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

July 31, 2019

Dr. Mary Lou Dunzik-Gougar, Reactor Administrator
And Professor and Chair of Nuclear Engineering
College of Science and Engineering
Idaho State University
921 S. 8th Avenue, MS 8060
Pocatello, ID 83209-8060

SUBJECT: EXAMINATION REPORT NO. 50-284/OL-19-01, IDAHO STATE UNIVERSITY

Dear Dr. Dunzik-Gougar:

During the week of June 3rd, 2019, the U.S. Nuclear Regulatory Commission (NRC) administered operator licensing examinations at your Idaho State University AGN-201m 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 Mrs. Paulette Torres at (301) 415-5656 or via internet e-mail Paulette.Torres@nrc.gov.

Sincerely,

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

Docket No. 50-284

Enclosures:
1. Examination Report No. 50-284/OL-19-01
2. Facility Comments with NRC Resolution
3. Written examination

cc: w/o enclosures: See next page

cc:

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Test, Research and Training
Reactor Newsletter
Attention: Amber Johnson
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U.S. NUCLEAR REGULATORY COMMISSION
OPERATOR LICENSING EXAMINATION REPORT

REPORT NO.: 50-284/OL-19-01

FACILITY DOCKET NO.: 50-284

FACILITY LICENSE NO.: R-110

FACILITY: Idaho State University AGN-201m Reactor

EXAMINATION DATES: June 03-05, 2019

SUBMITTED BY: Paulette Torres, Chief Examiner — 06/13/2019 Date

SUMMARY:
During the week of June 3, 2019, the NRC administered operator licensing examinations to five Reactor Operator (RO) candidates. All candidates passed all portions of the written and operating exam.

REPORT DETAILS

1. Examiner: Paulette Torres, Chief Examiner, NRC

2. Results:

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

3. Exit Meeting:
Paulette Torres, Chief Examiner, NRC
Dr. Mary Lou Dunzik-Gougar, Reactor Administrator, ISU
Theodore Pollock, Senior Reactor Operator, ISU

The facility licensee agreed to email their comments on the written examination which were incorporated into the examination report (see Enclosure 2). The ISU AGN-201m console was out of service during periods of the NRC operating exam precluding the ability of conducting the manipulations of the control part of the exam when required. The NRC examiner recommends the NRC inspector to look further at this issue. The NRC examiner found trends in the topics of common deficiency between all candidates: (1) knowledge of 10 CFR 50.59 and 50.90; (2) internal process for changes to technical specifications, procedures, and equipment; (3) radiation monitor operability; and (4) RO and AO responsibilities. The facility should consider strengthening these areas for future examinations.

ENCLOSURE 1

FACILITY COMMENTS ON THE WRITTEN EXAM WITH NRC RESOLUTION

QUESTION A.12 [1.0 point]
What order process is the radioactive decay differential equation?

a. Zero

b. First

c. Second

d. Third

Answer: b
REF: Burns, 2.4.6, pg. 2-30
Mathematically, radioactive decay can be represented by the first order, linear differential equation $dA/dt = -\lambda A$ where A is the number density of radioactive atoms of a substance and λ is called the decay constant.

Facility Comments & Recommendations: The order of a differential equation is something that is taught in a differential equation course. This course is not a requirement for reactor operators; however, it is expected that operators be able to manipulate the decay and power equations, which are the integral solutions of differential equations. In other words, operators need to understand the logarithmic or exponential nature of decay and of power changes with respect to time. The equation sheet provided for the exam includes no differential equations. Because ROs are not expected to manipulate differential equation, there seems to be no reason for them to know what order a differential equation is. I suggest that knowing the order of a differential equation does not make an operator better at carrying out his/her responsibilities. A question that touches on the logarithmic or exponential nature of decay or of power changes would be quite appropriate.

Reference(s): A complete first course in differential equations (https://www.udemy.com/a-complete-first-course-in-differential-equations/); equation sheet provided with the U.S. Nuclear Regulatory Commission Non-Power Reactor License Examination administered 06/03/2019.

NRC Resolution: The NRC understands the facility comments. Question A.12 will be deleted from the examination.

QUESTION A.14 [1.0 point]
Which ONE of the following is the primary mechanism for transferring heat through the cladding of a fuel rod?

a. Conduction

b. Convection

c. Radiation

d. Mass Transfer

Answer: a
REF: Lamarsh 3rd, Section 8.3, pg. 417

Facility Comments & Recommendations: The fuel in the AGN-201 is comprised of polyethylene disks in which the UO_2 is dispersed. These disks are stacked in the core tank, which also contains part of the graphite reflector, the thermal fuse and core support assembly, and the control and safety rod thimbles. There is sufficient air-filled clearance between core and reflector to insure free fall of the bottom half of the core during the most severe transient. There is no fuel cladding and there is essentially no heat produced in the 5 W reactor. Any heat that would be produced would be transferred to the air via radiation and to the material in contact with the fuel disks via conduction. So, this question isn't relevant to the AGN-201 and if it were changed to be relevant to the AGN-201, there would be two correct answers.

Reference(s): technical specifications 5.1 a and b

NRC Resolution: The NRC understands the facility comments. Question A.14 will be deleted from the examination.

QUESTION A.17 [1.0 point]
About two minutes following a reactor scram, period has stabilized, and is decreasing at a CONSTANT rate. If reactor power is 10^{-5} % full power what will the power be in three minutes?

a. 5×10^{-6} % full power

b. 2×10^{-6} % full power

c. 1×10^{-6} % full power

d. 5×10^{-7} % full power

Answer: c

REF: $P = P_0 e^{-(t/T)} = 10^{-5} \times e^{-(180sec/80sec)} = 10^{-5} \times e^{-2.25} = 0.1054 \times 10^{-5} = 1.054 \times 10^{-6}$

Facility Comments & Recommendations: As we discussed in our exit meeting, depending on the interpretation of this question regarding when the power was 10^{-5}% full power (at scram or at 2 minutes) and the point from which 3 minutes is measured (from scram or from 2 minutes), there are multiple correct answers. The question would be much more clear if written as follows: At the time a reactor is scrammed, the power is 10^{-5}% full power. What is the power at 3 minutes after scram? (Because the period is 80 seconds almost instantaneously after scram, the solution would be $P = 10^{-5}e^{-(180/80)} = 1x10^{-5}$% full power (answer c.))

NRC Resolution: The NRC understands the facility comments. Question A.12 will be deleted from the examination.

QUESTION B.05 [1.0 point]

As a research reactor licensed operator, you were unable to perform the functions of an operator for the minimum number of hours during the previous calendar quarter. What are the minimum number of hours you must complete before resumption of functions authorized by your license?

a. 4

b. 6

c. 8

d. 12

Answer: b

REF: 10 CFR 55.53 (f)

Facility Comments & Recommendations: This question requires a level of knowledge/memorization expected at the level of Reactor Supervisor, who is the person responsible for the re-instating of an RO to regular duties. It would make a good oral exam question for an SRO candidate. ROs are responsible for knowing and acting on the requirements to maintain their licenses and also that if they don't fulfill the requirements they will need to go to the RS to figure out next steps. I suggest that having memorized the particular number of hours required to make up for a lax in fulfilling their quarterly training requirements will not make an RO a better/more efficient/safer operator. References: Tech Spec Sections 6.1.3, 6.1.4 and 6.3

NRC Resolution: Thank you for the comment. 10 CFR 55.53 Conditions of License section

(f) states "If paragraph (e) of this section is not met, before resumption of functions authorized by a license issued under this part, an authorized representative of the facility licensee shall certify the following: (1) That the qualifications and status of the licensee are current and valid; and (2) That the licensee has completed a minimum of 40 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. The 40 hours must have included a complete tour of the plant and all required shift turnover procedures. For senior operators limited to fuel handling under paragraph (c) of this section, one shift must have been completed. For test and research reactors, a minimum of six hours must have been completed.

QUESTION C.02 [1.0 point]
With the maximum worth rod stuck in the core, the shutdown margin is about:

a. 0.65% Δk/k

b. 2.20% Δk/k

c. 3.35% Δk/k

d. 4.00% Δk/k

Answer: b
REF: SAR 5.2, pg. 72

Facility Comments & Recommendations: This question seems most appropriate for an oral exam, rather than written. ROs are required to know/understand the minimum required shut down margin as a matter of safety. In addition, they know the relative worths of each rod. The answer to this question requires memorization of facts from the Emergency Plan, which doesn't necessarily make an RO a better/more efficient/safer operator. Rather, ROs are required to know what to do in the case of an emergency and the circumstances that warrant emergency status.
Reference: Tech Spec Sections 1.2 and 3.1, and Emergency Plan Sections 5, 7 and 8

NRC Resolution: The NRC understands the facility comments. Question C.02 will be deleted from the examination.

QUESTION C.03 [1.0 point]
What would be the radiation levels for gamma rays at 5 watts at the outside surface of the concrete shield? About _____.

a. 0.14 mrem/hr (1.4 μSv/hr)

b. 3.40 mrem/hr (34 μSv/hr)

c. 7 mrem/hr (0.07 mSv/hr)

d. 170 mrem/hr (1.7 mSv/hr)

Answer: c
REF: SAR 5.6, pg. 94

Facility Comments & Recommendations: The section of the emergency plan from which this question was crafted is specific to operations of the reactor without water in the shield tank, rather than in the case of normal operations. This is not clear in the question. Further, there seems no reason to memorize dose numbers for such an unusual scenario, but rather trainees should have an idea where to look for such information. The answer to this question requires memorization of facts from the Emergency Plan, which doesn't necessarily make an RO a better/more efficient/safer operator. Reference: SAR Section 5.6

NRC Resolution: The NRC understands the facility comments. Question C.03 will be deleted from the examination.

QUESTION C.18 [1.0 point]
Which ONE of the following correctly describes the characteristic of the fuel disks used at the ISU reactor?

a. The uranium content is approximately 670 grams enriched to <20.0% Uranuim-235 dispersed in approximately 11 kilograms of polyethylene.

b. The uranium content is approximately 670 grams enriched to <19.0% Uranuim-235 dispersed in approximately 11 kilograms of polyethylene.

c. The uranium content is approximately 670 grams enriched to <20.0% Uranuim-235 dispersed in approximately 25 kilograms of polyethylene.

d. The uranium content is approximately 670 grams enriched to <19.0% Uranuim-235 dispersed in approximately 25 kilograms of polyethylene.

Answer: a
REF: TS 5.1.a, pg. 18

Facility Comments & Recommendations: Answering this question requires memorization of the mass (or the density) of polyethylene in the core. For safety purposes, the ROs are required to know the mass of fissile material, the ^{235}U enrichment, the relative loading of fissile material in the fuse vs the fuel disks, the approximate size of the core (fuel disks) and the amount of fissile material in the control rods. The mass of the polyethylene itself seems a somewhat trivial fact, but certainly a valid question for an oral exam. Reference: Tech Specs Section 5.1

NRC Resolution: Thank you for the comment. This question is related to the design features of the reactor and candidates are expected to be in deep familiar with Technical Specifications. We will consider writing the question differently in the future.

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

FACILITY: Idaho State University

REACTOR TYPE: AGN-201

DATE ADMINISTERED: 06/03/2019

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
17.00 ~~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
18.00 ~~20.00~~	33.3	_____	_____	C. FACILITY AND RADIATION MONITORING SYSTEMS
55.00 ~~60.00~~		_____ FINAL GRADE	_____ %	TOTALS

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

_____
Candidate's Signature

A. Reactor Theory, Thermohydraulics & Facility Operating Characteristics

ANSWER SHEET

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 ___~~ Deleted per facility comment

A13 a b c d ___

~~A14 a b c d ___~~ Deleted per facility comment

A15 a b c d ___

A16 a b c d ___

~~A17 a b c d ___~~ Deleted per facility comment

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

ANSWER SHEET

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

ANSWER SHEET

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 ___~~ Deleted per facility comment

~~C03 a b c d ___~~ Deleted per facility comment

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 only 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

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

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

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

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

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

$$\ell^* = 1\times10^{-4}\,\text{sec}$$

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

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

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

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

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

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

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

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

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

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

$$T_{\frac{1}{2}} = \frac{0.693}{\lambda} \qquad \Delta\rho = \frac{K_{eff_2}-K_{eff_1}}{K_{eff_1}K_{eff_2}}$$

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

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

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

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

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

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

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1 Curie = 3.7 x 10^{10} dis/sec

1 Horsepower = 2.54 x 10^3 BTU/hr

1 BTU = 778 ft-lbf

1 gal (H_2O) ≈ 8 lbm

c_P = 1.0 BTU/hr/lbm/°F
1ft = 30.48 cm

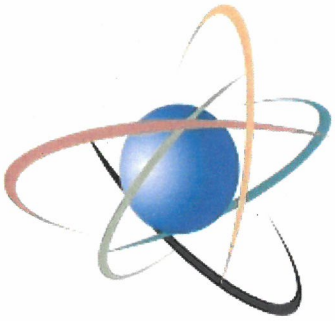
1 kg = 2.21 lbm

1 Mw = 3.41 x 10^6 BTU/hr

°F = 9/5 °C + 32

°C = 5/9 (°F - 32)

c_p = 1 cal/sec/gm/°C



U.S.NRC

UNITED STATES NUCLEAR REGULATORY COMMISSION

Protecting People and the Environment

Idaho State University

Operator Licensing Examination

Week of June 3, 2019

QUESTION A.01 [1.0 point]
Energy Yield (ΔQ) from a nuclear fission reaction is in the range of (or is approximately):

a. < 1 eV

b. 1.86 keV

c. 200 MeV

d. 1000 MeV

QUESTION A.02 [1.0 point]
A reactor is subcritical if:

a. $\rho = 1.0$

b. $K_{eff} < 1.0$ or $\rho < 0.0$

c. $K\infty = 1.0$, $\rho = \beta$

d. $K_{eff} > 1.0$ or $\rho > 0.0$

QUESTION A.03 [1.0 point]
What is the meaning of any point on a differential rod worth curve? Represents

a. The amount of reactivity that one inch of rod motion would insert at that position in the core.

b. The zero reactivity when the rod is on the bottom and the positive reactivity being added as the rod is withdrawn.

c. The negative reactivity added as the rod is inserted.

d. The cumulative area under the differential curve starting from the bottom of the core.

QUESTION A.04 [1.0 point]
Which ONE of the following changes does not require a movement of control rods in order to maintain constant reactor power?

a. Pool water temperature decrease

b. U-235 burnup

c. Xe-135 buildup

d. N-16 formation

QUESTION A.05 [1.0 point]
The effective multiplication factor (K_{eff}) can be determined by dividing the number of neutrons produced from fission in the fourth generation by the number of neutrons produced from fission in the _____ generation.

a. First

b. Second

c. Third

d. Fifth

QUESTION A.06 [1.0 point]
Because the temperature of the fuel reacts immediately to changes in reactor power, the Fuel Temperature Coefficient is also called the:

a. Prompt Temperature Coefficient

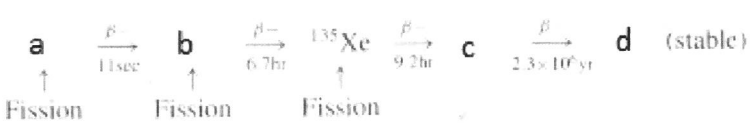
b. Moderator Temperature Coefficient

c. Nuclear Doppler Effect

d. Void Coefficient

QUESTION A.07 [1.0 point, 0.25 each]
Match the items in Column A with the isotopes in Column B.
The most important fission product poison is ^{135}Xe. The process that show how this isotope is formed and its decay is:

Column A



Column B

1. ^{135}Ba
2. ^{135}Cs
3. ^{135}I
4. ^{135}Te

QUESTION A.08 [1.0 point]
Delayed neutrons contribute more to reactor stability than prompt neutrons because they _____ the average neutron generation time and are born at a _____ kinetic energy.

a. Decrease, lower

b. Increase, lower

c. Decrease, higher

d. Increase, higher

QUESTION A.09 [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.10 [1.0 point]
Reactivity is defined as the:

a. Fractional change in neutron population per generation.

b. Number of neutrons by which neutron population changes per generation.

c. Rate of change of reactor power in neutron per second.

d. Change in the number of neutrons per second that causes a fission event.

QUESTION A.11 [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.12 [1.0 point]**~~ Deleted per facility comment
~~What order process is the radioactive decay differential equation?~~

~~a. Zero~~

~~b. First~~

~~c. Second~~

~~d. Third~~

QUESTION A.13 [1.0 point]
Which ONE of the following is the major source of heat generation after an operating reactor has been shut down and cooled down for several days?

a. Resonance capture

b. Fission fragment decay

c. Delayed neutron reactions

d. Corrosion product activation

~~**QUESTION A.14 [1.0 point]** Deleted per facility comment~~
~~Which ONE of the following is the primary mechanism for transferring heat through the cladding of a fuel rod?~~

~~a. Conduction~~

~~b. Convection~~

~~c. Radiation~~

~~d. Mass Transfer~~

QUESTION A.15 [1.0 point]
The reaction $_{93}Np^{239} \rightarrow$ _____ + $_{94}Pu^{239}$ is an example of:

a. Alpha Decay

b. Beta Decay

c. Gamma Emission

d. Electron Capture

QUESTION A.16 [1.0 point]
What is the effect of delayed neutrons on the neutron flux decay following a scram from full power?

a. Adds negative reactivity creating a greater shutdown margin.

b. Adds positive reactivity due to the fuel temperature decrease following the scram.

c. Limits the final rate at which power decreases to a -80 second period.

d. Decreases the mean neutron lifetime.

~~**QUESTION A.17 [1.0 point]**~~ Deleted per facility comment
~~About two minutes following a reactor scram, period has stabilized, and is decreasing at a CONSTANT rate. If reactor power is 10^{-5} % full power what will the power be in three minutes?~~

~~a. 5×10^{-6} % full power~~

~~b. 2×10^{-6} % full power~~

~~c. 1×10^{-6} % full power~~

~~d. 5×10^{-7} % full power~~

QUESTION A.18 [1.0 point]
Which ONE of the following most accurately describes the reason that fission products such as Xenon-135 and Samarium-149 have the most substantial impact in reactor design and operation?

a. Xenon-135 and Samarium-149 cause excess positive reactivity in the core.

b. Xenon-135 and Samarium-149 burn up causes an increase in the thermal flux.

c. Xenon-135 and Samarium-149 have large absorption cross sections resulting in a large removal of neutrons from the reactor.

d. Xenon-135 and Samarium-149 produce fast fission neutrons, resulting in the net increase in the fast neutron population of the reactor core.

QUESTION A.19 [1.0 point]
If Beta for U-235 is 0.0065 and Beta effective is approximately 0.007, how does this difference affect reactor period in the reactor period equation, $T=(\beta-p)/\lambda p$? This difference produces a _____ for a given addition of reactivity with Beta effective.

a. Longer period

b. Shorter period

c. Stable period

d. Decay constant (λ) increase

QUESTION A.20 [1.0 point]
Which ONE of the following is defined as the balance between production of neutrons and their absorption in the core for which core leakage can be neglected?

a. Utilization Factor

b. Reproduction Factor

c. Infinite Multiplication Factor

d. Effective Multiplication Factor

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

QUESTION B.01 [1.0 point]
What is the HALF LIFE of the isotope contained in a sample which produces the following count rates?

Time (Minutes)	Counts per Minute (cpm)
Initial count	840
30	740
60	615
90	512
180	270

a. 310 minutes

b. 210 minutes

c. 110 minutes

d. 60 minutes

QUESTION B.02 [1.0 point]
In an emergency in order to protect the public health and safety, 10 CFR 50.54 allows the operator to depart from a license condition or a technical specification. What is the minimum level of authorization needed to deviate from this action?

a. Reactor Director

b. Reactor Supervisor

c. Licensed Reactor Operator

d. Licensed Senior Reactor Operator

QUESTION B.03 [1.0 point]
The exposure rate for a point source is 100 mR/hr at a distance of 4 m. What is the exposure rate at a distance of 2 m?

a. 200 mR/hr

b. 400 mR/hr

c. 600 mR/hr

d. 800 mR/hr

QUESTION B.04 [1.0 point]
Given the following instruments, which ONE is the best to check your hands and clothing for beta-gamma contamination upon leaving a contamination zone?

a. GM Pancake

b. Ionization chamber survey instrument

c. Portable sodium Iodide (NaI) detector

d. Zinc Sulfide (ZnS) detector

QUESTION B.05 [1.0 point]
As a research reactor licensed operator, you were unable to perform the functions of an operator for the minimum number of hours during the previous calendar quarter. What are the minimum number of hours you must complete before resumption of functions authorized by your license?

a. 4

b. 6

c. 8

d. 12

QUESTION B.06 [1.0 point]
The average reactivity addition rate for each control or safety rod shall not exceed _____ per second.

a. 0.065% Δk/k

b. 0.65% Δk/k

c. 1.0% Δk/k

d. 5.0% Δk/k

QUESTION B.07 [1.0 point]
Per Emergency Plan, TLD badges and/or self-reading dosimeters shall be worn by all personnel who enter restricted areas. This is an example of:

a. Assessment Actions

b. Corrective Actions

c. Protective Actions

d. Recovery Actions

QUESTION B.08 [1.0 point]
Which ONE of the following Surveillance Procedures calls for a 100 M ohm resistor as equipment required?

a. SP#1

b. SP#2

c. SP#3

d. SP#4

QUESTION B.09 [1.0 point]
Per Technical Specifications, a _____ is one which may be inserted, removed or manipulated while the reactor is critical.

a. Movable Experiment

b. Removable Experiment

c. Secured Experiment

d. Unsecured Experiment

QUESTION B.10 [1.0 point]
The Period Scram OK check is done under the:

a. Over-Current Relay checks

b. Channel #1 checks

c. Channel #2 checks

d. Channel #3 checks

QUESTION B.11 [1.0 point]
The seismic displacement interlock shall be _____ annually.

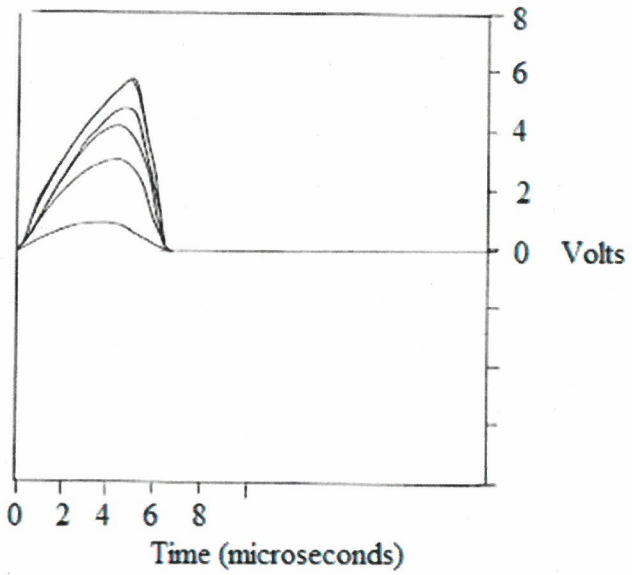
a. Channel-Checked

b. Channel-Calibrated

c. Channel-Replaced

d. Channel-Tested

QUESTION B.12 [1.0 point]
The below figure represents the Expected Pulse Shape of _____.



a. Reactor Period

b. Channel #1

c. Channel #2

d. Channel #3

QUESTION B.13 [1.0 point]
Per AGN-201 Operating Procedures, which ONE of the following sections ask the operator to verify the "INTERLOCK OK" light is energized?

a. STARTUP

b. PRESTART DATA

c. PREOPERATIONAL CHECKS

d. ROD DROP TEST AND FINAL PREPARATION

QUESTION B.14 [1.0 point]
The Director of Emergency Operations, with recommendation from the _____, shall be approve all building re-entry.

a. Idaho State Police

b. Pocatello Fire Department

c. US Nuclear Regulatory Commission

d. Reactor Safety and Recovery Operations Coordinator

QUESTION B.15 [1.0 point]
Which ONE of the following reactor control and safety systems has a function that Scram at levels < 5% of Full Scale?

a. Nuclear Safety Channel No. 2 (Log Power Channel) Low Power

b. Nuclear Safety Channel No. 2 (Log Power Channel) High Power

c. Nuclear Safety Channel No. 3 (Linear Power Channel) Low Power

d. Nuclear Safety Channel No. 3 (Linear Power Channel) High Power

QUESTION B.16 [1.0 point]
During an emergency, reactor personnel will gather at the _____ insuring everyone is accounted for and checked for radioactive contamination.

a. Hold Station, Room 101.

b. Reactor Laboratory, Room 20.

c. Subcritical Assembly Laboratory, Room 23.

d. Nuclear Engineering Laboratory Entrance Hallway, Room 14.

QUESTION B.17 [1.0 point]
Per AGN-201 Rod Maintenance Procedure, the operator removes the dash pot by unscrewing and place it in the lay-down area for all of the following EXCEPT:

a. Coarse Control Rod (CCR)

b. Fine Control Rod (FCR)

c. Safety Rod #1 (SR-1)

d. Safety Rod #2 (SR-2)

QUESTION B.18 [1.0 point]
The Emergency Plan for the Nuclear Facilities At Idaho State University: AGN-201M Nuclear Reactor and Subcritical Assembly shall apply to the _____.

a. Operations Area

b. Operations Boundary

c. Emergency Planning Zone

d. Emergency Support Center

QUESTION B.19 [1.0 point]
Which ONE of the following is an example of an emergency procedure described in the emergency plan?

a. Bomb threat.

b. Fuel element failure.

c. Measured dose rate.

d. Individual injury.

QUESTION B.20 [1.0 point]
All of the following materials shall be doubly encapsulated EXCEPT:

a. Corrosive

b. Explosives

c. Gases

d. Liquids

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

QUESTION C.01 [1.0 point]
Which part of the Nuclear Operations Area has a radiation field of 6 mr/hr present when the reactor is operating at 5W power level?

a. The Counting Laboratory, Room 22.

b. The Subcritical Laboratory, Room 23.

c. The Reactor Suppervisor's Office, Room 15.

d. The Observation/Conference Room, Room 19.

~~**QUESTION C.02 [1.0 point]** Deleted per facility comment~~
~~With the maximum worth rod stuck in the core, the shutdown margin is about:~~

~~a. 0.65% Δk/k~~

~~b. 2.20% Δk/k~~

~~c. 3.35% Δk/k~~

~~d. 4.00% Δk/k~~

~~**QUESTION C.03 [1.0 point]** Deleted per facility comment~~
~~What would be the radiation levels for gamma rays at 5 watts at the outside surface of the concrete shield? About _____.~~

~~a. 0.14 mrem/hr (1.4 μSv/hr)~~

~~b. 3.40 mrem/hr (34 μSv/hr)~~

~~c. 7 mrem/hr (0.07 mSv/hr)~~

~~d. 170 mrem/hr (1.7 mSv/hr)~~

QUESTION C.04 [1.0 point]
The Ra(Be) source utilizes a _____ reaction.

a. (α,η)

b. (γ,α)

c. $(\beta+)$

d. (η,γ)

QUESTION C.05 [1.0 point]
The two reactor core fuel discs 1-cm high have approximately _____ grams of ^{235}U.

a. 3.6 g

b. 29 g

c. 58 g

d. 96 g

QUESTION C.06 [1.0 point]
W.R.T Channel No. 1, a _____ is located in the cable tray on top of the reactor for signal conditioning of the pulses from the detector.

a. Preamplifier

b. Proportional Counter

c. High Voltage Power Supply

d. Discriminating Count Rate Meter

QUESTION C.07 [1.0 point]
The ISU radiation worker occupational dose limit 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.08 [1.0 point]
All of the following are characteristics/functions of the thermal fuse EXCEPT:

a. Designed to soften at 100°C.

b. Located near the center of the core.

c. Provides a space for core expansion and gas accumulation.

d. Permits the bottom core section to drop 5 cm (2") to the bottom of the core tank.

QUESTION C.09 [1.0 point]
_____ provides protection from the possibility of a grid to cathode short in the 6L6 vacuum tube.

a. Period Trip Relay

b. Overcurrent Meter Relay

c. Magnet-Current Reversal Relay

d. Reset Relay

QUESTION C.10 [1.0 point]
Which ONE of the following relays is not connected to the SCRAM bus?

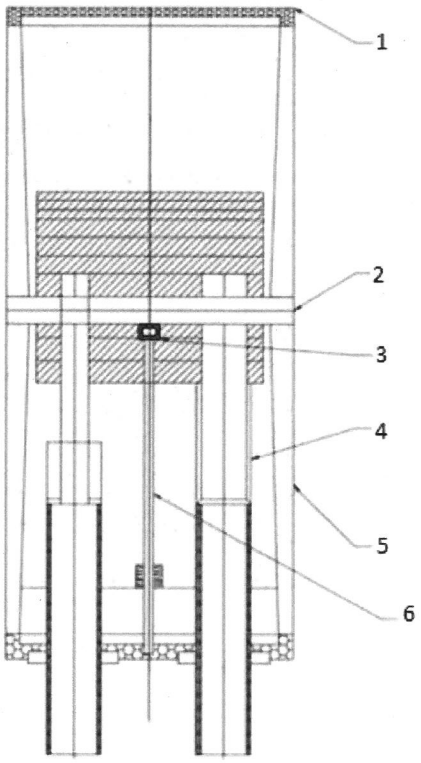
a. Reset Button

b. Seismic

c. Water Level

d. Radiation Alarm

QUESTION C.11 [1 point, 0.25 each]
Identify the best answer from the components labeled 1 through 6 on the figure of the AGN-201 core tank and contents provided. (Note: Only one answer per number.)



a. Glory Hole _____

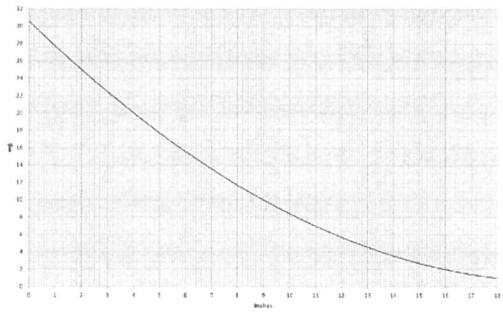
b. Thermal Fuse _____

c. Core Support Assembly _____

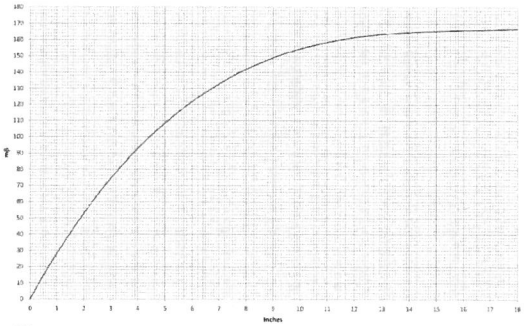
d. Control and Safety Rod Thimbles _____

QUESTION C.12 [1.0 point]
Which ONE of the following figures represent an Integral Worth Curve?

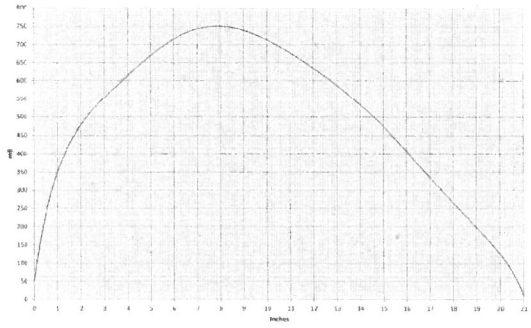
a.



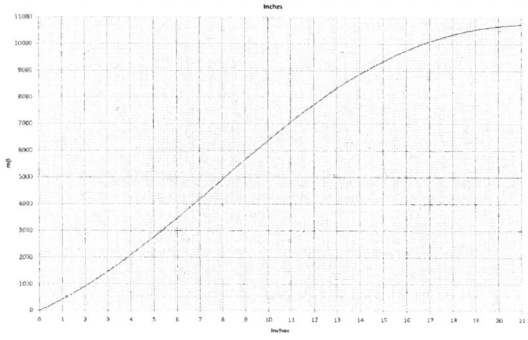
b.



c.



d.



QUESTION C.13 [1.0 point]
The reactor Gamma Shield is a 10 cm thick of _____ completely surrounding the reflector.

a. Aluminum

b. Graphite

c. Lead

d. Polyethylene

QUESTION C.14 [1.0 point]
All Channel #1, Channel #2, and Channel #3 instruments at ISU are _____.

a. Fission Chambers

b. Gamma Ion Chambers

c. Compensated Ion Chambers

d. Uncompensated Ion Chambers

QUESTION C.15 [1.0 point]
Who must authorize every reactor startup?

a. The Licensed RO

b. The licensed SRO

c. The Certified Observer on Duty

d. The Reactor Supervisor

QUESTION C.16 [1.0 point]
Which ONE of the following is an hydraulic (oil-filled) or pneumatic control rod drive component used to decelerate each scrammable rod during the last 10 cm of travel?

a. Double Lead Screw Drivetrain

b. Synchro Generator

c. Electromagnet

d. Dashpot

QUESTION C.17 [1.0 point]
The safety rods and coarse control rod shall be interlocked under conditions such as the following EXCEPT:

a. Reactor startup cannot commence unless both safety rods and coarse control rods are fully withdrawn from the core.

b. The coarse control rod cannot be inserted unless both safety rods are fully inserted.

c. Only one safety rod can be inserted at a time.

d. Scrams not reset.

QUESTION C.18 [1.0 point]
Which ONE of the following correctly describes the characteristic of the fuel disks used at the ISU reactor?

a. The uranium content is approximately 670 grams enriched to <20.0% Uranuim-235 dispersed in approximately 11 kilograms of polyethylene.

b. The uranium content is approximately 670 grams enriched to <19.0% Uranuim-235 dispersed in approximately 11 kilograms of polyethylene.

c. The uranium content is approximately 670 grams enriched to <20.0% Uranuim-235 dispersed in approximately 25 kilograms of polyethylene.

d. The uranium content is approximately 670 grams enriched to <19.0% Uranuim-235 dispersed in approximately 25 kilograms of polyethylene.

QUESTION C.19 [1.0 point]
What is the gas region that corresponds to the Channel #2 neutron detector?

a. The Ionization Region

b. The Proportional Region

c. The Geiger-Muller Region

d. The Recombination Region

QUESTION C.20 [1.0 point]
Per Technical Specifications, Fuel, including fueled experiments and fuel devices not in the reactor, shall be stored in locked rooms in the College of Engineering laboratories. The storage array shall be such that k_{eff} is _____ for all conditions of moderation and reflection.

a. no greater than 0.9

b. equal to 1

c. less than 0.8

d. equal to 1.0178

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

A.01
Answer: c
REF: Lamarsh 3rd, Table 3.6, pg. 88

A.02
Answer: b
REF: Burns, Table 3.5, pg. 3-22

A.03
Answer: a
REF: Burns, Example 7.2 (b), pg. 7-4

A.04
Answer: d
REF: Burns, Problem 7.7.4, pg. 7-17

A.05
Answer: c
REF: Burns, Section 3.3.1, pg. 3-16

A.06
Answer: a
REF: Lamarsh 3rd ed., Section 7.4, pg. 367

A.07
Answer: a, 4 b, 3 c,2 d,1
REF: Lamarsh 3rd ed., Section 7.5, pg. 377
Burns, Figure 8.1, pg. 8-6
RO_Lecture_2_RS, pg. 23

A.08
Answer: b
REF: Burns, Section 3.2.4, pg. 3-12 and Section 3.4.4, pg. 3-33

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

A.10
Answer: a
REF: Burns, Section 1.3.1, pg. 1-5

A.11
Answer: d
REF: Knife, Nuclear Engineering, 2nd ed., pg. 142

~~**A.12**~~ Deleted per facility comment
~~Answer: b~~
~~REF: Burns, 2.4.6, pg. 2-30~~
~~Mathematically, radioactive decay can be represented by the first order, linear differential equation $dA/dt = -\lambda A$ where A is the number density of radioactive atoms of a substance and λ is called the decay constant.~~

A.13
Answer: b
REF: DOE Fundamentals Handbook, NP-03, pg. 34

~~**A.14**~~ Deleted per facility comment
~~Answer: a~~
~~REF: Lamarsh 3rd, Section 8.3, pg. 417~~

A.15
Answer: b
REF: DOE Fundamentals Handbook, NP-01, pg. 24

A.16
Answer: c
REF: Burns, Section 4.10.12, pg. 4-32 to 4-33

~~**A.17**~~ Deleted per facility comment
~~Answer: c~~
~~REF: $P = P_0 e^{-(t/T)} = 10^{-5} \times e^{-(180sec/80sec)} = 10^{-5} \times e^{-2.25} = 0.1054 \times 10^{-5} = 1.054 \times 10^{-6}$~~

A.18
Answer: c
REF: DOE Fundamentals Handbook, NP-03, pg. 34

A.19
Answer: a
REF: Burns, Example 3.4.3, pg. 3-32, 3-33
In the reactor period equation, $T=(\beta-p)/\lambda p$, if Beta effective is used instead of Beta for U-235, the term $(\beta_{eff}-p)$ is larger giving a longer period.

A.20
Answer: c
REF: DOE Fundamentals Handbook, NP-03, pg. 9

B.01
Answer: c
REF: $A = A_0 e^{-\lambda t}$
$270 = 840e^{-180\lambda}$, $180\lambda = -\ln(0.321)$, $\lambda = 0.00631\ min^{-1}$
$t_{1/2} = 0.693 / \lambda$, $= 0.693 / 0.00631\ min^{-1} = 109.8$ minutes

B.02
Answer: d
REF: 10 CFR 50.54(y)

B.03
Answer: b
REF: $I_2 = I_1 D_1^2 / d_2^2 = (100\ mR/hr)(4m)^2 / (2m)^2 = 400\ mR/hr$

B.04
Answer: a
REF: Glasstone, Sesonske, Nuclear Reactor Engineering, Section 9.88, pg. 537

B.05
Answer: b
REF: 10 CFR 55.53 (f)

B.06
Answer: a
REF: TS 3.2 (b), pg. 9

B.07
Answer: c
REF: EP 7.3.3, pg. 12

B.08
Answer: c
REF: SP#3 equipment required
SP#3A Checkoff Sheet

B.09
Answer: a
REF: TS 1.9 (d), pg. 3

B.10
Answer: c
REF: Rev.5 Check sheets, pg. 1/3

B.11
Answer: d
REF: TS 4.2 (d), pg. 15

B.12
Answer: b
REF: SP-1, II. Figure One, pg. 2

B.13
Answer: c
REF: OP-1 and OP-2, Rev-4, II. PREOPERATIONAL CHECKS

B.14
Answer: d
REF: EP Appendix C6.8, pg. 26

B.15
Answer: c
REF: TS Table 3.1, pg. 11

B.16
Answer: a
REF: EP 2.10, pg. 4

B.17
Answer: b
REF: MP-1, REV. 6, II.1.a., pg. 3

B.18
Answer: c
REF: EP 6.0, pg. 9

B.19
Answer: a
REF: EP Appendix C2, pg. 23

B.20
Answer: b
REF: TS 3.3 (a), pg. 11

C.01
Answer: d
REF: SAR 3.2.4, pg. 38

~~**C.02**~~ Deleted per facility comment
~~Answer: b~~
~~REF: SAR 5.2, pg. 72~~

~~**C.03**~~ Deleted per facility comment
~~Answer: c~~
~~REF: SAR 5.6, pg. 94~~

C.04
Answer: a
REF: SAR Table 4.2-1, pg. 47

C.05
Answer: b
REF: SAR table 4.2-1 pg. 46

C.06
Answer: a
REF: SAR 4.3.2, pg.60

C.07
Answer: c
REF: RO_Lecture_2_RS, pg. 22

C.08
Answer: c
REF: SAR 4.1, pg. 40

C.09
Answer: b
REF: SAR Figure 4.3-8, pg. 66
SAR 4.3.2, pg. 65

C.10
Answer: d
REF: RO_Lecture_6_CS, pg. 4

C.11

Answer: a, 2 b, 3, c, 6 d, 4
REF: SAR Figure 4.2-3, pg. 44
RO_Lecture_1_Intro, pg. 4

C.12
Answer: d
REF: RO_Lecture_3_BRT, pg. 81-84

C.13
Answer: c
REF: SAR Table 4.2-1, pg. 46
SAR Figure 4.3-2, pg. 55
RO_Lecture_2_RS, pg. 13
TS 5.1.b, pg. 18

C.14
Answer: d
REF: RO_Lecture_5_NI, pg. 27, 30, 33

C.15
Answer: d
REF: RO_Lecture_4_BO, pg. 11, 14

C.16
Answer: d
REF: SAR 4.3.1, pg. 54

C.17
Answer: d
REF: TS 3.2.c, pg. 9

C.18
Answer: a
REF: TS 5.1.a, pg. 18

C.19
Answer: a
REF: RO_Lecture_5_NI, pg. 19, 30
SAR 4.3.2, pg. 62

C.20
Answer: a
REF: TS 5.2, pg. 19
RO_Lecture_1_Intro, pg. 22

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