September 9, 2011

Dr. Jay F. Kunze
Idaho State University
833 South Eighth Street
Pocatello, ID 83209

SUBJECT: EXAMINATION REPORT NO. 50-284/OL-11-01, IDAHO STATE UNIVERSITY

Dear Dr. Kunze:

During the week of July 25, 2011, the U.S. Nuclear Regulatory Commission (NRC) administered operator licensing examination at your Idaho State University AGN reactor. The examination was conducted according to NUREG-1478, "Operator Licensing Examiner Standards for Research and Test Reactors," Revision 2, published in June 2007. Examination questions and preliminary findings were discussed at the conclusion of the examination with those members of your staff identified in the enclosed report.

In accordance with Title 10, Section 2.390 of the Code of Federal Regulations, a copy of this letter and the enclosures will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records (PARS) component of NRC's Agencywide Documents Access and Management System (ADAMS). ADAMS is accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html (the Public Electronic Reading Room). The NRC is forwarding the individual grades to you in a separate letter which will not be released publicly. If you have any questions concerning this examination, please contact Patrick Isaac at 301-415-1019 or via email at patrick.isaac@nrc.gov.

Sincerely,

/RA/

Johnny H. Eads, Jr., Chief
Research and Test Reactors Oversight Branch
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Docket No. 50-284

Enclosures: 1. Examination Report No. 50-284/OL-11-01
2. Corrected Written Examination

cc: Adam Mallicoat, Reactor Supervisor, Idaho State University

cc: w/o enclosures: See next page

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DISTRIBUTION w/ encls.:
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OFFICE	PROB:CE	IOLB:LA	PROB:BC
NAME	PIsaac	CRevelle	JEads
DATE	08/30/11	09/09/11	9/9/11

OFFICIAL RECORD COPY

cc:

Idaho State University
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College of Engineering Dean
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Pocatello, ID 83209-8060

Idaho State University
ATTN: Dr. Richard R. Brey
Radiation Safety Officer
Physics Department
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Toni Hardesty, Director
Idaho Dept. of Environmental Quality
1410 North Hilton Boise, ID 83606

Test, Research and Training
Reactor Newsletter
202 Nuclear Sciences Center
University of Florida
Gainesville, FL 32611

EXAMINATION REPORT NO: 50-284/OL-11-01

FACILITY: Idaho State University

FACILITY DOCKET NO.: 50-284

FACILITY LICENSE NO.: R-110

SUBMITTED BY: _______/JNguyen for RA/_______ __9/9/11___
Patrick J. Isaac, Chief Examiner Date

SUMMARY:

During the week of July 25, 2011, the NRC administered operator licensing examinations to one Senior Reactor Operator Instant (SROI), one Senior Reactor Operator Upgrade, and two Reactor Operator candidates. The SROI candidate failed the examinations. All other candidates passed the examinations and have been issued a license to operate the Idaho State University reactor.

REPORT DETAILS

1. Examiner: Patrick J. Isaac, Chief Examiner

2. Results:

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

3. Exit Meeting:

Adam Mallicoat, Idaho State University
Patrick Isaac, NRC, Examiner

The NRC Examiner thanked the facility for their support in the administration of the examinations and agreed to make the following changes to the written examination:

Question A.7 - Accept both answers “b” and “d” as correct.

Question C.14 - Accept “b” as the correct answer

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

FACILITY: Idaho State University

REACTOR TYPE: AGN-201

DATE ADMINISTERED: July 25, 2011

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	35.3	___________	_____	**A. REACTOR THEORY, THERMODYNAMICS AND FACILITY OPERATING CHARACTERISTICS**
18.00	35.3	___________	_____	**B. NORMAL AND EMERGENCY OPERATING PROCEDURES AND RADIOLOGICAL CONTROLS**
15.00	29.4	___________	_____	**C. FACILITY AND RADIATION MONITORING SYSTEMS**
51.00		___________ FINAL GRADE	_____ %	**TOTALS**

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

____
Candidate's Signature

A. RX THEORY, THERMO & FAC OP CHARS

A N S W E R   S H E E T

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

001 a b c d ___

002 a b c d ___

003 a b c d ___

004 a b c d ___

005 a b c d ___

006 a b c d ___

007 a b c d ___

008 a b c d ___

009 a b c d ___

010 a b c d ___

011 a b c d ___

012 a b c d ___

013 a b c d ___

014 a b c d ___

015 a b c d ___

016 a b c d ___

017 a b c d ___

018 a b c d ___

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

B. NORMAL/EMERG PROCEDURES & RAD CON

A N S W E R S H E E T

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

001 a b c d ___

002 a b c d ___

003 a ___ b ___ c ___ d ___

004 a ___ b ___ c ___ d ___

005 a ___ b ___ c ___ d ___

006 a b c d ___

007 a b c d ___

008 a b c d ___

009 a b c d ___

010 a b c d ___

011 a b c d ___

012 a b c d ___

013 a b c d ___

014 a b c d ___

015 a b c d ___

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

C. PLANT AND RAD MONITORING SYSTEMS

A N S W E R   S H E E T

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

001 a b c d ___

002 a b c d ___

003 a b c d ___

004 a b c d ___

005 a b c d ___

006 a b c d ___

007 a b c d ___

008 a b c d ___

009 a b c d ___

010 a b c d ___

011 a b c d ___

012 a b c d ___

013 a b c d ___

014 a b c d ___

015 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 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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$A_f = A_o(1-e^{-\lambda t})$$

$$I = I_o e^{-\mu x}$$

$$\mu_m = \frac{\mu}{\rho}$$

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

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

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

QUESTION A.01 [1.0]
Which ONE of the following neutrons would result in the highest probability of fission for ^{235}U?

a. Thermal neutron (0.025 eV)

b. Epi-Thermal neutron (1 eV)

c. Prompt neutron (0.7 MeV)

d. Fast neutron (2 MeV)

QUESTION A.02 [1.0]
Which of the following power manipulations would take the longest to complete assuming the same period is maintained?

a. 100 mW to 400 mW

b. 400 mW to 500 mW

c. 1 W to 3.5 W

d. 3.5 W to 4.5 W

QUESTION A.03 [1.0]
A critical reactor is operating at a steady-state power level of 1.00 W. Reactor power is increased to a new steady-state power level of 1.05 W. Neglecting any temperature effects, what reactivity insertion is required to accomplish this?

a. 0.05 delta k/k.

b. 5.0% delta k/k.

c. 1.05% delta k/k.

d. Indeterminate, since any amount of positive reactivity could be used.

QUESTION A.04 [1.0]
Which ONE of the following factors in the six-factor formula can be varied by the reactor operator?

a. Fast fission factor.

b. Reproduction factor.

c. Fast non-leakage factor.

d. Thermal utilization factor.

QUESTION A.05 [1.0]
If reactor period (τ) is at 25 seconds, approximately how long will it take for reactor power to increase by a factor of 10?

a. 10 seconds

b. 25 seconds

c. 1 minute

d. 3 minutes

QUESTION A.06 [1.0]
The AGN-201 is designed to produce a fission rate within the thermal fuse that is approximately twice the average of the core. Which ONE of the following describes how this higher reaction rate is accomplished?

a. The polystyrene media used in the thermal fuse is a better moderator, raising the thermal flux in the fuse area.

b. The non-uniform fuel loading in the upper fuel disc increases the thermal flux in fuse area.

c. The fuel enrichment used in the thermal fuse is twice that of the balance of the core resulting in a higher fission rate in the fuse area.

d. The fuel density used in the thermal fuse is twice that of the balance of the core resulting in a higher fission rate in the fuse area.

QUESTION A.07 [1.0]
Which one of the following is the purpose of having an installed neutron source?

a. To compensate for neutrons absorbed by experiments installed into the reactor.

b. To generate a sufficient neutron population to start a fission chain for reactor startup.

c. To provide for a means to allow reactivity changes to occur in a subcritical reactor.

d. To generate a detectable neutron level for monitoring reactivity changes in a shutdown reactor.

QUESTION A.08 [1.0]
At the beginning of a reactor startup, Keff is 0.90 with a count rate of 30 CPS. Power is increased to a new, steady value of 60 CPS. The new Keff is:

a. 0.91

b. 0.925

c. 0.95

d. 0.975

QUESTION A.09 [1.0]
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

QUESTION A.10 [1.0]
Which one of the following is the reason for the steady-state period after a reactor scram?

a. -80 seconds, due to the decay of the longest lived delayed neutron precursor.

b. -56 seconds, due to the decay of the longest lived delayed neutron precursor.

c. -10^{-5} seconds, due to the rapid insertion of reactivity greater than β_{eff}.

d. $-\infty$, due to the rapid insertion of reactivity greater than β_{eff}.

QUESTION A.11 [1.0]
Of the approximately 200 Mev of energy released per fission event, the largest amount appears in the form of:

a. Beta and gamma radiation

b. Prompt and delayed neutrons

c. Kinetic energy of the fission fragments

d. Alpha radiation

QUESTION A.12 [1.0]
The reactor is at 5 watts, when someone inserts an experiment which causes a 10 second positive period. If the scram delay time is 1 second and the lowest scram setpoint is 9.7 watts, which ONE of the following is the MAXIMUM power the reactor will reach prior to scramming?

a. 9.1 watts

b. 10.7 watts

c. 15.5 watts

d. 25 watts

QUESTION A.13 [1.0]
During a reactor startup, you insert Coarse Rod #1 in 5 equal steps of 8 cm. The reactor is still subcritical after the fifth step. Which one of the following statements best describes reactor behavior during these 5 rod insertions.

a. Each withdrawal added the same amount of reactivity.

b. For equal reactivity insertions, reactor power will increase the same amount.

c. The time for reactor power to stabilize after the fifth insertion is longer than the time after the first.

d. If you were to decrease the time between rod insertions, final critical rod height would decrease.

QUESTION A.14 [1.0]
Which ONE of the following is the DOMINANT factor in determining the differential reactivity worth of a control rod?

a. Radial and axial flux.

b. Total reactor power.

c. Control rod speed.

d. Delayed neutron fraction.

QUESTION A.15 [1.0]
The reactor is shutdown by 1.0% Δk/k and an experiment is placed into the glory hole. Count rate on the startup channel increased from 15 cps to 30 cps. What is the worth of the experiment?

a. positive 1.01% Δk/k

b. negative 1.01% Δk/k

c. positive 0.508% Δk/k

d. negative 0.508% Δk/k

QUESTION A.16 [1.0]
If K_{eff} equals 1.0, how much reactivity must be added to the core to make the reactor prompt critical?

a. 10% ΔK/K

b. 75% ΔK/K

c. 10 ΔK/K

d. 75 ΔK/K

QUESTION A.17 [1.0]
What effect does Doppler Broadening for U-238 have on neutrons in a critical core?

a. More fission

b. More absorption

c. More scattering

d. More leakage

QUESTION A.18 [1.0]
While the reactor is shutdown you place an experiment into the glory hole to determine its worth. The reactor is shutdown by 2% ΔK/K. Before insertion of the experiment, Channel #1 reads 70 cps. After insertion of the experiment, Channel #1 reads 35 cps. What is the worth of the experiment?

a. -2.1% ΔK/K

b. -1.05% ΔK/K

c. -0.21% ΔK/K

d. -0.105% ΔK/K

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

QUESTION B.01 [1.0]
Which one of the following is the correct value and reason for the minimum shield water temperature in the technical specifications?

a. 15°C. To limit the final power reached during a reactor excursion prior to the fuse melting.

b. 10°C. To limit the final power reached during a reactor excursion prior to the fuse melting.

c. 15°C. To limit the potential positive reactivity addition associated with a decrease in temperature.

d. 10°C. To limit the potential positive reactivity addition associated with a decrease in temperature.

QUESTION B.02 [1.0]
Which ONE of the following is the power level above which the thermal column door must be closed?

a. 0.01 watts

b. 0.05 watts

c. 0.1 watts

d. 0.5 watts

QUESTION B.03 [2.0, 0.5 each]
Match the Area radiation levels in column A with the corresponding area type (as defined by 10 CFR 20) from column B. (Some of the items in Col. B may be used more than once or not at all)

	Column A		Column B
a.	2 mr/hr	1.	Unrestricted
b.	5 mr/hr	2.	Radiation Area
c.	10 mr/hr	3.	High Radiation Area
d.	100 mr/hr	4.	Very High Radiation Area

QUESTION B.04 [2.0, 0.5 each]
Match the operator license requirements in Column A with the proper time period from column B.

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

QUESTION B.05 [2.0, 0.5 each]
Identify each of the following values as either a Safety Limit (SL), a Limited Safety Setting (LSSS) or a Limiting Condition for Operation (LCO).

a. Power ≥ 100 watts

b. Temperature ≥ 120 °C

c. Excess Reactivity 0.65% Δk/k (corrected to 20 °C)

d. Safety Rod with a reactivity addition rate of 0.065% Δk/k.

QUESTION B.06 [1.0]
Given the following information, calculate the half-life of the sample.

Time (in minutes)	Counts per minute
0	900
30	740
60	615
90	512
120	427
180	294

a. 551 minutes

b. 122 minutes

c. 111 minutes

d. 100 minutes

QUESTION B.07 [1.0]
During a survey you read 100 mrem/hr with the window open and 40 mRem/hr with the window closed. Which ONE of the following is the dose rate due to GAMMA radiation?

a. 140 mRem/Hr

b. 100 mRem/Hr

c. 60 mRem/Hr

d. 40 mRem/Hr

QUESTION B.08 [1.0]
"A channel test of Nuclear Safety Channels #1, #2 and #3 shall be performed prior to the first reactor startup of the day or prior to each reactor operation extending more than one day." This is an example of a(n):

a. safety limit.

b. limiting condition for operation.

c. limiting safety system setting.

d. surveillance requirement.

QUESTION B.09 [1.0]
Which ONE of the following is the basis for the maximum core temperature safety limit?

a. Prevent separation of the core.

b. Prevent melting of the polyethylene core material.

c. Prevent operating personnel from being exposed to high temperature.

d. Prevent spontaneous ignition of the graphite reflector.

QUESTION B.10 [1.0]
Prior to opening the core tank the reactor must be secured for …

a. 12 hours

b. 24 hours

c. 2 days

d. 7 days

QUESTION B.11 [1.0]
In the event of any emergency, if the radiation level outside of the operations area exceeds _______ mR/hr, the operator shall order an evacuation.

a. 10.

b. 50.

c. 75.

d. 100.

QUESTION B.12 [1.0]
In accordance with Emergency procedures, in the event of a fire, which ONE of the following actions should the reactor operator perform immediately after securing the reactor?

a. Notify the Pocatello Police Department.

b. Notify the U.S. NRC Operations Center.

c. Initiate a building evacuation.

d. Notify the Reactor Supervisor.

QUESTION B.13 [1.0]
The total scram withdrawal time of the coarse control rod and the safety rods must be less than:

a. 200 milliseconds.

b. 500 milliseconds.

c. 800 milliseconds.

d. 1000 milliseconds.

QUESTION B.14 [1.0]
You performed a startup this morning with the pneumatic tube terminus and no experiment in the reactor. After shutting down, one hour later, you removed the tube. No other changes were made to the reactor. During a new startup the new core excess will be …

a. larger than the previous startup.

b. smaller than the previous startup.

c. the same as the previous startup.

d. dependent on the time of shutdown.

QUESTION B.15 [1.0]
You have evacuated the EPZ. Which ONE of the following ISU staff positions is responsible (by title) for authorizing reentry?

a. The Senior Reactor Operator

b. The Reactor Supervisor

c. The Director of Emergency Operations

d. The ISU Radiation Safety Officer

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

QUESTION C.01 [1.0]
Where would you go to deenergize the ventilation system during an emergency?

a. On the reactor room wall opposite room 15 (Reactor Supervisor Office)

b. On the corridor wall just outside the door to room 23 (Subcritical Assembly Laboratory).

c. On the corridor wall just outside the door to room 19 (Reactor Observation Room).

d. Just inside the door to room 22 (Counting Laboratory).

QUESTION C.02 [1.0]
Which one of the following is the reason you rotate the Nuclear Instrumentation Channel #1 range switch counterclockwise after depressing the "RAISE" button?

a. To prevent a reactor trip due to excessive period.

b. To prevent a low level trip of the Safety Channel #1 sensitrol.

c. To compensate for control rod shadowing effects on Safety Channel #1, at higher power levels.

d. To bring Safety Channel #1 readings into agreement with Safety Channels #2 and #3.

QUESTION C.03 [1.0]
Which ONE of the following is NOT an interlock preventing rod insertion?

a. Both safety rods must be fully inserted prior to inserting the coarse control rod.

b. Both safety rods must be fully inserted prior to inserting the fine control rod.

c. The coarse control rod must be fully withdrawn prior to inserting the safety rods.

d. The fine control rod must be greater than or equal to half inserted prior to inserting the safety rods.

QUESTION C.04 [1.0]
Which ONE of the following is the gas used in the rabbit tube assembly?

a. Air

b. Carbon Dioxide

c. Helium

d. Nitrogen

QUESTION C.05 [1.0]
Which ONE of the following signals will result in opening the interlock bus?

a. Manual scram switch

b. Period trip

c. Earthquake sensor

d. Channel #1 high (95% full scale)

QUESTION C.06 [1.0]
Which one of the following detectors is used for Nuclear Instrumentation Channel #2?

a. BF_3 filled Proportional Counter

b. BF_3 filled Ionization Chamber

c. BF_3 filled Geiger-Muller tuber

d. U^{235} lined Fission Chamber

QUESTION C.07 [1.0]
Which ONE of the following statements correctly completes the sentence concerning the access ports? The access ports …

a. penetrate through the shield tank, passing by the reflector and the lead shield.

b. pass through the shield tank up to the lead shield

c. pass through the shield tank, lead shield and the reflector up to the core container.

d. pass through the shield tank up to the reflector

QUESTION C.08 [1.0]
The reactor is critical, with the Fine Control Rod (FCR) fully inserted. If you wish to reposition the FCR to the mid-plane of its travel, how far and in what direction must you move the Coarse Control Rod (CCR), maintaining critical conditions?

a. 6.7 cm, out of core

b. 3.3 cm, into core

c. 3.3 cm, out of core

d. 6.7 cm, into core

QUESTION C.09 [1.0]
The Low Level Interlock is controlled by power level indication from:

a. Channel 1.

b. Channel 2.

c. Channel 3.

d. Auxiliary Channel.

QUESTION C.10 [1.0]
Which ONE of the following conditions will prevent the operator from inserting the control rods into the core?

a. Shielding water less than 1 inch from the manhole opening.

b. Earthquake of negligible horizontal amplitude.

c. Water temperature of 20 ^{o}C.

d. Channel #1 reset button depressed.

QUESTION C.11 [1.0]
The U-235 fuel in the AGN is contained in fuel disks and control rods. Of the total fuel in the reactor, approximately how much is contained in the control and safety rods?

a. 9%.

b. 24%.

c. 55%

d. 78%.

QUESTION C.12 [1.0]
Which ONE of the following describes the design purpose of the space in the top section of the core tank above the reactor core and the reflector?

a. Ensures free fall of the bottom half of the core during the most severe transient.

b. Increases the fast neutron population in the vicinity of experiments placed in the access ports.

c. Allows for accumulation of fission product gases created during reactor operation.

d. Prevents core damage during the design basis earthquake and 6 cm. displacements.

QUESTION C.13 [1.0]
Which ONE of the following does NOT automatically cause a reactor scram?

a. Reactor period.

b. Radiation level.

c. Water level.

d. Power failure.

QUESTION C.14 [1.0]
Which one of the following materials will have a positive effect on reactivity when inserted into the Glory Hole?

a. Borated Polyethylene

b. Polyethylene

c. Natural Uranium

d. Gold

QUESTION C.15 [1.0]
When using the movable tank on the top of the reactor as a Thermal Neutron column, it is filled with …

a. Water

b. Beryllium

c. Graphite

d. Heavy Water

(***** END OF CATEGORY C *****)
(********** END OF EXAMINATION **********)

SECTION A. RX THEORY, THERMO & FAC OP CHARS

A.01 a
REF: Lamarsh, Introduction to Nuclear Engineering, 3rd Edition, page 78.

A.02 a
REF: Lamarsh, Introduction to Nuclear Engineering, 3rd Edition, page 346.

A.03 d
REF: Lamarsh, Introduction to Nuclear Engineering, 3rd Edition, page 329.

A.04 d
REF: Lamarsh, Introduction to Nuclear Engineering, 3rd Edition, page 312.

A.05 c
REF: SUR (in decades per minute) = 26.06/τ OR $\ln (P_0/P) = t/\tau \Rightarrow \ln(10) = \text{time}/25$
$\Rightarrow 2.302585092994 = \text{time}/25$ seconds. time = 2.3026 × 25 = 57.6 seconds or ≈ 1 minute

A.06 d
REF: Safety Analysis Report, dated November 23, 1995, pg. 104.

A.07 b or d
REF: Glasstone S, and Sesonske, A, *Nuclear Reactor Engineering,* Kreiger Publishing, Malabar, Florida, 1991, §§ 2.70 — 2.74, pp. 65 — 66.

A.08 c
REF: Lamarsh, Introduction To Nuclear Engineering, 3rd Edition.
$(CR_2/CR_1) = (1-K_{eff0})/(1-K_{eff1})$ $(60/30) = (0.90)(1-K_{eff1})$ Keff1 = 0.95

A.09 a
REF: Lamarsh, Introduction to Nuclear Engineering, 3rd Edition, page 361, 362.

A.10 a
REF: Lamarsh, J.R., *Introduction to Nuclear Engineering,* Addison-Wesley Publishing, Reading, Massachusetts, 1983, § 7.1, p. 289.

SECTION A. RX THEORY, THERMO & FAC OP CHARS

A.11 c
REF: Lamarsh, Introduction to Nuclear Engineering, 3rd Edition, page 88.

A.12 b
REF: Glasstone, S. & Sesonske, , § 5.18
$P = P_0\ e^{t/\tau} = 9.7 \times e^{1/10} = 9.7 \times\ 1.1052 = 10.72$

A.13 c
REF: Lamarsh does not cover reactor characteristics for approach to critical.

A.14 a
REF: Glasstone, S. And Sesonske, A, § 5.225.

A.15 c
REF: $SDM = 1 - K_{eff}/K_{eff}$ or $K_{eff} = 1/(1 + SDM) = 1/(1 + .01) = 0.990$
$CR_1/CR_2 = (1 - K_{eff2})/(1 - K_{eff1})$ or $1 - K_{eff2} = (1 - K_{eff1})\ CR_1/CR_2 = 0.0099\ (15/30) = .00495$
$1 - K_{eff2} = 0.00495$ $K_{eff} = 1 - 0.00495 = 0.995$
Reactivity Added $= (K_{eff1} - K_{eff2})/K_{eff1}K_{eff2}$ $= (0.990 - 0.995)/(0.995 \times 0.990) =$
0.005076 (positive) or 0.508%

A.16 b
REF: Lamarsh, J.R., *Introduction to Nuclear Engineering,* Addison-Wesley Publishing, Reading, Massachusetts, 1983, § 7.1, pp. 286 — 287.

A.17 b
REF: Lamarsh, Introduction to Nuclear Engineering, 3rd Edition, page 369.

A.18 a
REF: $SDM = (1 - K_{eff})/K_{eff}$ $K_{eff} = 1/(1 + SDM)$ Given SDM = 0.2 □ $K_{eff} = 1/(1 + 0.2) = 1/1.02$
Initial $K_{eff} = .9804$ $CR_1/\ CR_2 = (1 - K_{eff1})/(1 - K_{eff2})$ Rearranging: $K_{eff2} = 1 - (1 - K_{eff1}) \times CR_2/CR_1$
$K_{eff2} = 1 - [(1 - 0.9804) \times 35/70] = 1 - 0.0196 \times 2 = 1 - 0.0392 = 0.9608$
$\Delta\rho = (K_{eff2} - K_{eff1})/K_{eff2}\ K_{eff2} = (0.9804 - 0.9608)/(0.9804 \times 0.9608) = 0.0196/\ 0.94197$
$\Delta\rho = 0.02081$

SECTION B. NORMAL/EMERG PROCEDURES & RAD CON

B.01 c
REF: ISU Technical Specifications § 3.2, p. 10

B.02 d
REF: ISU TS § 3.4

B.03 a, 1; b, 2; c, 2; d, 3
REF: 10 CFR 20 § 20.1003 *Definitions*

B.04 a, 6; b, 2; c, 2 or 1; d, 1 ISU Requal plan has yearly written.
REF: 10 CFR 55.21, 10 CFR 55.55, 10 CFR 55.59, ISU Requalification Plan

B.05 a, SL; b, LSSS; c, LCO; d, LCO
REF: ISU TS §§ 2.1, 2.2 and 3.0

B.06 c
REF:
A ~=~ A_0 e^{lambda(t)}~~~~ 294 ~=~ 900`e^{lambda `180} ~~~ {ln left(294 over 900 right)} over 180 ~=~ lambda ~ = ~0.00621 #
{ln(0.5)} over {0.00621} ~=~ 111

B.07 d
REF: Dose (γ) = Dose with window closed

B.08 d
REF: ISU Technical Specification 4.2.c

B.09 b
REF: ISU Technical Specification 2.1.b

B.10 b
REF: Maintenance Procedure #2 Prerequisites and Safety

B.11 a
REF: ISU Emerg. Plan Sect C.6

B.12 c
REF: Emergency Plan, Section 4, “Fire or Explosion”

B.13 d
REF: ISU Technical Specification 3.2.a

B.14 c
REF: ISU Experimental Plan No. 19 *Sample Transfer by Pneumatic Tube,* Safety Analysis p. 3

B.15 c
REF: Emergency Plan, *Nuclear Emergency* p. 13.

SECTION C. PLANT AND RAD MONITORING SYSTEMS

C.01 a
REF: Emergency Plan, Section 7.3.2

C.02 b
REF: ISU OP-1 Chap. V *Startup* Step A.3

C.03 d
REF: ISU SAR § 4.3.1 Control Rods

C.04 d
REF: NRC examination bank

C.05 c
REF: NRC Examination Question Bank

C.06 b
REF: ISU SAR § 4,3,2, p. 61

C.07 c
REF: NRC Examination Question Bank

C.08 b
REF: NRC Examination Question Bank

C.09 a
REF: Safety Analysis Report, dated November 23, 1995, pg. 58

C.10 d
REF: Safety Analysis Report, dated November 23, 1995, pg. 69

C.11 a
REF: Safety Analysis Report, dated November 23, 1995, pg. 46-47

C.12 c
REF: Safety Analysis Report, dated November 23, 1995, pg. 41

C.13 b
REF: Safety Analysis Report, dated November 23, 1995, pg. 57.

C.14 b
REF: NRC Examination Question Bank

C.15 c
REF: ISU SAR, § 4.1