1.8 day
b. Ar^{41} gamma energy	1) 10 KeV	2) 100 KeV	3) 1 MeV	4) 10 MeV
c. N^{16} half-life	1) 7 sec	2) 7 min	3) 7 hour	4) 7 day
d. N^{16} gamma energy	1) 6 kev	2) 60 keV	3) 600 keV	4) 6 Mev

Answer: B.13 a. = 3; b. = 3; c. = 1; d. = 4
Reference: Standard NRC Rad Question

Question B.014 [1.0 point] (16.0)
If estimated critical position differs from actual critical position by more than one degree you must:

a. stop and recalculate the estimated critical position prior to further rod withdrawal.

b. shut down the reactor.

c. notify the Reactor Supervisor.

d. notify the Chief Nuclear Engineer.

Answer: B.14 c.
Reference: OI 1.1 § II.I p. 4 {Modified 1996 NBSR Requalification Examination Question}

Question: B.015 [1.0 point] (17.0)
The fission products monitor located in the helium sweep gas will give an indication of a …. ?

a. A “pin-hole” breach in the cladding.

b. Activation of argon in air from the reactor.

c. Disassociation of water and nitrogen 16 production.

d. Activation of aluminum from reactor and primary piping materials.

Answer: B.15 a.
Reference: TS 3.7.1 Monitoring Systems and Effluent Limits

Question: B.016 [1.0 point] (18.0)
The total exposure from effluents from the reactor facility to a person at the site boundary shall not exceed ……

a. 100 mrem per 24 hour period

b. 100 mrem per calendar year

c. 500 mrem per 24 hour period

d. 500 mrem per calendar year

Answer: B.16 b.
Reference: TS 3.7.2 Effluents

Question: B.017 [1.0 point] (19.0)
According to the Administrative Rules, the ***MINIMUM*** number of nuclear instruments required for refueling is …

a. one on-scale instrument with trip safety function

b. two on-scale instruments with trip safety function

c. one on-scale instrument

d. two on-scale instruments

Answer: B.17 d.
Reference: Administrative Rule 3.0, § III.A, also Administrative Rule 6.0 § I.B.

Question B.018 [1.0 point] (20.0)
The emergency plan allows the operator to take action which deviates from emergency procedures during an emergency. Which ONE of the following is the minimum level of staff that may authorize this action?

a. Reactor Operator

b. Senior Reactor Operator

c. Emergency Director

d. Emergency Coordinator

Answer: B.18 c.
Reference: Emergency Instructions Introduction, ¶ 2.

Question: B.019 [1.0 point] (21.0)
Which ONE of the following correctly completes the sentence. While the reactor is OPERATING, the process test switch may be placed in the "2 of 2" position …

a. for not longer than 8 hours to allow the checking of a channel's operability.

b. indefinitely if power is reduced below 10 MW before changing the selector's position.

c. up to a maximum of 12 hours if no experiments are inserted into the reactor.

d. while maintaining a steady power level but must be returned to the "1 of 2" position prior to changing power.

Answer: B.19 a.
Reference: Operation Instructions Manual, O.I. 5.7. "Operation of the Process Instrumentation Safety System", Page 2 of 3

Question: B.020 [1.0 point] (22.0)
While operating one of the shim arms falls to its lower stop. Per Annunciator Procedure 0.4 *"Stuck or Faulty Operation of Shim Arms"* you should …

a. maintain the reactor as is (subcritical) until Reactor Supervisor directs corrective action.

b. continue to operate if able to latch and shim out the fallen shim arm.

c. continue to operate using the remaining shim arms to stay critical.

d. shutdown the reactor.

Answer: B.20 d.
Reference: Annunciator Procedures, A.P. 0.4.

Section C Facility and Radiation Monitoring Systems

Question C.001 [1.0 point] (1.0)
You discover several scratches on the outer plate of a fuel element. You inform the Reactor Supervisor who decides to use the element. The decision to use this element was

a. appropriate because the outer plates contain no fuel.
b. inappropriate because of the higher fuel loading of the outer plates.
c. inappropriate because it could lead to fission product release from the plate due to reduced cladding.
d. appropriate because the outer two plates are thicker than the inner plates, due to thicker cladding.

Answer C.01 a.
Reference: NBSR Requalification Exam administered April 1998.

Question: C.002 [1.0 point] (2.0)
During a reactor startup, the 123 Strainer Inlet Isolation valve SCV-200 is inadvertently left closed. As the startup progresses, the reactor receives a rundown signal, the signal was due to

a. low secondary flow
b. low thermal shield flow
c. high inlet temperature
d. high outlet temperature

Answer: C.02 d.
Reference: NIST SAR Sections 5.2.2.7.1 Strainer & 5.2.4.1 Removal of Heat from the Fuel

Question C.003 [1.0 point] (3.0)
Operation with the shim safety arms less than 12° is prohibited because …

a. the worth of the shim arms below this level is insignificant
b. the scram spring force is insufficient to overcome shock absorber resistance.
c. there is too much stress on the shim arm below this angle.
d. the scram spring force is insufficient to overcome the pressure differential due to full core flow.

Answer: C.03 b.
Reference: NBSR Reactor Operations Training Guide

Question: C.004 [1.0 point] (4.0)
Which ONE of the following correctly describes where Critical Panel 1 (CP-1) receives power from?

a. Directly from MCCA-7

b. Directly from the 20 kVA uninterruptible power supplies (UPS)

c. Directly from either Scott Transformer T9 or T10.

d. Directly from the battery

Answer: C.04 c.
Reference: NBSR Reactor Operations Training Guide, § 5.0 NBSR Electrical Systems

Question C.005 [2.0 points, 0.5 each] (6.0)
Identify each of the essential electrical loads listed as being powered by AC Only (AC), DC Only, (DC) or AC or DC (AC/DC).

a. Emergency Cooling Sump

b. D_2O Shutdown Pumps

c. Emergency Exhaust Fans (EF 5 and EF 6)

d. Annunciator Power and Evacuation Alarm

Answer: C.05 a. = AC; b. = AC/DC; c. = AC/DC; d. = DC
Reference: NBSR Reactor Operations Training Guide

Question: C.006 [1.0 point] (7.0)
Reactor level is increasing above 168 inches. Which ONE of the following is the AUTOMATIC reactor scram which will occur?

a. High reactor D_2O level.

b. High flux on NC-6, NC-7 or NC-8.

c. Low reactor D_2O level.

d. High Reactor ΔT

Answer: C.06 c.
Reference: Annunicator Procedure AN.3.1 "Hi Reactor D_2O level"

Section C Facility and Radiation Monitoring Systems

Question C.007 [1.0 point] (8.0)
Which ONE of the following Reactor Rundown Signals can NOT be bypassed?

a. Cold Source flow
b. Cold Source pressure
c. Reactor Outlet Temperature
d. Reactor Thermal Power.

Answer: C.07 c.
Reference: NBSR Reactor Operations Training Guide

Question: C.008 [1.0 point] (9.0)
The purpose of the fuel element latching bar is to prevent an element from lifting out of the lower grid plate resulting in ………

a. A reduction in flow to the element.
b. Changes in the neutron flux to experiments.
c. Restrictions that could prevent a shim arm from operating.
d. Changes to the radial and axial flux pattern that could damage the fuel.

Answer: C.08 a.
Reference: TS 3.9.2 Fuel Handling

Question C.009 [1.0 point] (10.0)
WHICH ONE of the listed components within the Helium Sweep Gas system is responsible for the recombination of disassociated D_2 and O_2?

a. The ¼” thick aluminum vessel containing alumina-palladium pellets.
b. The ¼” aluminum plate tank containing an activated charcoal filter.
c. The 6061 aluminum cylinder Gas Holder.
d. The 304 Stainless Steel cold Trap.

Answer: C.09 a.
Reference: NBSR Training Guide, 4.7 HELIUM SWEEP GAS SYSTEM

Question: C.010 [1.0 point] (11.0)
The emergency exhaust system is designed to pass reactor building effluents through high-efficiency particulate filters capable of removing particles of ____ μm or greater with an efficiency of at least 99% and the charcoal filters are capable of removing greater than ____ of the Iodine from the air.

a. 0.3 μm 99%

b. 0.1 μm 98%

c. 0.2 μm 95%

d. 0.5 μm 96%

Answer: C.10 a.
Reference: TS 3.5 Ventilation System

Question C.011 [1.0 point] (12.0)
Which ONE of the following is the method used to get rid of radioactive liquid waste? Radioactive liquid waste is sent to Health Physics where it is

a. held, for decay of short lived isotopes then sampled for 10CFR20 limits and if satisfactory, pumped to the sewer system.

b. put through evaporators, filters ion exchangers, reducing the liquid waste to proper solid form.

c. diluted to less than 10CFR20 limits, then pumped to the sewer system.

d. tested for 10CFR20 limits, then pumped to the sewer system.

Answer: C.11 b.
Reference: NBSR Training Guide, § 4.1.2.2. 3rd ¶.

Section C Facility and Radiation Monitoring Systems

Question: C.012 [1.0 point] (13.0)
Which ONE of the following is the actual method that negative building pressure is maintained following a containment building isolation and normal ventilation shutdown due to high radiation? (Assume AC power is available, no operator action, and the containment building pressure is being maintained by the emergency exhaust system.)

a. automatic fan cycling on and off to maintain a pressure of -0.25".

b. manual fan cycling on and off to maintain a pressure of -0.25".

c. automatic fan cycling on and off to maintain a pressure of -0.1".

d. manual fan cycling on and off to maintain a pressure of -0.1".

Answer: C.12 a.
Reference: NBSR Training Guide, § 4.10.3, "Ventilation System Under accident conditions".

Question C.013 [1.0 point] (14.0)
The Compensated Ion Chambers used at NIST do not have the compensating voltage connected. The reason that compensating voltage is not required is because …

a. the Deuterium in the primary absorbs many gammas (gamma-neutron reaction).

b. the Tritium in the primary absorbs many gammas (gamma-neutron reaction).

c. there are lead windows located between the core and the detectors which absorb many gammas.

d. a D_2O moderated core must be larger than an H_2O moderated core resulting in greater self-shielding of gammas.

Answer: C.13 c.
Reference: NBSR Training Guide, §§ 6.2.3 and 6.2.4, p. 46

Question: C.014 [1.0 point, 0.25 each] (15.0)
Match the Storage Pool cooling system components with their primary responsibilities.

a. Suspended Solids	1. Pre and Post Filters
b. Dissolved Solids	2. Ultraviolet Treatment Unit
c. Kill Biological Impurities	3. Collection Basin
d. Floating Detritus (Mosquito Larvae, dust etc.)	4. HOH Ion Exchanger

Answer: C.14 a. = 1; b. = 4; c. = 2; d. = 3
Reference: NBSR Training Guide, figure 4.10.

Section C Facility and Radiation Monitoring Systems

Question C.015 [1.0 point] (15.0)
Which ONE of the following is the purpose of the thermal shield?

a. To thermalize neutrons for detection by nuclear instrumentation
b. To reduce the amount of gamma radiation heating of the biological shield.
c. To reduce the amount of gamma radiation reaching the nuclear instrumentation.
d. To reduce the amount of neutron radiation heating of the biological shield.

Answer: C.15 b.
Reference: NBSR Operations Training Guide, § 7.2 Thermal Shield

Question: C.016 [1.0 point] (16.0)
What type of detector does the T^3 channel use?

a. Ion chamber
b. Geiger Counter
c. Scintillation Detector
d. Proportional Counter

Answer: C.16 a.
Reference: NBSR Training Guide, § 6.4.7.

Question C.017 [1.0 point] (17.0)
Which ONE of the following is the reason that many D_2O valves are equipped with spark plugs?

a. To recombine D_2 and O leaking from the primary, thereby reducing explosion risk.
b. To detect primary leak due to a diaphragm rupture.
c. To detect valve vibration due to excessive flow.
d. To detect open/closed position of valve.

Answer: C.17 b.
Reference: NBSR Operations Training Guide, § 2.4.2

Section C Facility and Radiation Monitoring Systems

Question C.018 [1.0 point] (18.0)
Identify each of the following conditions as a **S**cram, **R**un**D**own or **N**either.

a. Period on NC-6 at 5 sec (currently <10% of full power.)

b. Thermal power at 22 MW.

c. Reactor outlet temperature at 135ºF

d. Reactor level at 142”

Answer: C.18 a. = ~~RD~~ S; b. = N; c. = RD; d. = RD
Reference: AP 6.1 – Scram and AP 6.2 - Rundown
Answer “a.” corrected per facility comment.

Question: C.019 [1.0 point] (19.0)
How long is the D2O system designed to provide cooling on a once-through basis?

a. 1 hour

b. 1.5 hours

c. 2 hours

d. 2.5 hours

Answer: C.19 d.
Reference: TS 3.3.2 Emergency Core Cooling

Question: C.020 [1.0 point] (20.0)
How much negative reactivity does the moderator dump provide?

a. The most reactive shim arms fully withdrawn.

b. Two shims arms fully withdrawn.

c. Three shims arms fully withdrawn and the regulating rod fully withdrawn.

d. All four shims arms fully withdrawn.

Answer: C.20 d.
Reference: TS 3.3.3 Moderator Dump System