February 13, 2008

Mr. Michael Whaley, Manager
KSU Nuclear Reactor Facility
Department of Mechanical and Nuclear Engineering
112 Ward Hall
Kansas State University
Manhattan, KS 66506-2500

SUBJECT: INITIAL EXAMINATION REPORT NO. 50-188/OL-08-01, KANSAS STATE UNIVERSITY TRIGA REACTOR

Dear Mr. Whaley:

During the week of January 14, 2008, the NRC administered an operator licensing examination at your Kansas State University TRIGA 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 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. Paul V. Doyle Jr. at (301) 415-1058 or via internet e-mail pvd@nrc.gov.

Sincerely,

/RA/

Johnny Eads, Chief
Research and Test Reactors Branch B
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Docket No. 50-188

Enclosures:
1. Initial Examination Report No. 50-188/OL-08-01
2. Facility comments on written examination with NRC resolution
3. Written examination with facility comments incorporated

cc without enclosures:
Please see next page

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DATE	02/12/2008		02/13/2008		02/13/2008	

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cc:

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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-08-01

FACILITY DOCKET NO.: 50-188

FACILITY LICENSE NO.: R-88

FACILITY: Kansas State University TRIGA reactor

EXAMINATION DATES: January 15 – 22, 2008

SUBMITTED BY: /RA/ 2/12/08
Paul V. Doyle Jr., Chief Examiner Date

SUMMARY:

During the week of January 14, 2008, the NRC administered operator licensing examinations to seven reactor operator candidates. Three candidates failed the written examination. One failed sections A, B and overall. One failed section B and overall. One failed section C, but passed overall. All seven candidates passed their respective operating tests.

REPORT DETAILS

1. Examiner: Paul V. Doyle Jr., Chief Examiner, NRC

2. Results:

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

3. Exit Meeting:
Paul V. Doyle Jr., NRC, Examiner
Paul M. Whaley, Reactor Manager, Kansas State University

During the exit meeting the facility gave the examiner a heads-up on some comments on the written examination which were being contemplated. The examiner mentioned that he noticed one universal weakness in radiological controls and one in nuclear instrumentation. Both these items are in the individual candidate reports, being forwarded to the facility by separate letter.

ENCLOSURE 1

FACILITY COMMENTS ON WRITTEN EXAMINATION

Could you describe or send me a sketch of the "integral rod worth curve" used in question 1? I'm not challenging the question, but am asking that you review one for future usage.

Question A.14, "ELASTIC SCATTERING is the process by which a neutron collides with a nucleus and..." the answer key indicates "recoils with the same kinetic energy it had prior to collision." In elastic scattering, momentum and kinetic energy are conserved. For conservation of momentum, either the target nucleus carries some moment from the collision or the neutron trajectory (speed and direction) is unchanged. If the nucleus has some recoil velocity because of the collision, conservation of energy requires the neutron kinetic energy be smaller. If the neutron trajectory is unchanged, there was no interaction.

Question B.08, "primary source (irradiation of air, irradiation of water, or fission product)" for Ar-41 could be irradiation of air (argon in air) OR irradiation of water (since air is dissolved in pool water). Therefore, this question has two correct answers, "irradiation of air," and "irradiation of water."

Question B.16, the answer key indicates "c. 1 1/2 hours," is the correct answer. The question does not request the smallest interval, and removal of the sample at answer "d. 2 hours" meets the criteria posed in the question. Therefore, this question has two correct answers, c and d.

Question C.08, "Which of the following determines the amount of reactivity that is inserted by the transient control rod during a pulse?" the answer key indicates, "the anvil of the shock absorber," with a reference to the SAR figure 7.8. I am unable to find anvil on the figure, and it is not a term used at K-State. SAR 7.3.b indicates, "The throw of the piston, and hence the amount of reactivity inserted into the core during pulsing operations, is regulated by adjusting the worm gear and ball-screw assembly." Cylinder position is synonymous with "throw of the piston," answer b ("The position of the cylinder"). Therefore, "b" is also a correct answer.

Question C.11, "Upon receipt of a scram signal with the automatic flux control system engaged, the regulating rod..." the answer key indicates d, "magnet is de-energized, the rod falls into the core, but the drive must be manually driven into the core." In automatic, the regulating rod cannot be manually controlled. If the mode selector switch is positioned to automatic following a scram, the drive will automatically position the drive to fully inserted. Unless the action of moving the mode selector switch to "Steady State" is interpreted as manually driving the control rod, this question does not have a correct answer.

Question C.13, "The ONLY automatic scram available in PULSE MODE is..." the answer key indicates "a. high fuel temperature," based on Technical Specifications. SAR 7.4 indicates, "(the percent power channel high voltage power supply scram remains active)." Therefore, the premise in this question is not correct; there are two scrams available in automatic.

Question C.14, "When the mode switch is placed in the AUTO position, the..." the answer key indicates the correct answer is “b” regulating rod moves in response to the linear channel signal." In automatic power level control, NLW-1000 (Log wide range channel) provides a period signal to the auto flux controller to limit the control signal when the period is greater than 30 sec. Therefore, answer “c” regulating rod moves in response to the wide range log channel signal" is also correct; there are two correct answers, "b" and "c."

Question C.15 item "d. Automatic control" may also (i.s., for the reason indicated above) be either "1. Wide Range Log," or "2. Multi-Range Linear."

NRC RESOLUTION OF FACILITY COMMENTS

Question A.14: Partially agree with comment. Although the question was not worded precisely, it was worded well enough that all of the candidates understood the correct answer. Therefore no change in grading is warranted. In order to make the question more precise, the question will be reworded as follows:

QUESTION A.14 [1.0 point]
ELASTIC SCATTERING is the process by which a neutron collides with a nucleus and it …

a. and the nucleus recoil~~s~~ with the same total kinetic energy as the neutron and nucleus ~~it~~ had prior to the collision

b. and the nucleus recoil~~s~~ with less total kinetic energy than the neutron and nucleus ~~it~~ had prior to the collision with the nucleus emitting a gamma ray.

c. is absorbed, with the nucleus emitting a gamma ray.

d. and the nucleus recoil~~s~~ with a higher total kinetic energy than the neutron and nucleus ~~it~~ had prior to the collision with the nucleus emitting a gamma ray.

Question B.08: Disagree with comment. The question is not asking where the radio-isotopes are being created. Water is made up of oxygen and hydrogen molecules of which O^{16} interacts with a neutron flux to create N^{16}. Argon, is NOT a component of water. It is however a component of air. Argon makes up approximately 0.9% of air. Some air is entrained in the water in the pool. As such, some argon is entrained in the water in the pool. This argon is irradiated near the core, resulting in Ar^{41} in the pool. However, once again it is the argon in the air entrained in the water which is the source of the Ar^{41}, not the water itself.

Question B.16: Agree with comment. Answer key has been modified to show either ‘c’ or ‘d’ as correct answer.

Question C.08: Agree with comment. Answer key has been modified to show either ‘b’ or ‘c’ as correct answer.

Question C.11: Partially agree with comment. Although the question was not worded precisely, it was worded well enough that most of the candidates understood the correct answer. Therefore no change in grading is warranted. In order to make the question more precise, the question will be reworded as follows:

QUESTION C.11 [1.0 point]
Upon receipt of a scram signal with the automatic flux control system engaged, the regulating rod …

a. magnet is de-energized, the rod falls into the core, and the drive is automatically driven in.

b. and drive remain where they are, and the operator must take action to drive both ~~must be manually driven~~ into the core.

c. and drive both automatically drive into the core.

d. magnet is de-energized, the rod falls into the core, but the operator must take action to return the drive ~~must be manually driven into the core~~ to the fully inserted position.

Question C.13: Agree with comment. The question stem in master has been modified from “The ONLY automatic scram available in PULSE MODE is …” to, “Which ONE of the following automatic scrams is available in Pulse Mode?” No grading change is warranted.

Question C.14: Agree with comment. Answer key has been modified to show either ‘b’ or ‘c’ as correct answer.

Question C.15: Agree with comment. Answer key has been modified to show either ‘1’ or ‘2’ as the correct answer for part “d” of the question.

OPERATOR LICENSING EXAMINATION

With Answer Key

UNITED STATES NUCLEAR REGULATORY COMMISSION

KANSAS STATE UNIVERSITY

January 15, 2008

Enclosure 3

QUESTION A.01 [2.0 points, 0.5 each]

Using the drawing of the Integral Rod Worth Curve provided, identify each of the following reactivity worths.

a. Total Rod Worth	1. B - A
b. Actual Shutdown Margin	2. C - A
c. Technical Specification Shutdown Margin Limit	3. C - B
d. Excess Reactivity	4. D - C
	5. E - C
	6. E - D
	7. E - A

QUESTION A.02 [1.0 point]

Reactor power is rising on a 30 second period. Approximately how long will it take for power to double?

a. 35 seconds

b. 50 seconds

c. 70 seconds

d. 100 seconds

QUESTION A.03 [2 points, ½ each]

Match the description of plant conditions in column A with resulting xenon conditions in column B.

Column A	Column B
a. 4 hours after a power increase	1. Xenon concentration is increasing to a peak
b. 2 hours after a power decrease	2. Xenon concentration is decreasing to a trough
c. 16 hours after a “clean” startup	3. Xenon concentration is approximately zero (reactor is “clean”)
d. 72 hours after a shutdown	4. Xenon concentration is “relatively” steady at a “non-zero” value

QUESTION A.04 [1.0 point]
The number of neutrons passing through a one square centimeter of target material per second is the definition of which one of the following?

a. Neutron Population (np)

b. Neutron Impact Potential (nip)

c. Neutron Flux (nv)

d. Neutron Density (nd)

QUESTION A.05 [1.0 point]
The neutron microscopic cross-section for absorption (σ_a) of an isotope generally …

a. increases as neutron energy increases

b. decreases as neutron energy increases

c. increases as target nucleus mass increases

d. decreases as target nucleus mass increases

QUESTION A.06 [1.0 point]
A reactor contains three safety rods and a control rod. Which one of the following would result in a determination of the excess reactivity of this reactor?

a. The reactor is critical at a low power level, with all safety rods full out and the control rod at some position. The reactivity remaining in the control rod (i.e. its rod worth from its present position to full out) is the excess reactivity.

b. The reactor is shutdown. Two safety rods are withdrawn until the reactor becomes critical. The total rod worth withdrawn is the excess reactivity.

c. The reactor is at full power. The total worth of all rods withdrawn is the excess reactivity.

d. The reactor is at full power. The total worth remaining in all the safety rods and the control rod (i.e. their worth from their present positions to full out) is the excess reactivity.

QUESTION A.07 [1.0 point]
The neutron microscopic cross-section for absorption σ_a generally …

a. increases as neutron energy increases

b. decreases as neutron energy increases

c. increases as target nucleus mass increases

d. decreases as target nucleus mass increases

QUESTION A.08 [1.0 point]

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%

QUESTION A.09 [1.0 point]

You are assigned to check the operation of a new nuclear instrumentation channel. You know that the reactor will stabilize with a - 80 second period shortly after shutdown. To check the channel you measure the time for power to decrease by a factor of 10. This time should be approximately…

a. 45 seconds (¾ minute)

b. 90 seconds (1-½ minutes)

c. 135 seconds (2-¼ minutes)

d. 180 seconds (3 minutes)

QUESTION A.10 [2.0 points. 2 each]

Match each term in column A with the correct definition in column B.

	Column A		Column B
a.	Prompt Neutron	1.	A neutron in equilibrium with its surroundings.
b.	Fast Neutron	2.	A neutron born directly from fission.
c.	Thermal Neutron	3.	A neutron born due to decay of a fission product.
d.	Delayed Neutron	4.	A neutron at an energy level greater than its surroundings.

QUESTION A.11 [1.0 point]

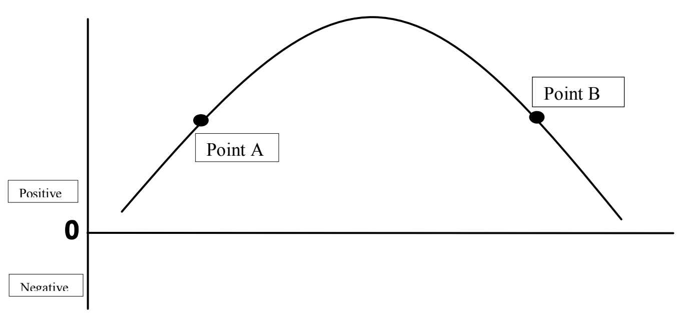
Shown below is a trace of reactor period as a function of time. Between points A and B reactor power is:

a. continually increasing.

b. continually decreasing.

c. increasing, then decreasing.

d. constant.



QUESTION A.12 [1.0 point]

A thin foil target of 10% copper and 90% aluminum is in a thermal neutron beam. Given $\sigma_{a\ Cu}$ = 3.79 barns, $\sigma_{a\ Al}$ = 0.23 barns, $\sigma_{s\ Cu}$ = 7.90 barns, and $\sigma_{s\ Al}$ =1.49 barns, which ONE of the following reactions has the highest probability of occurring? A neutron …

a. scattering reaction with aluminum

b. scattering reaction with copper

c. absorption in aluminum

d. absorption in copper

QUESTION A.13 [1.0 point]

Which ONE of the reactions below is an example of a **PHOTONEUTRON** source?

a. ${}_{1}H^{2} + {}_{0}\gamma^{0} \rightarrow {}_{1}H^{1} + {}_{0}n^{1}$

b. ${}_{92}U^{238} \rightarrow {}_{35}Br^{87} + {}_{57}La^{148} + 3{}_{0}n^{1} + {}_{0}\gamma^{0}$

c. ${}_{51}Sb^{123} + {}_{0}n^{1} \rightarrow {}_{1}H^{1} + {}_{0}\gamma^{0}$

d. ${}_{4}Be^{9} + {}_{2}\alpha^{4} \rightarrow {}_{6}C^{12} + {}_{0}n^{1}$

QUESTION A.14 [1.0 point] Comments incorporated per facility comment

ELASTIC SCATTERING is the process by which a neutron collides with a nucleus and it …

a. and the nucleus recoil~~s~~ with the same total kinetic energy as the neutron and nucleus ~~it~~ had prior to the collision

b. and the nucleus recoil~~s~~ with less total kinetic energy than the neutron and nucleus ~~it~~ had prior to the collision with the nucleus emitting a gamma ray.

c. is absorbed, with the nucleus emitting a gamma ray.

d. and the nucleus recoil~~s~~ with a higher total kinetic energy than the neutron and nucleus ~~it~~ had prior to the collision with the nucleus emitting a gamma ray.

QUESTION A.15 [1.0 point]

Which ONE of the following is the major source of energy released during fission?

a. Absorption of prompt gamma rays

b. Slowing down of fission fragments

c. Neutrino interactions

d. Fission neutron scattering

QUESTION A.16 [1.0 point]
You enter the control room and note that all nuclear instrumentation channels show a steady neutron level, and no rods are in motion. Which ONE of the following conditions **CANNOT** be true?

a. The reactor is critical.

b. The reactor is subcritical.

c. The reactor is supercritical.

d. The neutron source has been removed from the core.

QUESTION A.17 [1.0 point]
The reactor is subcritical with a K_{eff} of 0.95. Which ONE of the following is the shutdown margin?

a. 5.00% ΔK/K

b. 5.26% ΔK/K

c. 19.0% ΔK/K

d. 20.0% ΔK/K

QUESTION B.01 [1.0 point]
Which ONE of the following situations would illustrate a time when the reactor is shutdown but ***NOT*** secured?

a. One of the control rod drives is removed for inspection; the rod is decoupled and is fully inserted into the core, all other rods are fully inserted and the console key is in the 'off' position and removed.

b. All control rods are fully inserted; the console key is in the 'off' position and removed, while fuel is being rearranged in the fuel storage racks.

c. The control rods are withdrawn to a subcritical position, the core is subcritical by $1.20.

d. An experiment having a reactivity of 50¢ is installed in the reactor with all control rods fully inserted and the key removed

QUESTION B.02 [2.0 points, 0.5 each]
Match the type of radiation in column A with its associated Quality Factor (10CFR20) from column B.

Column A	Column B
a. alpha	1
b. beta	2
c. gamma	5
d. neutron (unknown energy)	10
	20

QUESTION B.03 [2.0 points, 0.5 each]
Match the terms in column A with their respective definitions in column B.

Column A	Column B
a. Radioactivity	1. The thickness of a material which will reduce a gamma flux by a factor of two.
b. Contamination	2. An impurity which pollutes or adulterates another substance. In radiological safety, contamination refers to the radioactive materials which are the sources of ionizing radiations.
c. Dose	3. The quantity of radiation absorbed per unit mass by the body or by any portion of the body.
d. Half-thickness	4. That property of a substance which causes it to emit ionizing radiation. This property is the spontaneous transmutation of the atoms of the substance.

QUESTION B.04 [1.0 point]
Following neutron radiography, one must not reenter the reactor bay until …

a. Reactor power is less than 50 Kilowatts

b. Reactor power is less than 5 Kilowatts

c. Reactor power is less than 50 watts

d. Reactor power is less than 5 watts

QUESTION B.05 [1.0 point]
Many research reactors use different methods to reduce the dose due to N^{16} at the pool top. If the method used keeps the N^{16} ten (10) feet below the surface of the water, and a half-thickness for the N^{16} gamma(s) is one foot for water, then the dose due to N^{16} is reduced (approximately) by a factor of … (Note: Neglect any reduction in dose rate due to half-life.)

a. 20

b. 100

c. 200

d. 1000

QUESTION B.06 [2.0 points, ½ each]
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

QUESTION B.07 [1.0 point]
Based on the Requalification Plan for licensed personnel, each licensed operator must complete a minimum of ______ reactivity manipulations during each 2 year cycle.

a. 4

b. 10

c. 20

d. 28

QUESTION B.08 [1.0 point, 0.25 each]
Identify the PRIMARY source (irradiation of air, irradiation of water, or fission product) of EACH of the radioisotopes listed.

a. $_{1}H^{3}$

b. $_{18}Ar^{41}$

c. $_{7}N^{16}$

d. $_{54}Xe^{135}$

QUESTION B.09 [1.0 point]
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.

QUESTION B.10 [1.0 point]
The **CURIE** content of a radioactive source is a measure of

a. the number of radioactive atoms in the source.

b. the amount of energy emitted per unit time by the source

c. the amount of damage to soft body tissue per unit time.

d. the number of nuclear disintegrations per unit time.

QUESTION B.11 [1.0 point]
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.

QUESTION B.12 [1.0 point]
Which ONE of the following statements correctly describes the relationship between the Safety Limit (SL) and the Limiting Safety System Setting (LSSS)?

a. The SL is a maximum operationally limiting value that prevents exceeding the LSSS during normal operations.

b. The SL is a parameter that assures the integrity of the fuel cladding. The LSSS initiates protective actions to preclude reading the SL.

c. The LSSS is a parameter that assures the integrity of the fuel cladding. The SL initiates protective action to preclude reaching the LSSS.

d. The SL is a maximum setpoint for instrumentation response. The LSSS is the minimum number of channels required to be operable.

QUESTION B.13 [2.0 points, ½ each]
Identify each of the four surveillances listed as a channel **CHECK**, a channel **TEST**, or a channel **CAL**ibration.

a. During shutdown you verify operation of period channel by verifying power decreases by a factor of 10 in three minutes

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.

QUESTION B.14 [1.0 point]
10CFR50.54(x) states: *"A licensee may take reasonable action that departs from a license condition or a technical specification (contained in a license issued under this part) in an emergency when this action is immediately needed to protect the public health and safety and no action consistent with license conditions and technical specifications that can provide adequate or equivalent protection is immediately apparent."* 10CFR50.54(y) states that the minimum level of management which may authorize this action is …

a. any Reactor Operator licensed at facility

b. any Senior Reactor Operator licensed at facility

c. Facility Manager (or equivalent at facility).

d. NRC Project Manager

QUESTION B.15 [1.0 point]
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 a 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.

QUESTION B.16 [1.0 point]
You initially remove a sample from the pool reading 1 R/hr at 30 cm from the source. You then replace the sample in the pool. An hour later you remove the sample and the reading is now 390 mR/hr at 30 cm. You again replace the sample back in the pool. How much longer should you wait to be able to bring out the sample without generating a high radiation area?

a. ½ hour

b. 1 hour

c. 1½ hours

d. 2 hours

QUESTION C.01 [2.0 points, ½ each]
Match the purification system conditions listed in column A with their respective causes listed in column B. Each choice is used only once.

Column A	Column B
a. High Radiation Level at demineralizer.	1. Channeling in demineralizer.
b. High Radiation Level downstream of demineralizer.	2. Fuel element failure.
c. High flow rate through demineralizer.	3. High temperature in demineralizer system
d. High pressure upstream of demineralizer.	4. Clogged demineralizer

QUESTION C.02 [1.0 point]
WHICH ONE of the following detectors is used primarily to measure Ar^{41} released to the environment?

a. NONE, Ar^{41} has too short a half-life to require environmental monitoring.

b. The Noble Gas Channel of the Air Monitoring System located above the pool.

c. The Particulate Channel of the Air Monitoring System located above the pool.

d. The Continuous Air Radiation Monitor at the 12 foot level.

QUESTION C.03 [1.0 point]
Which one of the following correctly describes the operation of a Thermocouple?

a. A bi-metallic strip which winds/unwinds due to different thermal expansion constants for the two metals, one end is fixed and the other moves a lever proportional to the temperature change.

b. a junction of two dissimilar metals, generating a potential (voltage) proportional to temperature changes.

c. a precision wound resistor, placed in a Wheatstone bridge, the resistance of the resistor varies proportionally to temperature changes.

d. a liquid filled container which expands and contracts proportional to temperature changes, one part of which is connected to a lever.

QUESTION C.04 [1.0 point]
Which ONE of the following is the main function performed by the **DISCRIMINATOR** circuit in the Startup Channel?

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

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

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

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

QUESTION C.05 [2.0 points, ½ each]
Match the control rod drive mechanism part from column "A" with the correct function in column "B".

COLUMN A	COLUMN B
a. Piston	1. Provide rod bottom indication.
b. Potentiometer	2. Provide rod full withdrawn indication.
c. Spring-loaded Pull Rod armature	3. Provide rod position indication when the electromagnet engages the armature.
d. Push Rod	4. Works with dash pot to slow rod near bottom of its travel.

QUESTION C.06 [1.0 point]
For a standard control rod, the red light is OFF, the white light is OFF and the blue light is ON. This is an indication that the rod and drive are …

a. not in contact, and are somewhere between full up and full down.

b. in contact, and are somewhere between full up and full down.

c. in contact, and are both are full up.

d. in contact, and are both full down.

QUESTION C.07 [1.0 point]
The normal rods use electric drive motors for positioning. The transient rod operates by

a. pneumatics (air)

b. pneumatics (Nitrogen)

c. hydraulics (Water)

d. hydraulics (Oil)

QUESTION C.08 [1.0 point]
Which of the following determines the amount of reactivity that is inserted by the Transient Control Rod during a pulse operation?

a. The air pressure applied to the Transition Rod pneumatic piston.

b. The position of the cylinder.

c. The anvil of the shock absorber.

d. The Drive Up switch on the cylinder.

QUESTION C.09 [1.0 point]
According to Procedure # 16, “TRIGA MK II Reactor Shutdown” the reactor can be shut down using an intentional safety system scram. This can be accomplished by …

a. driving the control rods to their down positions and actuating the manual scram bar.

b. actuating the manual scram bar.

c. raising reactor power to the scram setpoint.

d. manually adjusting a scram setpoint until a scram signal is generated.

QUESTION C.10 [1.0 point]
Which One of the following statements correctly describes the purpose of the potentiometer in the control rod assembly? The potentiometer provides …

a. rod position indication when the electro-magnet engages the connecting rod armature.

b. a variable voltage to the rod drive motor for regulating control rod speed.

c. potential voltage as required for resetting the electro-magnet current.

d. the potential voltage to latch the connecting rod.

QUESTION C.11 [1.0 point] Comments incorporated per facility comment
Upon receipt of a scram signal with the automatic flux control system engaged, the regulating rod …

a. magnet is de-energized, the rod falls into the core, and the drive is automatically driven in.

b. and drive remain where they are, and the operator must take action to drive both ~~must be manually driven~~ into the core.

c. and drive both automatically drive into the core.

d. magnet is de-energized, the rod falls into the core, but the operator must take action to return the drive ~~must be manually driven into the core~~ to the fully inserted position.

QUESTION C.12 [1.0 point]
The neutron source in use in the core is made of …

a. americium-beryllium

b. antimony-beryllium

c. plutonium-beryllium

d. californium

QUESTION C.13 [1.0 point]
The ONLY automatic scram available in PULSE MODE is …

a. high fuel temperature.

b. short reactor period.

c. linear multi-range power.

d. percent power.

QUESTION C.14 [1.0 point]
When the mode switch is placed in the **"AUTO"** position the …

a. period scram is bypassed.

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

c. regulating rod moves in response to the wide range log channel signal.

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

QUESTION C.15 [2.0 points, 0.5 each]
Match the action provided in column A, with the correct Nuclear Instrumentation Channel from column B. (Items in column b may be used once, more than once, or not at all. There should be only one answer per column A item.)

a. < 2 cps rod withdrawal inhibit	1. Wide Range Log
b. 1 kilowatt pulse	2. Multi-Range Linear
c. Period scram	3. Percent Power
d. Automatic Control	4. Pulse Channel

QUESTION C.16 [2.0 point, 0.67 each]
Match the Nuclear Instrumentation Channel provided in column A, with the correct Detector from column B. Each choice is used only once.

Column A	Column B
a. Wide Range Logarithmic Channel	1. Compensated Ion Chamber
b. Wide Range Linear Channel	2. Fission Chamber
c. Pulse and Power Channel	3. Uncompensated Ion Chamber

A.01 a, 7; b, 2; c, 6; d, 5
REF: Standard NRC Question

A.02 c
REF: $P = P_0 e^{t/T}$ —> ln(2) = time ÷ 100 seconds –> time = ln (2) x 100 sec. 0.693 x 100 ≈ 0.7 x 100 ≈ 70 sec.

A.03 a, 2; b, 1; c, 4; d, 3
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, Volume

A.04 c
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, Volume

A.05 b
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, Volume

A.06 a
REF: T.S. Definition 1.8,

A.07 b
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, Volume

A.08 a
REF: $P = P_0 e^{t/\tau}$ $\ln(P/P_0) = t/\tau$ 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.

A.09 d
REF: $P/P_0 = e^{-T/\tau}$ ln(0.1) = - T(time)/τ(-80sec) Time = ln (0.1) × -80 sec = 184 seconds ≈ 3 minutes

A.10 a, 2; b, 4; c, 1; d, 3
REF: Burn, R., Introduction to Nuclear Reactor Operations, 8 1988, '' 3.2.2, p. 3 7

A.11 a
REF: Standard NRC Question[1]

A.12 a 0.1 × 3.79 = 0.379 0.9 × 0.23 = 0.207 0.1 × 7.9 = 0.79 0.9 × 1.49 = 1.34
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, Volume

A.13 a
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, Volume

A.14 a
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, Volume

A.15 b
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, Volume

A.16 c
REF: DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, Volume

A.17 b
Ref: $SDM = (1 - K_{eff})/K_{eff} = (1 – 0.95)/0.95 = 0.05/0.95 = 0.526$

B.01 c
REF: Technical Specifications § 1 *Definitions*.

B.02 a, 20; b, 1; c, 1; d, 10
REF: 10CFR20.100x

B.03 a, 4; b, 2; c, 3; d, 1
REF: Standard NRC question

B.04 d
REF: Rewrite of facility supplied question

B.05 d
REF: Basic Radiological Controls knowledge: "Half-Thickness and Tenth-Thickness". $2^{10} = 1024$

B.06 a, 4; b, 2; c, 1; d, 3
REF: Standard NRC Health Physics Question

B.07 b
REF: *Requalification Program --- License R-88*, Chapter 3 Continuing Activities, § 3.1

B.08 a, Water; b, Air; c, Water; d, Fission
REF: Standard NRC question.

B.09 a
REF: Technical specification § 6.1(c)

B.10 d
REF: Standard Health Physics Definition.

B.11 b
REF: Emergency Plan § 1.5.2

B.12 b
REF: Standard NRC question on Safety Limits

B.13 a, **CHECK or TEST**; B, **CHECK**; C, **TEST**; D, **CAL,** second correct answer added per examiner review
REF: Tech Spec. § 1, Definitions

B.14 b
REF: 10CFR50.54(y)

B.15 c
REF: Tech. Spec. §§ 6.9, 3.1.3(1), 3.3.4(e), 4.1.2 & 1

B.16 c or d, second correct answer added per facility comment
REF: $I_t = I_0 e^{-\lambda t}$ 390 mR/hr ÷ 1000 mR/hr = $e^{-\lambda 1hr}$ ln(0.39) = -λ * 1 hr. λ = 0.9416 $hour^{-1}$
SOLVING for additional time: $If = I_t e^{-\lambda t}$ 100mR/hr = 390 mR/hr $e^{-0.9416 (time)}$ ln (0.25) = -0.9163 * time
time = 1.4454

C.01 a, 2; b, 3; c, 1; d, 4
Ref: Standard NRC cleanup loop question.

C.02 b
REF: SAR § 7.7, Figure 7.15.

C.03 b
REF: Standard NRC question

C.04 b
REF: Standard NRC Question for proportional counters. SAR chapter 7 shows a Fission Chamber.

C.05 a. 4; b. 3; c. 1; d. 2
REF: Standard TRIGA Mk II question

C.06 b
REF: Modification of facility supplied question per discussion with A. Meyer 01/11/2008.

C.07 a
REF: Safety Analysis Report, § 7.3, Figure 7.8

C.08 c or b, second correct answer added per facility comment
REF: Safety Analysis Report, § 7.3, Figure 7.8

C.09 d
REF: Procedure # 16, also NRC examination administered January, 2005

C.10 a
REF: Safety Analysis Report § 7.3.4.a, 6th ¶, page 7-12.

C.11 d
REF: Procedure 23, Rewrite of January 2005 NRC examination question.

C.12 a
REF: SAR page 4-8

C.13 a
REF: Technical Specifications Table I.

C.14 b or c, second correct answer added per facility comment
REF: Procedure # 23

C.15 a, 1 or 2; b, 1; c, 1; d, 2 second correct answer added per facility comment
REF: Training Manual A1-15 through 17.

C.16 a, 2; b, 1; c, 3
REF: Modification of three facility supplied questions.