U.S. NUCLEAR REGULATORY COMMISSION REGION I
OPERATOR LICENSING EXAMINATION REPORT

EXAMINATION REPORT NO. 50-170/88-01(OL)

FACILITY DOCKET NO. 50-170

FACILITY LICENSE NO. R-84

LICENSEE: Defense Nuclear Agency
Armed Forces Radiobiology Research Institute
Bethesda, Maryland 20814

FACILITY: Armed Forces Radiobiology Research Institute

EXAMINATION DATES: February 24 and 25, 1988

CHIEF EXAMINER: [signature] 30 Mar 88
Barry S. Norris — Date
Senior Operations Engineer, DRS

APPROVED BY: [signature] for 30 Mar 88
Peter W. Eselgroth, Chief — Date
PWR Section, Division of Reactor Safety

SUMMARY: Written and operating examinations tests were administered to one Senior Reactor Operator candidate. The candidate passed the operating examination but failed two sections of the written examination.

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DETAILS

TYPE OF EXAMINATIONS: Replacement

EXAMINATION RESULTS:

	SRO Pass/Fail
Written	0 / 1
Operating	1 / 0
Overall	0 / 1

CHIEF EXAMINER AT SITE: B. S. Norris, USNRC

OTHER EXAMINERS: W. S. Roesener, EG&G

No exit meeting was held since there was only a single candidate. Mr. Moore, of your staff, and the examiners resolved the facility comments on the written examination (Attachment 2).

Attachments:
1. SRO Written Examination and Answer Key
2. Facility Comments on Written Examination and NRC Resolution

Attachment 1

U. S. NUCLEAR REGULATORY COMMISSION
SENIOR REACTOR OPERATOR LICENSE EXAMINATION

FACILITY: AFRRI

REACTOR TYPE: TRIGA MARK-F

DATE ADMINSTERED: 88/02/24

MASTER COPY

EXAMINER: ROESENER, S.

CANDIDATE

INSTRUCTIONS TO CANDIDATE:

Use separate paper for the answers. Write answers on one side only. Staple question sheet on top of the answer sheets. Points for each question are indicated in parentheses after the question. The passing grade requires at least 70% in each category. Examination papers will be picked up six (6) hours after the examination starts.

CATEGORY VALUE	% OF TOTAL	CANDIDATE'S SCORE	% OF CATEGORY VALUE	CATEGORY
~~20.00~~ 18.00	20.00			H. REACTOR THEORY
20.00	20.00			I. RADIOACTIVE MATERIALS HANDLING DISPOSAL AND HAZARDS
20.00	20.00			J. SPECIFIC OPERATING CHARACTERISTICS
~~20.00~~ 19.00	20.00			K. FUEL HANDLING AND CORE PARAMETERS
20.00	20.00			L. ADMINISTRATIVE PROCEDURES, CONDITIONS AND LIMITATIONS
97.00			%	Totals

Category values changed due to:
H.03 reduced by 0.50 points
H.08.a deleted (1.50 points)
K.11.c deleted (1.00 point)

Final Grade

BL [signature] 22 Mar 88

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

MASTER COPY

Candidate's Signature

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. 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.

3. Use black ink or dark pencil only to facilitate legible reproductions.

4. Print your name in the blank provided on the cover sheet of the examination.

5. Fill in the date on the cover sheet of the examination (if necessary).

6. Use only the paper provided for answers.

7. Print your name in the upper right-hand corner of the first page of each section of the answer sheet.

8. Consecutively number each answer sheet, write "End of Category __" as appropriate, start each category on a new page, write only on one side of the paper, and write "Last Page" on the last answer sheet.

9. Number each answer as to category and number, for example, 1.4, 6.3.

10. Skip at least three lines between each answer.

11. Separate answer sheets from pad and place finished answer sheets face down on your desk or table.

12. Use abbreviations only if they are commonly used in facility literature.

13. The point value for each question is indicated in parentheses after the question and can be used as a guide for the depth of answer required.

14. Show all calculations, methods, or assumptions used to obtain an answer to mathematical problems whether indicated in the question or not.

15. Partial credit may be given. Therefore, ANSWER ALL PARTS OF THE QUESTION AND DO NOT LEAVE ANY ANSWER BLANK.

16. If parts of the examination are not clear as to intent, ask questions of the examiner only.

17. You must sign the statement on the cover sheet that indicates that the work is your own and you have not received or been given assistance in completing the examination. This must be done after the examination has been completed.

18. When you complete your examination, you shall:

a. Assemble your examination as follows:

(1) Exam questions on top.

(2) Exam aids - figures, tables, etc.

(3) Answer pages including figures which are part of the answer.

b. Turn in your copy of the examination and all pages used to answer the examination questions.

c. Turn in all scrap paper and the balance of the paper that you did not use for answering the questions.

d. Leave the examination area, as defined by the examiner. If after leaving, you are found in this area while the examination is still in progress, your license may be denied or revoked.

QUESTION H.01 (1.00)

The reactor is operating at 1 MW as indicated by the nuclear instruments. Using the given information, determine if the power indicated by the instruments is correct.

GIVEN:
Primary cooling system secured
Pool temperature rise in 30 minutes is 7.5 deg C

SHOW YOUR WORK. Helpful equations and constants are included in attachments A-1 thru A-4.

QUESTION H.02 (1.00)

Assume that the primary cooling system heat exchanger had a significant buildup of corrosion products and other deposits on the inside of the tubes, and that primary flow through the heat exchanger was held constant.

How would the difference in primary side temperature between the heat exchanger inlet and outlet be affected? EXPLAIN WHY.

QUESTION H.03 (~~1.50~~ 1.00)

Explain why the transient rod is worth approximately twice as much as the regulating rod.

QUESTION H.04 (2.00)

State TWO reasons for including the Samarium wafers in the ~~control~~ fuel rods.

QUESTION H.05 (2.00)

a. Define BETA EFFECTIVE. (1.00)

b. Explain why BETA EFFECTIVE is greater the BETA. (1.00)

(***** CATEGORY H CONTINUED ON NEXT PAGE *****)

QUESTION H.06 (2.00)

State TWO reasons for using a neutron source to perform startups at AFFRI.

QUESTION H.07 (3.00)

a. Define EXCESS REACTIVITY. (1.00)

b. List FOUR ways in which AFFRI personnel may adjust excess reactivity. (2.00)

QUESTION H.08 ~~(3.00)~~ (1.50)

The reactor operator is conducting a routine reactor startup after it has been shutdown for several days. Prior to withdrawing a rod she reads a stable power of 10 cps on the wide range log channel. Immediately after withdrawing this blade she reads a power of 16 cps.

Deleted a. ~~If she performed no rod motion for five minutes, would the count rate INCREASE, DECREASE or REMAIN THE SAME? EXPLAIN, assuming the reactor is subcritical at 16 cps.~~ ~~(1.50)~~

b. After 5 minutes she withdraws another rod such that the same amount of reactivity is added as in "a" above but the reactor is still subcritical. Is the change in power for this second rod withdrawal GREATER THAN, LESS THAN or THE SAME AS the change in power observed for the first rod withdrawal?
EXPLAIN your answer. (1.50)

QUESTION H.09 (2.00)

Assuming the reactor to be critical at 100 kW:

a. Explain the initial (prompt) response of the reactor power to a ten inch drop of the regulating rod. A general explanation is desired NOT a calculation. (1.00)

b. Describe the behavior of reactor power at two minutes following the ten inch rod drop. (1.00)

(***** CATEGORY H CONTINUED ON NEXT PAGE *****)

QUESTION H.10 (2.50)

After the reactor has been brought critical at 1 watt, the operator withdraws the regulating rod and adds 0.165% delta K/K. Assuming no further control rod manipulations or linear power scrams, sketch the response of the power level as a function of time. Attachments A-1 thru A-4 contain necessary constants and equations and attachments A-5 thru A-22 contain various useful reactivity curves. Show all calculations.

(***** END OF CATEGORY H *****)

QUESTION I.01 (2.00)

List the location of FOUR of the HOT waste drains located on the first floor within the boundaries of the REACTOR FACILITY.

QUESTION I.02 (3.00)

a. What kind of discharges is the WARM waste drain system designed to accept? (1.00)

b. State the capacity and number of tanks dedicated to WARM discharges. (1.00)

c. State TWO ways in which WARM drains are identified? (1.00)

QUESTION I.03 (3.00)

After irradiation, a rabbit is to be removed from the CET (Core Experiment Tube):

a. State the dosimetry requirements for the personnel present in the reactor room (at the CET). (1.00)

b. Name the three minimum required personnel (by title or department) that must be present for this operation and state where they shall be located (by room). (2.00)

QUESTION I.04 (2.00)

List the FOUR general actions that a radiation worker should take to control a spill of radioactive liquid.

(***** CATEGORY I CONTINUED ON NEXT PAGE *****)

QUESTION 1.05 (4.00)

For the following radiation equipment list:
1. The type of detector.
2. The location of ALL readout meters (Some may readout in MORE than one location).
3. The high level alarm setpoint.

a. Reactor room CAM (Primary). (1.00)

b. R-2. (1.00)

c. Criticality Monitor (Both day and night alarm setpoints). (1.00)

d. Stack Gas Monitor. (1.00)

QUESTION 1.06 (2.00)

What TWO radiological conditions will necessitate leaving the primary Emergency Action Station (EAS) and going to the secondary EAS?

QUESTION 1.07 (2.00)

State the type and range of the portable radiation detectors available INSIDE the reactor control room. (DO NOT include the instruments in the emergency cache just outside the control room door.)

QUESTION 1.08 (2.00)

Define the following:

a. By-product Material (1.00)

b. High Radiation Area (1.00)

(***** END OF CATEGORY I *****)

QUESTION J.01 (2.00)

Half way through a 6 hour reactor operation run you discover that the normal ventilation exhaust damper ~~above the fume hood~~ has been blocked open by a student performing experiments in the hood. You can not close the damper because it was damaged.

a. What actions should be taken relative to reactor operation? (1.00)

b. Is the event reportable? Why or why not? (1.00)

(A copy of the ventilation Technical Specification is included as attachment A-26.)

QUESTION J.02 (1.00)

Explain the mechanism by which the transient control rod is dropped into the core on a scram signal.

QUESTION J.03 (1.00)

WHAT protects the reactor control console from voltage surges and WHY is this protection needed?

QUESTION J.04 (1.00)

Multiple Choice:

Which one of the following receives its power from transformer 42A (located in room 3152)?

a. cooling tower fans

b. ventilation exhaust fan EF-1

c. radiation monitor panel

d. reactor control panel

e. air compressor for transient rod and lead door seal

QUESTION J.05 (3.00)

List FOUR of the interlocks associated with the Rod Withdrawal Prevent circuit any one of which will prevent withdrawal of ALL rods. Include in your answer the associated setpoint.

QUESTION J.06 (1.00)

What design feature minimizes the bottoming impact of a control rod drive piston?

QUESTION J.07 (1.00)

Why is air pressure at 9 psi supplied to the shield door bearings?

QUESTION J.08 (3.00)

What are the THREE basic functions of the water purification system?

QUESTION J.09 (2.00)

List the THREE special indications in effect only in the Pulse Mode of operation. Include in your answer BOTH the parameter and the method of display.

QUESTION J.10 (1.00)

If a pulse of $2.50 is fired from cold critical conditions and a subsequent scram does not occur, what will be the final steady state power assuming no operator action. Useful reactivity curves are included as attachments A-5 thru A-22.

QUESTION J.11 (2.50)

During the performance of a normal K excess calculation, the operator decides to pull the transient rod first, the safety rod next then the shim rod and finally to go critical on the regulating rod. The operator makes a mistake on the first withdrawal, pulling the transient rod to 65% instead of 25%. Assume the power with the transient rod at 65% is .05 watts and assume that the core is in position 567.

a. If the operator does not notice her mistake and continues withdrawal of the other rods, which rod will be moving when the reactor goes critical? Show all calculations used to arrive at your answer. (2.00)

b. If the operator continues to pull the rod in "a" above, what will be the first automatic action to take place, a PERIOD RWP, a POWER SCRAM, or a TEMPERATURE SCRAM? (0.50)

Useful constants equations and reactivity curves are included as attachments A-1 thru A-22.

QUESTION J.12 (0.50)

TRUE OR FALSE

A rupture in the primary coolant return piping is prevented from draining the core below the top of the core by small holes drilled in both the suction and return piping level three feet above the top of the core.

QUESTION J.13 (1.00)

State the complete Technical Specification limits on bulk and purification outlet conductivity.

***** END OF CATEGORY J *****

QUESTION K.01 (3.00)

Explain why the procedure for loading fuel from the inside ring out is more conservative than loading fuel from the outside in. Include in your answer a sketch of the 1/M plots for each loading scheme.

QUESTION K.02 (1.00)

If the reactor was operating at 1 MW and a fuel element developed a crack in the cladding, how would the operator first receive an indication of the failure?

QUESTION K.03 (1.00)

State the Safety Limit and the Safety System Settings. Include both the parameter and the setpoint.

QUESTION K.04 (3.00)

According to Technical Specifications, with fuel present in the core, when is the reactor considered secured?

QUESTION K.05 (1.00)

TRUE or FALSE?

a. The Technical Specification limit on transverse bend is based in part on the prevention of hot spots resulting from touching fuel rods. (0.50)

b. The Technical Specification limit on fuel rod elongation is based in part on ensuring adequate coolant flow. (0.50)

(***** CATEGORY K CONTINUED ON NEXT PAGE *****)

QUESTION K.06 (2.00)

a. An experiment is loaded into the B-ring of the core when the reactor is operating at 1 MW. After loading the experiment, the reactor power level decreases to 500 KW. How much reactivity was added by the experiment? Useful reactivity curves are included as attachments A-5 thru A-22. (~~1.00~~) 0.50

b. If the same experiment had been loaded in the outer ring would you expect the final power level to be GREATER THAN, LESS THAN or EQUAL TO 500 kW? EXPLAIN your choice. (~~1.00~~) 1.50

QUESTION K.07 (2.00)

The reactor core is in position 231, power is 1.0 MW, Mode I operation. The shield doors are fully open and both exposure room doors are closed. If the core carriage control (core dolly) malfunctions and starts driving the core toward the center of the tank, will the reactor be SUPER-CRITICAL, SUB-CRITICAL, or CRITICAL when the core reaches position 567. JUSTIFY your answer.

ASSUME: NO OPERATOR ACTIONS
ALL OTHER SYSTEMS FUNCTIONING NORMALLY (2.00)

QUESTION K.08 (1.00)

The inspection of the ~~control~~ fuel rods required annually is scheduled this week. The three previous inspections were conducted 14, 25, and 40 months ago. Can an experiment be run this week without inspecting the control rods? Justify your answer. A copy of the applicable Technical Specification is included as attachment A-25.

QUESTION K.09 (0.50)

TRUE or FALSE?

In-core experiments shall not be placed in adjacent fuel positions of the B-ring and/or C-ring. (0.50)

QUESTION K.10 (2.00)

In the core loading procedure, fuel rods are inserted in large groups until there are a total of 66 rods in the core, thereafter the rods are inserted 2 at a time.

a. Explain why rods are added in such large groups up to 66 and then only added two at a time thereafter.

b. How is criticality tested for after each group of rods is inserted?

QUESTION K.11 ~~(3.00)~~ (2.50)

Assume that the core can be made critical with an excess reactivity of $.40 with 68 fuel elements in the core.

a. Estimate the maximum number of fuel rods that can be inserted without exceeding Technical Specification excess delta K limits. (1.00)

b. If no experiments are to be loaded, how many extra core sites will be left to fill once all the fuel is loaded? (0.50)

~~c. What is done with the non fueled positions discussed in "b" above?~~ (~~1.00~~)
Deleted

d. If an experiment is added to the core that is worth a NEGATIVE $.50 of reactivity, would the maximum number of rods allowed in "a" above INCREASE, DECREASE or REMAIN THE SAME? (0.50)

e. If an experiment is added to the core that is worth a POSITIVE $.50 of reactivity, would the maximum number of rods allowed in "a" above INCREASE, DECREASE or REMAIN THE SAME? (0.50)

(***** END OF CATEGORY K *****)

QUESTION L.01 (2.00)

What is the minimum staff required when the reactor is NOT secured?

QUESTION L.02 (3.00)

For each of the following, state who (by title or position), is responsible:

a. For final approval on a Reactor Use Request. (0.50)

b. For authorizing entry of a visitor into an exposure room. (TWO answers required). (1.00)

c. For Reactor Facility Key Control. (0.50)

d. For supervising the insertion of an approved in-core experiment. (0.50)

e. For supervision of the loading of the core. (0.50)

QUESTION L.03 (4.00)

Indicate whether each of the following situations would require immediate shutdown of the reactor. Consider each situation separately JUSTIFY your answer.

a. Reactor power spiked to 1.15 MW during Mode I operations and is now at 900 KW. (1.00)

b. The log power channel fails while operating in the Pulse mode. (1.00)

c. Power increases as rods are manually driven into the core while at 500 kw. Pool temperature is 95 F and the primary and secondary pumps are operating. The reason for the increase is not known. (1.00)

d. An area radiation monitor (R-3) in the reactor room is found to be inoperable. (1.00)

(***** CATEGORY L CONTINUED ON NEXT PAGE *****)

QUESTION L.04 (2.00)

10CFR55 defines an operator as any individual who manipulates a control of a facility:

a. Define the term "control". (1.00)

b. Under what conditions is the person physically manipulating a control not required to hold a valid operator's license? (1.00)

QUESTION L.05 (2.50)

While showing a trainee how to operate a reactor control room fire alarm, you accidentally set it off. State your immediate actions. Assume that the reactor is critical and that you are the current operator in charge.

QUESTION L.06 (2.00)

State the order of succession of command for the Emergency Action Station (EAS) Commander according to the "Emergency Plan for the AFRRI TRIGA Reactor Facility".

QUESTION L.07 (1.00)

How could the EAS commander determine who was inside the AFRRI complex during nonduty hours?

QUESTION L.08 (0.50)

TRUE or FALSE?

The EAS Commander has the authority to make on-the-spot decisions and to direct or perform immediate actions deemed necessary provided that the ECP Commander is informed of such immediate decisions and actions as soon after the fact as possible.

QUESTION L.09 (3.00)

a. Define Emergency Action Levels (EAL)? (1.00)

b. Give example EALs for two of the emergency classes used at AFFRI. (2.00)

(***** END OF CATEGORY L *****)
(********** END OF EXAMINATION **********)

ANSWER H.01 (1.00)

Tank constant is 1.48 deg C/100 kW-hr [0.25]

[7.5 deg C/0.5 hr] [100 kW-hr/1.48 deg C] = 1013 kW or 1.013 MW [0.50]

Indication is correct [0.25] (1.00)

REFERENCE

AFRRI Sample Questions F.6 and J.1.

ANSWER H.02 (1.00)

~~The delta T will decrease [0.50] because the corrosion layer will act as insulation and reduce the heat transfer coefficient reducing the heat removed [0.50].~~ (1.00)

REFERENCE

Murray, R. L.; Nuclear Energy p. 138.

ANSWER H.03 (~~1.50~~ 1.00)

Because the transient rod is located in a region of higher flux as compared to the regulating rod
OR
Because the transient rod absorbs more neutrons than the regulating rod. (1.00)

~~Since the absorber portions of the two control rods are identical [0.50] and since the transient rod is located in a region of higher flux [0.50], the transient rod will absorb more neutrons and will therefore be worth more [0.50].~~ (~~1.50~~)

REFERENCE

Fundamentals of Nuclear Reactor Engineering, Ch. 3, Para. 85.

→ Two possible answers depending on assumptions as follows:

The ΔT will decrease [0.50].

Explanation: The corrosion layer inhibits heat transfer across the primary to secondary boundary [0.10]. In order to continue adequate heat transfer across the boundary the primary temperature must rise [0.10]. Assuming this rise results in significant additional loses of heat to ambient [0.10], the heat transfered across the heat exchanger will decrease [0.10]. With constant primary flow and a decrease in heat transfered [0.10] the ΔT will decrease.

OR

The ΔT will remain constant [0.50].

Explanation: If the losses to ambient do not change significantly [0.20] then the heat transfered in the heat exchanger must remain constant [0.20]. With primary flow and heat transfer constant [0.10]

(***** CATEGORY H CONTINUED ON NEXT PAGE *****)

ANSWER H.04 (2.00)

1. Functions as a burnable poison.

   OR

   Extends the life of a rod by limiting the excess reactivity of a new fuel rod and then burning out as the rod ages to help account for fuel burnup and fission product buildup.

2. Functions as a flux suppressor.

   OR

   Helps to flatten out the axial flux distribution by suppressing the flux peaks at the ends of the fueled region of the rod.

REFERENCE

Fundamentals of Nuclear Reactor Engineering, Ch. 4, Paras. 101 & 1C2.
AFRRI Sample Questions C.6.

ANSWER H.05 (2.00)

a. The fraction of the thermal neutron population that was born delayed. (1.00)

b. Since delayed neutrons are born at lower energies than prompt neutrons [0.50] they are more likely to reach thermal energies [0.50]. (Therefore, the fraction of delayed neutrons at thermal energies (beta effective) is greater than the fraction of delayed neutrons at birth (beta).) (1.00)

REFERENCE

A Listing of Terms/Concepts/Definitions for the AFFRI TRIGA Reactor, p. 7.
AFRRI Sample Questions H.2 & H.9.

(***** CATEGORY H CONTINUED ON NEXT PAGE *****)

ANSWER H.06 (2.00)

1. The source is used to check low level instrumentation [1.00].

2. The source is used to insure safe, controlled startup of the reactor [1.00]. (2.00)

REFERENCE

AFRRI Sample Questions A.2.
Fundamentals of Nuclear Reactor Engineering, Ch. 4, Para. 149.

ANSWER H.07 (3.00)

a. That amount of reactivity remaining in the core greater than what is needed to bring the reactor cold critical. (1.00)

b. Any four of the following at 0.50 each:

1. Moving the core.

2. Adding (removing) fuel.

3. Reshuffling fuel.

4. Changing fuel (refueling).

5. Changing experiments (including exposure room modifications).

6. Installing (removing) the core experiment tube (CET). (2.00)

7. By depleting the fuel (operating the reactor).

REFERENCE

AFRRI Sample Questions A.6.
A Listing of Terms/Concepts/Definitions for the AFFRI TRIGA Reactor, p. 19

(***** CATEGORY H CONTINUED ON NEXT PAGE *****)

ANSWER H.08 ~~(3.00)~~ (1.50)

a. Deleted INCREASE [0.50]. Right after the rod motion ceases subcritical multiplication equilibrium level is not yet established [0.50]. The level will continue to increase until the new equilibrium is reached [0.50]. ~~(1.50)~~

b. GREATER THAN [0.50]. As the multiplication factor approaches one (or as the reactor approaches criticality) [0.50], the number of generations required to reach equilibrium increases [0.50] and therefore the change in count rate increases. (1.50)

OR

The final equilibrium level is proportional to [1/(1-K)] = (1 -1/p). As K approaches 1, p approaches zero from the negative side and each step change in reactivity causes (1 - 1/p) to change (increase) by a larger amount resulting in a larger increase in the associated neutron level (or count rate). (As p approaches 0 from the negative side (1 - 1/p) approaches infinity.) (Note Bien: p = rho.) (1.50)

REFERENCE

Fundamentals of Nuclear Reactor Engineering, Ch. 5, Para. 158.

ANSWER H.09 (2.00)

a. The reactor power will drop immediately [0.50] due to the quick response of the prompt neutrons to the change in reactivity [0.50]. (1.00)

b. At two minutes the reactor power will be decreasing [0.50] at a rate controlled by the decay of delayed neutron precursors [0.50]. (1.00)

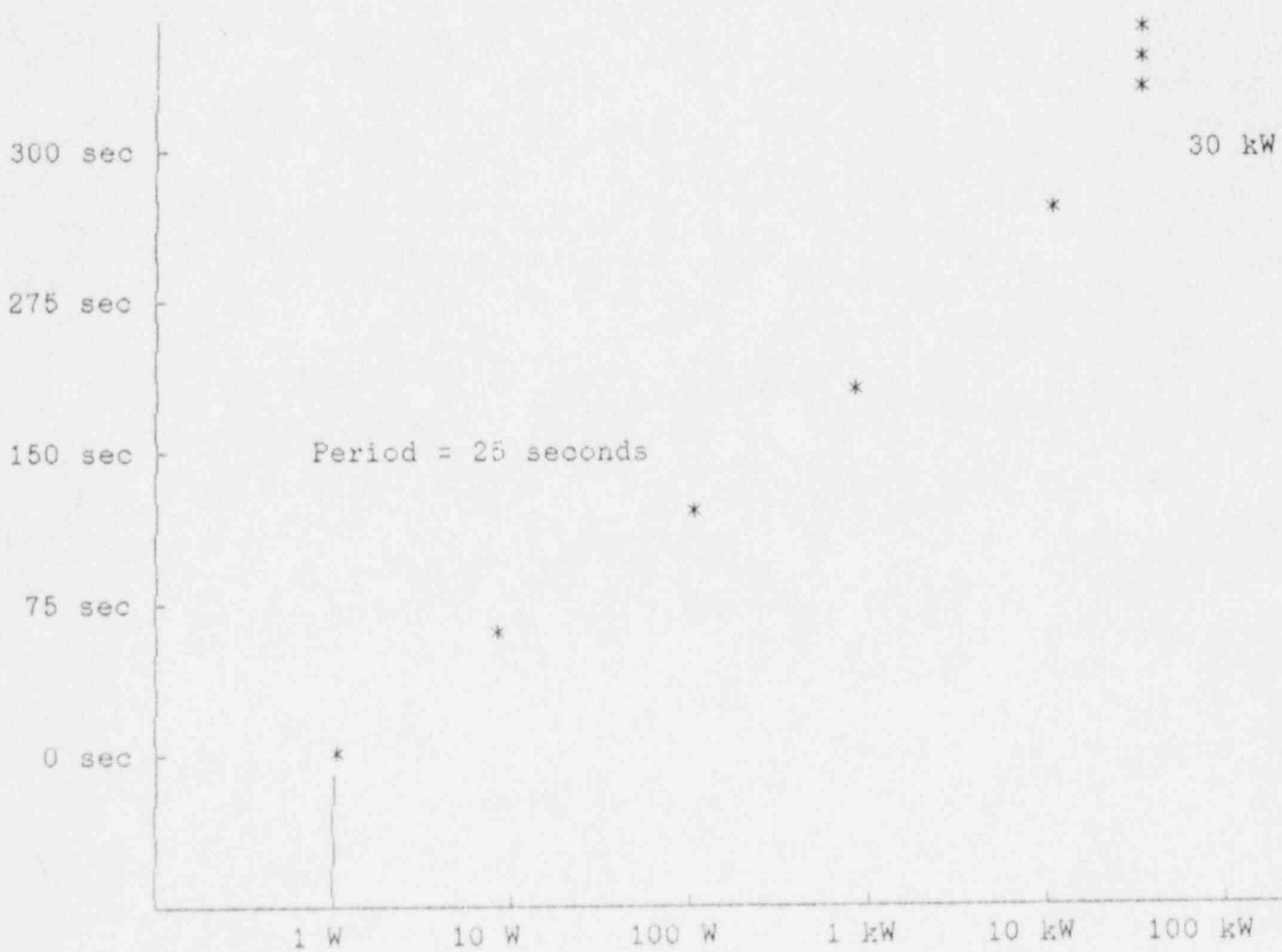
REFERENCE

Fundamentals of Nuclear Reactor Engineering, Ch. 2, Para. 79.

(***** CATEGORY H CONTINUED ON NEXT PAGE *****)

ANSWER H.10 (2.50)

(The reactor will go on a positive period of 25 sec based on the inhour curve. The reactor will rise to a stable power level with a reactivity change due to the negative temperature coefficient equal and opposite to that added by the rods. It will rise at the 25 second period at first and then tail off as the power r'se begins to add significant negative reactivity. .165% delta K/K = $.235 so power will rise to approximately 30 kW.)



(***** CATEGORY H CONTINUED ON NEXT PAGE *****)

Grading : Correct period 25 sec (+/- 1 sec) and/or correct time from initial to final time 350 sec (+/- 100 sec) [1.00]

Correct final power 30 kW (+/- 20 kW) [1.00]

General shape of Graph [0.50]

REFERENCE

Fundamentals of Nuclear Reactor Engineering, Ch. 3, paras. 78,79, & 88.

(***** END OF CATEGORY H *****)

ANSWER I.01 (2.00)

Any four of the following at 0.50 each:

1. Floor of Exposure Room #1.
2. Floor of Exposure Room #2.
3. Floor of (warm storage) Heat Exchanger Room (1121).
4. Floor of hallway to (warm storage) Heat Exchanger Room (1120).

REFERENCE

Operations Manual for the AFRRI TRIGA Mark-F Reactor, Figure 3-13 "Liquid radioactive waste drains located on the first floor of AFFRI".

ANSWER I.02 (3.00)

a. Liquid wastes containing low-level radioactive activation and contamination. (1.00)

b. 5 tanks at 5000 gallons each. (1.00)

c. 1. Painted yellow [0.50].

   2. Marked with a yellow "WARM DRAIN" sign [0.50]. (1.00)

REFERENCE

Operations Manual for the AFRRI TRIGA Mark-F Reactor, Ch. 3, p. 59.
AFRRI Radiological Safety Manual, p. 40.

(***** CATEGORY I CONTINUED ON NEXT PAGE *****)

ANSWER I.03 (3.00)

a. AFRRI radiation dosimetry device [0.33].
Pocket ion chamber dosimeter [0.33].
Wrist dosimetry [0.34]. (1.00)

b. Reactor Room [0.25]-
SAF monitor[0.50]
reactor staff member [0.50]
Control Room [0.25] -
reactor operator (SRO acceptable) [0.50] (2.00)

REFERENCE

Operations Procedures for the AFRRI TRIGA Mark-F Reactor, Proc. I, Tab B.
AFRRI Radiological Safety Manual, p. 13.

ANSWER I.04 (2.00)

1. Contain the spill [0.~~3~~50] ~~if this can be safely done [0.20].~~

2. Inform nearby people [0.~~3~~50] ~~so they can either assist [0.10 or evacuate [0.10].~~

3. Isolate the area [0.50] (so no one else can be contaminated).

4. Call SAF [0.50], (even if it involves contaminating the telephone). (2.00)

REFERENCE

AFRRI Radiological Safety Manual, p. 38.

(***** CATEGORY I CONTINUED ON NEXT PAGE *****)

ANSWER I.05 (4.00)

(0.25 points for each part)

a. 1. GM-Tube
   2. On unit (Reactor Room)
      Control Room
   3. 10 Kcpm

b. 1. Scintillation
   2. Control Room
      ~~Security Office (3112)~~ Emergency Response Team Center (3434)
   3. 10 mr

c. 1. Scintillation
   2. Control Room
   3. 50 mr by day
      20 mr by night

d. 1. Proportional Counter
   2. Control Room
      Environmental Surveillance Room (~~Upper~~ Equipment Room)(3152)
   3. 1500 cpm

OR d 1. Scintillation
     2. Control Room
        Reactor Room
     3. 889 cpm

REFERENCE

Operations Manual for the AFRRI TRIGA Mark-F Reactor, Ch. 6, p.115, 125, 126, 139-151.
AFRRI Sample Questions G-24.
Operations Procedures for the AFRRI TRIGA Mark-F Reactor, Proc. VIII, Tab C.
Emergency Plan for the AFRRI TRIGA Reactor Facility, pp. 56 - 58.

ANSWER I.06 (2.00)

1. Radiation levels greater than 100 mr/hr [0.50] at the center of the control room [0.50].

2. Reactor room CAM high-level alarm [0.50] in conjunction with compromise of the reactor room to reactor control room boundary [0.50] (such that there is airborne contamination in the control room). (2.00)

(***** CATEGORY I CONTINUED ON NEXT PAGE *****)

REFERENCE

Emergency Plan for the AFRRI TRIGA Reactor Facility, pp. 56 - 58.

ANSWER I.07 (2.00)

Teletector - High + Low Range
Victorene - Low Range

CAF There is a high range and a low range at 1.00 point each. (2.00)

REFERENCE

Emergency Plan for the AFRRI TRIGA Reactor Facility, p. 59.

ANSWER I.08 (2.00)

a. Any radioactive material, except special nuclear material, yielded in or made radioactive by exposure to the radiation incident to the process of producing or using special nuclear material. (1.00)

b. Any area accessible to personnel in which there exists radiation,(originating in whole or in part within licensed material) at such levels that a major portion of the body [0.25] could receive in any one hour a dose in excess of 100 mr [0.75]. (1.00)

REFERENCE

A Listing of Terms/Concepts/Definitions for the AFFRI TRIGA Reactor, pp. 8 & 23.

(***** END OF CATEGORY I *****)

ANSWER J.01 (2.00)

a. (Since the system is incapable of performing its intended functions in a normal manner, i.e. since the system is inoperable) it is necessary to immediately secure reactor operation. (1.00)

b. The event is reportable since the reactor was operated in violation of a limiting condition for operation. (Specifically, the reactor was operated with the ventilation system inoperable AND not secured). (Note - the 48 hour time limit applies to operation with the ventilation system SECURED!) (1.00)

REFERENCE

Technical Specifications, Sec 3.4 & 4.4.

ANSWER J.02 (1.00)

Scram signal deenergizes a three way air solenoid valve [0.25] which interrupts the air supply and relieves pressure on the air cylinder [0.50] allowing the piston to drop by gravity [0.25]. (1.00)

REFERENCE

Operations Manual for the AFRRI TRIGA Mark-F Reactor, Ch. 2, pp. 28-33.

ANSWER J.03 (1.00)

A voltage regulator [0.50] to prevent overloading circuits in the reactor console [0.50]. (1.00)

REFERENCE

Operations Manual for the AFRRI TRIGA Mark-F Reactor, Ch. 4, p. 70.

(***** CATEGORY J CONTINUED ON NEXT PAGE *****)

ANSWER J.04 (1.00)

d.

REFERENCE

Operations Manual for the AFRRI TRIGA Mark-F Reactor, Ch. 4, Figs. 4-7 "Electric power distribution system for reactor building" & 4-11 "MCC power distribution for reactor support equipment".

ANSWER J.05 (3.00)

Any four of the following at 0.50 for the interlock and 0.25 for the setpoint:

1. Period - 3 seconds
2. Source - .5 cps
3. Water bulk temperature - 50 C
4. Fission chamber high voltage loss - 20%
5. Operational calibrate - Operational channel in any position except operate (3.00)

REFERENCE

Operating Procedure for the AFRRI TRIGA Mark-F Reactor, Sec VIII, Tab-C.
Operations Manual for the AFRRI TRIGA Mark-F Reactor, Ch. 7, pp. 92 & 93.

ANSWER J.06 (1.00)

When the piston is near (within 2 inches of) the bottom of its travel, its movement is restrained by the dashpot action of the graded vents in the lower end of the guide barrel. (1.00)

(***** CATEGORY J CONTINUED ON NEXT PAGE *****)

REFERENCE

Operations Manual for the AFRRI TRIGA Mark-F Reactor, Ch. 2, p. 27.

ANSWER J.07 (1.00)

To minimize the likelihood of water leaking into the housing if the seal should rupture. (1.00)

REFERENCE

Operations Manual for the AFRRI TRIGA Mark-F Reactor, Ch. 4, p. 68.

ANSWER J.08 (3.00)

1. It maintains low electrical conductivity of the reactor coolant (to minimize the corrosion of all reactor components) [1.00].

2. It reduces radioactivity in the water (by removing particulates and soluble impurities) [1.00].

3. It helps to maintain the optical clarity of the water [1.00]. (3.00)

REFERENCE

Operations Manual for the AFRRI TRIGA Mark-F Reactor, Ch. 3, p. 41.

ANSWER J.09 (2.00)

1. Peak power level [0.33] is displayed on the chart recorder [0.33].

2. Integrated power [0.34] is displayed on the safety channel 2 meter (the megawatt-sec meter) [0.34].

3. Fuel temperature [0.33] is displayed on the chart recorder [0.33]. (2.00)

(***** CATEGORY J CONTINUED ON NEXT PAGE *****)

REFERENCE

Operations Manual for the AFRRI TRIGA Mark-F Reactor, Ch. 5, pp. 98 & 99.

ANSWER J.10 (1.00)

580 kW (+/- 20 kW) (The $2.50 insertion is offset by the negative reactivity inserted by the fuel at a power of 580 kW). (1.00)

REFERENCE

AFRRI Sample Questions J.13.

ANSWER J.11 (2.50)

a. Normal criticality for this configuration occurs when rods have added $1.85 + $1.86 + $.71 + $.63 = $5.05 [1.00].

65% of the transient rod is worth $2.79 and all of the safety rod is worth $1.86 leaving $5.05 - $2.79 - $1.86 = $.40 to criticality [0.50]. Therefore, the shim rod will be moving (through 37.5) at criticality [0.50]. (2.00)

b. PERIOD RWP [0.50].

(EXPLANATION)
(A 3 second period occurs at $.75. (Known from square wave operation or may be calculated). For the situation discussed, an insertion of $.75 would occur at 63.5 on the shim rod. With a rod speed of about 8 sec per 1% rod motion the total time to 63.5 beyond criticality is 21 seconds. Even conservatively assuming an average 3 second period for the entire 21 seconds gives a power increase of only:

$e^{21/3}$ = 1096 or a final power of the order of 500 watts which is well below the power scram and well below the point of any significant heat addition to the fuel to either cause a scram or to insert significant negative reactivity via the temperature coefficient.)

(***** CATEGORY J CONTINUED ON NEXT PAGE *****)

REFERENCE

Operating Procedure for the AFRRI TRIGA Mark-F Reactor, Sec. VIII, Tabs D & F.
Worth curves for position 567.

ANSWER J.12 (0.50)

FALSE (0.50)

REFERENCE

Operations Manual for the AFRRI TRIGA Mark-F Reactor, Ch. 3, p. 41.

ANSWER J.13 (1.00)

Purification - 2 micromhos/cm [0.25] averaged over one week [0.25].

Bulk - 5 micromhos/cm [0.25] averaged over one week [0.25]. (1.00)

REFERENCE

AFRRI Technical Specifications 3.3.

(***** END OF CATEGORY J *****)

ANSWER K.01 (3.00)

See attached FIGURE F-1 [1.00 each].

Because the fuel worth increases from the outside edge to the inside ring of the core [0.25], the outside to inside loading scheme leads to an initial overestimate of the number of fuel elements required for criticality [0.25] while the procedure used at AFRRI (inside out) leads to an initial underestimate [0.25] which is more conservative and safer [0.25]. (3.00)

REFERENCE

Fundamentals of Nuclear Reactor Engineering, Ch. 5, Para. 160.

ANSWER K.02 (1.00)

The reactor room CAM would alarm.

REFERENCE

AFRRI Sample Questions I.8.

ANSWER K.03 (1.00)

1. Maximum fuel temperature [0.25] shall not exceed 1000 C [0.25].

2. Measured fuel temperature [0.25] shall not exceed 600 C [0.25]. (1.00)

REFERENCE

AFRRI Technical Specifications 2.1 & 2.2.

(***** CATEGORY K CONTINUED ON NEXT PAGE *****)

ANSWER K.04 (3.00)

1. The reactor is shut down [0.50].

2. The console key switch is in the "OFF" position [0.25], and the key is removed from the console [0.25] and is under the control of a licensed operator [0.25], or is stored in a locked storage area [0.25].

3. No work is in progress involving in-core fuel handling [0.10] or refueling operations [0.10], maintenance of the reactor [0.10] or control mechanisms [0.10], or insertion or withdrawal of in-core experiments [0.10], unless sufficient fuel is removed to insure a $0.50 (or greater) shutdown margin [0.50] with the most reactive control rod removed [0.50]. (3.00)

REFERENCE

AFRRI Technical Specifications 1.19.

ANSWER K.05 (1.00)

a. FALSE (0.50)

b. TRUE (0.50)

REFERENCE

AFRRI Technical Specifications 5.2.2.

ANSWER K.06 (2.00)

a. $1.12 (+/- $.1) (0.50)

b. GREATER THAN [0.50].

The core outer ring has a lower flux and therefore the experiment would not insert as much negative reactivity [1.00]. (1.50)

(***** CATEGORY K CONTINUED ON NEXT PAGE *****)

REFERENCE

Fundamentals of Nuclear Reactor Engineering, Ch. 3, Para. 82 - 84.
AFRRI Sample Questions C.15.

ANSWER K.07 (2.00)

SUBCRITICAL [0.5].

As the reactor moves positive reactivity is added (from t increased reflection) [0.50]. The rods are in manual thus power ir ases [0.50]. When the HI-FLUX scram setpoint (1.1 MW) is reached, the reactor scrams [0.50]. (2.00)

REFERENCE

Fundamentals of Nuclear Reactor Engineering, Ch. 3, Para. 83.

ANSWER K.08 (1.00)

Yes [0.50].

TS surveillance is one year not to exceed 15 months and was not violated in any of the above cases [0.50]. (Note: AFRRI TS do not include 3.25 x interval requirement.)

REFERENCE

AFRRI Technical Specifications 4.1.

ANSWER K.09 (0.50)

TRUE

REFERENCE

AFRRI Technical Specifications 5.2.2.

ANSWER K.10 (2.00)

a. Experience shows that approximately 67 fuel elements are required to go critical [0.50]. Therefore, 66 elements should not normally cause criticality to occur and therefore it is not necessary to predict criticality conditions as often [0.50].

b. Control rods are withdrawn to 50% and 100% [0.33], changes in detector readings are noted [0.33] and a 1/M plot is constructed to predict criticality [0.34]. (2.00)

REFERENCE

AFRRI Technical Specifications 5.3.
Operating Procedure for the AFRRI TRIGA Mark-F Reactor, Sec VII.

ANSWER K.11 ~~(3.50)~~ (2.50)

a. Max excess = \$5.00 [0.50]

Fuel rod worth in the F ring is \$.28/rod

Therefore: (\$5.00 - \$.40)/ \$.28/rod = 16.4

16 rods may be added [0.50]. (1.00)

b. 3 (87 -68 -16) (0.50)

~~c. SAF (Aluminum dummies?)~~ Deleted ~~(1.00)~~

d. REMAIN THE SAME (0.50)

e. DECREASE (0.50)

REFERENCE

Operations Manual for the AFRRI TRIGA Mark-F Reactor, Ch. 1, p. 18.
AFRRI Technical Specifications 3.1.3

(***** END OF CATEGORY K *****)

ANSWER L.01 (2.00)

1. SRO on call [0.5].
2. RO or SRO in the control room [0.5].
3. Radiation Control Technician on call [0.5].
4. Another person within the AFRRI complex [0.5]. (2.00)

REFERENCE

Technical Specifications, 6.1.3.2

ANSWER L.02 (3.00)

a. Reactor Facility Director. (0.50)

b. Reactor Facility Director [0.50]
AND the Head of Radiation Safety Dept. [0.50]. (1.00)

c. Reactor Operations Supervisor. (0.50)

d. SRO. (0.50)

e. Reactor Facility Director OR Reactor Operations Supervisor. (0.50)

REFERENCE

Operating Procedure for the AFRRI TRIGA Mark-F Reactor:
a. Sec I
b. Sec I, Tab A
c. Sec V
d. Sec I, Tab E
e. Sec VII

(***** CATEGORY L CONTINUED ON NEXT PAGE *****)

ANSWER L.03 (4.00)

a. Shutdown is required [0.50] since safety system has failed to operate [0.50]. (1.00)

b. Shutdown is not required [0.50] since the log power channel is not required to be operational in the pulse mode [0.50]. (1.00)

c. Shutdown [0.50] (to avoid an accident) since the operator cannot control the reactor by normal means [0.50]. (1.00)

d. Shutdown is not required [0.50] since R-3 is an additional area monitor not required by Technical Specifications [0.50]. (1.00)

REFERENCE

Technical Specifications:
a. 3.2.2.

b. 3.2.1.

d. 3.5.1.

Operating Procedure for the AFRRI TRIGA Mark-F Reactor:
c. Sec. VI.

ANSWER L.04 (2.00)

a. Devices (apparatus and mechanisms) of a nuclear reactor, the manipulation of which directly affect the reactivity or power of the reactor. (1.00)

b. The individual manipulating the control must be under the direction of and in the presence of a licensed reactor operator [0.50] and the manipulation must be part of the individuals training as a student [0.50]. (1.00)

REFERENCE

10CFR55, Part 55.4 , 55.9 and 55.13.

(***** CATEGORY L CONTINUED ON NEXT PAGE *****)

ANSWER L.05 (2.50)

1. SCRAM the reactor [0.50].

2. Secure any exposure facilities which are in use [0.50].

3. Remove the logbook [0.10], emergency guide [0.10], radios [0.10], teletector [0.10], tool kit [0.10], and keys [0.10] and report to the EAS [0.40].

4. Do NOT lock reactor area doors [0.50]. (2.50)

REFERENCE

Operating Procedure for the AFRRI TRIGA Mark-F Reactor, Sec. VI
AFRRI 3020.2H, Enclosure 4, p. 13.

ANSWER L.06 (2.00)

1. Reactor Physicist-in-Charge (Will accept Reactor Facility Director) [0.50].

2. Reactor Operations Supervisor [0.50].

3. Most-senior licensed SRO present [0.50].

4. Most-senior licensed RO present [0.50]. (2.00)

REFERENCE

Emergency Plan for the AFRRI TRIGA Reactor Facility, p. 23.

ANSWER L.07 (1.00)

He can look at the Security Area Register. (1.00)

(***** CATEGORY L CONTINUED ON NEXT PAGE *****)

REFERENCE

AFRRI 3020.2H, Enclosure 4, p. 14.

ANSWER L.08 (0.50)

TRUE

REFERENCE

Emergency Plan for the AFRRI TRIGA Reactor Facility, p. 30.

ANSWER L.09 (3.00)

a. EALs are thresholds for establishing (entering) an emergency class. (1.00)

b. Any two of the following at 1.00 each:

See the attached Emergency Classification Guide.

Parts of any one of the EALs that are complete within themselves such as "Receipt of a vague bomb threat" for Class 0, or "Verified visual observation of fuel damage involving multiple clad failures," for Class 2 are accepted for full credit. (2.00)

REFERENCE

Emergency Plan for the AFRRI TRIGA Reactor Facility, p. 39-42.

(***** END OF CATEGORY L *****)
(********** END OF EXAMINATION **********)

Emergency Action Levels to accompany Checklist VI.

Table 5.1. Emergency Classification Guide

Emergency Class	Emergency Action Level (EAL)	Purpose
Class #: Events Less Severe Than The Lowest Category	Receipt or notification of vague bomb threats or civil disturbances non-specific to the reactor Observation or notification of personnel injury or disablement within the operations boundary Notification or receipt of officially declared severe weather warnings for the area Observation of a small but unusual loss or drop of normal reactor pool water that is determined to be within the capabilities of the normal makeup water system(s) Observation of a minor radiation incident within the operations boundary to include an experiment failure post-irradiation during, for example, normal retrieval or handling operations or via receipt of unexpected higher than normal reactor facility radiation readings or alarm(s) below the EAL thresholds identified for a Class 1, "Notification of Unusual Event" emergency condition listed below Fire alarm or observation/notification of a fire or explosion determined to be outside of and not immediately adjacent to the reactor operations boundary or not involving the reactor facility.	1. Alert staff to possible escalation 2. Initiate assessment and/ or confirmatory actions, as necessary 3. Provide treatment and/ or initiate corrective actions, as necessary

(continued next page)

Table 5.1—continued

Emergency Class	Emergency Action Level (EAL)	Purpose
Class I: Notification of Unusual Event	Receipt or notification of bomb threats or civil disturbances specifically directed against the reactor and having potential radiological release or reactor facility structural damage implications Notification or receipt of an unanticipated reactor facility intrusion detection system alarm(s). (Note: Such events will be acted upon in accordance with the AFRRI Reactor Facility Physical Security Plan, which is protected from public disclosure.) Sustained fire (≥10 minute duration) or minor explosion within the operations boundary (especially within the reactor room) which could adversely affect the reactor or its control systems; determined via observation, notification, or a fire alarm determined to be initiated from within the reactor operations boundary Official report/notification or observation of existing or imminent severe natural phenomena in the immediate local area which might cause reactor facility structural damage Low pool water level alarm actuation (loss of ≥6 inches of water from the normal pool water level) in conjunction with observation or notification of a continuing unusual or significant loss of pool water, to include observation/notification of unplanned leaks/breaks in the primary coolant boundary, all of which are either isolatable or determined to be within the capabilities of the normal and emergency makeup water systems such that core uncovering is not possible or is not likely without further escalation Visual observation cues of actual or suspected in-pool fuel damage or clad failure(s) or actuation of unanticipated radiation alarms (with or without visual cues for an experiment failure), specifically: R1 radiation area monitor (RAM), located near the surface of the reactor pool, ≥500 mR/hr for ≥1 minute; R2 RAM, located on the west wall of the reactor room, ≥10 mR/hr for ≥1 minute; E3 RAM, located on the west wall of the reactor prep area adjacent to and acting as a radiation streaming detector for exposure room #1, ≥10 mR/hr for ≥1 minute; E6 RAM, located on the west wall of the reactor prep area adjacent to and acting as a radiation streaming detector for exposure room #2, ≥10 mR/hr for ≥1 minute; R5 RAM, located on the cable trail boom to the reactor core dolly carriage and acting as a criticality monitor during reactor shutdown or secured periods, ≥50 mR/hr for ≥1 minute; stack gas monitor, which samples and monitors the gaseous radioactive effluents from the AFRRI reactor stack, equivalently ≥800 times MPC_{air} for Ar-41 (unrestricted area) for ≥1 minute; or the reactor room continuous air monitor (CAM), which samples air (specifically particulates contained within the air) from directly over the core near the pool surface, equivalently ≥100 times MPC_{air} for unknowns (restricted area) for ≥1 minute—all of which must be unanticipated alarms	1. Assure that emergency personnel are readily available to respond, as necessary 2. Perform confirmatory and/or extent-of-consequences assessments, as necessary 3. Perform corrective and protective actions, as necessary 4. Provide appropriate off-site agencies with current status information] (Rev 3/84)

(continued next page)

Table 5.1—continued

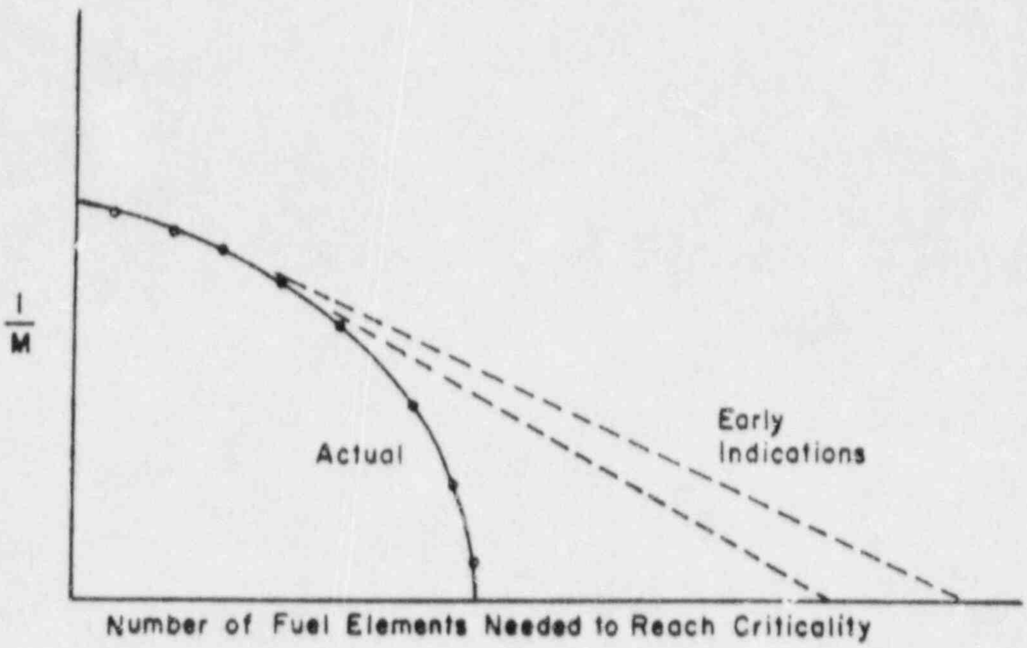
Emergency Class	Emergency Action Level (EAL)	Purpose
Class 2: Alert	Observation of an irradiated fuel element clad rupture during a fuel handling operation, specifically if the occurrence is out-of-pool, i.e., in air rather than water Official report or observation of severe natural phenomena onsite causing damage to the reactor facility structure in conjunction with the unanticipated EAL radiation alarm(s) identified under class 1, "Notification of Unusual Event," above Reactor facility fire alarm or report/observation of a sustained fire (≥10 minute duration) or explosion (including missile impact) within the operations boundary that is determined to have directly compromised the reactor facility structure (especially and particularly the reactor room) in conjunction with the unanticipated EAL radiation alarm(s) identified under Class 1, "Notification of Unusual Event," above Low pool water level alarm actuation (loss of ≥6 inches of water from the normal pool water level) in conjunction with observation or notification of a very drastic or continuing significant loss of pool water which is determined to be in excess of the capabilities of the normal and emergency makeup water systems and which can ultimately or does actually lead to the core becoming uncovered Verified visual observation of severe/extensive fuel damage involving multiple clad failures (alone), or unanticipated alarms of the reactor room CAM (at the EAL threshold identified for a Class 1, "Notification of Unusual Event," above) in conjunction with radiation alarms for R1, R2, and R5, and/or the stack gas monitor (also at the EAL threshold levels identified for a Class 1, "Notification of Unusual Event," above) provided the alarms are concurrent, for a duration ≥1 minute, and unanticipated	1. Assure emergency organization is activated and manned 2. Cease and/or alter normal activities, as necessary 3. Isolate and/or evacuate affected system(s)/area(s), as necessary 4. Perform confirmatory and extent-of-consequences assessments, as necessary 5. Perform corrective actions, as necessary 6. Perform protective actions, as necessary 7. Provide notification to and consultation with appropriate offsite agencies, as necessary 8. Provide information for the public through the Defense Nuclear Agency (DNA) Public Affairs/Information Office

Notes: 1) "Unanticipated" within Table 5.1 and sections 4.0 and 5.0 essentially is used to ensure that the alarm or other threshold indication is in fact associated with a real emergency hazard and not, for example, as a result of a test or calibration of the system or as a result of planned and approved special work permit operations where such alarms or thresholds would be anticipated as a matter of course.

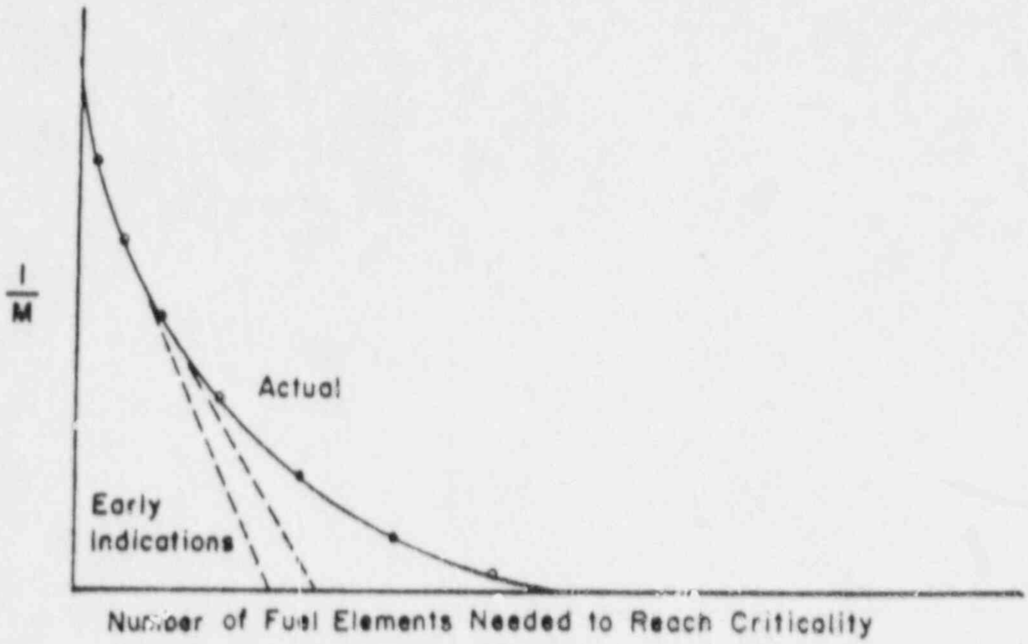
2) 800 times MPC_{air} (unrestricted area) for Ar^{41} at the top of the stack is equivalent to ≲2.2 x 10^{-2} m R/hr at the AFRRI site boundary. (Rev 3/84)

3) 100 MPC_{air}-minutes for unknowns (restricted area) in the reactor room is equivalent to 0.375 MPC_{air}-day for unknowns (unrestricted area) at the top of the AFRRI stack (this assumes no HEPA filtration and a dilution factor of 0.18).

FIGURE F-1



OUTSIDE ELEMENTS ARE LOADED FIRST



CENTER ELEMENTS ARE LOADED FIRST

ATTACHMENT A-1

9 SEP 87

AFRRI-TRIGA REACTOR PARAMETERS

Prompt Neutron Lifetime 39 uSec
Beta effective (B_{eff}) 0.0070

Prompt Negative Temperature Coefficient of Reactivity

-1.26×10^{-4} ^k/k/°C (-\$0.018/°C)

Steady State Temperature Coefficient of Reactivity

-5.1×10^{-5} ^k/k/°C (-\$0.007/°C)

Void Coefficient of Reactivity

-0.2×10^{-4} ^k/k/1% Void

Tank Constant 1.48°C/100 KW-hr

Power Coefficient of Reactivity:

15 Watts to 100KW	$0.59
15 Watts to 1 MW	$3.47

Nominal Fuel Element Worth (compared to H2O)

RING	%^k/k	($)
B	0.89	1.27
C	0.73	1.04
D	0.57	0.82
E	0.31	0.44
F	0.20	0.28

Nominal Control Rod Worths:

Standard Control Rod	$1.84
Transient Control Rod	3.66
Standard Control Rod Follower	0.20
Transient Control Rod Follower	0.30

Other Magic Numbers:
E = 3.1×10^{10} fissions/Watt-second
v = 2.47 neutrons/fission

REFLECTOR COEFFIENTS

Core Position	Rod Position	Measured Excess	Difference from Pos 567
231	REG 63.3	$3.66	$0.51
567	REG 43.2	4.17	----
833	REG 4[illegible].0	4.12	0.05
903	REG 61.2	3.68	0.49

In all positions, the remaining control rods were configured as follows: SAFETY - UP SHIM - UP TRANS - 25.0

A-2

BASE DATA FOR CONTROL ROD CALIBRATION

POSITIVE PERIOD METHOD

For use with the inhour equation:

$$\rho\ (\$) = \frac{\ell^*}{\beta_{eff} T} + \frac{1}{\beta_{eff}} \sum_{i=1}^{6} \frac{\beta_i}{1 + \lambda_i T}$$

(Note: The first term may be neglected).

where $\ell^* = \frac{\bar{\ell}}{k_{eff}}$; $\bar{\ell} = 39 \times 10^{-6}$ seconds

T = period in seconds, $(k_{eff})_{max} \approx 1.024$

$\beta_{effective}$ = 0.007 (reference Oct 1975 Technical Specifications)

The delayed neutron group data was derived from data presented by Keepin, Wimett, and Zeigler in PHYSICAL REVIEW, Vol 107, pp 1044-1049, (1975) and is as follows:

Group	β ($)	$t_{1/2}$ (Sec)	λ (Sec^{-1})
1	0.0213 ± .002	55.72 ± 1.28	0.01244
2	0.1418 ± .007	22.72 + 0.71	0.03051
3	0.1270 ± .015	6.22 ± 0.23	0.1114
4	0.2557 ± .011	2.30 ± 0.09	0.3014
5	0.0746 ± .006	0.610 ± 0.083	1.1363
6	0.0270 ± .003	0.230 ± 0.025	3.0137

β_{actual} = 0.6474 ± 0.044 $\bar{T}_{1/2}$ = 9.022 sec (half life)

ν = 2.44 $\frac{neutrons}{Fission}$ $\bar{\tau}$ = 13.016 sec (mean life)

R. M. SAVAGE JR.
PIC, 3-10-80

REFERENCE EQUATIONS

ACTIVATION $A = A_o e^{-\lambda t} + \phi N\sigma_{out}(1-e^{-\lambda t})$ dps

$A = \sigma N\phi t\lambda$

R/Hr @1ft = 6CEn

FLUX $\phi = nv$ (neutrons/cm^2-sec

FUCH'S PULSE MODEL EQUATIONS

$$T_{max} = T_o + \frac{2(\rho-\beta)}{\alpha}\ (^\circ C)$$

$$E_{tot} = \frac{2(\rho-\beta)}{k(\alpha)}\ MWS$$

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

$$T = \frac{\ell}{\rho-\beta} \quad \text{initial period}$$

ℓ = 39µsec

$\alpha = 1.8¢/^\circ C = 1.26 \times 10^{-4}\Delta k/k$

$\beta = .007$

$k \approx 9.6$

Assumptions: Point Source, Adiabatic System, No Delayed Neutrons

IN-HOUR EQUATION ρ vs T

$$\rho = \frac{\ell}{Tk_{eff}} + \sum_{1}^{6} \frac{\beta_i}{1+\lambda_i T} \approx \frac{\beta_6}{1+\lambda_6 T}$$

$$\rho_\$ \approx \frac{1}{1+\lambda T} \quad \text{For } T > 10 \text{ sec.}$$

SUBCRITICAL MULTIPLICATION FACTOR M

$$M = \frac{C}{C_o} = \frac{1}{1-k}$$

$1/M = C_o/C$ Plotted vs Fuel Added (Rod Withdrawn)

NEUTRON SOURCE

3Ci Am Be 10^6 neutrons/sec

$$Am^{241} \rightarrow {}_2He^4 + Np^{237}$$

$${}_2He^4 + {}_4Be^9 \rightarrow \{{}_6C^{13}\} \rightarrow {}_6C^{12} + {}_0n^1$$

PERIOD T

$$N = N_o e^{t/T}$$

POWER P

$$P = \frac{V\Sigma_f \phi}{3.1\times10^{10}} \text{ Watts} \quad \text{Where V = Volume (cm}^3)$$

$$P = P_o e^{(\Delta k/\ell)t}$$

REFERENCE EQUATIONS
(Cont.)

REACTIVITY Measure of departure from prompt critical

$\rho = \frac{k-1}{k} = \frac{\Delta k}{k}$ $\$1 = \beta_{eff} \frac{\Delta k}{k}$

$\rho_{\$} = X \frac{k-1}{k\beta_{eff}}$ Where $\beta_{eff} = .007$

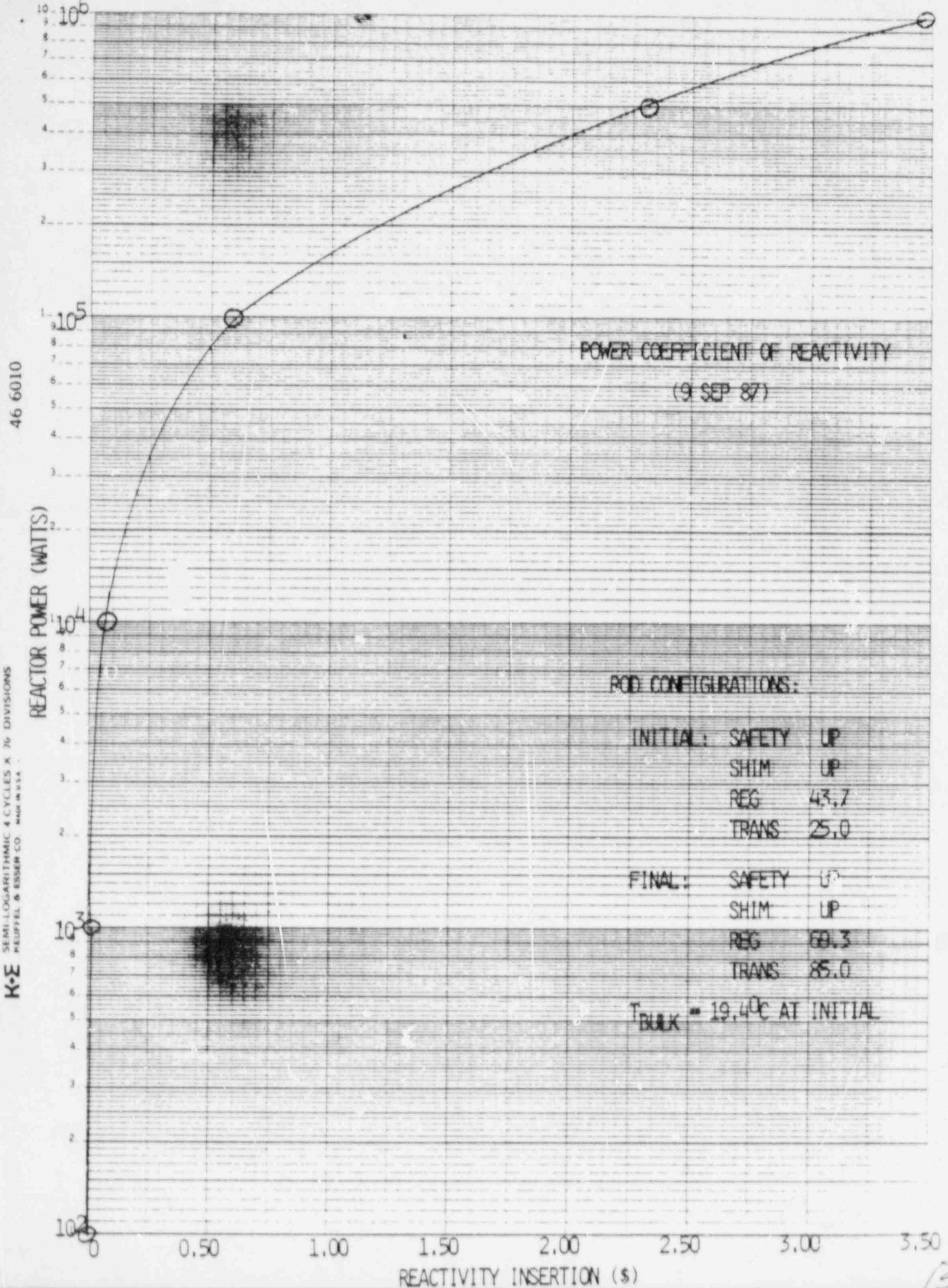
REACTOR SCRAM DECAY TIME

From Group 6: T = 80sec.

$t_{\frac{1}{2}}$ = 55.6 sec

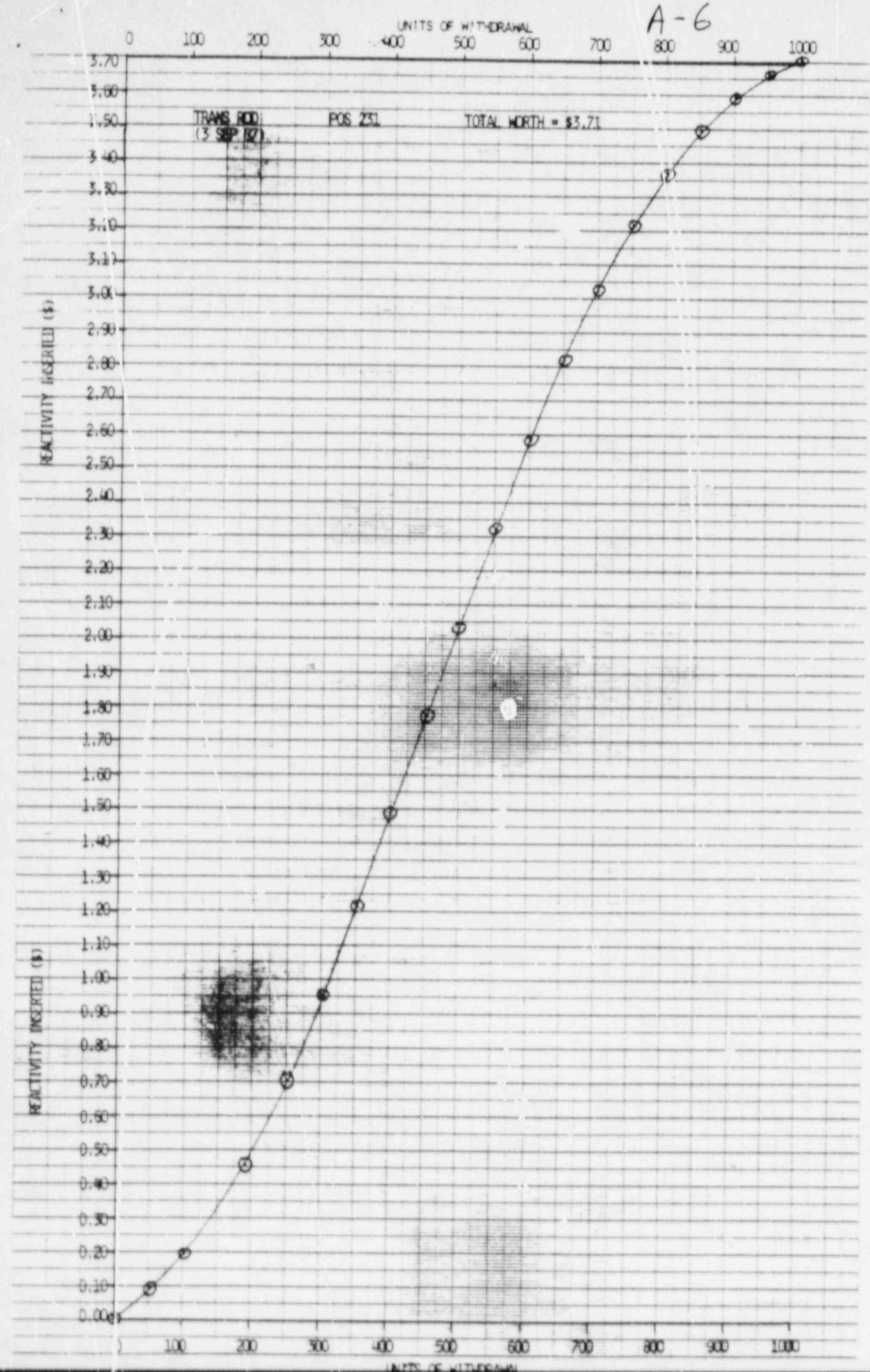
Precursor mean life = 12.7 sec

$I = (1+\mu x) \frac{I_o e^{-\mu x}}{4\pi r^2}$



POWER COEFFICIENT OF REACTIVITY
(9 SEP 87)
ROD CONFIGURATIONS:
INITIAL: SAFETY UP
SHIM UP
REG 43.7
TRANS 25.0
FINAL: SAFETY UP
SHIM UP
REG 60.3
TRANS 85.0
T_{BULK} = 19.4°C AT INITIAL
REACTOR POWER (WATTS)
REACTIVITY INSERTION ($)
10^2
10^3
10^4
10^5
10^6
0
0.50
1.00
1.50
2.00
2.50
3.00
3.50
K·E SEMI-LOGARITHMIC 4 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.
46 6010

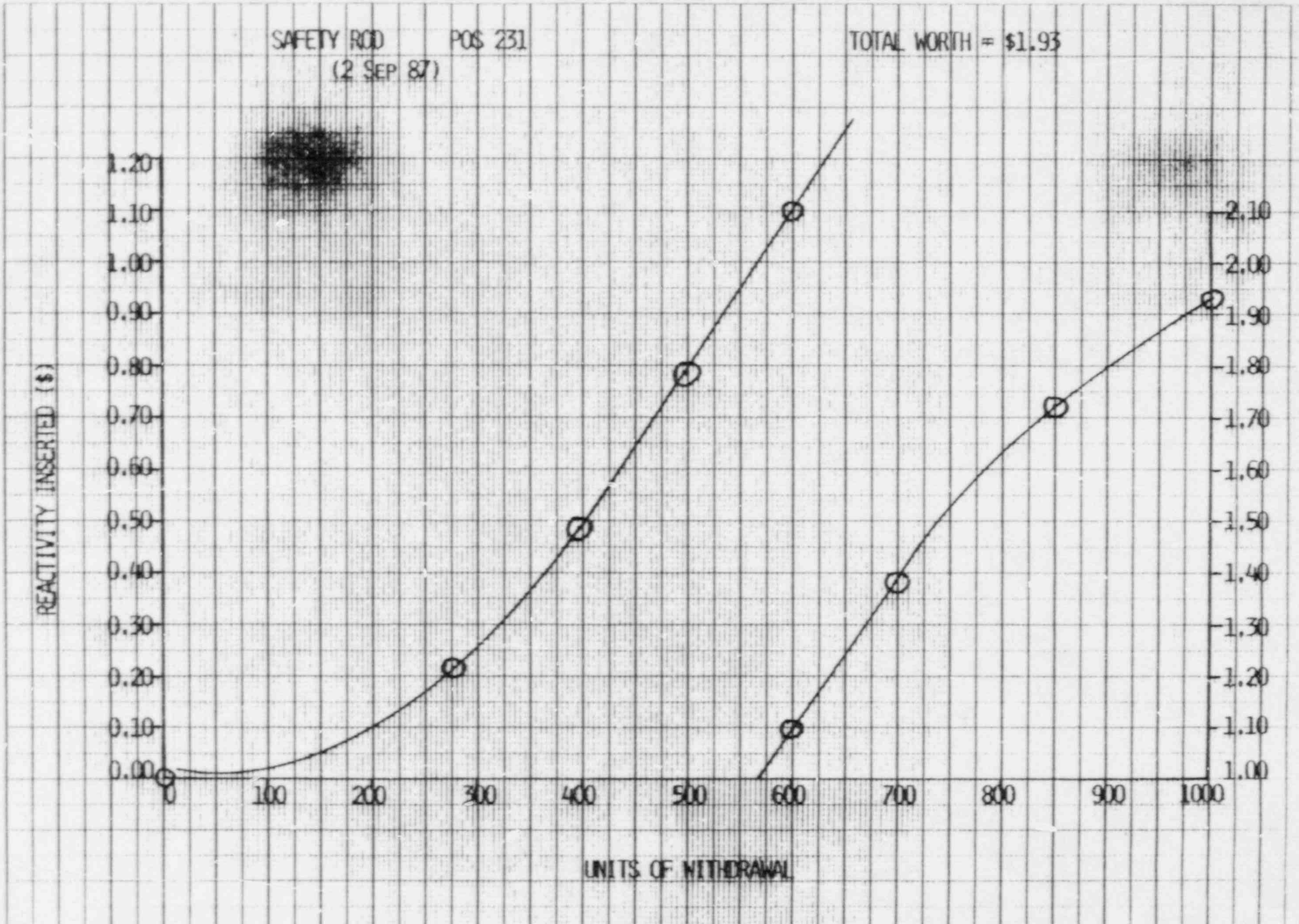
A-6


UNITS OF WITHDRAWAL
REACTIVITY INSERTED ($)
TRANS ROD (3 SEP 87)
POS 231
TOTAL WORTH = $3.71

(6)

K-E 10 X 10 TO THE CENTIMETER

461510



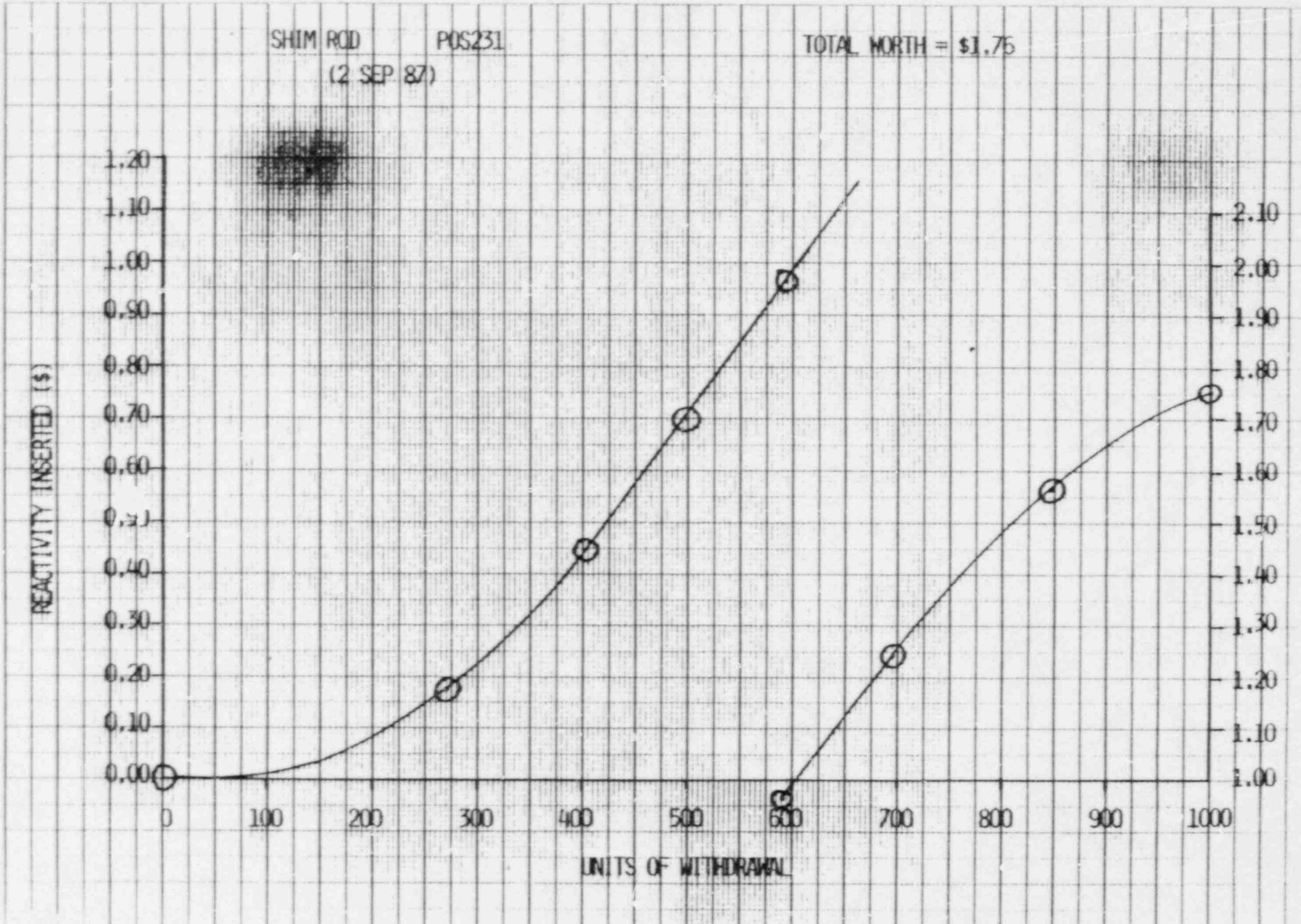
A-7

(7)

K-E 10 X 10 TO THE CENTIMETER KEUFFEL & ESSER CO. 461510

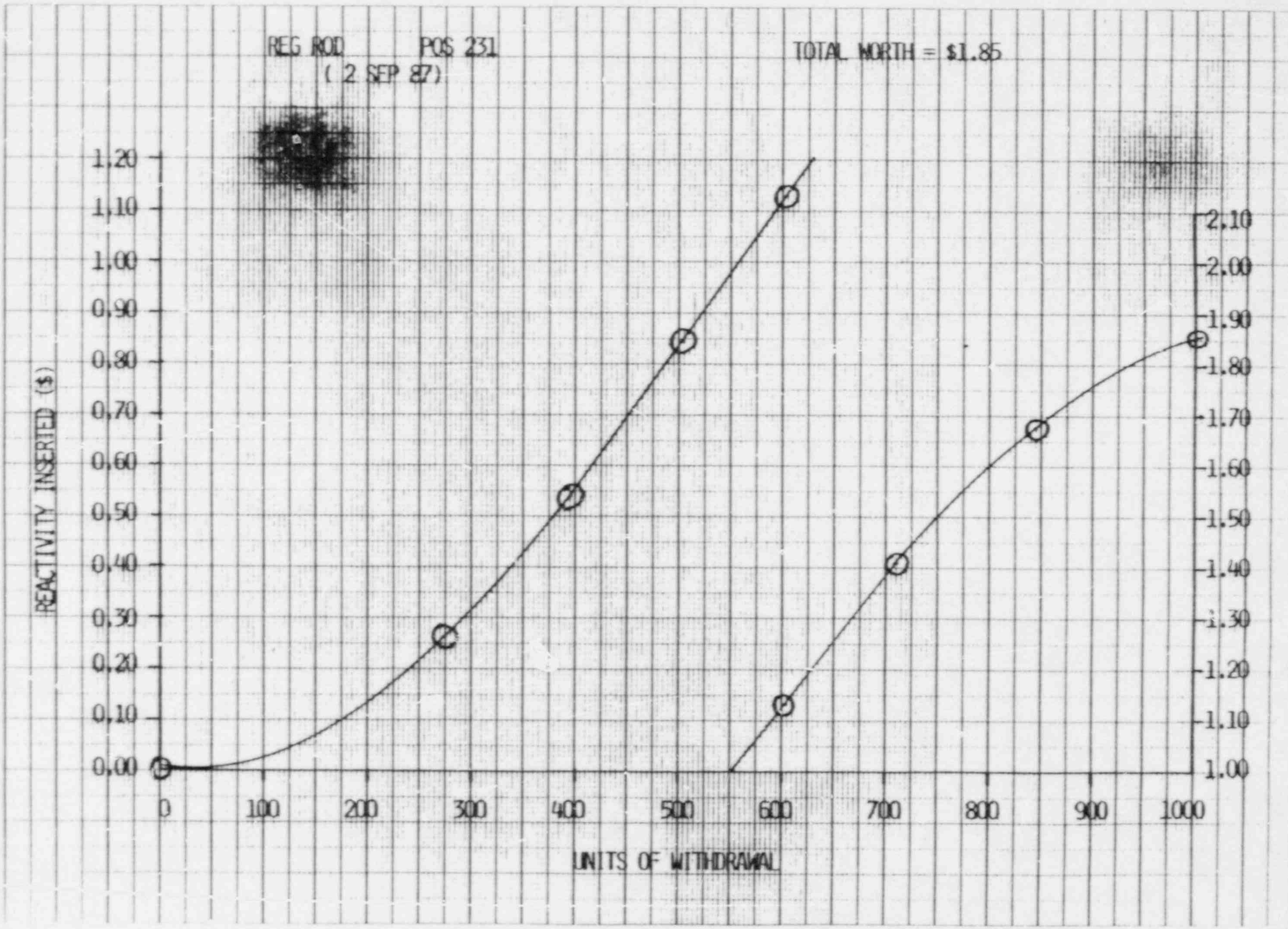
Verified JFF 15 Sep 87

A-8



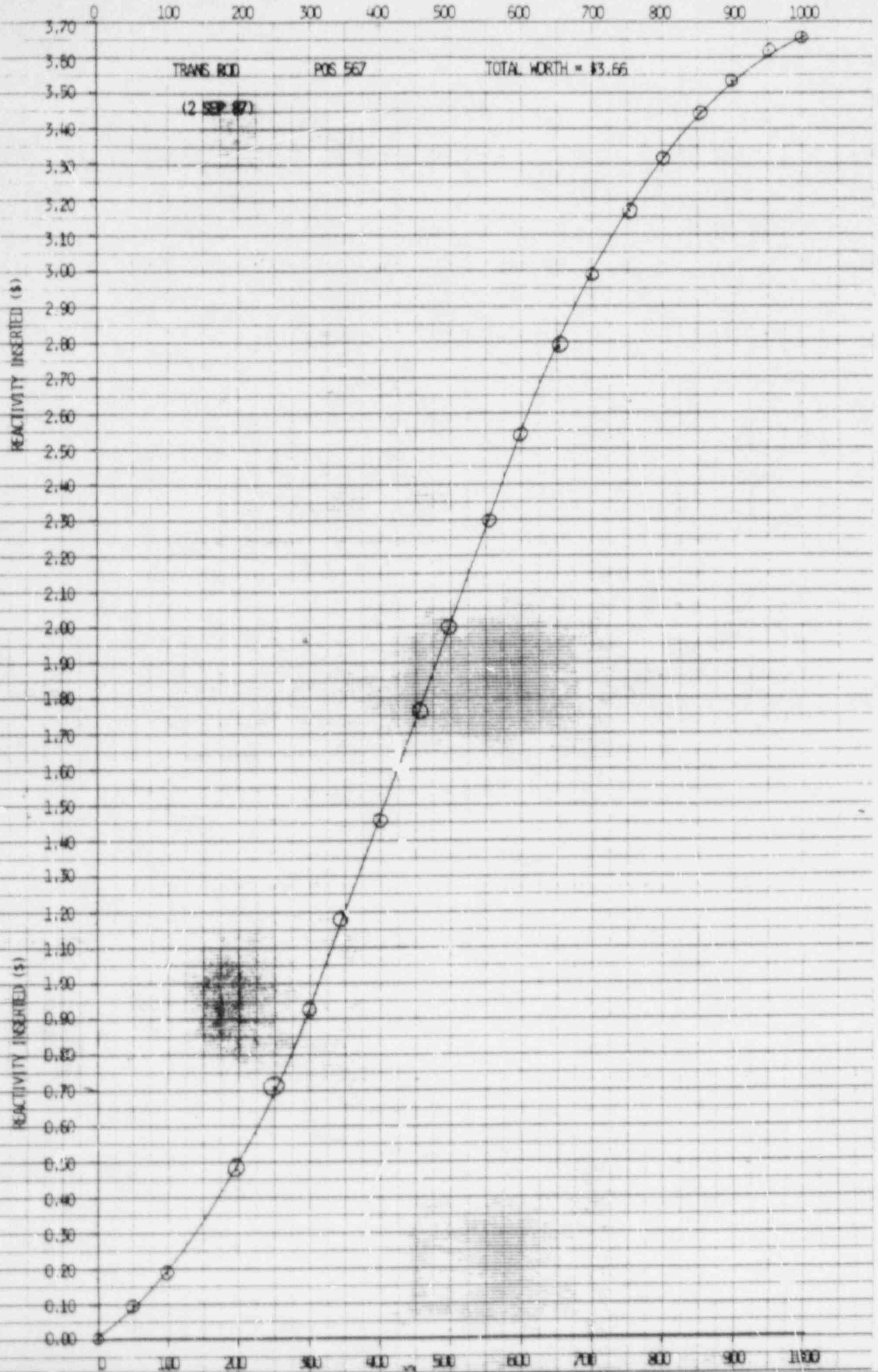
8

Verified JKE 15 Sep 8

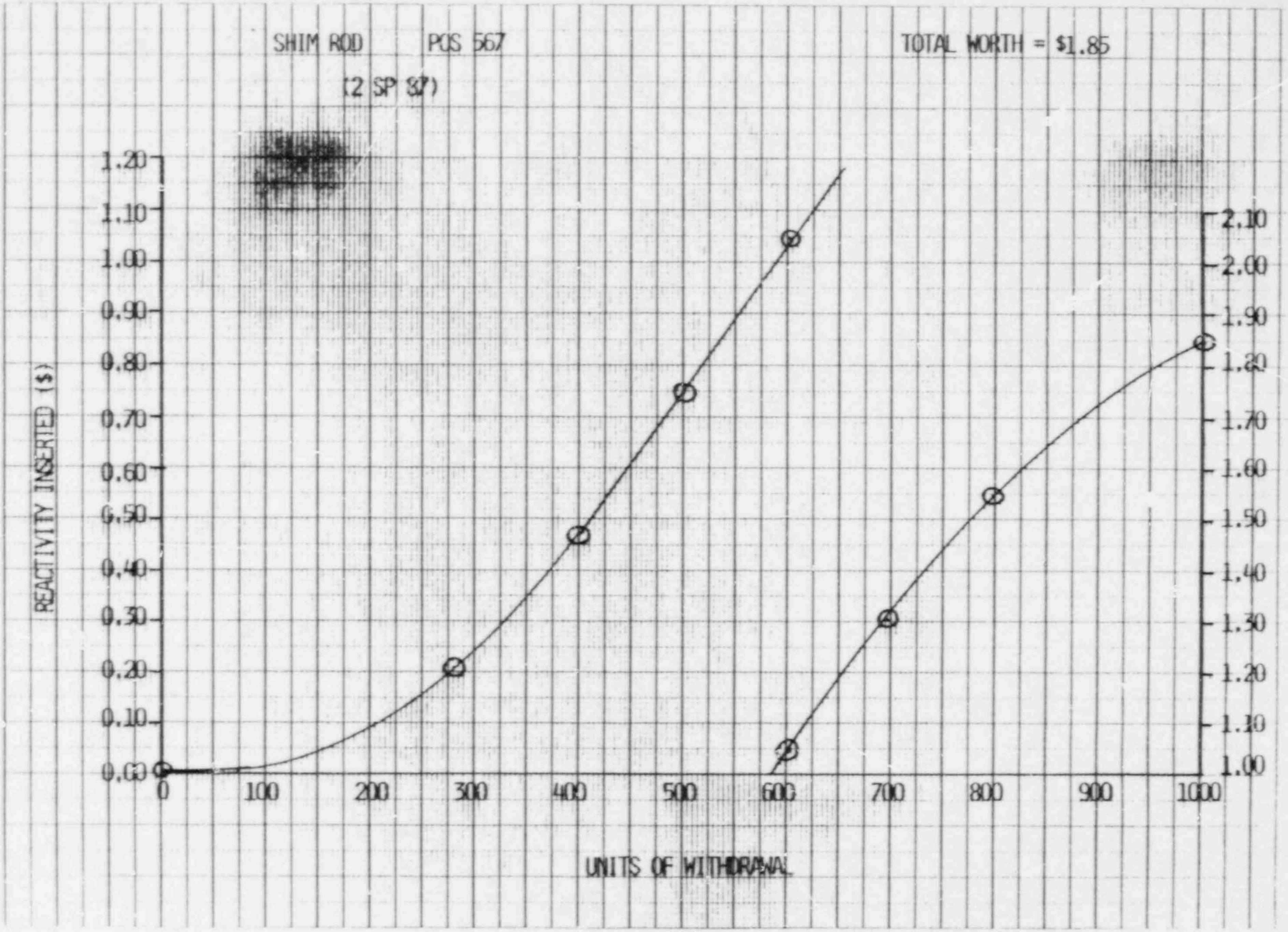


A-9

A -10


TRANS ROD
POS 567
TOTAL WORTH = $3.66
(2 SEP 87)
REACTIVITY INSERTED ($)
REACTIVITY INSERTED ($)
0
100
200
300
400
500
600
700
800
900
1000
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
1.10
1.20
1.30
1.40
1.50
1.60
1.70
1.80
1.90
2.00
2.10
2.20
2.30
2.40
2.50
2.60
2.70
2.80
2.90
3.00
3.10
3.20
3.30
3.40
3.50
3.60
3.70

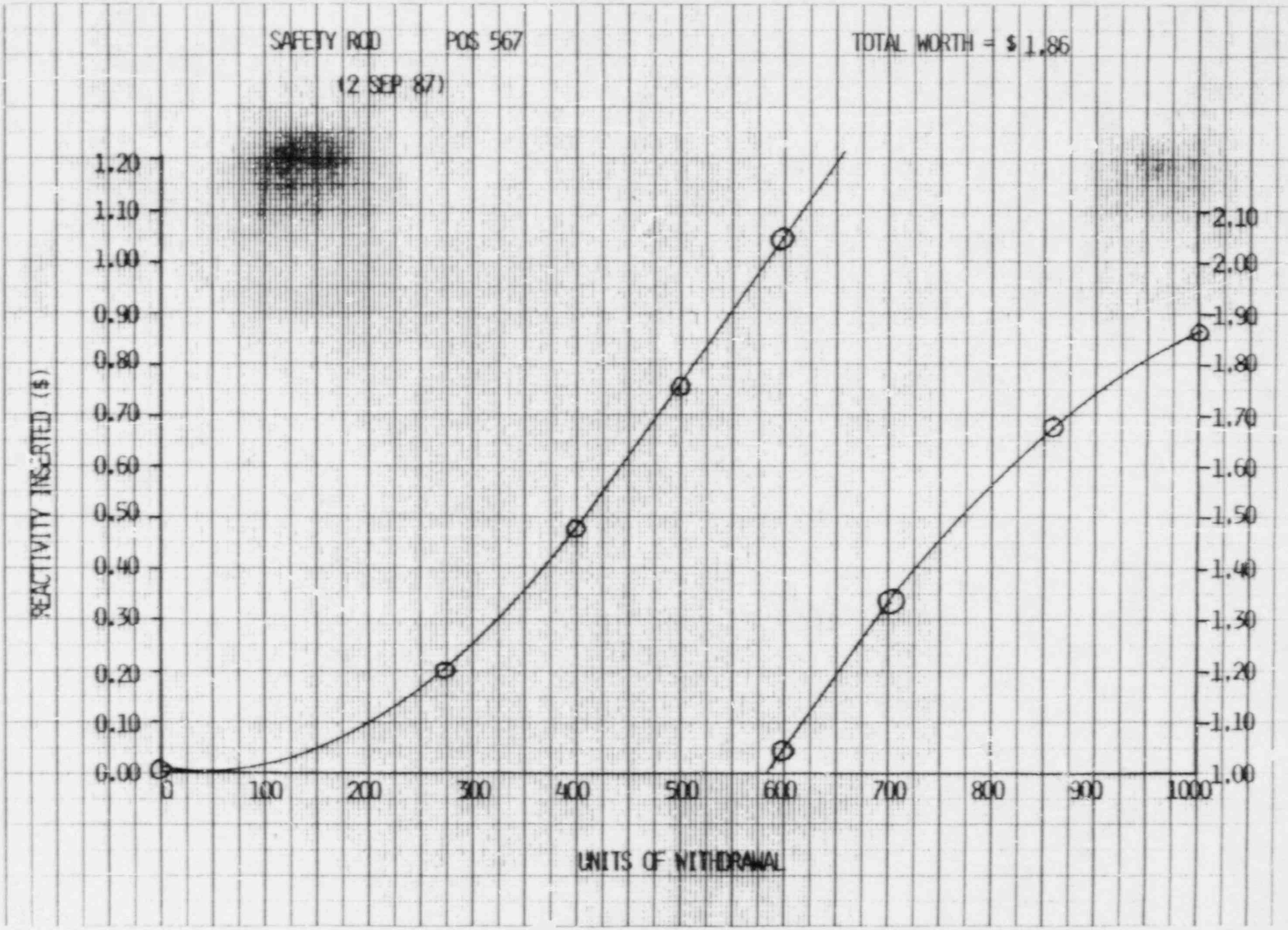
K-E 46 1510



A-11

(11)

K-E 10 X 10 TO THE CENTIMETER
KEUFFEL & ESSER CO.
461510



A-12

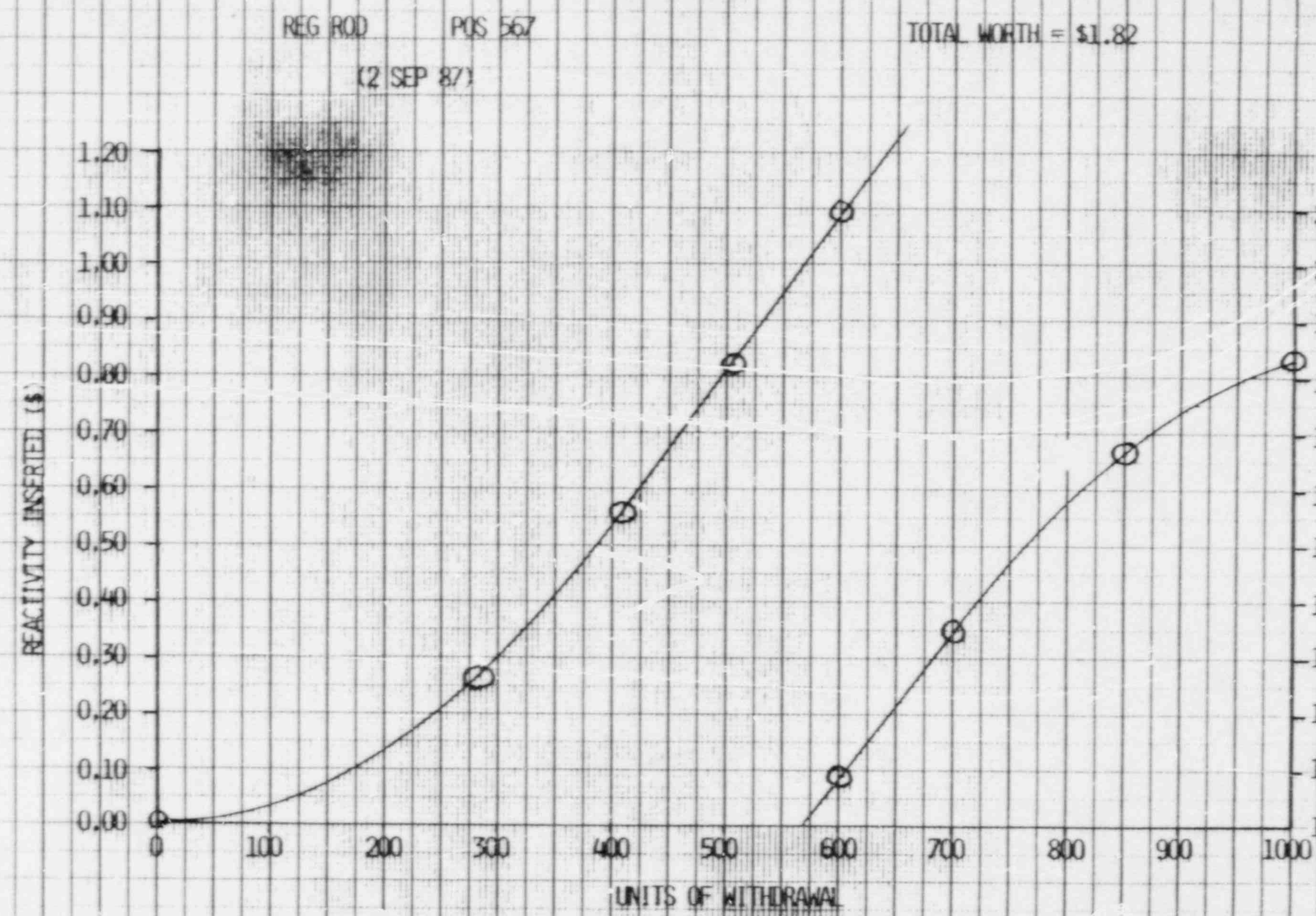
(12)

K-E 10 X 10 TO THE CENTIMETER
KEUFFEL & ESSER CO.

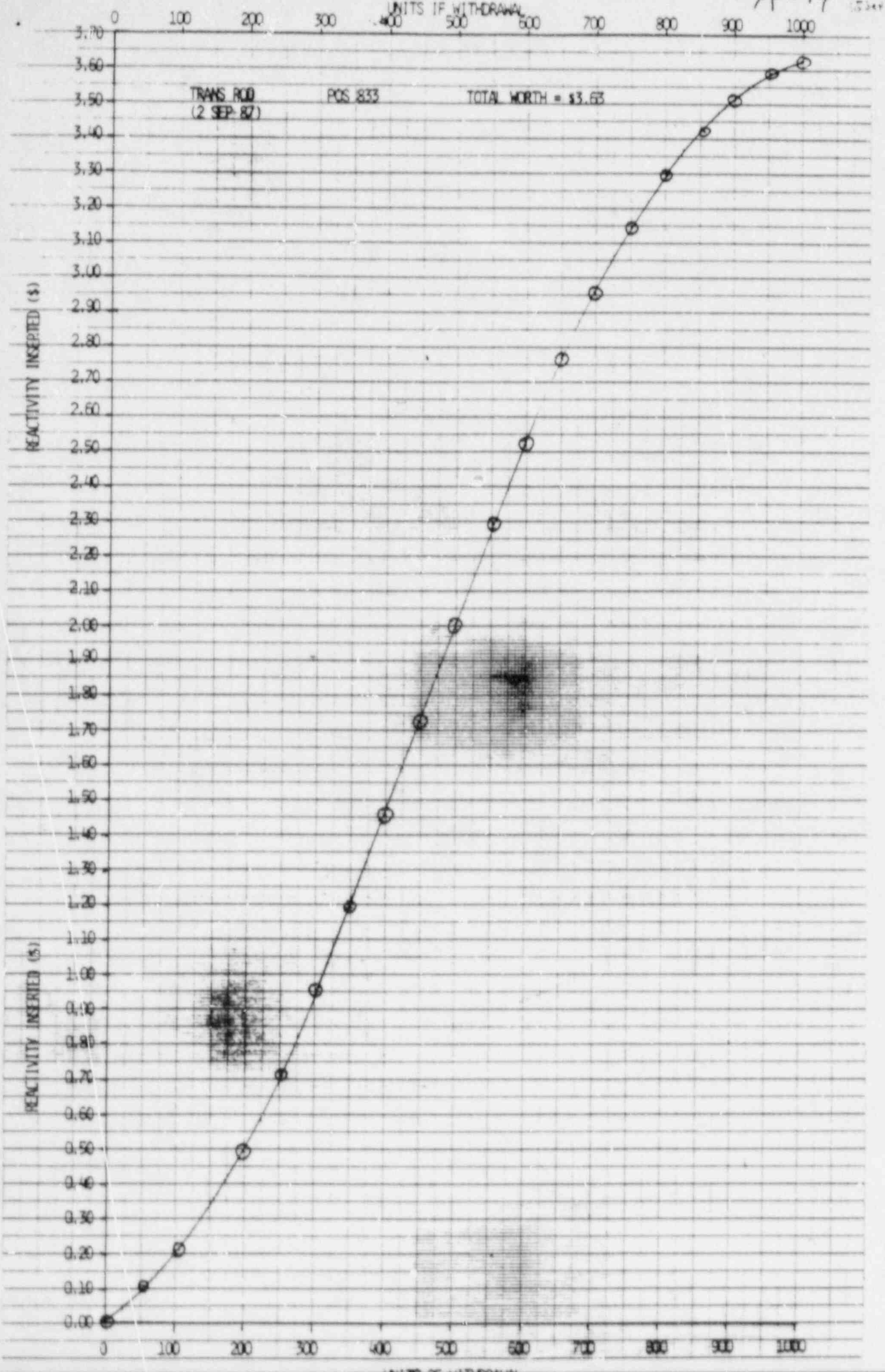
461510

Verified
JKF
15 Sep 87

A-13



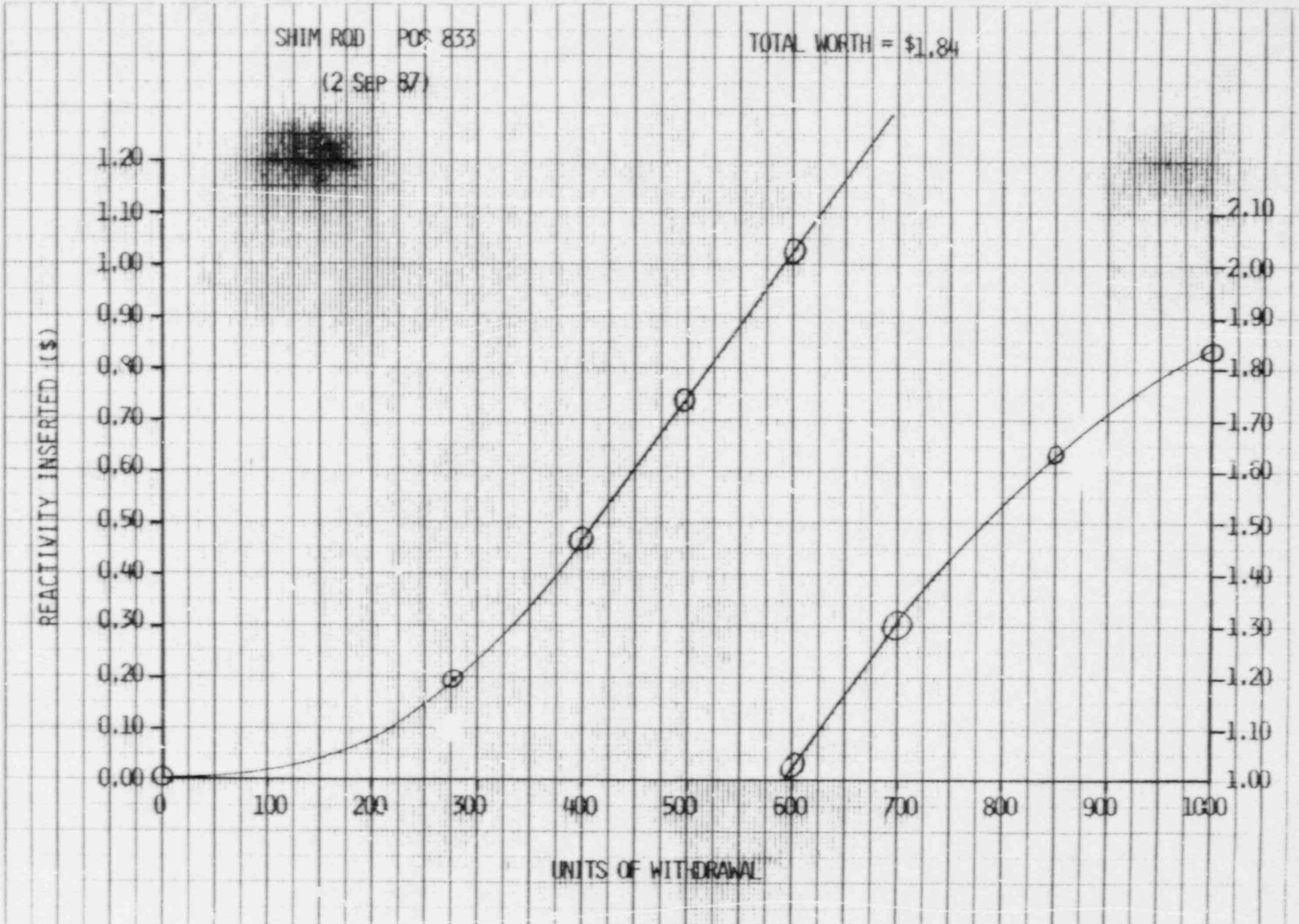
A-14



UNITS IF WITHDRAWAL
TRANS ROD
(2 SEP-87)
POS 833
TOTAL WORTH = $3.63
REACTIVITY INSERTED ($)
REACTIVITY INSERTED ($)

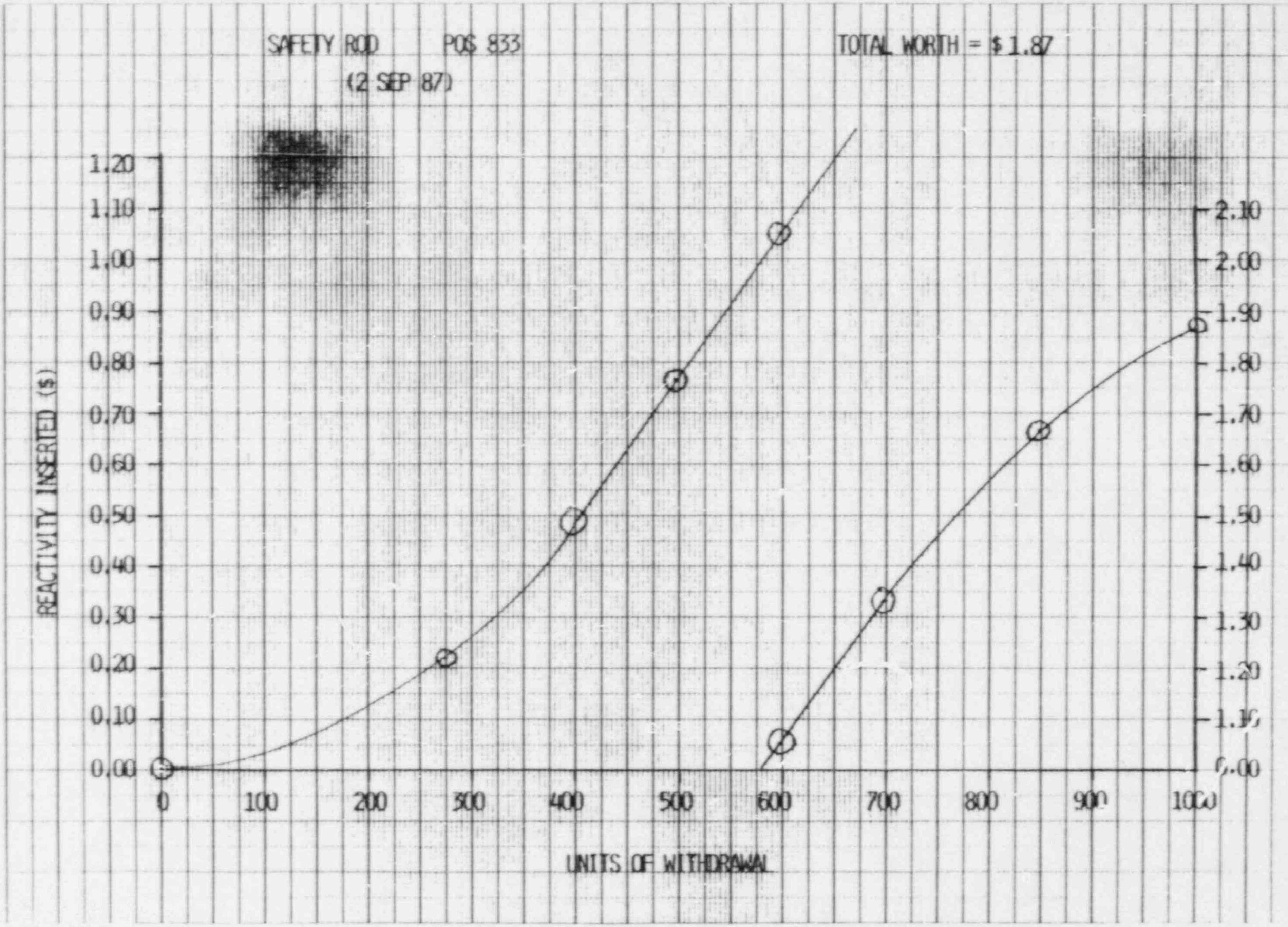
K-E 10 X 10 TO THE CENTIMETER 461510

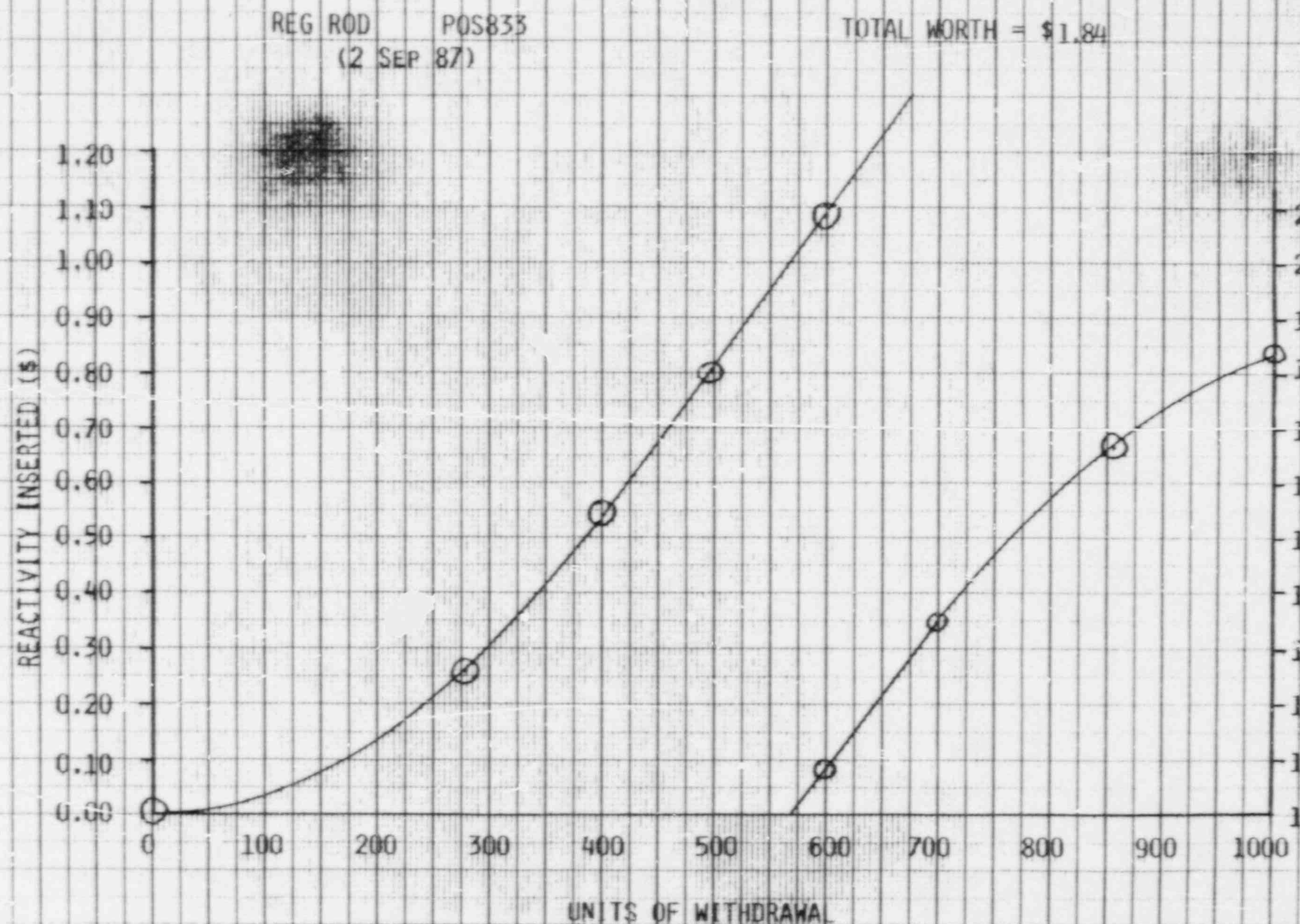
A-15



Verified JRF 15 Sep 87

A-16



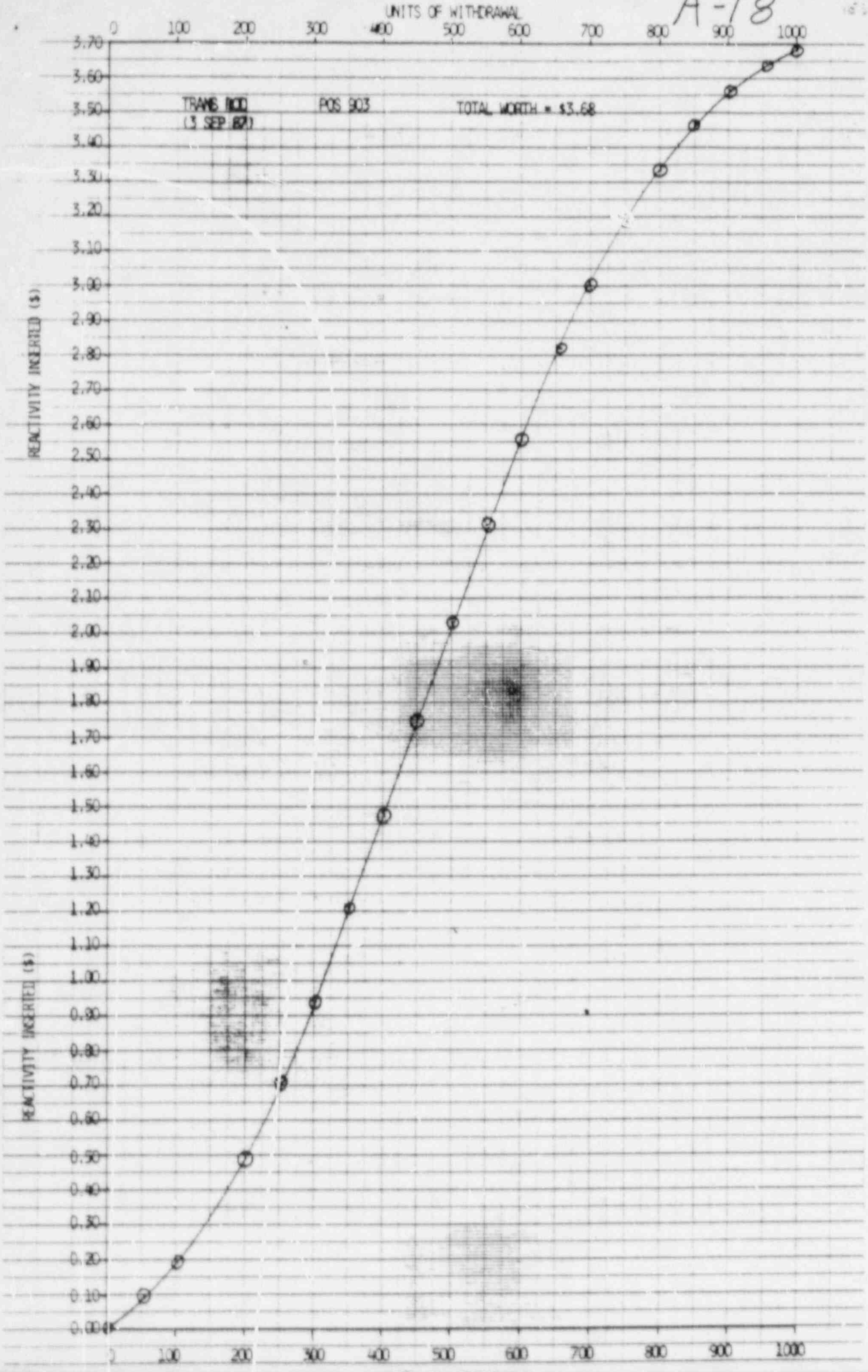


K·E 10 X 10 TO THE CENTIMETER KEUFFEL & ESSER CO. 461510

Verified JW 15 Sep 87

(17)

A-18

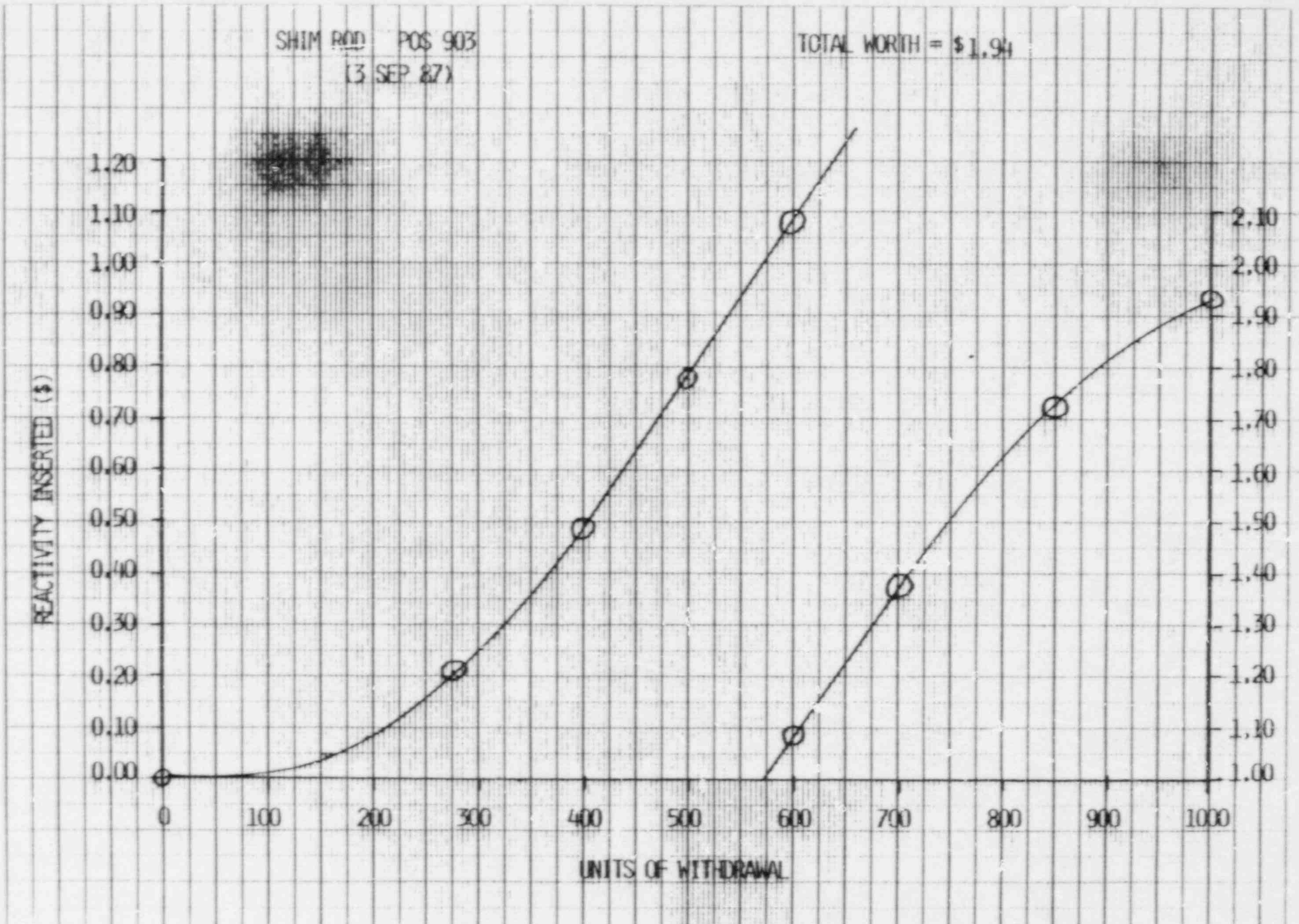


UNITS OF WITHDRAWAL
TRANS ROD
(3 SEP 87)
POS 903
TOTAL WORTH = $3.68
REACTIVITY INSERTED ($)
0
100
200
300
400
500
600
700
800
900
1000
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
1.10
1.20
1.30
1.40
1.50
1.60
1.70
1.80
1.90
2.00
2.10
2.20
2.30
2.40
2.50
2.60
2.70
2.80
2.90
3.00
3.10
3.20
3.30
3.40
3.50
3.60
3.70

K-E 10 X 10 TO THE CENTIMETER KEUFFEL & ESSER CO. 46 1510

Verification
15 Sep 87

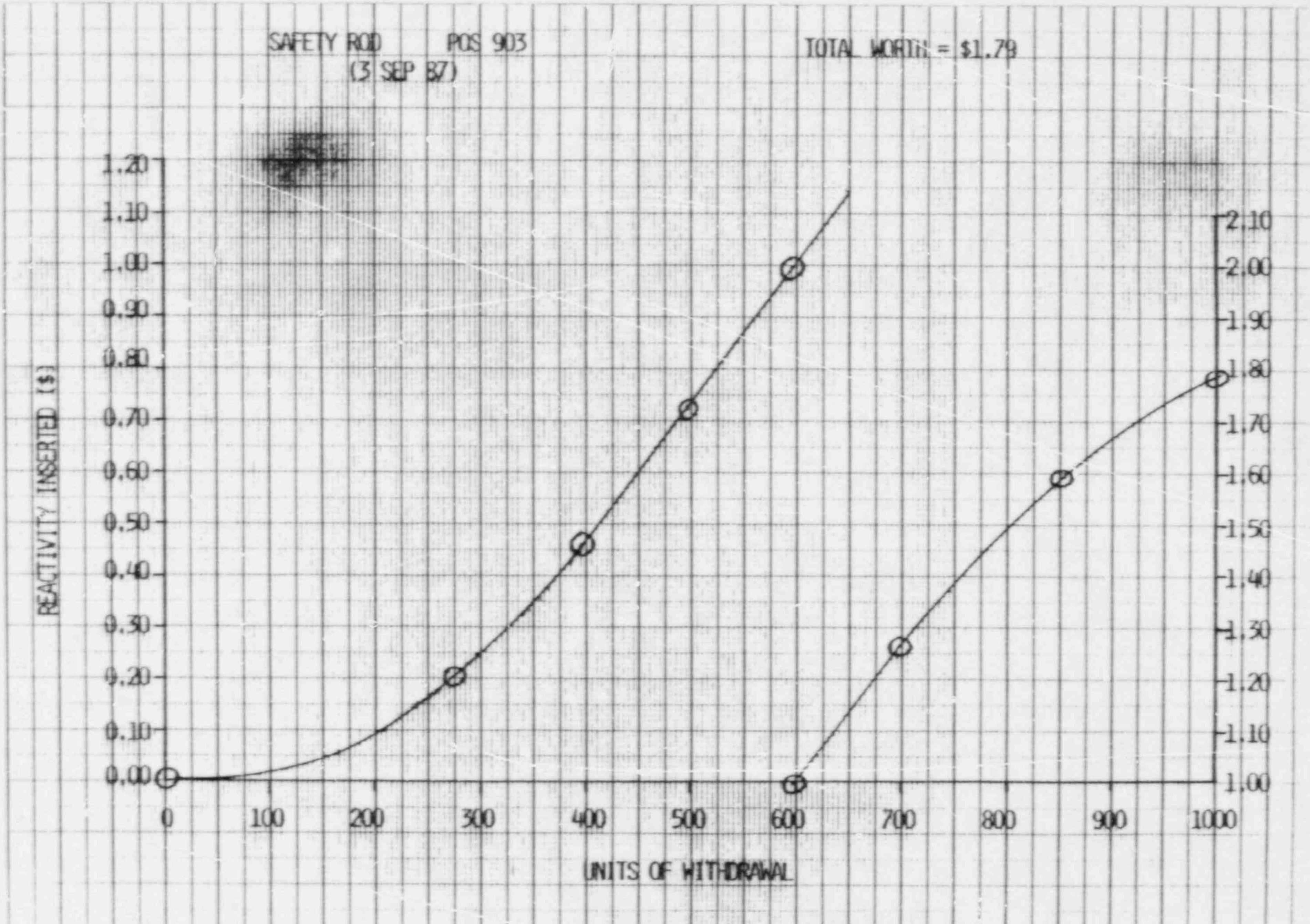
A-19



(19)

K-E 10 X 10 TO THE CENTIMETER
KEUFFEL & ESSER CO.
461510

A-20



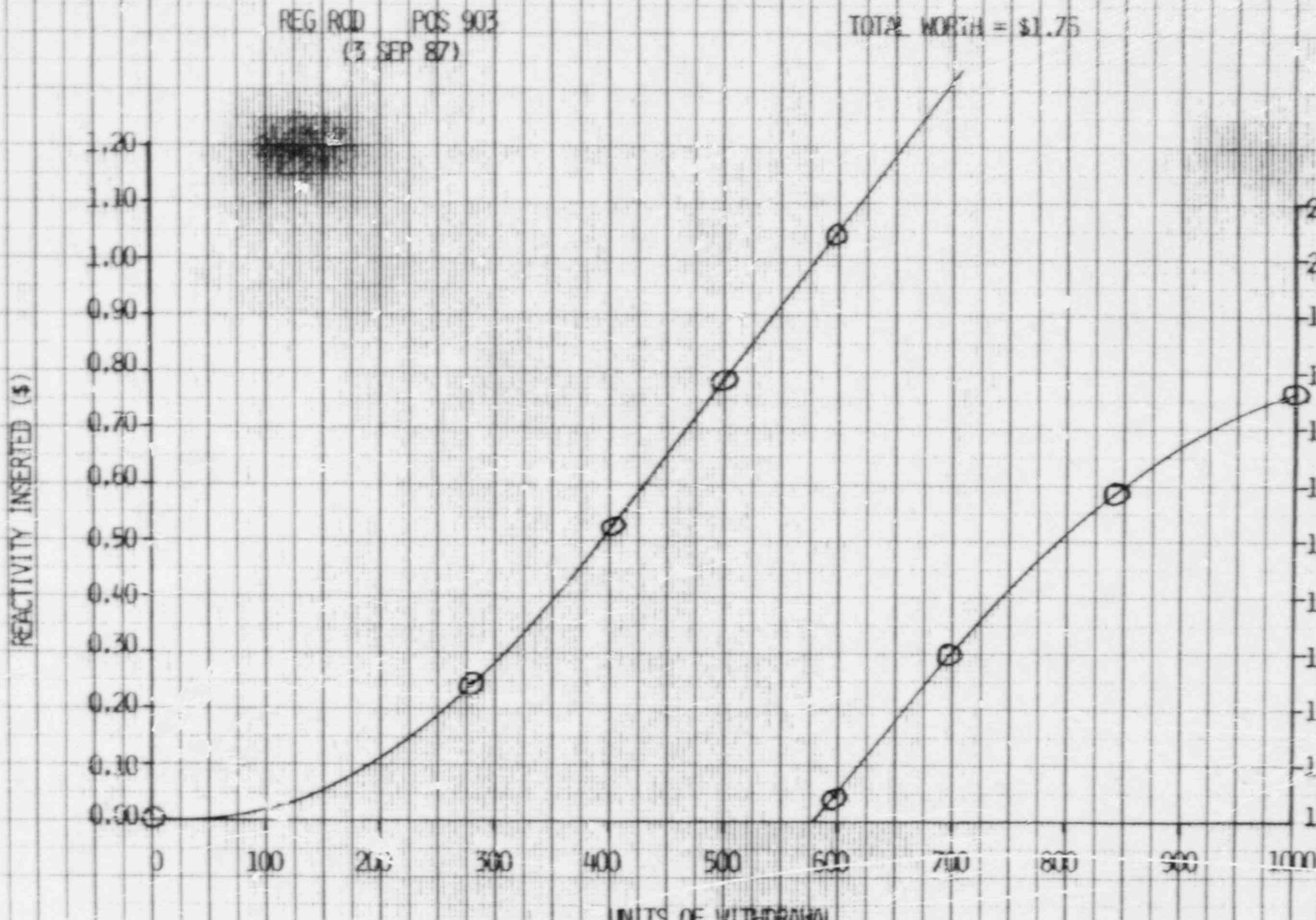
20

K+E 10 X 10 TO THE CENTIMETER
KEUFFEL & ESSER CO.

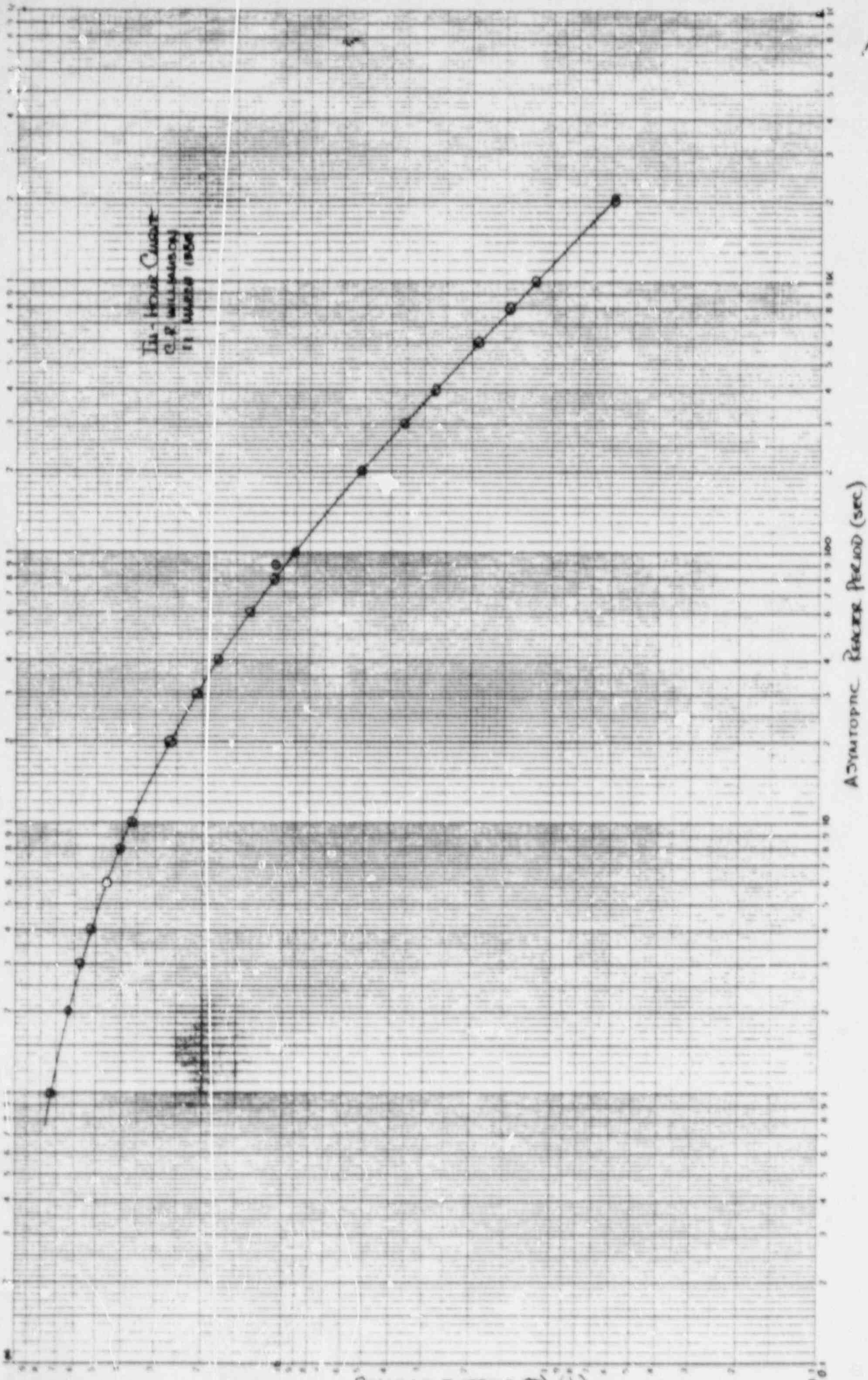
461510

Verified JRF 15 Sep 87

A-21

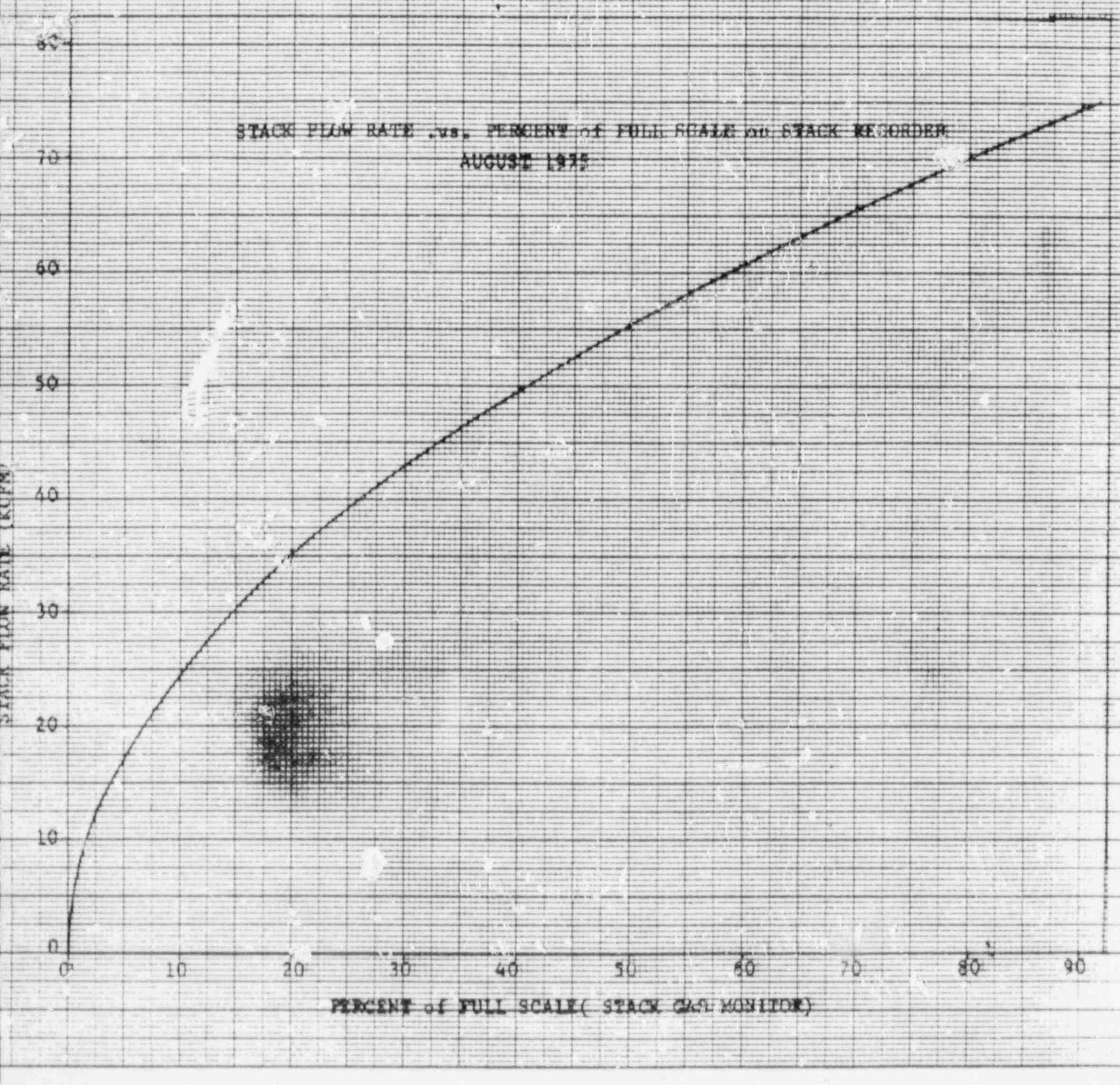


A-22



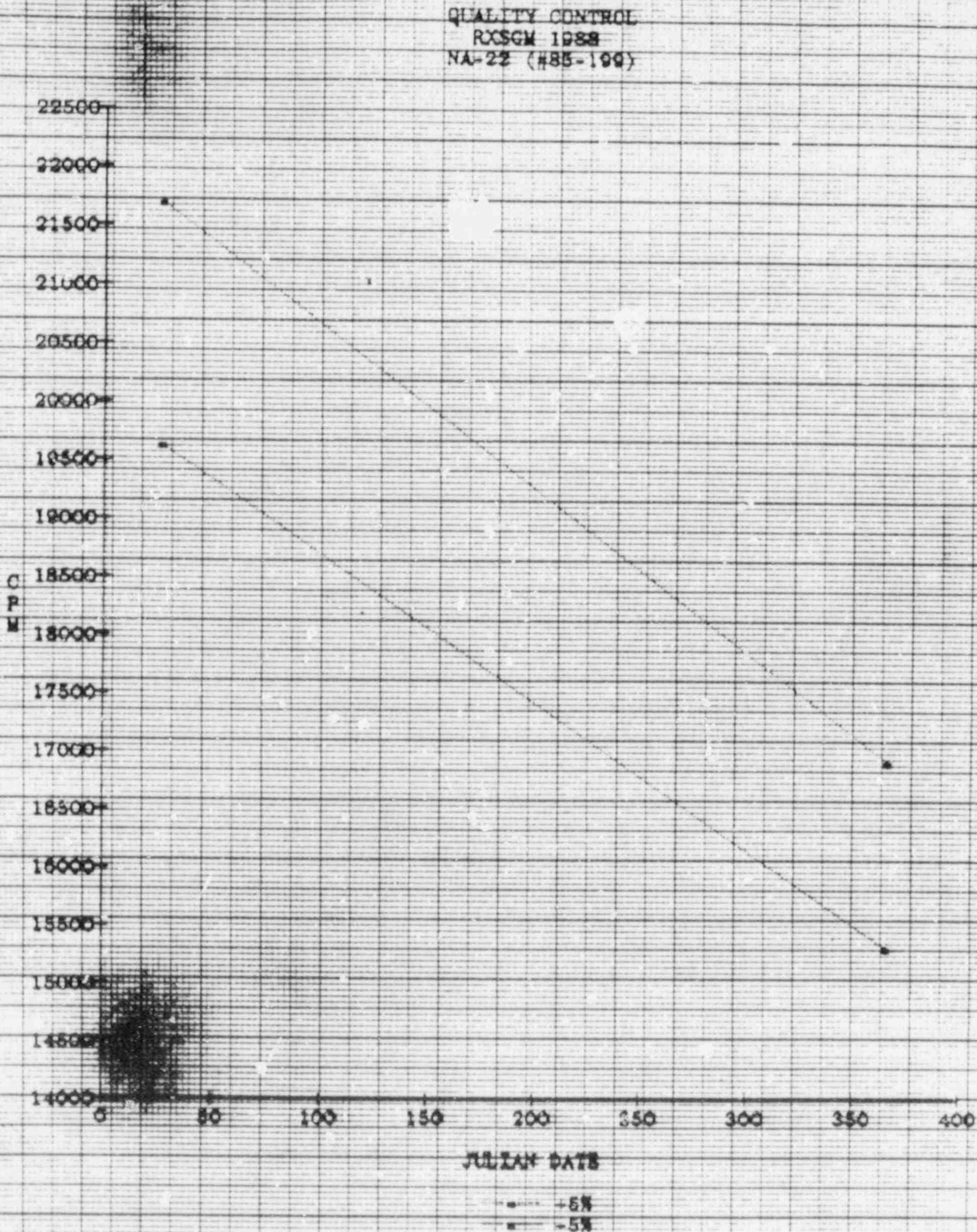
In-Hour Chart
Asymptotic Reactor Period (sec)
Reactivity Inserted (¢)

22


STACK FLOW RATE .vs. PERCENT of FULL SCALE on STACK RECORDER
AUGUST 1975
STACK FLOW RATE (KCFM)
0
10
20
30
40
50
60
70
80
0
10
20
30
40
50
60
70
80
90
PERCENT of FULL SCALE(STACK GAS MONITOR)

RXSGM88

27-JAN-88 7:28 Page 1



461510

K&E 10 X 10 TO THE CENTIMETER KEUFFEL & ESSER CO.

4.2.5 REACTOR FUEL ELEMENTS

Applicability

This specification applies to the surveillance requirements for the fuel elements.

Objective

The objective is to verify the integrity of the fuel element cladding.

Specifications

All the fuel elements shall be inspected for damage or deterioration, and measured for length and bow at intervals separated by not more than 500 pulses of insertion greater than $2.00 or annually (not to exceed 15 months), whichever occurs first.

3.4 VENTILATION SYSTEM

Applicability

This specification applies to the operation of the facility ventilation system.

Objective

The objective is to assure that the ventilation system is operable.

Specification

The reactor shall not be operated unless the facility ventilation system is operable, except for periods of time necessary (up to 48 hours) to test or permit minor repair of the system. In the event of a significant release of airborne radioactivity in the reactor room, the ventilation system to the reactor room shall be secured via closure dampers automatically by a signal from the reactor deck air particulate monitor.

Basis

During normal operation of the ventilation system, the concentration of argon-41 in unrestricted areas is below the MPC. In the event of a clad rupture resulting in a substantial release of airborne particulate radioactivity, the ventilation system shall be shut down, thereby isolating the reactor room automatically by spring-loaded, positive sealing dampers. Therefore, operation of the reactor with the ventilation system shut down for short periods of time to test or make repairs insures the same degree of control of release of radioactive materials. Moreover, radiation monitors within the building independent of those in the ventilation system will give warning of high levels of radiation that might occur during operation with the ventilation system secured.

4.4 VENTILATION SYSTEM

Applicability

This specification applies to the facility ventilation system isolation.

Objective

The objective is to assure the proper operation of the ventilation system in controlling the release of radioactive material into the unrestricted environment.

Specification

The operating mechanism of the positive sealing dampers in the reactor room ventilation system shall be verified to be operable and visually inspected at least monthly.

Basis

Experience accumulated over years of operation has demonstrated that the tests of the ventilation system on a monthly basis are sufficient to assure proper operation of the system and control of the release of radioactive material.

Attachment 2

REVIEW COMMENTS FOR THE ARMED FORCES RADIOBIOLOGY RESEARCH INSTITUTE SENIOR REACTOR OPERATOR WRITTEN EXAMINATION FEBRUARY 24, 1988

A. The specific facility comments concerning the requalification examinations, followed by the NRC resolution, are listed in the following paragraphs.

Question H.08

Facility Comment: Part "a" can be interpreted as a question on what the count rate is doing five minutes after the rod motion ceases as opposed to the change over the five minute period as implied by the question. Recommend that the answer, "REMAIN THE SAME", be allowed as a correct answer.

NRC Resolution: It is agreed that the question may be interpreted in two ways. Since the interpretation may not be apparent in the answer given by the candidate and, therefore, since the correctness of the candidates answer may not be apparent, the question is deleted.

Question J.01

Facility Comment: The exhaust damper is not located above the fume hood.

NRC Resolution: The words, "above the fume hood," will be deleted from the question in the exam bank. This discrepancy is not considered to have invalidated the question and the question remains intact.

Question J.05

Facility Comment: The question was confusing in that the word, "ALL", could be easily missed and, therefore, an incorrect answer could be given.

NRC Resolution: The question is valid and remains intact. The question will be reworded in the exam bank to place the, "ALL", in a more visible position.

Question J.12

Facility Comment: The question is confusing in that the first part about the existence of anti-siphoning holes is true but the second part dealing with hole location is false. Additionally the location of the holes is not considered to be very important information.

NRC Resolution: The entire question must be true for the correct answer to be, "TRUE". The question is not considered to be confusing and remains intact. Additionally, a feeling for whether the holes are located near the top of the pool or near the core is considered important from the standpoint of radiological concerns since the water is a very important shield.

Answer I.01

Facility Comment: The Heat Exchanger Room and Hallway are more commonly known as the warm storage area. Recommend you accept warm storage area as a correct answer.

Reference: AFRRI SAR page 3-3

NRC Resolution: Use of warm storage in place of Heat Exchanger Room and in place of Hallway to Heat Exchanger Room is accepted. Answer is changed to add, "(Warm Storage)" to both parts 3 and 4.

Answer I.05

Facility Comment: Part b - The meter readout has been moved to the Emergency Response Team center in room (3434).

Part d - A second stack gas monitor has been installed with the following characteristics:

1. Scintillation Device
2. Readout meters in Control Room & Reactor Room
3. Setpoint 889 cpm

Additionally room 3152 is called "Equipment Room", not "Upper Equipment Room"

Reference: AFRRI SAR, page 3-43, 44

NRC Resolution: Part b - changed as follows:

Deleted - "Security Office (3112)"

Added - "Emergency Response Team Center (3434)"

Part d - Added -

"OR

1. Scintillation
2. Control Room
   Reactor Room
3. 889 cpm"

Deleted - "Upper"

Answer I-07

Facility Comment: Detectors normally in control room are:
Teletector - High & Low range
Victorene - Low Range

NRC Resolution: Answers added as follows:

"Teletector [0.50] - High and Low Range [0.50]
Victorene [0.50] - Low Range [0.50]"

Answer K.11

Facility Comment: Part c - Either non-fueled elements or left empty would be acceptable. This situation has never been encountered as the reactor has never approached the excess reactivity limits noted in Technical Specifications.

NRC Resolution: Part c - Since no reference and no procedure exists to cover this situation, and since the reactor has never been operated in this condition, the question is considered inappropriate and is deleted.

B. The following changes were made to the examination as a result of final review an/or candidate questions during exam administration. All the changes to the question statements were publicly announced to the candidate during the exam by the exam proctor.

Question H.04

The word "control" was changed to "fuel".

Question K.08

The word "control" was changed to "fuel".

Answer H.02 [1.00]

Replace answer with the following:

"Two possible answers depending on assumptions as follows:

The T will decrease [0.50].

EXPLANATION: The corrosion layer inhibits heat transfer across the primary to secondary boundary [0.10]. In order to continue to transfer adequate heat across this boundary the primary temperature must rise [0.10]. Assuming that this rise results in significant additional losses of heat to ambient [0.10], the heat transferred across the heat exchanger will decrease [0.10]. With constant primary flow and a decrease in heat transferred [1.10] the T will decrease."

OR

The T will remain constant [0.50].

EXPLANATION: If losses to ambient do not change significantly [0.20] then the heat transferred in the heat exchanger must remain constant [0.20]. With constant primary flow and constant heat transfer the T will remain constant [0.10]."

Answer H.03

Replace answer given with following:

"Because the transient rod is located in a region of higher flux as compared to the regulating rod."

OR

Because the transient rod absorbs more neutrons than the regulating rod. (1.00)"

Change point value to 1.00.

Justification:

The answer was changed to appropriately reflect the question as stated. The point value was adjusted to be consistent with the difficulty of the altered question/answer pair.

Answer H.07

Add the following answer:

"7. By depleting the fuel (operating the reactor).

Justification:

Alternate correct answer.

Answer H.10

Alter grading to indicate the following:

Correct period 25 sec (+/-1 sec) and or correct time from initial to final time 350 sec (+/- 100 sec) [1.00]

Correct final power 30 kW (+/-20 kW) [1.00]

General Shape of Sketch [0.50]

Justification:

Clarify grading.

Answer I.04

Delete "if this can be safely done," and make first part of answer worth 0.50.

Delete "so they can either assist or evacuate," and make first part of answer worth 0.50.

Justification:

Questions asked for actions not for reasons for actions.

Question K.06

Change point value such that:

Part a. is worth 0.50.

Part b. is worth 1.50.

Justification:

Correction of editorial error.