November 13, 2002

Dr. Marye Anne Fox, Chancellor
Room A Holladay Hall
North Carolina State University
Post Office Box 7001
Raleigh, NC 27695-7001

SUBJECT: RETAKE EXAMINATION REPORT NO. 50-297/OL-03-01, NORTH CAROLINA STATE UNIVERSITY

Dear Dr. Fox:

On October 30, 2002, the NRC administered an operator licensing examination at your North Carolina State University Reactor. The examination was conducted according to NUREG-1478, "Non-Power Reactor Operator Licensing Examiner Standards," Revision 1.

In accordance with 10 CFR 2.790 of the Commission's regulations, a copy of this letter and the enclosures will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records (PARS) component of NRC's document system (ADAMS). ADAMS is accessible from the NRC Web site at (the Public Electronic Reading Room) http://www.nrc.gov/NRC/ADAMS/indesx.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 Paul Doyle at (301) 415-1058 or via internet E-mail at pvd@nrc.gov.

Sincerely,

/RA/

Patrick M. Madden, Section Chief
Research and Test Reactors Section
Operating Reactor Improvements Program
Division of Regulatory Improvement Programs
Office of Nuclear Reactor Regulation

Docket No. 50-297

Enclosures:
1. Retake Examination Report No. 50-297/OL-03-01
2. Examination and answer key (Corrected)

cc w/encls:
Please see next page

cc:

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

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<u>DISTRIBUTION</u> w/ encls.:

PUBLIC	RORP\R&TR r/f	PMadden
DHughes	Facility File (EBarnhill) O-6 D-17	

ADAMS ACCESSION #: ML023090532 **TEMPLATE #:NRR-074**

OFFICE	RORP:CE		IEHB:LA	E	RORP:SC	
NAME	PDoyle:rdr		EBarnhill		PMadden	
DATE	11/ 06 / 2002		11/ 06 /2002		11/ 07 /2002	

C = COVER E = COVER & ENCLOSURE N = NO COPY

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

REPORT NO.: 50-297/OL-03-01

FACILITY DOCKET NO.: 50-297

FACILITY LICENSE NO.: R-120

FACILITY: North Carolina State University

EXAMINATION DATES: October 30, 2002

SUBMITTED BY: ***/RA/*** 11/5/2002
Paul Doyle, Chief Examiner Date

SUMMARY:

On October 30, 2002, North Carolina State University staff administered an NRC prepared operator licensing retake examination to one Reactor Operator candidate. The candidate passed the written examination.

REPORT DETAILS

1. Examiners:
   Paul Doyle, Chief Examiner

2. Results:

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

3. Exit Meeting:

   NONE

NORTH CAROLINA STATE UNIVERSITY
With Answer Key

UNITED STATES NUCLEAR REGULATORY COMMISSION

OPERATOR LICENSING EXAMINATION
Section A ONLY

ENCLOSURE 2

QUESTION A.1 [2.0 points, ½ 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.2 [1.0 point]
During a Critical Experiment "1/M" data is required to be taken. What does the 1/M represent?

a. The inverse of the moderator coefficient of reactivity.

b. The inverse of core total U^{235} mass.

c. The inverse migration length of neutrons of varying energies.

d. The inverse multiplication of the count rate between generations.

QUESTION A.3 [1.0 point]
Which of the following statements correctly describe the influence of DELAYED NEUTRONS on the neutron life cycle? Delayed neutrons …

a. increase the time required for PU^{239} to moderate the fission process.

b. decrease the time required for the neutron population to change between generations.

c. increase the time required for the neutron population to change between generations.

d. decrease the amount of reflection possible with a steel reflector.

QUESTION A.4 [1.0 point]
Initially a reactor is subcritical with a K_{eff} of 0.96 and Nuclear instrumentation indicates 30 counts per second. A fuel element is removed and count rate drops to 10 counts per second. Assuming no other reactivity changes to the core, which ONE of the following is the new K_{eff} of the core?

a. 0.9733

b. 0.8800

c. 0.8433

d. 0.8000

QUESTION A.5 [1.0 point]
Which ONE of the following is an example of beta plus (β^+)decay?

a. $_{35}Br^{87} \rightarrow {}_{33}As^{83}$

b. $_{35}Br^{87} \rightarrow {}_{35}Br^{86}$

c. $_{35}Br^{87} \rightarrow {}_{34}Se^{87}$

d. $_{35}Br^{87} \rightarrow {}_{36}Kr^{87}$

QUESTION A.6 [1.0 point]
What is the period that would cause reactor power to double in 40 seconds?

a. 3.7 seconds

b. 27.7 seconds

c. 57.7 seconds

d. 80.0 seconds

QUESTION A.7 [1.0 point]
Reactor power is at 1 watt with a +30 second stable period. How long will it take to increase power to 500 watts?

a. 186 seconds

b. 140 seconds

c. 124 seconds

d. 81 seconds

QUESTION A.8 [1.0 point]
Which one of the following accurately describes a factor contributing to Xenon balance within the reactor?

a. Most Xe^{135} is formed by fission.

b. Te^{135} is a fission product which quickly decays to I^{135}.

c. Within approximately 8 hours after startup, Xe^{135} has reached its equilibrium value.

d. Several minutes following a reactor shutdown, Xe^{135} level is increasing because I^{135} is not being produced.

QUESTION   A.9 [1.0 point]
Delayed neutrons comprise approximately what percent of all neutrons produced in the reactor?

a. 0.65%

b. 1.3%

c. 6.5%

d. 13%

QUESTION   A.10   [1.0 point]
Given the following data, which ONE of the following is the closest to the half life of the material?

TIME	ACTIVITY
0	2400 cps
10 min.	1757 cps
20 min.	1286 cps
30 min.	941 cps
60 min.	369 cps

a. 11 minutes

b. 22 minutes

c. 44 minutes

d. 51 minutes

QUESTION   A.11   [1.0 point]
Which ONE of the following ***IS CORRECT*** with regard to criticality?

a. Critical rod height does NOT depend on how fast control rods are withdrawn.

b. Critical rod height dictates the reactor power level when criticality is first achieved.

c. The slower the approach to criticality, the lower the reactor power level will be when reaching criticality.

d. The reactivity of the reactor increases towards infinity during the approach to criticality.

QUESTION   A.12   [1.0 point]
Which ONE of the following describes a property of a ***GOOD MODERATOR***?

a. It slows down fast neutrons to thermal energy levels via a small number of collisions

b. It reduces gamma radiation to thermal energy levels via a small number of collisions

c. It slows down fast neutrons to thermal energy levels via a large number of collisions

d. It reduces gamma radiation to thermal energy levels via a large number of collisions

QUESTION A.13 [1.0 point]
What is the PRINCIPAL source of heat in the reactor after shutdown?

a. Cosmic radiation causing fission

b. Decay of fission products

c. Spontaneous fission within the core

d. Stored energy from the reactor and core materials

QUESTION A.14 [1.0 point]
β and βeff both describe the total fraction of delayed neutrons. The difference between the two is that β_{eff} is …

a. smaller than β since delayed neutrons are born at lower energy levels than prompt neutrons.

b. larger than β since delayed neutrons are born at lower energy levels than prompt neutrons.

c. smaller than β since delayed neutrons are born at higher energy levels than prompt neutrons.

d. larger than β since delayed neutrons are born at higher energy levels than prompt neutrons.

QUESTION A.15 [1.0 point]
Several processes occur that may increase or decrease the available number of neutrons. SELECT from the following the six-factor formula term that describes an **INCREASE** in the number of neutrons during the cycle.

a. Thermal utilization factor (f).

b. Resonance escape probability (p).

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

d. Reproduction factor (η).

QUESTION A.16 [1.0 point]
You perform a heat balance with the following parameters. Primary flow was 505 gal/min, the ΔT across the primary side of the heat exchanger was 13.5°F, and the pool had a **COOLDOWN RATE** of 3°F/hr. Which ONE of the following is the calculated Power? Constants: c_P = 0.998 BTU/Hr°F, 1 gallon of water = 8.272 lbm, and Volume of the pool = 15650 gallons.

a. 0.876 Mw

b. 0.989 Mw

c. 1.046 Mw

d. 1.103 Mw

QUESTION A.17 [1.0 point]
Given an ACP of 19.0 inches with average temperature at 70°F and Xenon free. Calculate the ECP with average temperature = 95.0°F and Xenon adding -200 pcm reactivity. Use the Gang Integral Rod Worth curve given in the handout. The source is **in** for both, and no changes in experiments.

a. 18.8 inches

b. 19.4 inches

c. 19.6 inches

d. 20.1 inches

QUESTION A.18 [1.0 point]
Which one of the following factors is most easily varied by the reactor operator?

a. reproduction factor

b. fast fission factor

c. fast non-leakage probability

d. thermal utilization factor

QUESTION A.19 [1.0 point]
Why is the stable negative period following a scram always the same value, regardless of initial power level? The rate of power change is dependent on the …

a. mean lifetime of the longest lived neutron delayed precursor.

b. constant decay rate of prompt neutrons.

c. mean lifetime of the shortest lived delayed neutron precursor.

d. constant decay rate of prompt gamma emitters.

A.1 a, 2; b, 4; c, 1; d, 3
REF: Pulstar Reactor Trainee Notebook, Chapter 2, § 2.2 and Chapter 1, § 1.4.4 ¶¶ 5 and 7.

A.2 d
REF: Pulstar Reactor Trainee Notebook, Chapter 1, Reactor Theory Handout equation 1.33.

A.3 c
REF: Pulstar Reactor Trainee Notebook, Chapter 2, § 2.3.

A.4 b
$CR_1/CR_2 = [1 - K_{eff2}]/[1 - K_{eff1}]$ 30/10 = $[1 - K_{eff}]/[1 - 0.96]$ $1 - K_{eff} = 3 \times 0.04 = 0.12$ $K_{eff} = 0.88$
REF: Pulstar Reactor Trainee Notebook, Equation Sheet.

A.5 c
REF: Standard NRC question

A.6 c
REF: $P = P_0\, e^{T/\tau}$, since $P = 2P_0$ then $\ln(2) = 40\text{sec}/\tau$ $\tau = 40\text{sec}/\ln(2) = 57.7$ sec

A.7 a
REF: $\ln(P/P_0) \times$ period = time, $\ln(500) \times 30 = 6.215 \times 30 = 186.4 \approx 186$ seconds

A.8 b
REF: Pulstar Reactor Trainee Notebook, Chapter 2, § 2.9.3.1.

A.9 a
REF: Pulstar Reactor Trainee Notebook, Chapter 2, § 2.2, p. 4.

A.10 b
REF: $I = I_0\, e^{-t/\tau}$ $\text{Ln}(369/2400) = 60\text{min}/\tau$ $\tau = 60\text{min}/[\ln(369/2400)] = 32.044\ \text{min}^{-1}$. $t_{½} = \ln(2) \times \tau = -22.211$

A.11 a
REF: Pulstar Reactor Trainee Notebook, Chapter 1, § 1.5.3, p. 19.

A.12 a
REF: Standard NRC question.

A.13 b
REF: Pulstar Reactor Trainee Notebook, Chapter 1, page 5.

A.14 b
REF: Pulstar Reactor Trainee Notebook, Chapter 2, § 2.3.

A.15 d
REF: Pulstar Reactor Trainee Notebook, Six Factor Formula handout.

A.16 a
REF: Pulstar Reactor Trainee Notebook, Chapter 3 Example 8.1.

A.17 d +25°F × -3.9pcm/°F = -97.5pcm + (-200pcm) = -297.5 pcm. On graph adding +297.5 would change rod position from 19.0 inches to 20.1 inches.
REF: Pulstar Reactor Trainee Notebook, Chapter 2 § 2.11.

A.18	d
REF:	Pulstar Reactor Trainee Notebook, Chapter 2 § 2.11.x

A.19	a
REF:	Pulstar Reactor Trainee Notebook, Chapter 2 § 2.11.x

U. S. NUCLEAR REGULATORY COMMISSION
RESEARCH AND TEST REACTOR OPERATOR LICENSING EXAMINATION

FACILITY: North Carolina State University

REACTOR TYPE: PULSTAR

DATE ADMINISTERED: 2002/10/30

CANDIDATE: ______________________________

INSTRUCTIONS TO CANDIDATE:
Answers are to be written on the answer sheets provided. Points for each question are indicated in brackets for each question. You must score 70% to pass. Examinations will be picked up one (1) hour after the examination starts.

Category Value	% of Total	% of Candidates Score	Category Value	Category
20.00	33.3	______	____	A. Reactor Theory, Thermodynamics and Facility Operating Characteristics
20.00		______	____% FINAL GRADE	TOTALS

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

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

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

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

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

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

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

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

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

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

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

12. There is a time limit of one (1) hour for completion of the examination.

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

EQUATION SHEET

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

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

$$\ell^* = 3 \ x \ 10^{-5} \ seconds$$

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

$$SCR\,(N_{eq}) = \frac{S}{-\rho} \approx \frac{S}{1-K_{eff}}$$

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

$$UR = 26.06\left[\frac{\lambda_{eff}\rho}{\beta_{eff}-\rho}\right] = \frac{26.06}{\tau}$$

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

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

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

$$P = P_0 \ e^{\frac{t}{\tau}}$$

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

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

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

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

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

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

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

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

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

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

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

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

---

1 Curie = 3.7 x 10^{10} dis/sec

1 kg = 2.21 lbm

1 Horsepower = 2.54 x 10^3 BTU/hr

1 Mw = 3.413 x 10^6 BTU/hr

1 BTU = 778 ft-lbf

°F = 9/5 °C + 32

1 gal (H_2O) ≈ 8.272 lbm

°C = 5/9 (°F - 32)

c_P = 0.998 BTU/hr/lbm/°F

c_p = 0.998 cal/sec/gm/°C

α_T = -3.9 pcm/°F

Pool Volume = 15650 gallons

Section A Ŗ Theory, Thermo, and Facility Characteristics

A.1a 1 2 3 4 ___

A.1b 1 2 3 4 ___

A.1c 1 2 3 4 ___

A.1d 1 2 3 4 ___

A.2 a b c d ___

A.3 a b c d ___

A.4 a b c d ___

A.5 a b c d ___

A.6 a b c d ___

A.7 a b c d ___

A.8 a b c d ___

A.9 a b c d ___

A.10 a b c d ___

A.11 a b c d ___

A.12 a b c d ___

A.13 a b c d ___

A.14 a b c d ___

A.15 a b c d ___

A.16 a b c d ___

A.17 a b c d ___

A.18 a b c d ___

A.19 a b c d ___

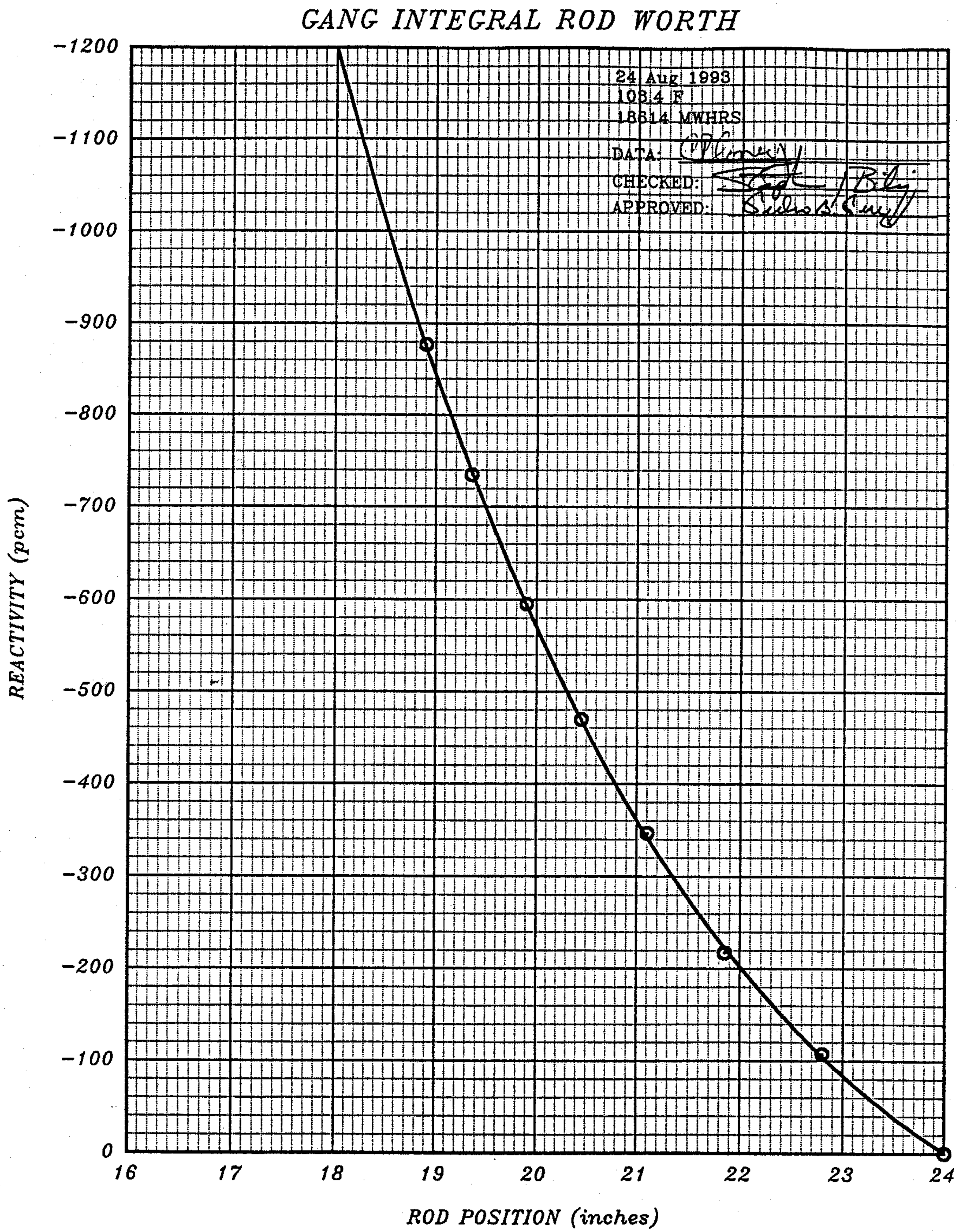

Figure 2.13 PULSTAR Ganged Integral Rod Worth

Question A.16 Heat Balance

505 gal/min	X	8.272 lbm/gal	X	60 min/hr	X	0.998 BTU/lbm°F	X	**13.5** ºF	=	3376894.3 BTU/hr
15650 gal	X	8.272 lbm/gal	X			0.998 BTU/lbm°F	X	**-3** ºF/hr		-387593.7 BTU/hr
										2989300.6 BTU/hr

Correct answer: **0.8758572Mw**

Flow rate only: **0.9894211Mw**

Pool Cooldown Only: **-0.113564Mw**

Sign error (Heatup instead of cooldown): **1.102985Mw**