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# Bulk Shielding Facility Quarterly Report April, May, and June of 1976

S. S. Hurt, III
E. D. Lance
J. R. Thomas

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OPERATIONS DIVISION

# BULK SHIELDING FACILITY QUARTERLY REPORT

## APRIL, MAY, AND JUNE OF 1976

S. S. Hurt, III
E. D. Lance
J. R. Thomas

Date Published: December 1976

**NOTICE** This document contains information of a preliminary nature. It is subject to revision or correction and therefore does not represent a final report.

OAK RIDGE NATIONAL LABORATORY
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ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

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## SUMMARY

The BSR operated at an average power level of 1,756 kw for 31.49% of the time during April, May, and June. Water-quality control in both the reactor primary and secondary cooling systems was satisfactory. The reactor was shut down for ∿16 days to repair a fault in the fiberglass lining of the pool.

The BSR was operated at low and variable power during this quarter for 79.784 hours as part of the training programs for nuclear engineering students from the University of Tennessee and Mississippi State University.

The PCA was also used in the above-mentioned training programs and was operated on six occasions when the University of Kentucky, Memphis State University, or Mississippi State University students actively participated in training laboratories.

## BULK SHIELDING REACTOR

### Operations

During this quarter, the reactor operated 31.49% of the time primarily for the irradiation of research experiments. It was operated at low and variable power (11.60% of the operating time) to enable nuclear engineering students from the University of Tennessee and Mississippi State University to perform training labs described elsewhere in this report. Basic operating data for this period are given in Table 1.

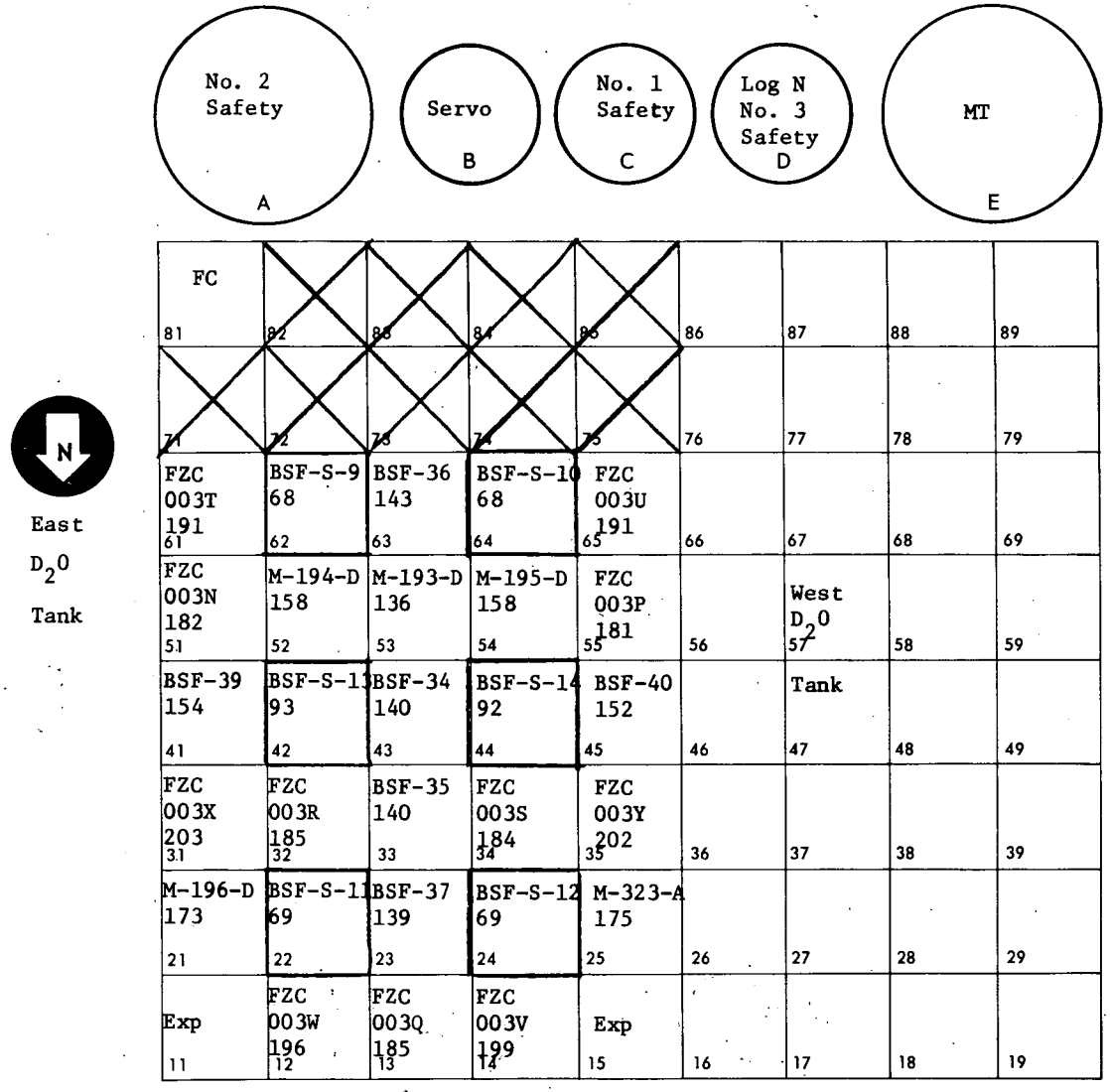
A new core configuration (Figure 2) is arranged for an experiment consisting of three sections of steel which will be irradiated at the north and east sides of the reactor core. The east $D_2O$ tank has been detached from the reactor structure and placed on a stationary stand in the pool and will be referred to as the stationary $D_2O$ tank. Two additional low weight fuel elements were added to the west side of the core in an attempt to increase the flux for the LTIF.

Table 1. Basic Operating Data
(April, May and June of 1976)

| | This Quarter | Last Quarter | Year To Date |
|---|---|---|---|
| Total energy, kwd | 50,301 | 37,412 | 87,713 |
| Average power, kw/operating hr. | 1,756 | 1,992 | 1,874 |
| Time operating, % | 31.49 | 20.64 | 26.06 |
| Reactor availability, % | 60.60 | 43.83 | 52.22 |
| Reactor water radioactivity counts $min^{-1}$ $ml^{-1}$ (av) | 1,349 | 2,229 | 1,789 |
| Reactor water resistivity, ohm-cm (av) | 1,109,000 | 946,000 | 1,027,500 |
| Standard fuel elements depleted | 0 | 0 | 0 |
| Control fuel elements depleted | 0 | 0 | 0 |
| Research samples | 50 | 36 | 86 |

Core loading 30 (Figure 1) was replaced by core loading 31 (Figure 2) on June 21, 1976, to provide adequate excess reactivity for versatile operation. The initial operating mass (4226 g $^{235}U$) of core loading 30 had been reduced to 4122 g due to burnup, thereby reducing the excess reactivity from 5.30% $\Delta k/k$ to $\sim$ 3.66% $\Delta k/k$ ($\sim$ 1.11% excess reactivity above xenon equilibrium).

Core loading 31 was accomplished by adding two partially depleted BSF-series fuel elements and three new MTR-series fuel elements. Core loading 31 had an initial operating mass of 4995 g which provided an excess reactivity of 5.49% $\Delta k/k$ (2.94% $\Delta k/k$ excess reactivity above xenon equilibrium). At the end of the quarter, the excess reactivity was $\sim$ 5.38% $\Delta k/k$ ($\sim$ 2.83% $\Delta k/k$ excess reactivity above xenon equilibrium).




## BSR CORE

30
LOADING NO.

2-20-76
DATE

Excess Reactivity - 5.30%

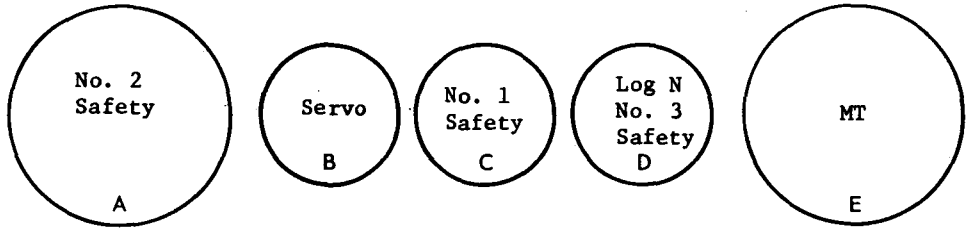
4226gm
OPERATING MASS

### ROD POSITIONS AT CRITICAL
(With Operating Mass)

| ROD NO. | IN. WITHDRAWN |
|---|---|
| 1 | 10.20 |
| 2 | 10.20 |
| 3 | 10.20 |
| 4 | 10.20 |
| 5 | 23.00 |
| 6 | 23.00 |

REMARKS:

Figure 1. Core Loading 30 — BSR.




| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| M-192-D 130 81 | FC 82 | A1 83 | A1 84 | BSF-38 134 85 | 86 | 87 | 88 | 89 |
| FZC 003T 188 71 | A1 72 | A1 73 | A1 74 | FZC 003U 188 75 | 76 | 77 | 78 | 79 |
| FZC 003N 178 61 | BSF-S-9 67 62 | BSF-36 139 63 | BSF-S-10 67 64 | FZC 003P 177 65 | 66 | 67 | 68 | 69 |
| M-13-H 202 51 | M-194-D 153 52 | FZC 003Q 182 53 | M-195-D 153 54 | M-14-H 203 55 | 56 | 57 | 58 | 59 |
| BSF-39 150 41 | BSF-S-11 90 42 | BSF-34 135 43 | BSF-S-14 89 44 | BSF-40 148 45 | 46 | $D_2O$ Tanks 47 | 48 | 49 |
| FZC 003X 198 31 | FZC 003R 179 32 | BSF-35 135 33 | FZC 003S 178 34 | FZC 003Y 197 35 | 36 | 37 | 38 | 39 |
| M-196-D 169 21 | BSF-S-13 68 22 | BSF-37 136 23 | BSF-S-12 67 24 | M-323-A 172 25 | 26 | 27 | 28 | 29 |
| BSF-28 132 11 | FZC 003W 193 12 | M-12-H 202 13 | FZC 003V 196 14 | Plug 15 | 16 | 17 | 18 | 19 |

## BSR CORE

31
LOADING NO.

June 21, 1976
DATE

Excess Reactivity - 5.49%

4995 gm
OPERATING MASS

### ROD POSITIONS AT CRITICAL
(With Operating Mass)

| ROD NO. | IN. WITHDRAWN | |
|---|---|---|
| 1 | 10.86 | 9.12 |
| 2 | 10.86 | 9.12 |
| 3 | 10.86 | 9.12 |
| 4 | 10.86 | 9.12 |
| 5 | 10.86 | 23.00 |
| 6 | 10.86 | 23.00 |

REMARKS:

Figure 2. Core Loading 31 — BSR.

Shutdowns

There were no unscheduled shutdowns during the quarter. Table 2 gives an analysis of the scheduled shutdowns.

Table 2. Analysis of Shutdowns

| Description of Shutdown | Number | Downtime (hrs) |
|---|---|---|
| Scheduled | | |
| Experimenters: | | |
| No request to operate | 10 | 622.867 |
| Repositioning of the reactor | 1 | 0.500 |
| Experiment insertion, removal, or data taking | 12 | 12.534 |
| Reactor Operations: | | |
| Special | 1 | 25.883 |
| University experiment preparation | 2 | 6.250 |
| BSR pool repair & reassembling reactor | 1 | 680.000 |
| Refueling critical runs | 14 | 3.000 |
| Quarterly | 1 | 111.250 |
| Shim rod calibrations | 1 | 33.250 |
| Subtotal | 43 | 1,439.534 |
| Unscheduled | | |
| Experimenters: | 0 | 0 |
| Reactor Operations: | 0 | 0 |
| Subtotal | 0 | 0 |
| Total | 43 | 1,439.534 |

Maintenance and Changes

Maintenance or changes on the instrumentation and mechanical components in the complex are listed in Tables 3, 4, 5, and 6. Table 7 presents the status of the ionization and fission chambers.

Table 3. Maintenance and Changes, Instrumentation and Controls

| Date | Component | Trouble or Change | Reason or Maintenance |
|---|---|---|---|
| 4-7-76 | Log N channel | Erratic readout | Replaced the Log N amplifier. |
| 4-22-76 | No. 1 rod drive position indicator | The clock-face readout device was replaced with a digital position readout. | The new unit was installed for test and evaluation of the new type of rod drive position indicator. |
| 4-22-76 through 4-26-76 | No. 2 TV camera | Poor picture reception | The Vidicon tube was replaced to correct the trouble. |
| 4-30-76 | Building evacuation system | Failure of the Magenta lights | A faulty socket for the Manual Evaucate Module was repaired to correct the trouble. |
| 5-5-76 | Log N channel | Erratic readout | The Log N amplifier was replaced. |
| 5-19-76 through 5-21-76 | Instrumentation | Routine | Quarterly checks. |
| 5-19-76 | Counting rate channel | Poor response | Replaced the balance motor in the count rate recorder and the Zener power supply in the count rate period recorder. |
| 5-20-76 | No. 1 safety channel | Poor response | Replaced the balance motor in the Servo recorder. |

Table 3 (Continued)

| Date | Component | Trouble or Change | Reason or Maintenance |
|---|---|---|---|
| 5-20-76 | Servo channel | Poor response | Replaced the balance motor in the servo recorder. |
| 5-20-76 | Public Address System | Amplifier failure | The amplifier electron tubes were replaced. |
| 6-25-76 | Servo channel | Insensitive braking action of the servo motor | A new rectifier was installed in the servo demand motor circuit. |

Table 4. Maintenance and Changes, Mechanical System

| Date | Component | Trouble or Change | Reason or Maintenance |
|---|---|---|---|
| 5-12-76 | Reactor secondary tower north fan | Coupling slipping | Replaced 6 1/2 lbs. of S. S. shot in the Dodge Flexi-dyne coupling. |
| 6-16-76 | Shim-rod drive assemblies Nos. 1 through 6 | Routine inspection | The drive assemblies were inspected, the magnets and clutch switches cleaned, the drive tubes brushed and flushed and the drive assemblies reinstalled. |

Table 5. Maintenance and Changes, Process System

| Date | Component | Trouble or Change | Reason or Maintenance |
|---|---|---|---|
| 6-28-76 and 6-29-76 | Secondary pH system | Erratic readout | The fluid in the reference pH probes was changed and the measuring pH probes were replaced. |

Table 6. Maintenance and Changes, BSR Services

| Date | Component | Trouble or Change | Reason or Maintenance |
|---|---|---|---|
| 5-27-76 | Air conditioning pump | Failure of motor | Replaced the motor starter coil. |

Table 7. Status of Ionization Chambers

| Chamber Serial No. | Location | Date Present Service Started | Previous Service | Remarks |
|---|---|---|---|---|
| | | Chambers in Service | | |
| CTC-3 (J-118) | Position A, No. 2 safety | 10-8-69 | LITR | The chamber was modified for underwater service in 1969. |
| PCP-III-106, SN-72-1 | Position B, servo | 5-12-75 | None | This new chamber was installed in the BSR in May, 1975. |
| CTC-4 (C-771) | Position C, No. 1 safety | 12-1-69 | LITR | The chamber was modified for underwater service in 1969. |
| PCP-III-106A, SN-72-2 | Position D, log-N and No. 3 safety | 11-13-73 | None | This new dual chamber was installed in the BSR in November, 1973. |
| C-1045 | CP-81, fission chamber | 10-1-69 | PCA | This fission chamber assembly was tranferred to the BSR from the PCA in October, 1969. |
| | | Chambers Not In Service | | |
| PCP (old type, no serial number) | Warehouse storage | | BSR | This chamber is of the old type and will be repaired if needed. |
| CIC (No. 62) | BSR storage | | BSR | This chamber is reserved for the PCA but can be used in an emergency for the BSR. |

Table 7 (continued)

| Chamber Serial No. | Location | Date Present Service Started | Previous Service | Remarks |
|---|---|---|---|---|
| CIC (No. 63) | BSR storage | | BSR | This chamber is reserved for the PCA but can be used in an emergency for the BSR. |
| PCP (Q975), No. 2) | BSR Storage | | BSR | This chamber is reserved for the PCA but can be used in an emergency for the BSR. |
| PCP-III-106, SN-66-1 | BSR storage | | BSR | Used as No. 2 safety and servo. Safety section failed in June, 1969, servo section failed in May, 1975. |
| PCP-III-106, SN-66-3 | ORR beam tube storage | | BSR and ORR | Used BSR and ORR 1967 through 1973. Last removed November, 1973. |
| PCP-III-106, SN-66-4 | ORR instrument shop | | BSR | Used in the BSR from 1968 to January, 1973. Repaired 1969. |

Fuel

Changes in the fuel inventory are reflected in Table 8.

Table 8. Fuel and Shim Rod Status

| | This Quarter | Last Quarter | Year To Date |
|---|---|---|---|
| Fuel elements depleted | 0 | 0 | 0 |
| Control-rod fuel elements depleted | 0 | 0 | 0 |
| New fuel elements placed in service | 3 | 2 | 5 |
| New control-rod fuel elements placed in service | 0 | 0 | 0 |
| New fuel elements available for use | 6 | 9 | 6 |
| New control-rod fuel elements available for use | 6 | 6 | 6 |
| Partially depleted fuel elements available for use | 2 | 4 | 2 |
| New shim rods placed in service | 0 | 0 | 0 |
| Boron stainless steel shim rods in use | 6 | 6 | 6 |
| Boron stainless steel shim rods available for use | 2 | 2 | 2 |

Experiment Facilities Assignment

Facility assignments are listed in Table 9. The tubes of the east $D_2O$ tank are not permanently assigned; they are used by various Laboratory personnel for short-term sample irradiations.

Table 9. Facilities Assignment

| Facility | Location | Division or Sponsor |
|---|---|---|
| Liquid helium cryostat | Southwest corner of pool using west $D_2O$ tank | Solid State |
| Liquid nitrogen cyrostat | On instrument bridge | Solid State |
| Ambient temperature facility | North face of core | Solid State |
| Front-face tube | North face of core | Solid State |
| Fast-neutron tube | Core position 15 | Solid State |
| Water-cooled tube | Core position 11 | Solid State |
| Dry thermal-neutron tubes* (N-4 and S-3) | Stationary $D_2O$ tank | Operations |
| Dry thermal-neutron tubes* (east, center, southwest, and northwest) | Stationary $D_2O$ tank | Operations |

*These facility tubes are for sample irradiations and are used by personnel of several divisions, primarily Analytical Chemistry and Solid State Division.

Demineralizer Performance

Table 10 gives detailed information on the condition of the primary water system for the preceding year and pertinent data on the performance of the bypass demineralizer.

Table 10. Demineralizer Performance Data

| Run No. | Initiation Date | Termination Date | Throughput (gal) | Gross Gamma (Counts $min^{-1}$ $ml^{-1}$) In | Gross Gamma (Counts $min^{-1}$ $ml^{-1}$) Out | pH In | pH Out | Specific Resistance (ohm-cm) In | Specific Resistance (ohm-cm) Out |
|---|---|---|---|---|---|---|---|---|---|
| 33 | 1-4-73 | 3-5-73 | 1,614,000 | 1,280 | 115 | 5.7 | 5.8 | 1,008,000 | 1,430,000 |
| 34 | 3-6-73 | 4-30-73 | 1,393,200 | 1,848 | 181 | 5.7 | 5.7 | 873,000 | 1,363,000 |
| 35 | 5-2-73 | 7-2-73 | 2,060,000 | 2,072 | 120 | 5.8 | 5.8 | 896,000 | 1,209,000 |
| 36 | 7-3-73 | 9-4-73 | 1,900,000 | 1,672 | 116 | 5.8 | 5.8 | 792,000 | 1,270,000 |
| 37 | 9-4-73 | 11-12-73 | 1,300,000 | 2,021 | 107 | 5.9 | 6.0 | 682,000 | 1,144,000 |
| 38 | 11-14-73 | 1-7-74 | 1,692,000 | 1,353 | 98 | 5.7 | 5.7 | 738,000 | 1,102,000 |
| 39 | 1-9-74 | 3-13-74 | 1,320,000 | 1,931 | 101 | 6.2 | 6.0 | 666,000 | 908,000 |
| *40 | 3-15-74 | 7-30-74 | 1,400,000 | 9 | 0 | 6.2 | 6.0 | 364,000 | 1,132,000 |
| 41 | 8-16-74 | 12-4-74 | 1,500,000 | 2,316 | 385 | 5.8 | 5.8 | 630,000 | 895,000 |
| **42 | 12-17-74 | 4-15-75 | 3,850,000 | 2,116 | 119 | 5.8 | 6.0 | 1,018,000 | 1,611,000 |
| 43 | 4-16-75 | 7-7-75 | 2,550,000 | 2,712 | 174 | 5.7 | 5.8 | 937,000 | 1,823,000 |
| 44 | 7-10-75 | 11-5-75 | 2,750,000 | 2,528 | 144 | 5.7 | 5.9 | 968,000 | 1,428,000 |
| 45 | 11-5-75 | 4-29-76 | 2,325,000 | 2,146 | 154 | 5.3 | 5.5 | 902,000 | 1,593,000 |
| 46 | 4-30-76 | In Service | 1,000,000 | 1,399 | 100 | 5.5 | 5.7 | 1,109,000 | 2,030,000 |

*The reactor was shut down during the entire run.

**New resin in the demineralizer columns.

## SPECIAL TESTS

### Efficiency Tests

Tests were performed by Inspection Engineering on the cell ventilation filters. Details are given in Table 11.

Table 11. Efficiency Tests Results, Filters

| Date | Unit | Type Test | Efficiency (%) |
|---|---|---|---|
| 4-1-76 | North Bank | Methyl Iodide | 83.73 |
| 4-1-76 | Center Bank | Methyl Iodide | 71.00 |
| 4-1-76 | South Bank | Methyl Iodide | 27.10 |
| 6-18-76 | North Bank | DOP | 99.985 |
| 6-18-76 | Center Bank | DOP | 99.995 |
| 6-18-76 | South Bank | DOP | 99.993 |

The University Nuclear Engineering Department Experiments

The BSR was used for training labs for university nuclear engineering students on seven occasions as described below.

Attenuation Experiment - The reactor was operated at variable power levels (on April 31 and 14, 1976) by the Operations Division staff while the University of Tennessee students, under the auspices of the Operations Division training supervisor, performed a neutron and gamma attenuation experiment. Basically, the experiment was an exercise in measuring neutron and gamma levels from an operating nuclear reactor as a function of distance through light-water medium.

Xenon Buildup and Decay Experiment - On April 2 and 3, 1976, and also on May 7, 8 and 9, 1976, following operation at 2 Mw to achieve xenon equilibrium, the power level of the BSR was reduced to 4 kw to begin an experiment for students from Mississippi State University and the University of Tennessee to study the buildup and decay of xenon in the BSR core. The students performed all activities associated with the experiment under the direct supervision of an Operations Division supervisor. The experiment, performed on a 24-hr/day schedule until completion, was an exercise in: (1) maintaining the reactor critical at 4 kw, (2) determining the reactivity worth of a shim rod under varying concentrations of xenon, and (3) determining the reactivity worth of xenon in the core as a function of time.

Operational Activities

| Date | Remarks |
|---|---|
| 5-20-76 | The emergency electrical power quarterly test was completed with satisfactory results. The test was performed by turning the emergency power transfer switch (circuit 18 in electrical power panel DP-1) to "OFF", thereby starting the ORR diesel generator which supplied electrical power to designated circuits in the control and pool rooms. |
| 5-27-76 | The containment system quarterly functional checks were performed with satisfactory results. |

Shim-Rod Calibrations

The BSR shim rods were calibrated after core loading 31 had been established. The results are shown in Appendix A. The total worth of all six rods was 10.97% $\Delta k/k$. The operating limit requirement that the reactor be operated with the ganged rods (all six) withdrawn at least 50% of their worth thus requires that the rods be $\geq$10.70 in. withdrawn when the reactor becomes critical for power operation. With rods 5 and 6 at 23 in. withdrawn, rods 1, 2, 3, and 4 can be withdrawn to 9.00 in. to comply with the same operating limit. Appendix A also shows the comparison of rod worths for October, 1971, January, 1972, September, 1974, and June, 1975.

## POOL CRITICAL ASSEMBLY

### Operations

The PCA was used 62.0 hours as an experiment facility for the benefit of nuclear engineering students from the University of Kentucky, Mississippi State University and Memphis State University. Operational activities in preparing the facility for use included a checkout of the reactor control instrumentation and preparation of the required loadings. The operational activities are listed in Table 12 (Usage of Pool Critical Facility). The PCA maintenance is listed in Table 13.

Table 12. Usage of Pool Critical Facility

| Date | Operational Activity | Purpose | Hours Used |
|---|---|---|---|
| 4-1-76 | Established core No. 77 to permit calibration of the regulating rod and the performance of the importance function experiment. | Training lab for the Mississippi State University nuclear engineering students. | 7.4 |
| 4-5-76 | Established core No. 181 to obtain a critical mass following the standard approach-to-critical procedure. Established core No. 182 to permit calibration of the regulating rod. | Training lab for the University of Kentucky nuclear engineering students. | 13.1 |
| 4-6-76 | Established core No. 183 to obtain a critical mass following the standard approach-to-critical procedure. Established core No. 184 to permit calibration of the regulating rod. | Training lab for the University of Kentucky nuclear engineering students. | 12.5 |
| 4-9-76 | Ionization chamber tests | Test facility for ORMAC | 6.0 |
| 6-28-76 and 6-29-76 | Established cores Nos. 185 and 186 to obtain a critical mass following the standard approach-to-critical procedure. | Training lab for the Memphis State University students. | 23.0 |

Table 13. PCA Maintenance

| Date | Component | Trouble or Change | Reason or Maintenance |
|---|---|---|---|
| 5-3-76 through 5-5-76 | Quarterly instrumentation checks | Routine | Completed with satisfactory results. |
| 5-3-76 | No. 1 magnet amplifier | Unsteady output. | Replaced two OA2 VR tubes. |
| 5-3-76 | Auxiliary counting rate channel | Did not meet specifications. | Replaced the pulse amplifier. |

# EXPERIMENTS

Experiments were conducted at the PCA by students from the Nuclear Engineering Departments of Mississippi State University, the University of Kentucky and Memphis State University as indicated in Table 12. These experiments are described briefly and were directly supervised by the training supervisor of the Operations Division.

## Approach-to-Critical

To demonstrate the technique of assembling a reactor core, a critical mass was loaded by the nuclear engineering students following the standard approach-to-critical procedure.

## Regulating-Rod Calibration

A technique used in calibrating reactor control rods was demonstrated by using the period method in calibrating the regulating rod. The exercise was performed by the nuclear engineering students.

## Statistical Weight

An experiment was performed to determine the effect of absorbers on the reactivity as a function of position in a special fuel element located in the reactor core. Using guidelines provided by the Operations supervisor, the experiment was performed by the nuclear engineering students.

APPENDIX A

# INTRA-LABORATORY CORRESPONDENCE

OAK RIDGE NATIONAL LABORATORY

June 24, 1976

TO: F. T. Binford

FROM: T. P. Hamrick

SUBJECT: Calibration of BSR Shim Rods

The BSR shim rods were calibrated following the refueling operation to establish BSR loading No. 31. The resulting reactivity worth curves are attached, along with a plot of excess reactivity remaining versus the ganged rod position of rods 1-4. Loading No. 31 resulted in a core with 5.49% Δk/k excess reactivity at a water temperature of 80°F.

As determined from this most recent calibration of the shim rods, the minimum position of the shim rods at critical are:

1. All six rods ganged at 10.70 inches withdrawn; and
2. Rods 5 and 6 at 23 inches withdrawn, rods 1-4 ganged at 9.0 inches withdrawn.

Rod worths determined during the five most recent calibrations are compared in Table 1 below:

Table 1. Comparison of BSR Rods Worths (% Δk/k)

| Rod No. | Oct. 1971 | Jan. 1972 | Sept. 1974 | June 1975 | June 1976 |
|---|---|---|---|---|---|
| 1 | 1.710 | 1.944 | 1.697 | 1.934 | 1.755 |
| 2 | 1.690 | 1.864 | 1.873 | 1.259 | 1.843 |
| 3 | 2.716 | 3.018 | 2.942 | 3.086 | 2.512 |
| 4 | 2.714 | 2.962 | 2.966 | 2.931 | 2.854 |
| 5 | 0.922 | 0.852 | 0.946 | 0.940 | 0.854 |
| 6 | 0.866 | 0.872 | 0.937 | 0.910 | 1.159 |
| 1-4 | 8.830 | 9.788 | 9.478 | 9.710 | 8.964 |
| 5-6 | 1.788 | 1.724 | 1.883 | 1.850 | 2.013 |
| Total | 10.618 | 11.512 | 11.361 | 11.560 | 10.977 |

T. P. Hamrick

T. P. Hamrick

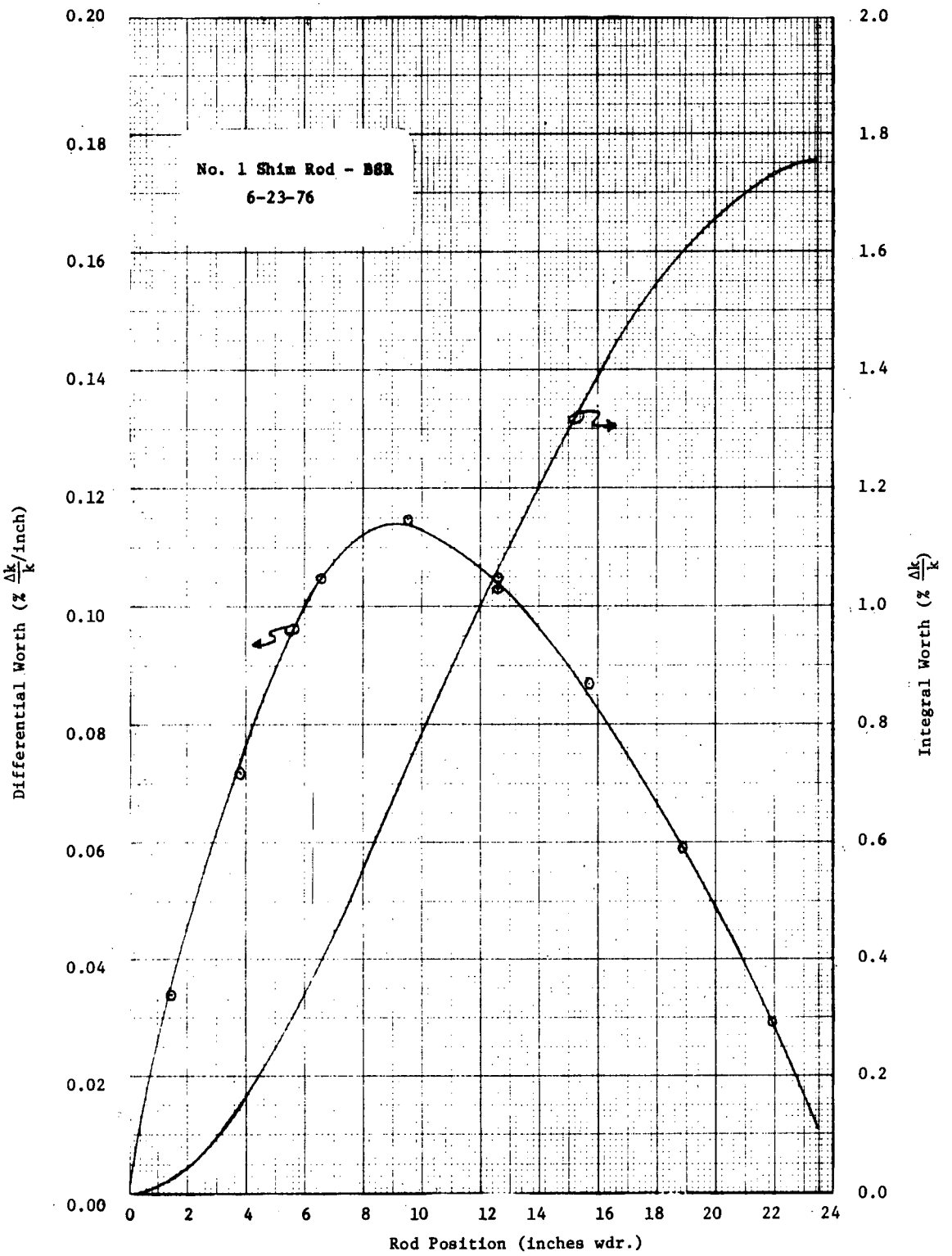
TPH:dsp

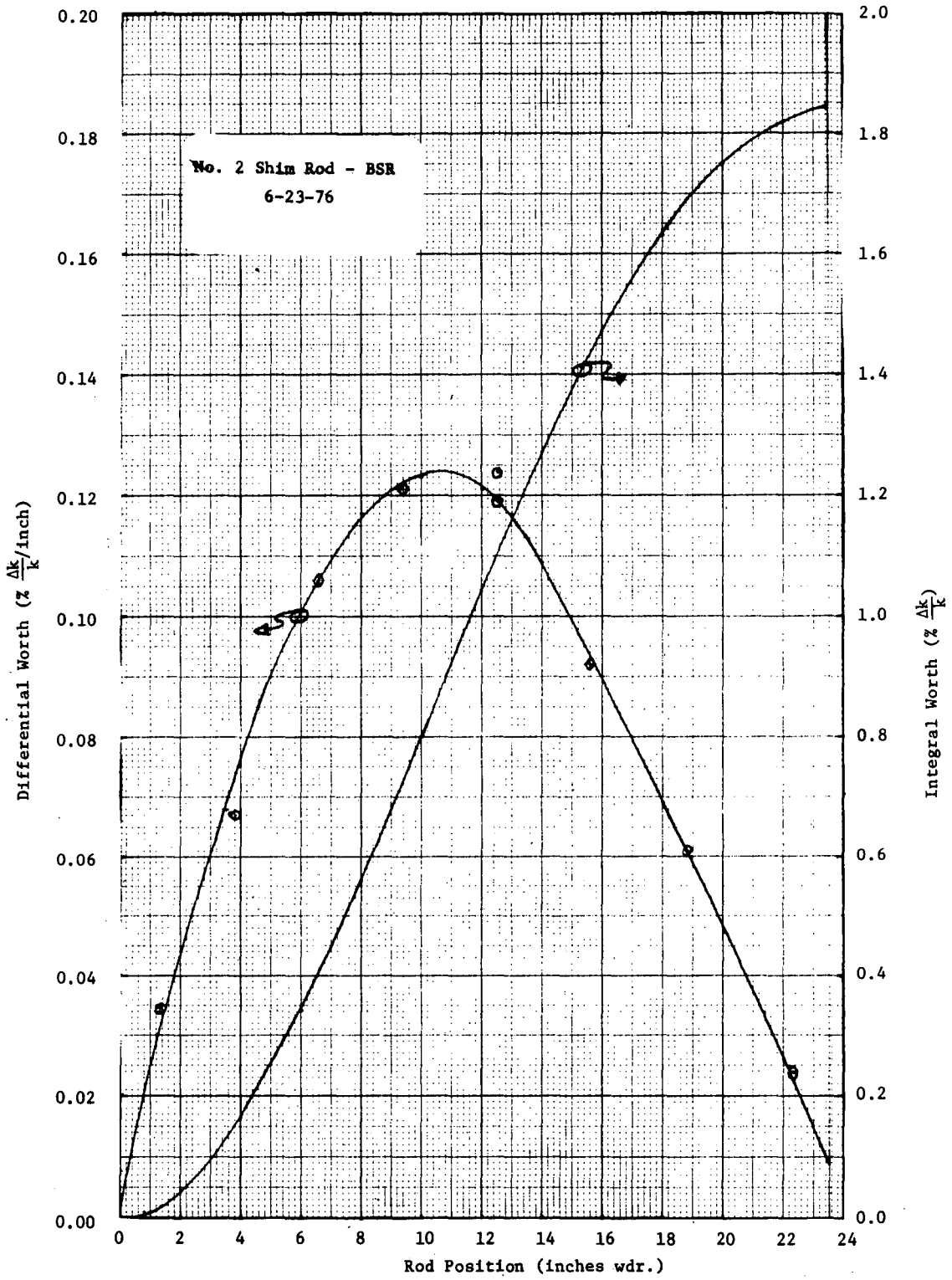
E. D. Lance

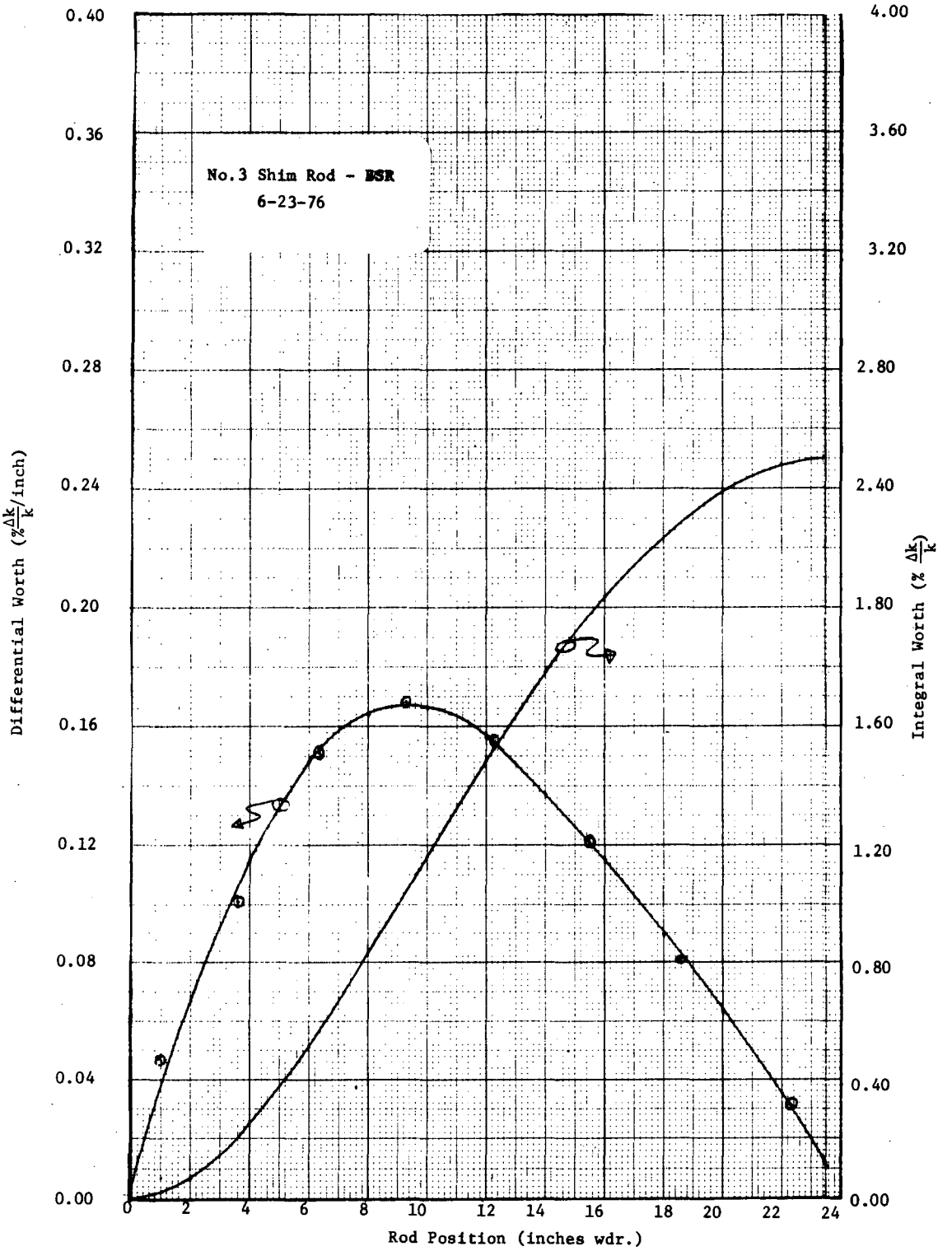
E. D. Lance

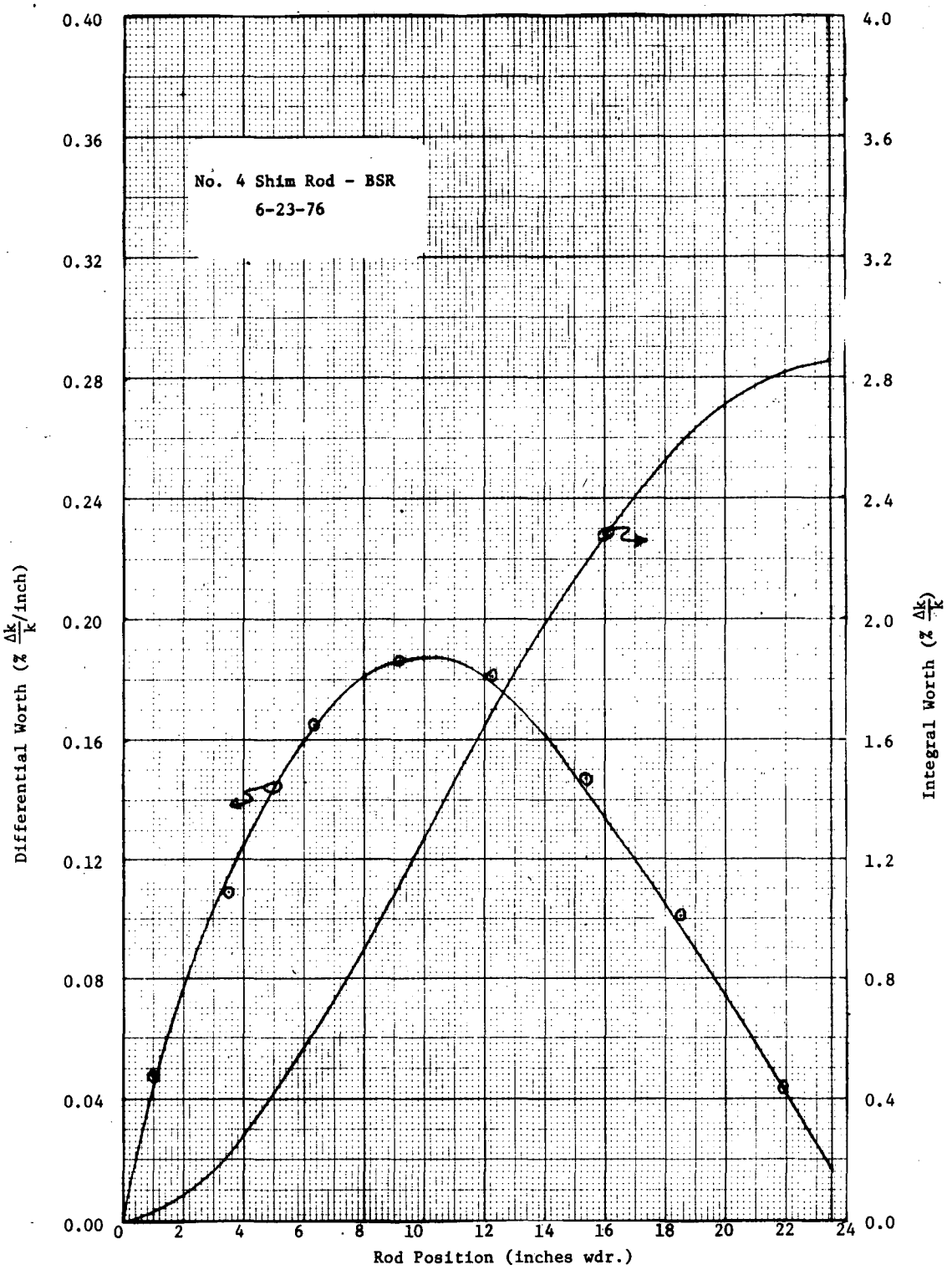
Attachments

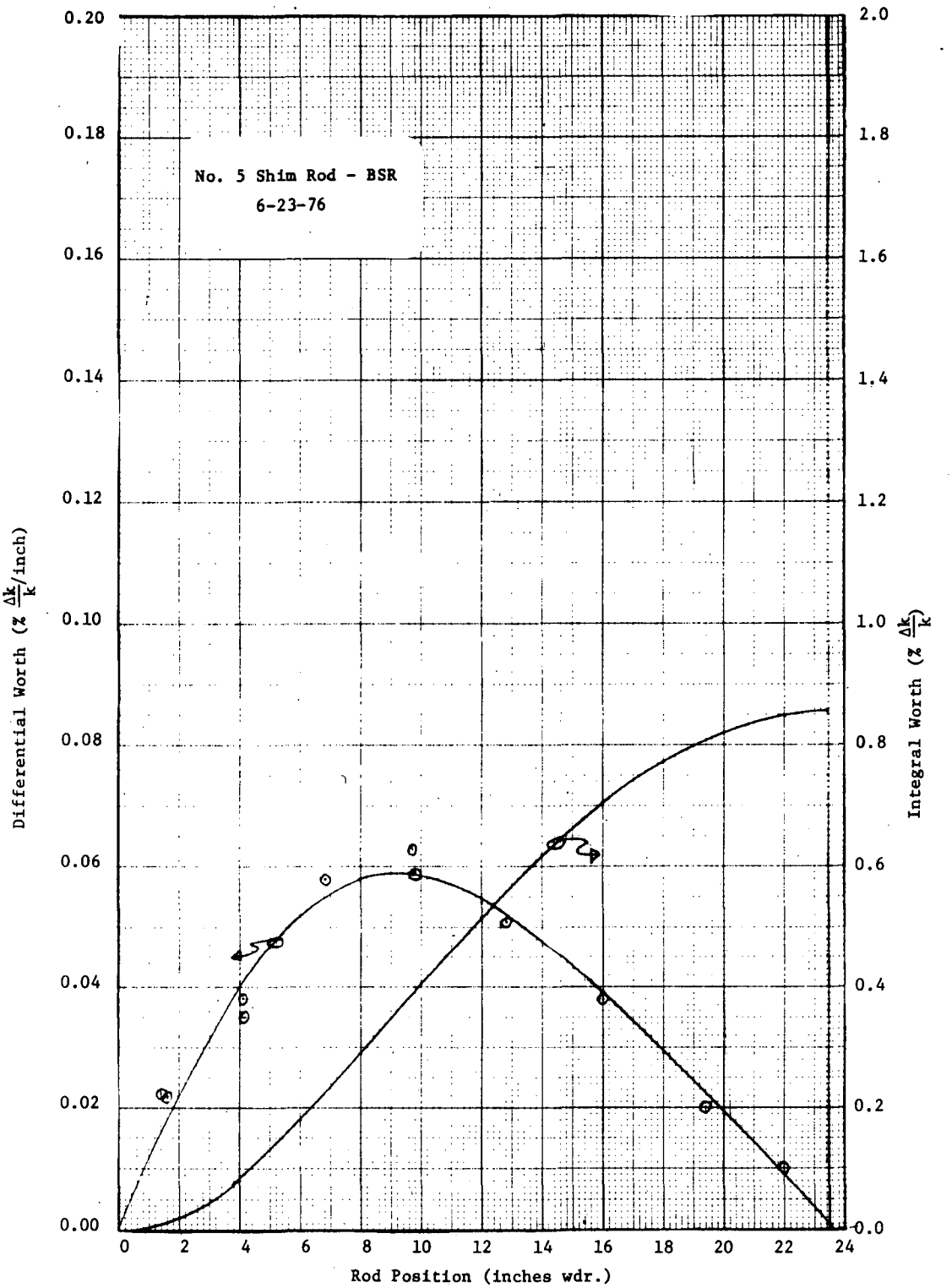
cc: C. D. Cagle
C. B. Gaither
S. S. Hurt
J. R. Thomas
BSR Control Room

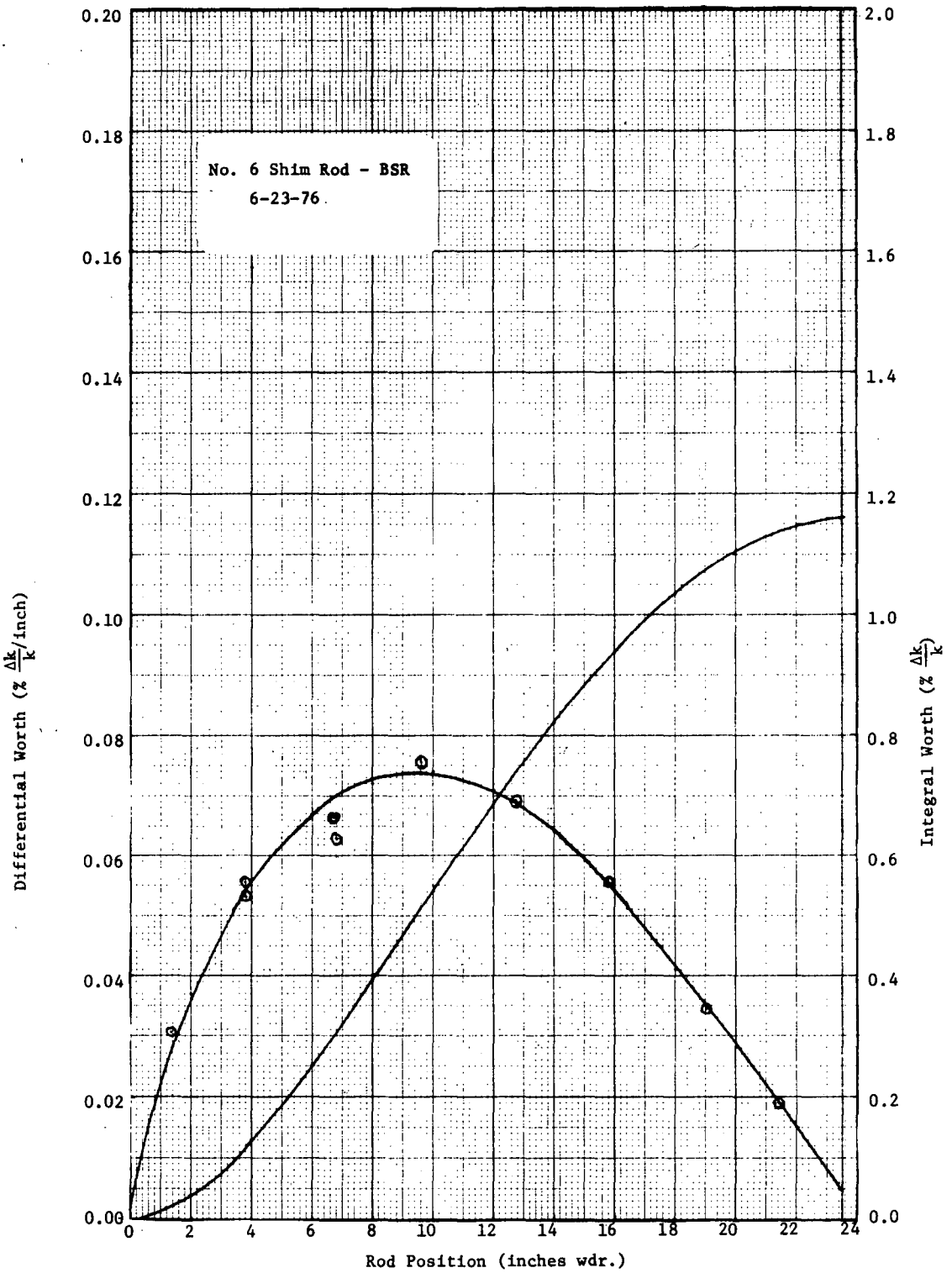

No. 1 Shim Rod - BSR
6-23-76
Differential Worth (% Δk/k/inch)
Integral Worth (% Δk/k)
Rod Position (inches wdr.)
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
0.16
0.18
0.20
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
0
2
4
6
8
10
12
14
16
18
20
22
24

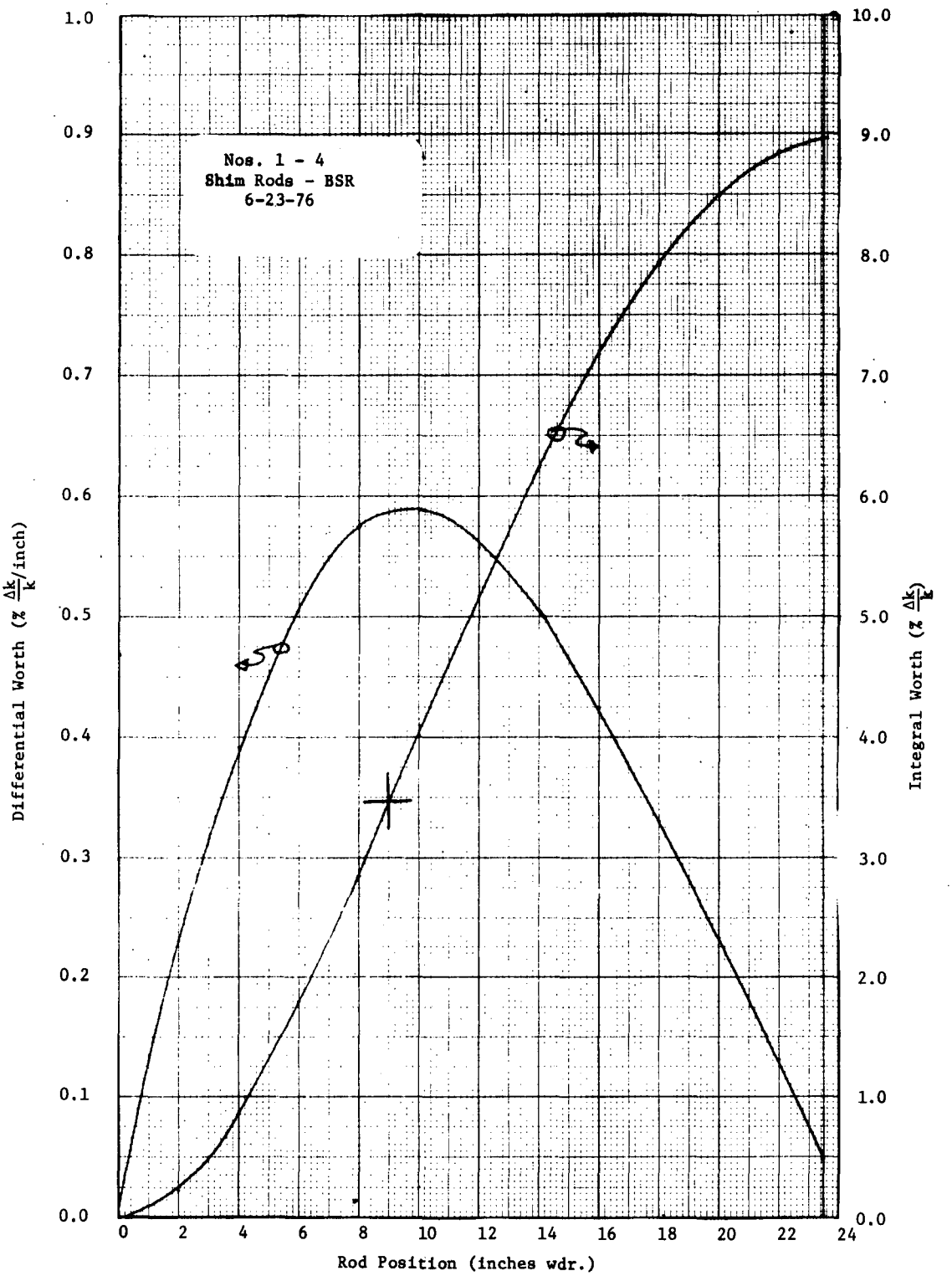

No. 2 Shim Rod - BSR
6-23-76
Differential Worth (% Δk/k/inch)
Integral Worth (% Δk/k)
Rod Position (inches wdr.)
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
2
4
6
8
10
12
14
16
18
20
22
24

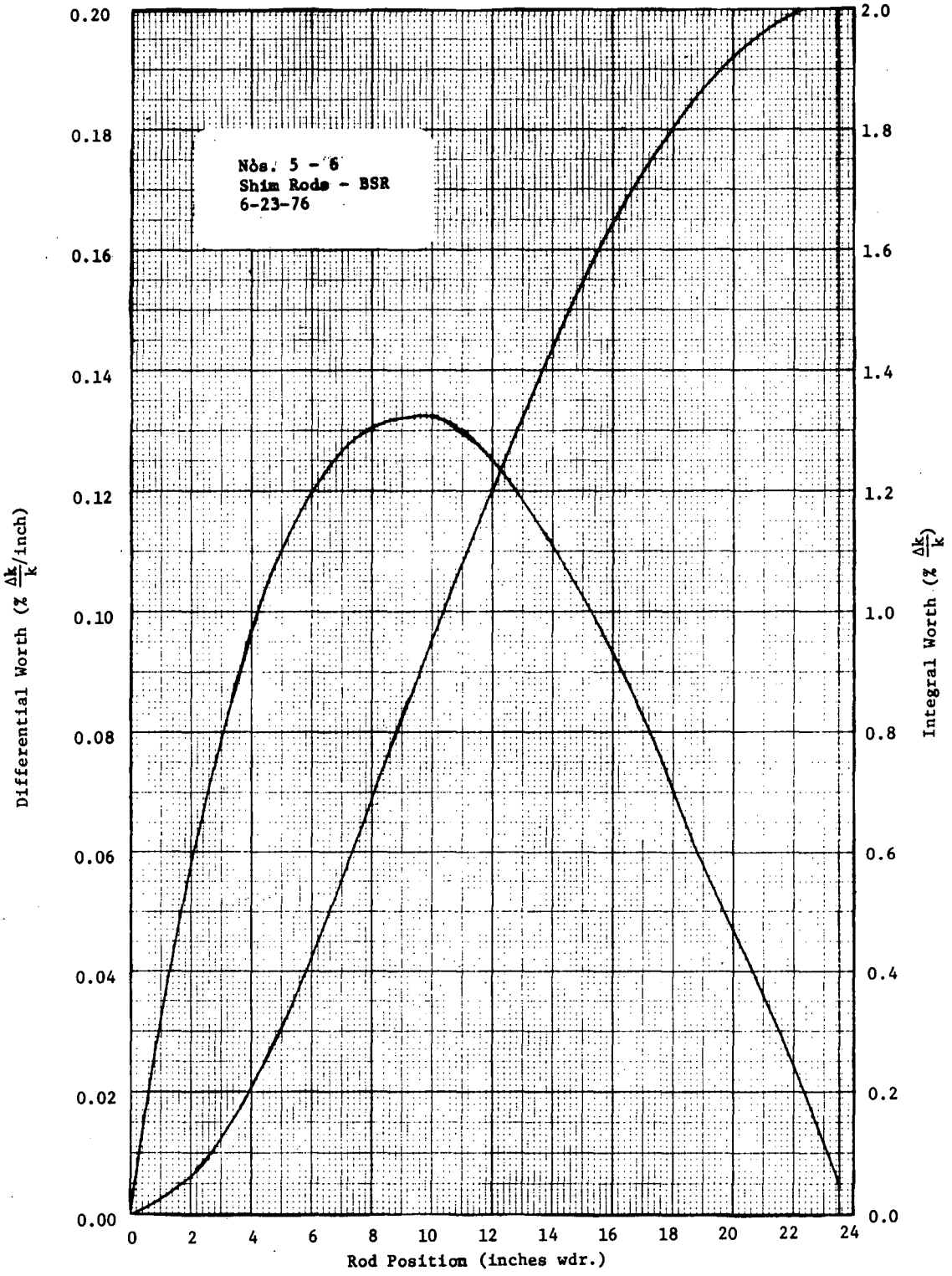

No.3 Shim Rod - BSR
6-23-76
Differential Worth (%Δk/k/inch)
Integral Worth (% Δk/k)
Rod Position (inches wdr.)
0.40
0.36
0.32
0.28
0.24
0.20
0.16
0.12
0.08
0.04
0.00
4.00
3.60
3.20
2.80
2.40
1.80
1.60
1.20
0.80
0.40
0.00
0
2
4
6
8
10
12
14
16
18
20
22
24

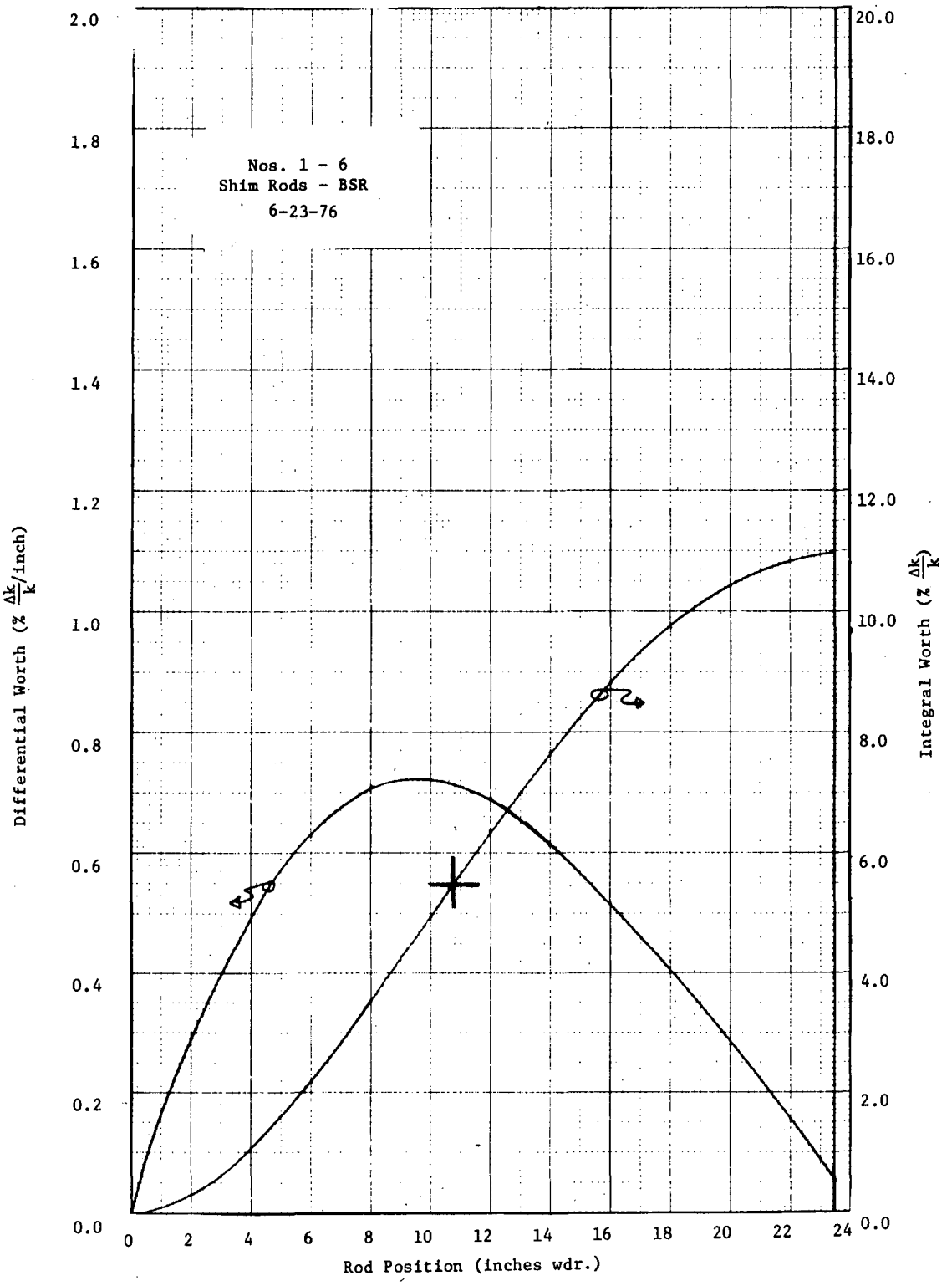

No. 4 Shim Rod - BSR
6-23-76
Differential Worth (% Δk/k/inch)
Integral Worth (% Δk/k)
Rod Position (inches wdr.)
0.40
0.36
0.32
0.28
0.24
0.20
0.16
0.12
0.08
0.04
0.00
4.0
3.6
3.2
2.8
2.4
2.0
1.6
1.2
0.8
0.4
0.0
0
2
4
6
8
10
12
14
16
18
20
22
24

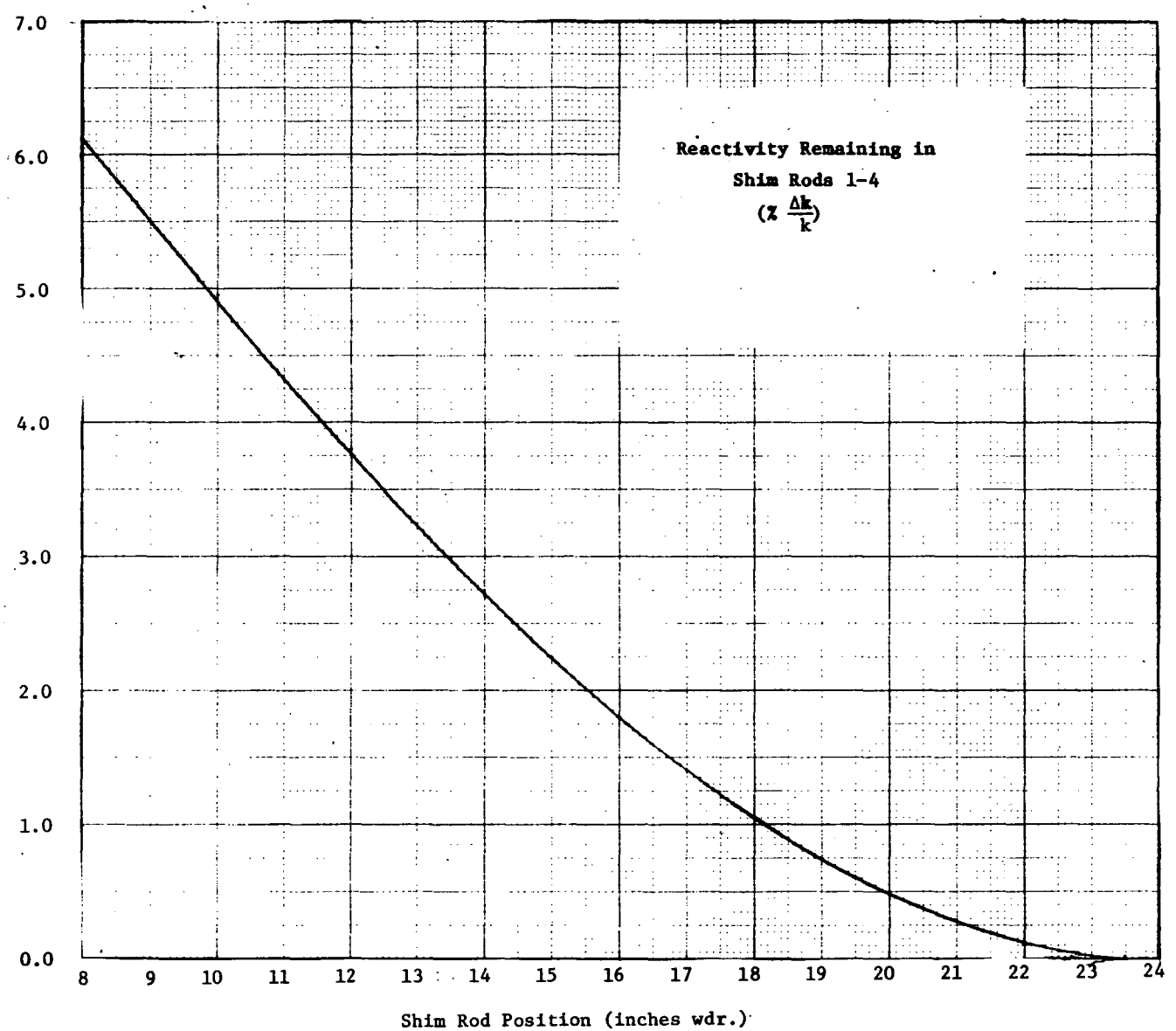

No. 5 Shim Rod - BSR
6-23-76
Differential Worth (% Δk/k/inch)
Integral Worth (% Δk/k)
Rod Position (inches wdr.)
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
2
4
6
8
10
12
14
16
18
20
22
24


No. 6 Shim Rod - BSR
6-23-76
Differential Worth (% Δk/k/inch)
Integral Worth (% Δk/k)
Rod Position (inches wdr.)
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
2
4
6
8
10
12
14
16
18
20
22
24


Nos. 1 - 4
Shim Rods - BSR
6-23-76
Differential Worth (% Δk/k/inch)
Integral Worth (% Δk/k)
Rod Position (inches wdr.)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0
2
4
6
8
10
12
14
16
18
20
22
24


Nos. 5 - 6
Shim Rods - BSR
6-23-76
Differential Worth (% Δk/k/inch)
Integral Worth (% Δk/k)
Rod Position (inches wdr.)
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
0.16
0.18
0.20
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
0
2
4
6
8
10
12
14
16
18
20
22
24


Nos. 1 - 6
Shim Rods - BSR
6-23-76
Differential Worth (% Δk/k/inch)
Integral Worth (% Δk/k)
Rod Position (inches wdr.)
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
0
2
4
6
8
10
12
14
16
18
20
22
24


Reactivity Remaining in
Shim Rods 1-4
(% Δk/k)
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
Shim Rod Position (inches wdr.)

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