December 14, 2011

Jeffrey A. Geuther, Ph.D.
Nuclear Reactor Manager
Kansas State University
112 Ward Hall
Manhattan, KS 66506

SUBJECT: EXAMINATION REPRT NO. 50-188/OL-12-01, KANSAS STATE UNIVERSITY

Dear Dr. Geuther:

During the week of November 28 2011, the U.S. Nuclear Regulatory Commission (NRC) administered operator licensing examinations at your University of Massachusetts – Lowell reactor. The examination was conducted according to NUREG-1478, "Operator Licensing Examiner Standards for Research and Test Reactors," Revision 2. Examination questions and preliminary findings were discussed 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 Phillip T. Young at 301-415-4094 or via internet e-mail Phillip.young@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. 50-188

Enclosures:
1. Examination Report No. 50-188/OL-12-01
2. Facility comments with resolution
3. Written examination with facility comments incorporated

cc without enclosures: see next page

Jeffrey A. Geuther, Ph.D.
Nuclear Reactor Manager
Kansas State University
112 Ward Hall
Manhattan, KS 66506

December 14, 2011

SUBJECT: EXAMINATION REPRT NO. 50-188/OL-12-01, KANSAS STATE UNIVERSITY

Dear Dr. Geuther:

During the week of November 28 2011, the U.S. Nuclear Regulatory Commission (NRC) administered operator licensing examinations at your University of Massachusetts – Lowell reactor. The examination was conducted according to NUREG-1478, "Operator Licensing Examiner Standards for Research and Test Reactors," Revision 2. Examination questions and preliminary findings were discussed 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 Phillip T. Young at 301-415-4094 or via internet e-mail Phillip.young@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. 50-188

Enclosures:
1. Examination Report No. 50-188/OL-12-01
2. Facility comments with resolution
3. Written examination with facility comments incorporated

cc without enclosures: See next page
<u>DISTRIBUTION</u> w/ encls.:
PUBLIC PROB r/f JEads Facility File CRevelle (O07-F8)
ADAMS ACCESSION #: ML113430016

OFFICE	PROB:CE	IOLB:LA	PROB:BC
NAME	PYoung	CRevelle	JEads
DATE	12/13/2011	12/13/2011	12/14/2011

OFFICIAL RECORD COPY

Kansas State University Docket No. 50-188

cc:

Office of the Governor
State of Kansas
Topeka, KS 66612

Thomas A. Conley, RRPJ, CHP, Section Chief
Radiation and Asbestos Control
KS Dept of Health & Environment
1000 SW Jackson, Suite 320
Topeka, KS 66612-1366

Mayor of Manhattan
P.O. Box 748
Manhattan, KS 66502

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

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

REPORT NO.: 50-188/OL-12-01

FACILITY DOCKET NO.: 50-188

FACILITY LICENSE NO.: R-88

FACILITY: Kansas State University

SUBMITTED BY: /RA/ 12/06/2011
Phillip T. Young, Chief Examiner Date

SUMMARY:

During the week of November 28 2011, the NRC administered license examinations to four Reactor Operator license and four Senior Reactor Operator Upgrade candidates. All four Senior Reactor Operator Upgrade candidates passed all applicable portions of the examination. One Reactor Operator candidate failed the written examination and failed the operating test. The remaining three Reactor Operator candidates passed all applicable portions of the examination.

REPORT DETAILS

1. Examiner: Phillip T. Young, Chief Examiner

2. Results:

	RO PASS/FAIL	SRO PASS/FAIL	TOTAL PASS/FAIL
Written	3/1	0/0	3/1
Operating Tests	3/1	4/0	7/1
Overall	3/1	4/0	7/1

3. Exit Meeting:
Phillip T. Young, NRC, Chief Examiner
Dr. Jeff Geuther, Director

The NRC Examiner thanked the facility for their support in the administration of the examinations. The examiner thanked the facility for their feedback on the written examination.

ENCLOSURE 1

FACILITY COMMENTS WITH NRC RESOLUTION

Dear Mr. Young,
After reviewing the examination given at Kansas State University on 11/28/11, the Facility has the following comments and recommendations.

Question B.01
In accordance with the Technical Specifications, which ONE condition below is **NOT** permissible when the reactor is operating?

a. Maximum available reactivity above cold, clean condition = $4.00.
b. Primary water temperature = 110 deg. F.
c. Pool water conductivity = 2 micromho/cm.
d. Fuel temperature = 400 deg. C.

Answer: B.01 a. Reference: KSU Technical Specifications and KSU Procedure 15, Attachment 1: Daily Checkout

Comment: The facility Technical Specification 3.1.3 states that the maximum available core reactivity with all control rods fully withdrawn is "less than" $4.00. However, TS 3.1.4 states that action must be taken to shut down the reactor and configure to reduce reactivity if reactivity with all rods fully withdrawn "exceeds" $4.00. Therefore the facility Technical Specifications can be read to indicate that operating with exactly $4.00 available reactivity above cold, clean condition is allowable (i.e., does not require action to be taken per TS 3.1.4), or not allowable (per TS 3.1.3). The accepted answer to question B.01 is that operation of the reactor with exactly $4.00 is not allowable. Due to the ambivalence of the TS as to whether there is actually a violation when excess reactivity is exactly equal to $4.00, the Facility suggests that question B.01 be withdrawn.

Justification: See comments above.

NRC Resolution: Facility comment accepted, question withdrawn from the examination and grading changed accordingly.

Question B.08
Which ONE of the following would be an initiating condition for an ALERT?

a. On-site life-threatening release of toxic or flammable gases.
b. Tornado damage to facility.
c. Threatened compromise of security.
d. Attempted sabotage.

Answer: B.08 b. Reference: Emergency Plan

Comment: Per the Emergency Plan Section 8.2, "Entry into the Reactor Facility of life-threatening toxic or flammable gases, requiring evacuation of the Reactor Facility" is an initiating condition for an Alert. The presence of toxic or flammable gases *potentially* requiring evacuation is an initiating condition for an Unusual Event per EP 8.2. Answer "a - On-site life-threatening release of toxic or flammable gases" did not specify whether evacuation was required. The Facility therefore recommends that both answer "a" and "b" be accepted as correct answers to the question.

Justification: See comments above.

NRC Resolution: Facility comment accepted, either answer ‘a’ or ‘b’ accepted and grading changed accordingly.

Question C.04

When the amber light on the control console associated with the pulse rod is extinguished, this indicates that:

a. the solenoid valve has been de-energized.
b. the shock absorber is located at its highest position.
c. the variable timer has timed out.
d. the air supply pressure is above 45 psig.

Answer: C.04 d.

Reference: KSU Training Manual, § 9, Transient Rod Drive Mechs.

Comment: There are two amber lights associated with the pulse rod. The amber light on the indication panel on the upper-right side of the console is extinguished when the air supply pressure is above 45 psig (answer "d"). The other amber light is the pulse rod "fire" button, and is lit when the solenoid valve is de-energized (i.e., no air is supplied to the pulse rod cylinder). The Facility therefore recommends that both answer "a" and answer "d" be accepted as correct answers to this question.

Justification: See comments above.

NRC Resolution: Facility comment accepted, either answer ‘a’ or ‘d’ accepted and grading changed accordingly.

Question C.05

During a loss of building electrical power:

a. power to reactor instrumentation will not be lost due to a fast transfer (less than 50 msec) to the reserve supply.
b. power to reactor instrumentation will be restored following a 5 second time delay as transfer to the reserve supply occurs.
c. power will be lost to reactor instrumentation but will be automatically restored when building power returns.
d. power will be lost to reactor instrumentation and will not return until building power returns and the line conditioner is manually reset.

Answer: C.05 d.

Reference: KSU Training Manual, General Characteristics, § 7, Reactor Instrumentation.

Comment: The reactor facility no longer uses a line conditioner. A surge protector must be reset following loss of building power, but this answer was not an option. The Facility therefore recommends that question C.05 be withdrawn.

Justification: See comments above.

NRC Resolution: Facility comment accepted, question withdrawn from the examination and grading changed accordingly.

Question C.19
When the reactor is in the steady state mode, two or more control rods may not be withdrawn simultaneously. The purpose of this interlock is to:

a. prevent the possibility of a sourceless startup.
b. minimize the possibility of pulsing a supercritical reactor.
c. prevent violation of the maximum reactivity insertion rate.
d. prevent the inadvertent pulsing of a reactor in the steady state mode.

Answer: C.19 c. Reference: Training Manual, page A1-18.

Comment: The new facility Technical Specifications no longer specify a maximum reactivity insertion rate. The interlock preventing simultaneous withdrawal of two control rods is therefore an artifact from earlier versions of the TS, which did specify a maximum reactivity insertion rate. Since there is no longer a maximum reactivity insertion rate, the Facility recommends that this question be withdrawn.

Justification: See comments above.

NRC Resolution: Facility comment accepted, question withdrawn from the examination and grading changed accordingly.

Thank you for considering the above comments pertaining to the examination.

Sincerely,

Jeffrey A. Geuther, Ph.D.
Nuclear Reactor Manager
Kansas State University
112 Ward Hall
Manhattan, KS 66506

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

FACILITY: Kansas State University

REACTOR TYPE: TRIGA

DATE ADMINISTERED: 11/28/2011

CANDIDATE: ______________________________

INSTRUCTIONS TO CANDIDATE:
Answers are to be written on the answer sheet provided. Attach the answer sheets to the examination. Points for each question are indicated in brackets for each question. A 70% in each section is required to pass the examination. Examinations will be picked up three (3) hours after the examination starts.

Category Value	% of Total	% of Candidates Score	Category Value	Category
20.00	33.3	______	____	A. Reactor Theory, Thermodynamics and Facility Operating Characteristics
19.00	33.3	______	____	B. Normal and Emergency Operating Procedures and Radiological Controls
19.00	33.3	______	____	C. Facility and Radiation Monitoring Systems
58.00		______	____% FINAL GRADE	TOTALS

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

____
Candidate's Signature

ENCLOSURE 3

NRC RULES AND GUIDELINES FOR LICENSE EXAMINATIONS

During the administration of this examination the following rules apply:

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

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

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

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

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

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

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

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

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

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

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

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

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

EQUATION SHEET's

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

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

$\ell^* = 1 \; x \; 10^{-4} \; seconds$

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

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

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

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

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

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

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

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

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

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

EQUATION SHEET's

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

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

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

$$T_{½} = \frac{0.693}{\lambda}$$

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

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

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

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

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

EQUATION SHEET's

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

1 Curie = 3.7 x 10^{10} dis/sec	**1 kg = 2.21 lbm**
1 Horsepower = 2.54 x 10^{3} BTU/hr	**1 Mw = 3.41 x 10^{6} BTU/hr**
1 BTU = 778 ft-lbf	**°F = 9/5°C + 32**
1 gal (H_2O) ≈ 8 lbm	**°C = 5/9 (°F - 32)**
c_P = 1.0 BTU/hr/lbm/°F	**c_p = 1 cal/sec/gm/°C**

Section A - Reactor Theory, Thermo & Facility Operating Characteristics

Question A.01 [1.0 point, 0.25 each] {1.0}

A fissile material is one which will fission upon the absorption of a THERMAL neutron. A fertile material is one which upon absorption of a neutron becomes a fissile material. Identify each of the listed isotopes as either fissile or fertile.

a. Th^{232}

b. U^{235}

c. U^{238}

d. Pu^{239}

Answer: A.01 a. = fertile; b. = fissile; c. = fertile; d. = fissile

Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1988, § 3.2 Example 3.2(a)

Question A.02 [1.0 point] {2.0}

The reactor supervisor tells you that the K_{eff} for the reactor is 0.955. How much reactivity must you add to the reactor to reach criticality?

a. +0.0471

b. +0.0450

c. -0.0471

d. -0.0450

Answer: A.02 a.

Reference: $\Delta\rho = (K_{eff1} - K_{eff2}) \div (K_{eff1} * K_{eff2})$

$\Delta\rho = (0.9550 - 1.0000) \div (0.9550 * 1.0000)$

$\Delta\rho = -0.0450 \div 0.9550 = -0.0471$

Question A.03 [1.0 point] {3.0}

When performing rod calibrations, many facilities pull the rod out a given increment, then measure the time for reactor power to double (doubling time), then calculate the reactor period. If the doubling time is 42 seconds, what is the reactor period?

a. 29 sec

b. 42 sec

c. 61 sec

d. 84 sec

Answer: A.03 c.

Reference: $\ln(2) = -time/\tau$ $\tau = time/(\ln(2)) = 60.59 \sim 61$ seconds

Question A.04 [1.0 point] {4.0}
A reactor has a shutdown margin of 0.0526 ΔK/K. Adding a reactor experiment increases the indicated count rate from 10 cps to 20 cps. Which one of the following is the new K_{eff} of the reactor?

a. 0.53

b. 0.90

c. 0.975

d. 1.001

Answer: A.04 c.
Reference: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory Volume 2, Module 4, Enabling Objective 3.6, p. 28.
$SDM = 1-K_{eff}/K_{eff} \rightarrow K_{eff} = 1/SDM + 1 \rightarrow K_{eff} = 1/0.0526 + 1 \rightarrow K_{eff} = .95$
$CR_1/CR_2 = (1 - K_{eff2}) / (1 - K_{eff1}) \rightarrow 10/20 = (1 - K_{eff2}) / (1 - 0.95)$
$(0.5) \times (0.05) = (1 - K_{eff2}) \rightarrow K_{eff2} = 1 - (0.5)(0.05) = 0.975$

Question A.05 [1.0 point, 0.20 each] {5.0}
Given a mother isotope of $({}_{35}Br^{87})^*$, identify each of the daughter isotopes as a result of α, β^+, β^-, γ, or n, decay.

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

b. ${}_{34}Se^{87}$

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

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

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

Answer: A.05 a. = α; b. = β^+; c. = n; d. = γ; e. = β^-
Reference: STD NRC question.

Question A.06 [1.0 point] {6.0}
WHICH ONE of the following describes the MAJOR contributions to the production and depletion of xenon in the reactor?

a. Produced directly from fission and depletes by neutron absorption only.

b. Produced from radioactive decay of iodine and depletes by neutron absorption only.

c. Produced directly from fission and depletes by radioactive decay and neutron absorption.

d. Produced from radioactive decay of iodine and depletes by radioactive decay and neutron absorption.

Answer: A.06 d.
Reference: Burn, R., Introduction of Nuclear Reactor Operations, © 1988, §

Question A.07 [1.0 point] {7.0}
The probability of neutron interaction per cm of travel in a material is defined as:

a. a neutron flux.

b. a mean free path.

c. a microscopic cross section.

d. a macroscopic cross section.

Answer: A.07 d.
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1982, Section 2.5.2, page 2-44.

Question A.08 [1.0 point] {8.0}
Which ONE of the following conditions would INCREASE the shutdown margin of a reactor?

a. Lowering moderator temperature if the moderator temperature coefficient is negative.

b. Inserting an experiment adding positive reactivity.

c. Depletion of a burnable poison.

d. Depletion of uranium fuel.

Answer: A.08 d.
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 6.2.3, p. 6-4.

Question A.09 [1.0 point] {9.0}
Which one of the following is the PRIMARY reason that delayed neutrons are so effective at controlling reactor power?

a. Delayed neutrons make up a very large fraction of the fission neutrons in the core.

b. Delayed neutrons have a much longer mean lifetime than prompt neutrons.

c. Delayed neutrons are born at lower energies than prompt neutrons.

d. Delayed neutrons are born at thermal energies.

Answer: A.09 b.
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1982, §§ 3.2.2 — 3.2.3

Question A.10 [1.0 point] {10.0}
Which one of the following is a correct statement concerning the factors affecting control rod worth?

a. As Rx power increases rod worth increases.

b. Fuel burn up causes the rod worth for periphery rods to decrease.

c. Fuel burn up causes the rod worth to increase in the center of the core.

d. The withdrawal of a rod causes the rod worth of the remaining inserted rods to increase.

Answer: A.10 d.
Reference: Burn, R., Introduction to Nuclear Reactor Operations, © 1982, § 7.2 & 7.3, pp. 7-1 — 7-10.

Question A.11 [1.0 point] {11.0}
Pool temperature increases by 20°F. Given α_T moderator = -0.0005 ΔK/K/°F and an average regulating rod worth of 0.004 ΔK/K/inch. By how much and in what direction did the regulating rod move to compensate for the temperature change?

a. 0.25 inches in

b. 0.25 inches out

c. 2.5 inches in

d. 2.5 inches out

Answer: A.11 d.
Reference: $+20°F \times -0.0005\ \Delta K/K/°F = -0.01\ \Delta K/K$. To compensate the rod must add $+0.01\ \Delta K/K$. $+0.01 \Delta K/K \div +0.004\ \Delta K/K/inch = +2.5$ inches

Question A.12 [1.0 point] {12.0}
You perform two startups with exactly the same core characteristics. During the first startup you proceed straight to criticality. During the second startup you receive a phone call after starting to pull rods, but before reaching criticality. How will this increase in time before reaching criticality affect reactor critical conditions? For the second startup

a. rod height will be the same, reactor power will be the same.
b. rod height will be the same, reactor power will be higher.
c. rod height will be higher, reactor power will be higher.
d. rod height will be lower, reactor power will be lower.

Answer: A.12 b.
Reference: Burn, R., *Introduction to Nuclear Reactor Operations,* © 1988, § 5.3

Question A.13 [1.0 point] {13.0}
A reactor is subcritical with a K_{eff} of 0.955. Which ONE of the following is the MINIMUM reactivity (ΔK/K) that must be added to produce prompt criticality? Given βeff=0.007

a. 0.007
b. 0.047
c. 0.054
d. 0.064

Answer: A.13 c.
Reference: from k=0.995 to criticality (k=1), ρ = (k-1)/k = -0.047 Δk/k or 0.047 Δk/k needs to be added to reach criticality. From criticality to JUST prompt, ρ = βeff is required, so minimum reactivity = 0.047+0.007= 0.054

Question A.14 [1.0 point] {14.0}
The ratio of the number of neutrons in one generation to the number of neutrons in the previous generation defines the:

a. fast fission factor.
b. neutron non-leakage factor.
c. neutron reproduction factor.
d. effective multiplication factor.

Answer: A.14 d.
Reference: Introduction to Nuclear Operation, Reed Burn, 1982, Sec 3.3

Question A.15 [1.0 point] {15.0}
Which ONE of the following does NOT affect the Effective Multiplication Factor $K_{eff?}$

a. The moderator-to-fuel ratio.

b. The moderator temperature.

c. The physical dimensions of the core.

d. The strength of an installed neutron souce.

Answer: A.15 d.
Reference: DOE Fundamentals Handbook, Module 3, pages 2-9.

Question A.16 [1.0 point] {16.0}
With the reactor on a constant period, which of the following changes in reactor power would take the **LONGEST** time?

a. 5% — from 1% to 6%

b. 15% — from 20% to 35%

c. 20% — from 40% to 60%

d. 25% — from 75% to 100%

Answer: A.16 a
Reference: $P = P_0 e^{t/\tau}$ $\ln(P/P_0) = t/\tau$ Since you are looking for which would take the longest time it is obvious to the most casual of observers that the ratio P/P_0 must be the largest.

Question A.17 [1.0 point] {17.0}
You've just increased power at a research reactor. As a result fuel temperature increased from 100°C to 120°C. For this reactor the fuel temperature coefficient (α_{tf}) is -0.01% Δk/k/°C, and the average rod worth for the regulating rod is 0.05% Δk/k/inch. How far and in what direction must you move the regulating rod to compensate? (Assume all other factors which could affect reactivity remain unchanged.)

a. 2 inches inward

b. 2 inches outward

c. 4 inches inward

d. 4 inches outward

Answer: A.17 d
Reference: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory
-0.0001Δk/k/°C × +20°C = -0.002Δk/k. To compensate must add +0.002Δk/k.
(0.002Δk/k) ÷ (0.0005%Δk/k/inch) = 4 inches in the positive (outward) direction.

Question A.18 [1.0 point] {18.0}
Several processes occur that may increase or decrease the available number of neutrons. SELECT from the following the six-factor formula term that describes an ***INCREASE*** in the number of neutrons during the cycle.

a. Thermal utilization factor (f).

b. Resonance escape probability (p).

c. Thermal non-leakage probability ($\mathscr{L}_{th}$).

d. Reproduction factor (η).

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

Question A.19 [1.0 point] {19.0}
Which of the following atoms will cause a neutron to lose the most energy during an elastic scattering reaction?

a. O^{16}

b. C^{12}

c. U^{235}

d. H^{1}

Answer: A.19 d
Reference: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory

Question A.20 [1.0 point] {20.0}
A reactor is operating at a constant power level with equilibrium xenon. Reactor power is then doubled. The equilibrium xenon level at the higher power level will be:

a. higher than its value at the lower power level, but not twice as high.

b. twice as high.

c. more than twice as high.

d. the same as at the lower power level.

Answer: A.20 a.
Reference: DOE Reference, Module 3, Xenon, page 37.

Question B.01 [1 point] {1.0}
Question Deleted per Facility Comment
~~In accordance with the Technical Specifications, which ONE condition below is **NOT** permissible when the reactor is operating?~~

~~a. Maximum available reactivity above cold, clean condition = $4.00.~~
~~b. Primary water temperature = 110 deg. F.~~
~~c. Pool water conductivity = 2 micromho/cm.~~
~~d. Fuel temperature = 400 deg. C.~~

~~Answer: B.01 a.~~
~~Reference: KSU Technical Specifications~~
~~KSU Procedure 15, Attachment 1: Daily Checkout~~

Question B.02 [1 point] {2.0}
Two senior reactor operators are operating the reactor at night. One receives a phone call for an emergency at home. What addition actions must be taken to continue to operate the reactor?

a. none, the single SRO may operate the reactor alone.
b. an operator-in-training, must be called in to accompany the SRO.
c. a licensed reactor operator must be called in to operate the reactor.
d. another licensed senior operator must be called in to either operate or supervise the operation of the reactor.

Answer: B.02 a
Reference: KSU Technical specification § 6.1(c)

Question B.03 [1 point, 0.25 each] {3.0}
Identify each of the four surveillances listed as a channel **CHECK**, a channel **TEST**, or a channel **CAL**ibration.

a. During performance of the Daily Checkout you verify the Bay differential pressure is negative.

b. Following maintenance on Nuclear Instrument channel 1 you compare its readings to Nuclear Instrument channel 2 readings.

c. You verify a temperature channel's operation by replacing the RTD with a precision variable resistance and checking proper output.

d. You a heat balance (calorimetric) on the primary system and based on Nuclear Instrumentation readings you make adjustments.

Answer: B.03 a. = CHECK; b. = CHECK; c. = TEST; d. = CAL
Reference : KSU Technical specification § 1, Definitions

Question B.04 [1 point] {4.0}
Technical Specification defines a reportable occurrence as … "2. VIOLATION OF SL, LSSS OR LCO; **NOTES**: Violation of an LSSS or LCO occurs through failure to comply with an "Action" statement when "Specification" is not met; failure to comply with the "Specification" is not by itself a violation. Surveillance Requirements must be met for all equipment/ components/conditions to be considered operable. Failure to perform surveillance within the required time interval or failure of a surveillance test shall result in the /component /condition being inoperable…. Using this guidance, which one of the following is a reportable occurrence, if discovered during normal operations?

a. The maximum available core reactivity (excess reactivity) with all control rods fully withdrawn is $3.50.

b. The Continuous Air Monitor has been inoperable for 20 days, the Exhaust Plenum Radiation monitor is operating normally.

c. The ventilation system has been inoperable for 15 days, there are no experiments in the core, but you are moving irradiated within the fuel storage racks.

d. The last semiannual shutdown margin determination was performed seven (7) months and three (3) weeks ago.

Answer: B.04 c.
Reference: KSU Technical specification §§ 6.9, 3.1.3(1), 3.3.4(e), 4.1.2 & 1

Question B.05 [1 point] {5.0}
In accordance with the Technical Specifications, which Reactor Safety System scrams are required to be operable in **BOTH** the Steady-State and Pulse modes?

a. Linear channel high power scram

b. Fuel temperature scram

c. Manual scram

d. Period scram.

Answer: B.05 c
Reference: KSU Technical Specifications, Table I.

Question B.06 [1 point] {6.0}
According to the Emergency Plan, the Emergency Planning Zone (EPZ) is

a. Room 110 (Reactor Bay).

b. Room 109 (Control Room) and Room 110 (Reactor Bay).

c. Ward Hall.

d. Ward Hall and the adjacent Fenced Area.

Answer: B.06 b.
Reference: Emergency Plan § 1.5.2

Question B.07 [1 point] {7.0}
There has been a confirmed breach of cladding for multiple fuel elements. In accordance with the Emergency Plan, this event would be classified as a(n):

a. Unusual Event.

b. Alert.

c. Site Emergency.

d. General Emergency.

Answer: B.07 b.
Reference: Emergency Plan, section 6.2.

Question B.08 [1 point] {8.0}
Which ONE of the following would be an initiating condition for an ALERT?

a. On-site life-threatening release of toxic or flammable gases.

b. Tornado damage to facility.

c. Threatened compromise of security.

d. Attempted sabotage.

Answer: B.08 b. or A. per facility comment
Reference: Emergency Plan

Question B.09 [1 point] {9.0}
Which ONE of the following would be an initiating condition for an Unusual Event?

a. Fire potentially affecting safety systems.

b. Indication of damage to a fuel element

c. Earthquake with damage to facility.

d. Tornado damage to facility.

Answer: B.09 b.
Reference: Emergency Plan Section 7.0

Question B.10 [1 point, 0.25 each] {10.0}
Match type of radiation (a thru d) with the proper penetrating power (1 thru 4)

a. Gamma	1. Stopped by thin sheet of paper
b. Beta	2. Stopped by thin sheet of metal
c. Alpha	3. Best shielded by light material
d. Neutron	4. Best shielded by dense material

Answer: B.10 a. = 4; b. = 2; c. = 1; d. = 3
Reference: Standard NRC Health Physics Question

Question B.11 [1 point] {11.0}
A survey instrument with a window probe is used to measure the beta-gamma dose rate from an irradiated experiment. The dose rate is 100 mrem/hour with the window open and 60 mrem/hour with the window closed. The gamma dose rate is:

a. 100 mrem/hour.
b. 60 mrem/hour.
c. 40 mrem/hour.
d. 160 mrem/hour.

Answer: B.11 b.
Reference: Standard NRC Radiation Health Physics Question

Question B.12 [1 point] {12.0}
A "high radiation area" is:

a. an area where airborne radioactive materials, composed wholly or partly of licensed material, exist in concentrations are In excess of the derived air concentrations (DACs) specified in appendix B, or an individual present in the area without respiratory protective equipment could exceed, during the hours an individual is present in a week, an intake of 0.6 percent of the annual limit on intake (ALI) or 12 DAC-hours.

b. an area accessible to individuals, in which radiation levels could result in an individual receiving a dose equivalent in excess of 0.005 rem (0.05 mSv) in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates.

c. an area, accessible to individuals, in which radiation levels from radiation sources external to the body could result in an individual receiving a dose equivalent in excess of 0.1 rem (1 mSv) in 1 hour at 30 centimeters from the radiation source or 30 centimeters from any surface that the radiation penetrates.

d. an area, access to which is limited by the licensee for the purpose of protecting individuals against undue risks from exposure to radiation and radioactive materials.

Answer: B.12 c.
Reference: Facility supplied question

Question B.13 [1 point, 0.25 each] {13.0}
Match the annual dose limit values to the type of exposure.

Type of Exposure	Annual Dose Limit Value
a. Extremities	1. 0.1 rem.
b. Lens of the Eye	2. 5.0 rem.
c. Occupational Total Effective Dose Equivalent (TEDE)	3. 15.0 rem.
d. TEDE to a member of the public	4. 50.0 rem.

Answer: B.13 a. = 4; b. = 3; c. = 2; d. = 1
Reference: 10 CFR 20 §§ 1201.a(2)(ii), 1201.a(1), 1201.a(2)(i), 1301

Question B.14 [1 point] {14.0}
A radioactive source generates a reading of 100 mr/hr at a distance of 10 feet. With two inches of lead shielding the reading drops to 50 mr/hr at a distance of 10 feet. If you were to add another four inches of the same type of shielding, the reading at 10 feet would drop to …

a. 25 mr/hr
b. 12½ mr/hr
c. 6¼ mr/hr
d. 3⅛ mr/hr

Answer: B.14 b.
Reference: 2" = one-half thichness ($T_{½}$). Using 3 half-thickness will drop the dose by a factor of $(½)^3$ = ⅛. 100/8 = 12.5

Question B.15 [1 point] {15.0}
You place a radiation monitor near the demineralizer during reactor operation. If you were to open the window on the detector you would expect the meter reading to … (Assume no piping leaks)

a. increase, because you would now be receiving a signal due to H^3 and O^{16} betas.

b. remain the same, because the Quality Factors for gamma and beta radiation are the same.

c. increase, because the Quality Factor for betas is greater than for gammas.

d. remain the same, because you still would not be detecting beta radiation.

Answer: B.15 d.
Reference: BASIC Radiological Concept (Betas don't make it through piping.)

Question B.16 [1 point] {16.0}
In the event of a reportable occurrence, the reactor shall be shutdown and not restarted until authorized by the:

a. Reactor Manager

b. Reactor Safeguards Committee

c. Head, Department of Nuclear and Mechanical Engineering

d. U.S. NRC

Answer: B.16 b.
Reference: Rewrite of facility supplied question.

Question B.17 [1 point] {17.0}
Which ONE of the following requires the direct supervision (i.e., presence) of an SRO?

a. Control rod calibrations.

b. Control rod drop time measurement.

c. Pulsing the reactor.

d. Discharging radioactive material to sanitary sewer

Answer: B.17 c.
Reference: Facility supplied question.

Question B.18 [1 point] {18.0}
An alpha particle assay of the primary coolant is to be performed. In accordance with Procedure No. 21, "Alpha-Particle Assay of Reactor Liquids," the purpose of this assay is to:

a. assure compliance with limits for alpha-particle activity in effluents to the sanitary sewer system.

b. detect the presence of uranium in the coolant due to clad leakage.

c. detect leakage from an in-core experiment.

d. detect the presence of N-16.

Answer B.18 a.
Reference: KSU Procedure No. 21.

Question B.19 [1 point] {19.0}
When checking the Pulse Power Interlock, Per Procedure No. 5 – Semi-Annual Check Minimum Interlock & SCRAM Checks, Sequentially WITHDRAW the shim, safety, AND the regulating rod UNTIL the DOWN light is de-energized. Then DEPRESS the Pulse Interlock pushbutton and VERIFY that the ____________. Which of the following expected indications is NOT correct for this situation?

a. all SCRAMs are reset

b. pulse interlock light is energized

c. the NLW-1000 is reading downscale

d. the SOURCE interlock light is de-energized

Answer: B.19 d.
Reference: KSU Procedure No. 5 – Semi-Annual Check Minimum Interlock & SCRAM Checks

Question B.20 [1 point] {20.0}
During fuel handling the Reactor Operator (RO) is required to record fuel movement in the control room operations log book. Which of the following is **completely** correct for the RO is required log entries?

a. When the fuel to be removed is out of the reactor core and after the tool is release from the fuel with the fuel in the desired location.

b. When the fuel handling tool is latched to fuel to be moved and after the tool is released from the fuel with the fuel in the desired location.

c. When the SRO in charge of the fuel movement directs the RO to make the log entry.

d. Only after the fuel is seated in the desired final location.

Answer: B.20 b.
Reference: KSU Procedure 26 Fuel Handling Procedure

Section C Facility and Radiation Monitoring Systems

Question C.01 [1.0 point] {1.0}
Reactor bay differential pressure is monitored by a standard Magnahelic gage.
The differential pressure monitor is required for reactor operation by Technical Specifications.
The differential pressure is read in inches of water, but the pressure standard used in calibration reads out in millimeters of water. For a Magnahelic reading of 0.20" of H_2O what will the standard read?

a. approximately 4.0 mm H_2O

b. approximately 4.6 mm H_2O

c. approximately 5.0 mm H_2O

d. approximately 5.8 mm H_2O

Answer: C.01 c.
Reference: KSU Procedure 29 - Differential Pressure Channel Calibration

Question C.02 [1.0 point] {2.0}
When the mode switch is placed in the "AUTO" position the …

a. period scram is bypassed.

b. regulating rod will not fall into the core following a scram.

c. regulating rod moves in response to the linear channel signal.

d. regulating rod movement will not be affected by changes in reactor period.

Answer: C.02 c.
Reference: KSU Procedure 23 - Automatic Flux Control System

Question C.03 [1.0 point] {3.0}
The cooling tower fan speed (off, low speed, high speed) is controlled by:

a. the temperature of secondary water entering the cooling tower.

b. the temperature of primary water entering the heat exchanger.

c. the temperature of secondary water leaving the cooling tower.

d. the temperature of primary water leaving the heat exchanger.

Answer: C.03 c.
Reference: KSU Training Manual, "General Characteristics," Coolant System.

Question C.04 [1.0 point] {4.0}
When the amber light on the control console associated with the pulse rod is extinguished, this indicates that:

a. the solenoid valve has been de-energized.

b. the shock absorber is located at its highest position.

c. the variable timer has timed out.

d. the air supply pressure is above 45 psig.

Answer: C.04 d. or a. per facility comment
Reference: KSU Training Manual, § 9, Transient Rod Drive Mechs.

Question C.05 [1.0 point] {5.0}
QUESTION DELETED PER FACILITY COMMENT
~~During a loss of building electrical power:~~
~~a. power to reactor instrumentation will not be lost due to a fast transfer (less than 50 msec) to the reserve supply.~~
~~b. power to reactor instrumentation will be restored following a 5 second time delay as transfer to the reserve supply occurs.~~
~~c. power will be lost to reactor instrumentation but will be automatically restored when building power returns.~~
~~d. power will be lost to reactor instrumentation and will not return until building power returns and the line conditioner is manually reset.~~
~~Answer: C.05 d.~~
~~Reference: KSU Training Manual, General Characteristics, § 7, Reactor Instrumentation.~~

Question C.06 [1.0 point] {6.0}
The reactor is in the steady state mode with the transient rod shock absorber fully inserted (full down) and no air applied. The shock absorber is moved upward, and the operator then attempts to apply air to the transient rod. Which ONE of the following results?

a. The air solenoid blocks air to the transient rod.

b. The transient rod moves up until it reaches the shock absorber.

c. The shock absorber returns to its full down position.

d. The shim rod moves into the core.

Answer: C.06 a.
Reference: KSU Procedures 5, Part 1.

Question C.07 [1.0 point] {7.0}
Coolant flow in the demineralizer loop of the reactor coolant system is measured by:

a. differential pressure across the filter.

b. a flow meter at the outlet of the demineralizer.

c. an orifice at the inlet to the heat exchanger.

d. a flowmeter at the inlet of the primary pump.

Answer: C.07 b.
Reference: KSU Training Manual, General Characteristics, Section 6, Coolant System, Fig. 5.

Question C.08 [1.0 point] {8.0}
Thermocouples in an instrumented TRIGA fuel element measure temperature at the:

a. interior surface of the cladding.

b. interior of the fuel.

c. outer surface of the fuel.

d. center of the zirconium rod.

Answer: C.08 b.
Reference: KSU Training Manual, General Characteristics, Section 7.1, Measurement.

Question C.09 [1.0 point] {9.0}
Which ONE of the following describes the purpose of the Pull Rod in the control rod drive assembly?

a. Actuates the rod **down** microswitch.

b. Provides rod full out position indication.

c. Automatically engages the control rod on a withdraw signal.

d. Provides a means for manually adjusting the rod position by pulling rod out.

Answer: C.09 a.
Reference: KSU Training Manual, Section 8.2, Circuit Operations.

Question C.10 [1.0 point] {10.0}
Which ONE of the following is the purpose of the mechanical filter installed in the cleanup loop?

a. Maintain low electrical conductivity of the water and a neutral pH.
b. Maintain optical transparency and minimal radioactivity of the water.
c. Maintain a neutral pH and optical transparency of the water.
d. Maintain minimal radioactivity and low electrical conductivity of the water.

Answer: C.10 b.
Reference: KSU Training Manual, General Characteristics, Section 6

Question C.11 [1.0 point] {11.0}
Which ONE of the following describes the action of the rod control system to drive the magnet draw tube down after a dropped rod? Downward motion of the draw tube is initiated by …

a. deenergizing the rod magnet.
b. closing the contact on the MAGNET DOWN limit switch.
c. closing the contact on the ROD DOWN limit switch.
d. de-energizing both contact light (DS317) and the MAGNET UP limit switch.

Answer: C.11 c.
Reference: KSU Training Manual, Section 8.2, Circuit Operations.

Question C.12 [1.0 point] {12.0}
When the percent power channel is used for neutron detection, how is the gamma flux accounted for?

a. Pulse height discrimination is used to eliminate the gamma flux.
b. The gamma flux is proportional to neutron flux and is counted with the neutrons.
c. The gamma flux is canceled by creating an equal and opposite gamma current in the detector.
d. The gamma flux passes through the detector with no interaction because of detector design.

Answer: C.12 b.
Reference: Training Manual, page A1-15.

Question C.13 [1.0 point, 0.25 each] {13.0}
Select from column B the actual rod movement that would result from attempting to move the rods in column A. (Items in column B may be used once, more than once or not at all.

Column A (Attempted Rod Move)	Column B (Result)
a. Attempt to withdraw reg rod (pulse mode).	1. Shim rod moves up.
b. Attempt to withdraw both shim and reg rods (steady state mode)	2. Reg rod moves up.
	3. Shim & reg rods move up.
c. Attempt to withdraw both pulse and reg rod (steady state mode).	4. Pulse rod moves up
d. Shim and pulse rods are up and attempt to withdraw pulse rod (steady state mode).	5. No rod motion.

Answer: C.13 a. = 5; b. = 5; c. = 4; d. = 4.
Reference: KSU Procedure No. 5, Part 1.

Question C.14 [1.0 point] {14.0}
The continuous air monitors are calibrated to detect the presence of:

a. noble gases from a leaking fuel element.
b. Ar^{41}
c. N^{16}
d. I^{131}

Answer: C.14 d.
Reference: KSU Procedure No. 8.

Question C.15 [1.0 point] {15.0}
The reactor is operating in the pulse mode when a reactor scram occurs. The transient rod solenoid valve:

a. is energized by the scram circuitry, which opens the valve and removes air from the cylinder.

b. is de-energized by the scram circuitry, which closes the valve and removes air from the cylinder.

c. is energized by a timer, which closes the valve and removes air from the cylinder.

d. is de-energized by a timer, which opens the valve and removes air from the cylinder.

Answer: C.15 d.
Reference: Training Manual, page A1-18.

Question C.16 [1.0 point] {16.0}
In the reactor cooling system, there is a pressure gauge on each side of the filter. The purpose of these gauges is to:

a. provide a computer input for measuring system pressure.
b. provide a differential pressure to measure flow through the deionizer.
c. measure the pressure drop across the filter to determine filter clogging.
d. measure primary pressure to ensure that it is always lower than secondary pressure.

Answer: C.16 c.
Reference: Training Manual, page A1-11.

Question C.16a [1.0 point] {16.0}
The outside air temperature is -15°F. The KSU reactor is operating at 100% power when the primary coolant temperature probe fails low. Which ONE of the following actions is performed by the secondary automatic control system if the temperature of the secondary cooling water is 62°F?

a. The cooling tower fan goes to slow speed and the secondary coolant flow bypasses the cooling tower.

b. The cooling tower fan goes to high speed and the secondary coolant flows to the cooling tower.

c. The cooling tower fan goes to slow speed and the secondary coolant flows to the cooling tower.

d. The cooling tower fan remains off and the secondary coolant flow bypasses the cooling tower.

Answer: C.16a d.
Reference: SAR - 5.3.2

Question C.17 [1.0 point] {17.0}
When the shim control rod is withdrawn, the withdrawing force is provided by the:

a. pull rod.
b. push rod
c. draw tube.
d. worm gear.

Answer: C.17 c.
Reference: Training Manual, page A1-16.

Question C.18 [1.0 point] {18.0}
When the reactor is operating at full power, the highest thermal neutron flux occurs at:

a. the E-ring.

b. the central thimble.

c. the rotary specimen rack.

d. the F-ring rabbit terminus.

Answer: C.18 b.
Reference: Training Manual, page A1-11.

Question C.19 [1.0 point] {19.0}
QUESTION DELETED PER FACILITY COMMENT
~~When the reactor is in the steady state mode, two or more control rods may not be withdrawn simultaneously. The purpose of this interlock is to:~~

~~a. prevent the possibility of a sourceless startup.~~
~~b. minimize the possibility of pulsing a supercritical reactor.~~
~~c. prevent violation of the maximum reactivity insertion rate.~~
~~d. prevent the inadvertent pulsing of a reactor in the steady state mode.~~

~~Answer: C.19 c.~~
~~Reference: Training Manual, page A1-18.~~

Question C.20 [1.0 point] {20.0}
Which ONE of the following is the main function performed by the **DISCRIMINATOR** circuit in the Startup Channel?

a. To convert the linear output of the Startup Channel Detector to a logarithmic signal for metering purposes.

b. To convert the logarithmic output of the metering circuit to a δt (delta time) output for period metering purposes.

c. To filter out small pulses due to gamma interactions, passing only pulses due to neutron events within the Startup Channel Detector.

d. To generate a current signal equal and of opposite polarity as the signal due to gammas generated within the Startup Channel Detector.

Answer: C.20 c.
Reference: Standard NRC Question for proportional counters.
SAR chapter 7 shows a Fission Chamber.