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

December 16, 2019

Dr. Marylou Dunik-Gougar
Reactor Administrator
Idaho State University
Professor of Nuclear Engineering
921 S. 8th Avenue, MS 8060
Pocatello, ID 83209-8060

SUBJECT: EXAMINATION REPORT NO. 50-284/OL-20-01, IDAHO STATE UNIVERSITY

Dear Dr. Dunzik-Gougar:

During the week of October 21, 2019, the U.S. Nuclear Regulatory Commission (NRC) administered an operator licensing examination at your Idaho State University research 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. John T. Nguyen at (301) 415-4007 or via internet e-mail John.Nguyen@nrc.gov.

Sincerely,

Anthony J. Mendiola, Chief
Non-Power Production and Utilization Facility
Oversight Branch
Division of Advanced Reactors and Non-Power
Production and Utilization Facilities
Office of Nuclear Reactor Regulation

Docket No. 50-284

Enclosures:
1. Examination Report No. 50-284/
OL-20-01
2. Written examination

cc: w/o enclosures: See next page

cc:

Dr. Scott D. Snyder
Idaho State University
Interim Vice President for Research
Mail Stop 8130
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John Longley, Radiation Safety Officer
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Idaho State University
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Director
Idaho Dept. of Environmental Quality
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Test, Research and Training
Reactor Newsletter
Attention: Ms. Amber Johnson
Dept. of Materials Science and Engineering
University of Maryland
4418 Stadium Drive
College Park, MD 20742-2115

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

REPORT NO.: 50-284/OL-20-01

FACILITY DOCKET NO.: 50-284

FACILITY LICENSE NO.: R-110

FACILITY: AGN

EXAMINATION DATES: October 21 - 24, 2019

SUBMITTED BY: John T. Nguyen, Chief Examiner   11/13/2019 Date

SUMMARY:
During the week of October 21, 2019, the NRC administered an operator licensing examination to three Senior Reactor Operator – Upgrade (SROU) and one Senior Reactor Operator Instant (SROI) candidates. One SROU candidate failed the operating test. All other candidates passed all applicable portions of the examination.

REPORT DETAILS

1. Examiner: John T. Nguyen, Chief Examiner, NRC

2. Results:

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

3. Exit Meeting:
John T. Nguyen, Chief Examiner, NRC
Mary Lou Dunzik-Gougar, Reactor Administrator, Idaho State University
Jonathan T. Scott, Training Supervisor, Idaho State University
Theodore Pollock, Senior Reactor Operator, Idaho State University

At the end of the meeting, the NRC examiner thanked the facility for their support in the administration of the examination. The examiner also discussed the generic weaknesses observed during the operating test to include questions related to the administrative procedure for replacing facility safety and non-safety significant equipment, the Emergency Plan license amendment, the 10 CFR 50.59 process, and the Safety control rod calibration procedures.

U.S.NRC
UNITED STATES NUCLEAR REGULATORY COMMISSION
Protecting People and the Environment

UNIVERSITY OF IDAHO

Operator Licensing Examination

Week of October 21, 2019

ENCLOSURE 2

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

FACILITY: Idaho State University

REACTOR TYPE: AGN

DATE ADMINISTERED: 10/24/2019

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
18.00	33.3	________	_____	A. REACTOR THEORY, THERMODYNAMICS AND FACILITY OPERATING CHARACTERISTICS
18.00	33.3	________	_____	B. NORMAL AND EMERGENCY OPERATING PROCEDURES AND RADIOLOGICAL CONTROLS
16.00	33.3	________	_____	C. FACILITY AND RADIATION MONITORING SYSTEMS
52.00		________ FINAL GRADE	_____ %	TOTALS

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

____
Candidate's Signature

Category A – Reactor Theory, Thermodynamics, & 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 ___ (0.25 each)

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 ___ (0.25 each)

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 ___ (0.25 each)

A16 a b c d ___

A17 a b c d ___

A18 a b c d ___

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

Category B – Normal/Emergency Operating 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 ___ (0.5 each)

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 ___

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

C. PLANT AND RAD 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 ___

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 ___ (0.5 each)

C14 a b c d ___

C15 a b c d ___

(***** END OF CATEGORY 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

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

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

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

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

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

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

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

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

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

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

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

$$M = \frac{1 - K_{eff_1}}{1 - K_{eff_2}}$$

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

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

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

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

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

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

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

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

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

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

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

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1 Curie = 3.7×10^{10} dis/sec
1 Horsepower = 2.54×10^3 BTU/hr
1 BTU = 778 ft-lb
1 gal (H_2O) ≈ 8 lb
c_P = 1.0 BTU/hr/lb/°F

1 kg = 2.21 lb
1 Mw = 3.41×10^6 BTU/hr
°F = 9/5 °C + 32
°C = 5/9 (°F - 32)
c_p = 1 cal/sec/gm/°C

QUESTION A.01 [1.0 point, 0.25 each]
A fissile material is one that will fission upon absorption of a thermal neutron. A fertile material is one that absorbs a neutron and becomes a fissile material. Identify each of the listed isotopes as either **fissile** or **fertile**.

a. U-238

b. Pu-239

c. Th-232

d. U-235

QUESTION A.02 [1.0 point]
The term "Prompt Critical" refers to:

a. a reactivity insertion which is less than $ß_{eff.}$

b. a reactor which is supercritical by using only prompt neutrons.

c. the instantaneous jump in power due to a removal of the control rods.

d. a reactor which is critical by using both prompt and delayed neutrons.

QUESTION A.03 [1.0 point]
The reactor is critical at 0.1 watt. A control rod is inserted a positive reactivity of 0.10% $\Delta k/k$. Which ONE of the following will be the stable reactor period as a result of this reactivity insertion? Given beta effective = 0.0076

a. 10 seconds

b. 29 seconds

c. 66 seconds

d. 80 seconds

QUESTION A.04 [1.0 point]
K_{eff} is K_{∞} times ...

a. the total non-leakage probability ($L_f \times L_{th}$)

b. the resonance escape probability (p)

c. the reproduction factor (η)

d. the fast fission factor (ε)

QUESTION A.05 [1.0 point]
Which type of neutron interaction (light nuclei) is most effective in moderating fast neutrons to thermal neutrons?

a. Neutron capture

b. Elastic scattering

c. Inelastic scattering

d. Charged particle reactions

QUESTION A.06 [1.0 point, 0.25 each]
Match the term listed in Column A with its corresponding unit listed in column B (use only once in column B).

	Column A	Column B
a.	1 barn	1. cm^{-1}
b.	Macroscopic Cross Section	2. 10^{-24} cm^2
c.	Neutron Flux	3. Neutrons / cm^2/sec
d.	Reaction Rate	4. Fissions / cm^3 sec

QUESTION A.07 [1.0 point]
A reactor with K_{eff} = 0.8 contributes 1000 neutrons in the first generation. Changing from first generation to third generation, what is the total number of neutrons produced in all three generations?

a. 2040 neutrons

b. 2440 neutrons

c. 3640 neutrons

d. 24040 neutrons

QUESTION A.08 [1.0 point]
If the multiplication factor, k, is increased from 0.800 to 0.950, the amount of reactivity added is:

a. 0.50 $\Delta k/k$

b. 0.150 $\Delta k/k$

c. -0.150 $\Delta k/k$

d. 0.197 $\Delta k/k$

QUESTION A.09 [1.0 point]
The Prompt Neutron Lifetime is approximately:

a. 10^{-4} second

b. 10^{-2} second

c. 12 seconds

d. 80 seconds

QUESTION A.10 [1.0 point]
Given a source strength of 5000 neutrons per second (N/sec) and a subcritical multiplication factor of 0.8, which ONE of the following is the expected stable neutron count rate?

a. 4000 N/sec

b. 6250 N/sec

c. 25000 N/sec

d. 50000 N/sec

QUESTION A.11 [1.0 point]
During a fuel loading of the core, as the reactor approaches criticality, the value of 1/M:

a. Increases toward one.

b. Decreases toward one.

c. Increases toward infinity.

d. Decreases toward zero.

QUESTION A.12 [1.0 point]
The reactor is critical and increasing in power. Power has increased from 20 mW to 40 mW in 10 seconds. How long will it take at this rate for power to increase from 0.040 W to 1 W?

a. 26 seconds

b. 46 seconds

c. 66 seconds

d. 80 seconds

QUESTION A.13 [1.0 point]
Which one of the following factors in the "six factor" formula is the most affected by the Negative Temperature Coefficient?

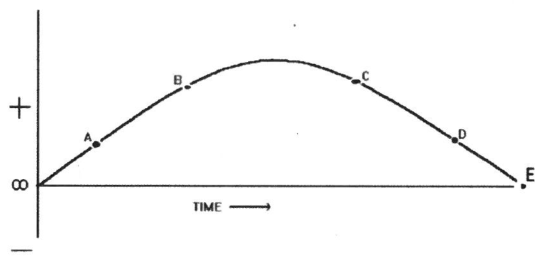
a. The fast fission factor

b. The thermal utilization factor

c. The resonance escape probability

d. The thermal non-leakage probability

QUESTION A.14 [1.0 point]
Shown below is a trace of reactor period as a function of time. From point B to point D reactor power is:



a. constant.

b. continually increasing.

c. increasing, then constant.

d. increasing, decreasing, then constant.

QUESTION A.15 [1.0 point, 0.25 each]
The listed isotopes are all potential daughter products due to the radioactive decay of $_{35}Br^{87}$. Identify the type of decay necessary (Alpha, Beta, Gamma or Neutron emission) to produce each of the isotopes.

a. $_{33}As^{83}$

b. $_{35}Br^{86}$

c. $_{35}Br^{87}$

d. $_{36}Kr^{87}$

QUESTION A.16 [1.0 point]
Calculate the shutdown margin by the Technical Specifications. Given the following worth:

Safety Rod 1	= $1.20
Safety Rod 2	= $1.50
Coarse Rod	= $1.10
Fine Rod	= $0.60

a. $0.60

b. $1.40

c. $2.90

d. $3.50

QUESTION A.17 [1.0 point]
Five minutes after shutting down the reactor, reactor power is 3×10^6 counts per minute (cpm). Which ONE of the following is the count rate you would expect two minutes later?

a. 1×10^6 cpm

b. 7×10^5 cpm

c. 5×10^5 cpm

d. 3×10^5 cpm

QUESTION A.18 [1.0 point]
Which ONE of the following is the major source of energy released during fission?

a. Absorption of prompt gamma rays

b. Fission fragments

c. Fission neutron scattering

d. Neutrino interactions

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

Category B: Normal/Emergency Operating Procedures and Radiological Controls

QUESTION B.01 [1.0 point]
Which of the following statements best states the MINIMUM staffing requirements when the reactor is not secured?

a. 2 ROs in the control room.

b. 1 SRO + 1 Certified Observer in the control room.

c. 1 RO in the control room + 1 SRO who can arrive at the facility in 15 minutes.

d. 1 RO + 1 Certified Observer in the control room + 1 SRO who can arrive at the facility in 30 minutes

QUESTION B.02 [1.0 point]
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 ten (10) feet. What percentage of the source consists of beta radiation?

a. 30%

b. 50%

c. 70%

d. 90%

QUESTION B.03 [1.0 point]
Select the most correct statement. Per ISU Technical Specifications, the reactor is considered "Shutdown"" when the core fuse melts resulting in separation of the core; AND:

a. the reactor is subcritical at $0.50.

b. No experiments are being moved or serviced that have, on movement, a reactivity worth exceeding the maximum allowed for a single experiment, or one dollar, whichever is smaller.

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. The reactor console key switch is in the "OFF" position and the key is removed from the console and under the control of a licensed operator.

QUESTION B.04 [1.0 point]
Per ISU Technical Specifications, temporary procedure changes which do NOT change the intent of the original procedure or involve a 10CFR50.59 review may be approved as a MINIMUM by the:

a. Senior Reactor Operator

b. Reactor Supervisor

c. Reactor Administrator and Reactor Safety Committee

d. Nuclear Regulatory Commission

QUESTION B.05 [1.0 point]
What type of radiation detector is used for surveying contaminated areas?

a. Ionization chamber

b. Proportional counter

c. Scintillation detector

d. Geiger-Mueller tube

QUESTION B.06 [1.0 point]
To prevent damage to the reactor or excessive release of radioactive materials in the event of an experiment failure, experiments containing corrosive materials shall:

a. be doubly encapsulated.

b. be limited to less than 10 grams.

c. not be inserted into the reactor or stored at the facility.

d. have a TEDE to any person occupying an unrestricted area in excess of 0.1 rem.

QUESTION B.07 [2.0 points, 0.5 each]
Identify each of the following surveillances as a channel check (CHECK), a channel test (TEST), or a channel calibration (CAL).

a. You expose a check source to the radiation area monitor detector to verify that its output is operable.

b. You adjust the Power Safety channels in accordance with recent data collected during a gold foil calibration.

c. During performance of the daily checklist, you depress a scram bar to verify a manual scram.

d. During a normal operation, you compare the readings of the Nuclear Safety channel #2 and the Nuclear Safety channel #3.

QUESTION B.08 [1.0 point]
The Emergency Planning Zone (EPZ) consists of:

a. Room 20 (Reactor Lab) and Room 23 (Subcritical Assembly) on the first level of the LEL building.

b. Room 20 (Reactor Lab) and Room 22 (Counting Lab) on the first level of the LEL building.

c. Room 23 (Subcritical Assembly) and Room 22 (Counting Lab) on the first level of the LEL

d. Room 126 (Machine Shop and Emergency Support Center) on the second level of the LEL building.

QUESTION B.09 [1.0 point]
Which ONE of the following would violate the Limiting Safety System Setting (LSSS) for the ISU?

a. The shutdown margin is less than one dollar.

b. Nuclear Safety Channel #2 exceeds 5.5 watts.

c. The average reactivity addition rate for each control rod exceeds 0.065% $\Delta k/k$ per second.

d. The core thermal fuse melts when heated to a temperature of about 120°C resulting in core separation and a reactivity loss greater than 5% $\Delta k/k$.

QUESTION B.10 [1.0 point]
Control rod scram times and average reactivity insertion shall be measured:

a. quarterly.

b. semi-annually.

c. annually.

d. every two years.

QUESTION B.11 [1.0 point]
The ISU Technical Specification basis for the shield water temperature interlock is to prevent:

a. breakdown of the graphite reflector.

b. radiation from the reactor core.

c. instrument inaccuracy.

d. reactivity additions.

QUESTION B.12 [1.0 point]
As a licensed reactor operator at the ISU, who is allowed to manipulate the controls of the reactor under your direction?

a. A local college newspaper reporter who wants to write a story on the safety of nuclear reactors.

b. A student participating in a reactor operator training program.

c. A health physicist who is trying to gain a certified health physicist (CHP) license.

d. An NRC examiner trying to make sure that all set points of the reactor are the same as listed in the technical specifications.

QUESTION B.13 [1.0 point]
"A loss of electric power shall cause the reactor to scram". This is an example of:

a. Limiting Safety System Settings.

b. Limiting Conditions for Operation.

c. Surveillance Requirements.

d. Design Features.

QUESTION B.14 [1.0 point]
Per 10CFR20, the occupational Total Effective Dose Equivalent (TEDE) is:

a. 0.1 rem

b. 0.5 rem

c. 5.0 rem

d. 15.0 rem

QUESTION B.15 [1.0 point]
80% of the decay of a 2-curie source results in emission of 100 Kev gamma. What is the dose rate at 1 foot?

a. 160 mRem

b. 960 mRem

c. 1600 mRem

d. 9600 mRem

QUESTION B.16 [1.0 point]
Reactor Operator works in a high radiation area for eight (8) hours a day. The dose rate in the area is 50 mrem/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. 10 days

b. 11 days

c. 12 days

d. 13 days

QUESTION B.17 [1.0 point]
Which ONE of the following is NOT considered a reportable event?

a. Deployment of the thermal fuse.

b. During the reactor operation, the operator found fission products released from fuel.

c. During the reactor operation, the operator found a disagreement between expected and actual critical rod positions of 0.4% $\Delta k/k$.

d. During the reactor training, a student will let the power drift up to the 6 watt- limit, whereupon a reactor scram occurs.

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

Category C: Facility and Radiation Monitoring Systems

QUESTION C.01 [1.0 point]
The movable shield doors above the thermal column shall be maintained in a ______ position whenever the reactor is operated at a power greater than _____ watts.

a. CLOSED /0.5

b. CLOSED /0.1

c. OPEN /0.5

d. OPEN /0.1

QUESTION C.02 [1.0 point]
Which ONE of the following channels uses a proportional counter?

a. Channel 1

b. Channel 2

c. Channel 3

d. Area Radiation Monitor

QUESTION C.03 [1.0 point]
During a reactor operation of 2 watts, you observe the shield water temperature indicates 14.7 °C. For this temperature, you should:

a. increase power, so you can observe the temperature change.

b. continue to operate because the shield water temperature is within TS limit.

c. shutdown the reactor; immediately report the result to Reactor Supervisor because the reactor control and safety systems are not operable.

d. continue operation; but immediately report the result to the Senior Reactor Operator since the temperature is decreasing below the facility operation limit.

QUESTION C.04 [1.0 point]
In the event the reactor fails to scram, TWO design features that prevent the core temperature exceeding the safety limit are:

a. The large temperature coefficient and the volume of water shield.

b. The Glory Hole Cadmium plug and the volume of water shield.

c. Melting of the Thermal fuse and the large negative temperature coefficient.

d. The large positive temperature coefficient and melting of the thermal fuse.

QUESTION C.05 [1.0 point]
Which ONE control rod listed below will NOT instantaneously eject from the core in the event of a SCRAM?

a. Coarse.
b. Fine.
c. Safety 1.
d. Safety 2.

QUESTION C.06 [1.0 point]
Which ONE of the following is a design feature of the ISU AGN-201M Core?

a. The reactor consists of 9 fuel discs with less than 20% U-235 enrichment.

b. The reactor consists of 9 fuel discs with less than 30% U-235 enrichment.

c. The reactor consists of 12 fuel discs with less than 20% U-235 enrichment.

d. The reactor consists of 12 fuel discs with less than 30% U-235 enrichment.

QUESTION C.07 [1.0 point]
A reactor operator removes the startup source after rods are above estimated critical height. By removing the startup source, the reactor power will:

a. increase.

b. decrease.

c. be the same.

d. cause a prompt jump to 0.01 watt.

QUESTION C.08 [1.0 point]
Per ISU Technical Specification, which ONE of the following is the acceptable time between the initiation of a scram signal and the time that the SAFETY rods are fully withdrawn from the core?

a. 1300 msec

b. 1200 msec

c. 1100 msec

d. 990 msec

Category C: Facility and Radiation Monitoring Systems

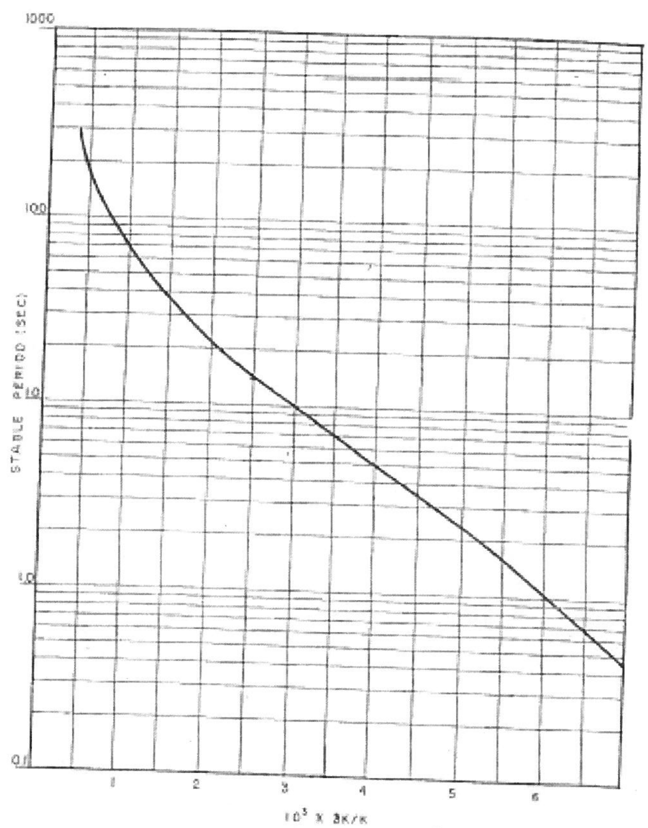
QUESTION C.09 [1.0 point]
The Figure below depicts:

a. Integral worth curve for the Fine Rod.

b. Integral worth curve for the Coarse Rod

c. Differential worth curve for the Fine Rod.

d. AGN-201 In-hour equation curve.



QUESTION C.10 [1.0 point]
Which ONE of the following is the MAIN function of the high-density graphite surrounding the reactor core?

a. To absorb thermal neutrons

b. To reduce neutron leakage

c. To absorb fission product gases

d. To increase neutron leakage

QUESTION C.11 [1.0 point]
Which ONE of the following would add the most **POSITIVE** reactivity to the reactor when placed it in the GLORY HOLE?

a. Boron

b. Polyethylene

c. Cadmium

d. Gold

QUESTION C.12 [1.0 point]
The MAIN purpose of the thermal fuse is to:

a. measure the temperature of fuel core.

b. measure any gases released from the fuel core.

c. separate the reactor core to prevent exceeding the Safety Limit (SL.)

d. send a scram signal to the Nuclear Safety # 2 if Limiting Safety System Setting (LSSS) is exceeded.

QUESTION C.13 [2.0 points, 0.5 each]
Match the input signals listed in column A with their respective responses listed in column B. (Items in column B may be used more than once or not at all.)

	Column A		Column B
a.	Shield water temperature = 17 ˚C	1.	Indication only
b.	Reactor period = 30 sec	2.	Scram
c.	Nuclear Safety # 2 = 120% of licensed power	3.	Interlock
d.	Try to move coarse control rod when both safety rods are fully down		

QUESTION C.14 [1.0 point]
The detector used for the Low Temperature switch is what type?

a. Ion Chamber.

b A simple bi-metallic thermal switch.

c. A chromel-alumel (Type K) thermocouple.

d. A precision platinum wound resistance temperature detector (RTD).

QUESTION C.15 [1.0 point]
The device used for the shield tank water level signal is a:

a. 6L6 scram tube.

b. Float switch.

c. Flow switch.

d. Pressure switch.

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

Category A: Reactor Theory, Thermodynamics, and Facility Operating Characteristics

A.01
Answer: a. = fertile; b. = fissile; c. = fertile; d. = fissile (0.25 each)
Reference: Burn, R., Introduction of Nuclear Reactor Operations, © 1988, Sec 3.2

A.02
Answer: b
Reference: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory Volume 2, Module 4, Enabling Objective 2.8, p. 15.

A.03
Answer: c
Reference: Reactivity added = 0.10 % Δk/k = 0.0010 Δk/k
$\tau = (\beta-\rho)/\lambda_{eff}*\rho = \frac{0.0076 - 0.0010}{(0.1)(0.0010)} = 66$ seconds

A.04
Answer: a
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1988,

A.05
Answer: b
Reference: Lamarsh 3rd ed., Section 3.6, pg. 68-71
Basic Nuclear Engineering 4th ed., Slowing Down of Neutrons, pg. 226-227

A.06
Answer: a(2) b(1) c(3) d(4) (0.25 each)
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, Sec 2.6

A.07
Answer: b
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1982, § 5.3, p. 5.6
For third generation=n + K*n + K^2 *n=1000+800+640= 2440neutrons

A.08
Answer: d
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1982, Sec 3.3.3, page 3-21.
Δρ = keff1-keff2/(keff1 x keff2) = 0.95-0.8 /(0.8*0.95)=0.197 Δk/k

A.09
Answer: a
Reference: DOE Handbook, Volume 1, NP-02, pg. 31

A.10
Answer: c
Reference: CR = S/(1-K) → CR = 5000/(1 - 0.8) = 25000 N/sec

A.11
Answer: d
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1988

A.12
Answer: b
Reference: $P = P_0e^{t/T}$ $40 = 20e^{10\ sec/T}$ $T = 14.4$ sec 1 watt = $0.040e^{t/14.4}$
t = 46 sec

A.13
Answer: b
Reference: Glasstone, S. and Sesonske, A, Nuclear Reactor Engineering, 1991, § 5.98, p. 264.

A.14
Answer: b
Reference: Reactor keeps increasing (positive period).

A.15
Answer: a, α, b, n; c, gamma; d, β^{+-}
Reference: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory

A.16
Answer: c
Reference: TS 1.28
$0.6 + 1.10 + 1.20 = $2.90

A.17
Answer: b
Reference: Burn, R., Introduction of Nuclear Reactor Operations, © 1988, Sec 4.6
For S/D reactor, τ = -80 seconds. Time = 120 seconds.
$P = P0\ e^{t/\tau} = 3 \times 10^{6}\ e^{-120/80} = 6.69 \times 10^{5}$

A.18
Answer: b
Reference: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory

Category B: Normal/Emergency Operating Procedures and Radiological Controls

B.01
Answer: d
Reference: ISU Technical Specifications 6.1.11

B.02
Answer: d
Reference: 10CFR20 - At 10 feet, there is no beta radiation.
Calculate gamma at 1 ft.
$DR1*(D1)^2 = DR2*(D2)^2$
$0.1*(10)^2 = DR2*(1)^2$
gamma at 1 foot = 10 mrem/hour.
Therefore, beta at 1 foot = 90 mrem/hour or 90%.

B.03
Answer: d
Reference: ISU Technical Specifications 1.1.22

B.04
Answer: b
Reference: ISU Technical Specifications 6.6

B.05
Answer: d
Reference: General Radiation Protection Practice

B.06
Answer: a
Reference: ISU Technical Specifications 3.3.a

B.07
Answer: a (test), b (cal), c (test) d (check) (0.5 each)
Reference: ISU Technical Specifications 1.1.3, 1.1.4, and 1.1.5

B.08
Answer: a
Reference: ISU Emergency Plan 6.0

B.09
Answer: d
Reference: TS 2.2.b.

B.10
Answer: c
Reference: ISU Technical Specifications 4.2

B.11
Answer: d
Reference: ISU Technical Specifications 3.2

B.12
Answer: b
Reference: 10 CFR 55.13

B.13
Answer: b
Reference: ISU Technical Specifications 3.2

B.14
Answer: c
Reference: 10 CFR 20

B.15
Answer: b
Reference: 6CEN = R/hr @ 1 ft. -> 6 x 2 x 0.8 x 0.1 = 0.96 R/hr at 1ft.

B.16
Answer: c
Reference: 10CFR20.1201(a)(1) $\frac{[5000 \text{ mr} \times 1 \text{ hr} \times \text{day}}{50 \text{ mr} * 8 \text{ hr}} = 12.5$ days
You cannot round off to 13 days that will exceed TEDE of 5 Rem

B.17
Answer: d
Reference: ISU Technical Specifications 6.9.2

Category C: Facility and Radiation Monitoring Systems

C.01
Answer: a
Reference: ISU Technical Specifications 3.4.c

C.02
Answer: a
Reference: ISU SAR 4.3.2

C.03
Answer: c
Reference: ISU Technical Specifications 3.2.f

C.04
Answer: c
Reference: ISU Technical Specifications 2.2, basis

C.05
Answer: b
Reference: NRC Standard Question

C.06
Answer: a
Reference: ISU SAR, Table 4.2-1

C.07
Answer: a
Reference: ISU Operating Procedure #1, Section V, Startup

C.08
Answer: d
Reference: ISU Technical Specifications 3.2.a

C.09
Answer: d
Reference: ISU SAR, Figure 4.2-5

C.10
Answer: b
Reference: NRC Standard Questions

C.11
Answer: b
Reference: NRC Standard Questions

<u>Category C: Facility and Radiation Monitoring Systems</u>

C.12
Answer: c
Reference: NRC Standard Question

C.13
Answer: a, 1; b, 1; c, 2; d, 3 (0.5 each)
Reference: ISU Technical Specifications 3.2

C.14
Answer: b
Reference: ISU SAR 4.3.4

C.15
Answer: b
Reference: ISU SAR, Table 4.2-1

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