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BULK SHIELDING FACILITY QUARTERLY REPORT JANUARY, FEBRUARY, MARCH 1972

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OAK RIDGE NATIONAL LABORATORY
OPERATED BY UNION CARBIDE CORPORATION • FOR THE U.S. ATOMIC ENERGY COMMISSION

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OPERATIONS DIVISION

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NOTICE This document contains information of a preliminary nature and was prepared primarily for internal use at the Oak Ridge National Laboratory. It is subject to revision or correction and therefore does not represent a final report.

OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37830
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SUMMARY

The BSR operated at an average power level of 1,742 kw for 33.2% of the time during January, February, and March. Water-quality control in both the reactor primary and secondary cooling systems was satisfactory. There was one unscheduled shutdown during the quarter as indicated in Table 2.

Changes as authorized by Mechanical Design Change Memos Nos. BSR-2Mw-3 and BSR-2Mw-4 were completed as indicated in Table 4.

The BSR was operated at low and variable power during this quarter for 68.7 hrs as a training aid for 20 trainees from the Tennessee Valley Authority (TVA) Browns Ferry nuclear power reactor.

The PCA was operated during the quarter as follows: ten days as a training aid for trainees from the Tennessee Valley Authority Browns Ferry nuclear power reactor and three days as a training aid for students from the Nuclear Engineering Department of the University of Tennessee.

BULK SHIELDING REACTOR

Operations

During this quarter, the reactor operated 33.2% of the time primarily for the irradiation of research experiments. It was also operated at low and variable power (9.5% of the operating time) to enable the trainees from the TVA Browns Ferry nuclear power reactor to receive and participate in reactor startup training and to perform two experiments described elsewhere in this report. The operating time for the quarter is less than the previous quarter because of the request of the experimenters for a series of experiments requiring only day-shift operation. Basic operating data for this period are given in Table 1.

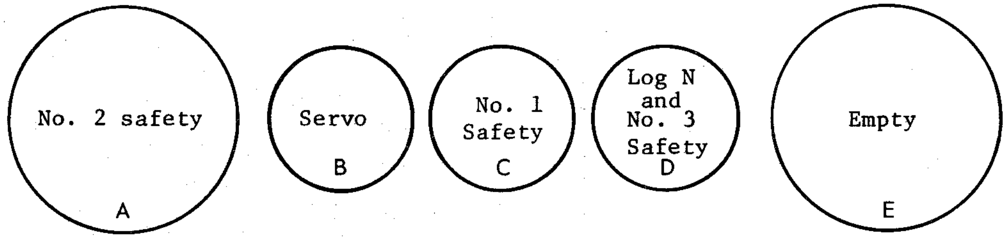
Table 1. Basic Operating Data
January, February, and March of 1972

	This Quarter	Last Quarter	Year To Date
Total energy, kwd	52,581	101,035	52,581
Average power, kw/operating hr	1,742	1,880	1,742
Time operating, %	33.2	58.4	33.2
Reactor availability, %	89.6	93.5	89.6
Reactor water radioactivity, counts min^{-1} ml^{-1} (av)	1,841	1,862	1,841
Reactor water resistivity, ohm-cm (av)	846,000	853,000	846,000
Standard fuel elements depleted	0	0	0
Control fuel elements depleted	2	0	2
Research samples	30	25	30

Core loading 20 (Figure 1) was converted to core loading 21 (Figure 2) on January 7, 1972, to provide adequate excess reactivity for versatile operation. The initial operating mass (3,976.218 g) of core loading 20 had been reduced to 3,936.093 g due to burnup, thereby reducing the excess reactivity from 3.35% $\Delta k/k$ to 3.15% $\Delta k/k$ ($\sim$0.60% $\Delta k/k$ excess reactivity above xenon equilibrium).

Core loading 21 was accomplished by replacing six fuel elements as follows: two new control-rod fuel elements were installed; one new BSF-series fuel element was installed; one partially depleted LITR-series fuel element was installed; and two partially depleted BSF-series fuel elements were installed. Core loading 21 had an initial operating mass of 4,092.058 g which provided an excess reactivity of 5.7% $\Delta k/k$ (3.15% $\Delta k/k$ excess reactivity above xenon equilibrium). At the end of the quarter, the excess reactivity is $\sim$4.8% $\Delta k/k$ ($\sim$2.25% $\Delta k/k$ excess reactivity above xenon equilibrium).

ORNL DWG. 72-3097



N

EAST D_2O TANK

FC 81	X 82	X 83	X 84	X 85	86	87	88	89
X 71	X 72	X 73	X 74	X 75	76	77	78	79
BSF-23 152.536 61	BSF-S-5 63.577 Shim Rod No. 5 62	BSF-36 187.145 63	BSF-S-6 63.865 Shim Rod No. 6 64	BSF-16 145.724 65	66	67	68	69
BSF-34 187.220 51	BSF-26 159.335 52	BSF-33 164.239 53	BSF-27 157.444 54	BSF-35 187.195 55	56	WEST D_2O TANK		59
BSF-7 140.029 41	BSF-S-9 89.430 Shim Rod No. 3 42	BSF-32 161.142 43	BSF-S-10 89.567 Shim Rod No. 4 44	BSF-18 139.315 45	46			49
BSF-24 145.031 31	BSF-28 154.563 32	BSF-31 162.523 33	BSF-29 154.413 34	BSF-25 143.722 35	36	37	38	39
M-193-D 192.293 21	BSF-S-7 78.233 Shim Rod No. 1 22	BSF-30 161.177 23	BSF-S-8 78.035 Shim Rod No. 2 24	BSF-37 188.950 25	26	27	28	29
Exp 11	BSF-17 142.911 12	BSF-19 144.217 13	BSF-20 142.334 14	Exp 15	16	17	18	19

BSR CORE

LOADING NO. 20

DATE December 14, 1971

Excess reactivity = ∿3.35% $\Delta k/k$

OPERATING MASS 3976.219

ROD POSITIONS AT CRITICAL
(With Operating Mass)

ROD NO.	IN. WITHDRAWN *
1	13.62
2	13.62
3	13.62
4	13.62
5	23.00
6	23.00

REMARKS:
*Some xenon ~~in core~~.

Kwhr at Beginning 35,679,165

[signature]

Fig. 1. Core Loading No. 20 - BSR

ORNL DWG. 72-6967

A	B	C	D	E
No. 2 Safety	Servo	No. 1 Safety	Log N and No. 3 Safety	Empty

EAST D_2O TANK

FC 81	X 82	X 83	X 84	X 85	86	87	88	89
X 71	X 72	X 73	X 74	X 75	76	77	78	79
BSF-23 151.386 61	BSF-S-7 77.493 Shim Rod 62 No. 5	BSF-36 185.361 63	BSF-S-8 77.295 Shim Rod 64 No. 6	BSF-16 144.665 65	66	67	68	69
BSF-34 185.537 51	BSF-26 157.387 52	BSF-33 162.218 53	BSF-27 155.555 54	BSF-35 185.440 55	56	WEST D_2O TANK		59
BSF-11 145.732 41	BSF-S-11 96.570 Shim Rod 42 No. 3	BSF-32 158.803 43	BSF-S-12 96.230 Shim Rod 44 No. 4	BSF-13 145.181 45	46			49
BSF-24 143.671 31	M-193-D 190.617 32	BSF-31 160.288 33	BSF-37 187.488 34	BSF-25 142.329 35	36	37	38	39
M-192-D 189.725 21	BSF-S-9 88.330 Shim Rod 22 No. 1	BSF-30 159.521 23	BSF-S-10 88.454 Shim Rod 24 No. 2	BSF-38 190.360 25	26	27	28	29
EXP 11	BSF-17 141.974 12	BSF-19 143.132 13	BSF-20 141.316 14	EXP 15	16	17	18	19

BSR CORE

LOADING NO.: 21

DATE: January 7, 1972

Excess Reactivity = 5.7% $\Delta k/k$

OPERATING MASS: 4,092.058

ROD POSITIONS AT CRITICAL
(With Operating Mass)

ROD NO.	IN. WITHDRAWN	
1	9.605	10.925
2	9.605	10.925
3	9.605	10.925
4	9.605	10.925
5	23.000	10.925
6	23.000	10.925

REMARKS:

Kwhr at beginning - 36,439,954

Fig. 2. Core Loading No. 21 - BSR

Shutdowns

There was one unscheduled shutdown during the quarter. The unscheduled shutdown and the associated incident report number is listed in Table 2. Table 3 gives an analysis of both scheduled and unscheduled shutdowns.

Table 2. Unscheduled Shutdowns

Date	Duration (hr)	Incident Report No.	Remarks
3-19-72	0.167	ORNL-72-15	The reactor power was automatically reduced to 0.1 N_L when the No. 3 safety recorder failed and drove upscale past 1.1 N_F.

Table 3. Analysis of Shutdowns

Description of Shutdown	Number	Downtime (hr)
Scheduled		
Experimenters:		
No request to operate	25	1,173.700
Experiment insertion	1	0.717
Experiment removal	1	0.333
To reposition reactor	1	0.467
Subtotal	28	1,175.217
Reactor Operations:		
Quarterly	2	120.167
Refueling critical runs	3	18.466
Shim rod calibrations	4	88.117
TVA personnel training	260	57.349
Subtotal	269	284.099
Unscheduled		
Experimenters	0	0.000
Reactor Operations	1	0.167
Subtotal	1	0.167
Total	298	1,459.483

Maintenance and Changes

Changes made in the mechanical systems to improve operating conditions and/or to perform special tests are documented by the BSR mechanical design change memoranda system. Those changes which were made during this report period are listed in Table 4. Maintenance or changes on the instrumentation and mechanical components in the complex are listed in Tables 5, 6, 7, and 8. Table 9 presents the status of the ionization and fission chambers.

Table 4. Mechanical Design Change Memoranda Completed During This Report Period

Change Memo No.	Subject	General Description
BSR-2Mw-3	Modifications to demineralizer	The automatic mode of regeneration, using the Cycloflow valves, was removed. A system using hand valves was installed. The modification involved replacing polyvinylchloride (PVC) lines with stainless steel pipe and valves.
BSR-2Mw-4	Ports for special flow tests for Inspection Engineering	Flow-tap units were installed on the ducts leading to the south, center, and north cell-ventilation filter banks. The ports will provide nine entry points into the ducts for flow monitoring. The flow measurements will be made one time only; and upon completion of the measurements, each pipe coupling will be plugged.

Table 5. Maintenance and Changes, Instrumentation and Controls

Date	Component	Trouble or Change	Reason or Maintenance
1-3-72	No. 1 TV	Failure of the Cohu receiver	The filament winding for the high voltage rectifier was replaced.
1-3-72	Log-N period amplifier	Failure of a condenser	The condenser across the voltage-regulating tubes was replaced.
1-11-72	No. 2 TV	Failure of the Sony camera	The Sony camera was removed for maintenance. The Apex camera was installed as a temporary replacement.
1-26-72	No. 2 TV	Sony camera reinstalled	The camera received a general overhaul at the Instrumentation and Controls Division shop.
2-3-72	No. 1 TV	Poor reception	The voltage-regulating tube in the Cohu receiver was replaced.
2-8-72	Facility Radiation and Contamination Alarm System	Failure in telephone line between Buildings 3010 and 2500	Repairs were made to a faulty connection.
2-9-72	Log counting-rate meter	Unable to calibrate to 60-cycle line current	The log counting-rate meter was replaced.
2-11-72	Public-address system	Amplifier failure	The amplifier was retubed.
2-14-72	Log-N amplifier	Replaced	The log-N amplifier was replaced because occasional spikes had been noted on the log-N and period recorders.

Table 5 (continued)

Date	Component	Trouble or Change	Reason or Maintenance
2-17-72	Ionization chamber, position E	Installed spare log-N ionization chamber	PCP-III, type 106, SN-66-2 (dual ionization) chamber was installed in previously empty position E. The dual chamber was removed from the ORR in May, 1971, due to failure of the uncompensated section. The gamma compensated section will be used as a spare chamber for the log-N channel.
2-22-72	Log-N channel	Momentary upscale spikes as noted on the log N and the log-N period recorders	The following maintenance was performed in an effort to isolate the trouble: switched to the spare log-N ionization chamber (momentary upscale spikes continued); and replaced the voltage-regulating tube in the log-N amplifier which corrected the condition.
2-25-72	Log counting-rate meter	Sluggish response	The 6H6 diode tube was replaced, correcting the condition.
3-6-72 through 3-12-72	Log-N channel	Momentary upscale spikes	The following work was completed in an effort to isolate the source of the momentary spikes as noted on the log N and log-N period recorders: replaced the voltage-regulator tube in the log-N amplifier; disconnected the ionization chamber and installed a current source input to the log-N amplifier with continuation of occasional spikes; the voltage regulator was retubed; and the chamber power supply was replaced.

Table 5 (continued)

Date	Component	Trouble or Change	Reason or Maintenance
3-13-72	TV No. 1	Failure of the Cohu receiver	The receiver was removed to the shop for a general overhaul and was reinstalled.
3-13-72 through 3-17-72	Log-N channel	Momentary upscale spikes	The following work was completed (continued from previous week) in an effort to isolate the source of the momentary spikes as noted on the log N and log-N period recorders: observation was continued using a current source input to the log-N amplifier and installed on ac line voltage monitor. The conclusion was that the momentary spikes were caused by ac line voltage variations.
3-20-72	No. 3 safety recorder	Recorder amplifier failure	The recorder amplifier was replaced with a spare unit due to a failure on March 9, 1972.
3-22-72	Portable pH meter	Erratic readout	General repairs were completed.

Table 6. Maintenance and Changes, Mechanical System

Date	Component	Trouble or Change	Reason or Maintenance
1-4-72	Shim-rod assembly from CP-62 (No. 5)	Refueling	The assembly was transferred to the in-pool work platform for maintenance as follows: spent control-rod fuel element BSF-S-5 was replaced with a new element, BSF-S-11; the shim rod was checked for dimensional changes with none being detected (passed freely through a 0.030-in. oversized gauge); the magnet and armature were inspected and cleaned--there was no evidence of corrosion noted; and inspection of other components indicated satisfactory conditions. The assembly was installed in CP-42 to become the No. 3 shim rod.
1-4-72	Shim-rod assembly from CP-22 (No. 1)	Refueling	The assembly containing control-rod fuel element BSF-S-7 was transferred to CP-62 to become the No. 5 shim rod.
1-4-72	Shim-rod assembly from CP-42 (No. 3)	Refueling	The assembly containing control-rod fuel element BSF-S-9 was transferred to CP-22 to become No. 1 shim rod.

Table 6 (continued)

Date	Component	Trouble or Change	Reason or Maintenance
1-4-72	Shim-rod assembly from CP-64 (No. 6)	Refueling	The assembly was transferred to the in-pool work platform for maintenance as follows: spent control-rod fuel element BSF-S-6 was replaced with a new element, BSF-S-12; the shim rod was checked for dimensional changes with none being detected (passed freely through a 0.030-in. oversized gauge); the armature was cleaned and inspected with no evidence of corrosion noted; the drive tube was brushed and flushed with water; the No. 4 shim-rod-drive assembly (containing the servo control drive motor) was installed in the assembly after cleaning and inspection of the magnet--there was no evidence of corrosion noted; and inspection of other components indicated satisfactory conditions. The assembly was installed in CP-44 to become No. 4 shim rod.
1-4-72	Shim-rod assembly from CP-44 (No. 4)	Refueling	The assembly containing control-rod fuel element BSF-S-10 was transferred to CP-24 to become the No. 2 shim rod. The drive tube and armature were brushed and flushed with water. The drive assembly which was formerly in CP-64 (No. 6) was installed in the shim-rod assembly following cleaning and inspection of the magnet and clutch switch. There was no evidence of corrosion on the magnet and armature.

Table 6 (continued)

Date	Component	Trouble or Change	Reason or Maintenance
1-4-72	Shim-rod assembly from CP-24 (No. 2)	Refueling	The assembly containing control-rod fuel element BSF-S-8 was transferred to CP-64 to become No. 6 shim rod. The drive assembly was removed for cleaning and inspection of the magnet and clutch switch. Before reinstalling the drive assembly, the drive tube and armature were brushed and flushed with water. There was no evidence of corrosion on the magnet and armature.
1-20-72	Reactor secondary tower south fan	Failure of the Dodge Flexidyne coupling	The following new parts were installed in the coupling: bearing, seals, rotor, and SS shot.
2-28-72	No. 5 control-rod-drive motor assembly	Failure of motor bearings	The spare control-rod-drive motor assembly was installed.
2-28-72	Cell-ventilation system	Adjustment of weights on west high bay relief damper	Adjustments were made to allow the damper to open on a high bay negative pressure of 0.2 in. H_2O.
3-28-72	No. 4 control-rod-drive motor assembly	Faulty tachometer retaining screws	Three new retaining screws were installed.

Table 6 (continued)

Date	Component	Trouble or Change	Reason or Maintenance
3-29-72	Shim-rod assembly from CP-22 (No. 1)	Scram time (time-of-flight from fully withdrawn to bottom seat) was 742 msec, as compared to a normal ∿487 msec	During the quarterly instrument checks, the scram time of the No. 1 control rod (time-of-flight from fully withdrawn to bottom seat) was found to be 742 msec, as compared to a normal ∿487 msec. The control-rod assembly was removed to the work platform for inspection, and the following work was completed before reinstallation: the control rod was checked for dimensional changes with none being detected (passed freely through a 0.030-in. oversized gauge); used a metal file to smooth the machined corners of the top of the control-rod fuel element assembly guide spacer to remove possible dragging effect; established vertical alignment between the lower guide tube and the control-rod fuel element assembly guide (improper alignment was the probable cause of the excessive time-of-flight since there was evidence of the control rod rubbing against the fuel element assembly guide); cleaned and inspected the armature; and cleaned and inspected the clutch switch and magnet. There was no evidence of corrosion. Following reinstallation, the time-of-flight was normal.
3-30-72	No. 5 selsyn (fine)	Faulty motor bearings	New bearings were installed.

Table 6 (continued)

Date	Component	Trouble or Change	Reason or Maintenance
3-13-72 through 3-17-72	Demineralizer	Converted to manual operation	The automatic mode of regeneration, using the Cycloflow valves, has required extensive maintenance and the operability has been unsatisfactory. A system using hand valves was installed to replace the Cycloflow valves, thereby converting from automatic to manual operation. The modification involved replacing the PVC lines with 304-L stainless steel pipe and valves as outlined in Mechanical Design Change Memo No. BSR-2Mw-3.
3-20-72	Secondary pH probe filter	Improper pH readout	Because of a reduction in water flow, the filter was removed, cleaned, and reinstalled.
3-28-72	Demineralizer acid regenerant tank	Failure of the acid line check valve	The acid line was removed for maintenance as follows: installed a new acid line check valve, and installed a new diaphragm in the air-operated valve.

Table 7. Maintenance and Changes, Process System

Date	Component	Trouble or Change	Reason or Maintenance
1-12-72	Secondary acid-addition system	Replaced	The Milton-Roy pump was replaced with a new Lapp Pulsafeeder pump.
1-18-72	Secondary acid-addition system	Faulty check valve	The check valve in the acid line on the exit side of the acid pump was replaced.
1-27-72	Cell-ventilation system	Installation of new charcoal in the center filter bank	Because the efficiency of the old charcoal filters was too low, new charcoal was installed to ensure filter reliability.
1-28-72	Secondary acid pump	Insufficient acid pumping rate	The new Lapp Pulsafeeder pump was removed to the shop for checks.
2-11-72	Primary pump	Routine adjustment on the pump packing gland	The packing gland was tightened to reduce the leak rate from ∿50 to ∿15 ml/min.
2-16-72	Secondary acid pump	Shop maintenance	The new Lapp Pulsafeeder pump was installed following replacement of the diaphragm head.
3-1-72	Cell-ventilation system	Installed ports for special flow tests for Inspection Engineering	Ports for special flow tests for Inspection Engineering were installed in the east, center, and west filter banks in accordance with Mechanical Design Change Memo No. BSR-2Mw-4.

Table 8. Maintenance and Changes, BSR Services

Date	Component	Trouble or Change	Reason or Maintenance
1-19-72	Air-conditioning units Nos. 1 and 2	Burst steam traps	The steam traps on both units were replaced.
2-3-72	Air-conditioning units Nos. 1 and 2	Replaced faulty steam condensate lines	Hand valves were installed upstream from the steam traps. New lines were installed downstream from the steam traps.
3-17-72	Air-conditioning unit No. 1	Noisy operation on "cool" position	The fan motor bearings were replaced.
3-17-72	Room "B" sink	Excessive hot and cold leaks	A new faucet was installed.

Table 9. Status of Ionization Chambers

Chamber Serial No.	Location	Date Present Service Started	Previous Service	Remarks
		Chambers in Service		
PCP-III-106, SN-66-1	Position B, servo	1-29-68	None	The uncompensated section of this chamber failed on June 16, 1969. It was in service as the No. 2 safety at the time of failure.
PCP-III-106, SN-66-4	Position D, log N and No. 3 safety	8-26-70	No. 3 safety and log N at the BSR	This chamber was repaired on May 6, 1969, and returned to service.
Modified LITR chamber CTC-4	Position C, No. 1 safety	12-1-69	LITR	This chamber, which was used in the LITR dry-channel position, was recanned so it could be used in water-cooled reactors such as the ORR and BSR. Pre-operational checks, including a check of saturation characteristics, indicated that the chamber is performing satisfactorily.

Table 9 (continued)

Chamber Serial No.	Location	Date Present Service Started	Previous Service	Remarks
Modified LITR chamber CTC-3	Position A, No. 2 safety	10-8-69	LITR	This chamber is similar to CTC-4. Pre-operational checks, including a check of saturation characteristics, indicated that the chamber is performing satisfactorily.
PCP-III-106, SN-66-2	Position E, spare log N	2-17-72	BSR and ORR	This dual chamber was installed in the BSR in May, 1969. In November, 1969, both sections failed, and repairs were made. The chamber was installed in the ORR in May, 1971. In July, 1971, the uncompensated section failed and the chamber was removed from the ORR to plug storage.
		Chambers not in Service		
PCP-III-106, SN-66-3	Instrument repair shop		No. 1 safety and log N at the BSR	Both sections had failed.
PCP (old type with no serial number)	BSR storage		BSR	This is in reserve for the PCA but can be used in an emergency for the BSR.

Table 9 (continued)

Chamber Serial No.	Location	Date Present Service Started	Previous Service	Remarks
PCP (old type with no serial number)	Warehouse storage		No. 2 safety at the BSR	This chamber is of the old type and will be repaired if and when it is needed.
CIC (old type with no serial number)	BSR storage		BSR	This chamber is in reserve for the PCA but can be used in an emergency for the BSR.
CIC (old type with no serial number)	BSR storage		BSR	This chamber is in reserve for the PCA but can be used in an emergency for the BSR.
Modified LITR chamber CTC-2	BSR storage (spare)	9-9-70	No. 3 safety at the BSR	This chamber was removed from service as the No. 3 safety since the uncompensated section of PCP-III-106, SN-66-4 could be used.

Fuel

Changes in the fuel inventory are reflected in Table 10.

Table 10. Fuel and Shim Rod Status

	This Quarter	Last Quarter	Year To Date
Fuel elements depleted	0	0	0
Control-rod fuel elements depleted	2	0	2
New fuel elements placed in service	1	4	1
New control-rod fuel elements placed in service	2	0	2
New fuel elements available for use	6	7	6
New control-rod fuel elements available for use	8	10	8
Partially depleted fuel elements available for use	18	17	18
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 11. 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 11. Facilities Assignment

Facility	Location	Division or Sponsor
Liquid helium cryostat	Southwest corner of pool using west D_2O tank	Solid State
Liquid nitrogen cryostat	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)	East D_2O tank	Unassigned
Dry thermal-neutron tubes (east, center, southwest, and northwest)	East D_2O tank	Unassigned

D_2O Tanks. - An off-gas hood to the normal off-gas (NOG) system was installed over the D_2O overflow bottles. The off-gas hood contains a Drierite bottle. Two 1/2-in. x 3-in. slots in the sides of the hood permit a sweep of air from the building (high-bay area) through the hood to prevent excessive negative pressure on the overflow bottles and to allow dried air intake on the contraction of the D_2O.

The functions of the off-gas system are as follows:

1. During expansion of the D_2O, gases will flow from the D_2O bottles through the Drierite bottle, into the off-gas hood, and into the NOG system along with a sweep of air from the high-bay area.
2. During contraction of the D_2O, air from the high-bay area will enter the hood through two slots, pass through the Drierite bottle, and enter the overflow bottle, thereby removing moisture which might contaminate the D_2O with H_2O.

Front-Face Irradiation Facility Tube. - The two 1-in.-diam pins on 5-in. centers were removed. A new plate containing two 5/8-in. pins on 4 3/8-in. centers was installed. The change was necessary to allow installation of the tubes on the presently used north face mounting bracket.

Demineralizer Performance

Table 12 gives detailed information on the condition of the primary water system and pertinent data on the performance of the bypass demineralizer.

Table 12. Demineralizer Performance Data

Run No.	Initiation Date	Termination Date	Throughput (gal)	Gross Gamma (Counts min^{-1} ml^{-1})		pH		Specific Resistance (ohm-cm)	
				In	Out	In	Out	In	Out
1	2-7-67	6-2-67	3,704,900	829	43	6.2	6.4	950,555	1,621,665
2	6-2-67	9-26-67	3,931,300	1,867	122	6.3	6.6	750,665	1,895,715
3	10-12-67	12-4-67	1,748,900	2,420	144	6.2	6.4	866,875	2,027,000
4	12-8-67	3-4-68	2,988,200	1,681	55	6.1	6.3	963,500	2,064,900
5	3-8-68	6-7-68	3,064,800	1,664	73	6.2	6.6	962,500	2,125,000
6	6-21-68	9-23-68	2,990,870	1,140	86	6.3	6.5	983,000	2,390,000
7	9-27-68	12-23-68	2,947,920	2,315	87	5.8	6.0	950,000	2,100,000
8	12-24-68	3-17-69	2,829,500	1,980	107	6.4	6.7	1,036,000	3,023,000
9	3-21-69	6-9-69	2,643,100	1,717	137	6.8[a]	6.9[a]	1,002,080	2,378,750
10	6-12-69	7-31-69	1,596,700	1,714	122	7.1[a]	7.2[a]	860,000	3,033,330
11	8-4-69	8-14-69[b]	278,500	1,253	134	7.3[a]	7.6[a]	800,000	2,500,000
12	8-19-69	10-21-69	2,166,200	1,622	124	6.0	6.1	1,000,000	2,500,000
13	10-24-69	11-17-69	682,900	1,644	93	5.8	5.9	864,000	1,420,000
14	11-22-69	12-5-69	394,400	1,325	172	6.4	6.4	720,000	1,267,860
15	12-24-69[c]	1-5-70	325,560	1,599	186	6.3	6.4	545,000	2,262,500

[a] These values, as measured by field instruments, are ∿0.6 pH high when compared to values obtained by laboratory instruments.

[b] The unit was removed from service for the resin columns to be regenerated because of a high pH output. The conductivity was satisfactory.

[c] The anion resin (21 cu ft) was replaced with resin formerly used in the LITR demineralizer (17.4 cu ft). This exchange was made after the BSR resin was inspected under magnification and found to be severely deteriorated (beads broken).

Table 12 (continued)

Run No.	Initiation Date	Termination Date	Throughput (gal)	Gross Gamma (Counts min^{-1} ml^{-1})		pH		Specific Resistance (ohm-cm)	
				In	Out	In	Out	In	Out
16	1-6-70	2-2-70	930,000	1,503	206	6.1	6.3	847,000	2,917,000
17	2-4-70	3-2-70	946,500	2,038	193	6.0	5.9	668,000	2,560,000
18	3-3-70	3-21-70	613,000	1,970	136	6.2	6.1	849,000	2,110,500
19	3-25-70	5-7-70	1,417,000	1,836	187	6.0	5.9	880,000	1,206,500
20	5-10-70	5-20-70	315,000[d]	1,600	180	5.6	5.4	810,000	1,450,000
21	5-20-70	7-15-70	1,756,300	1,960	190	6.1	6.0	900,000	2,100,000
22	7-17-70	9-2-70	787,000	1,168	93	6.0	5.9	633,850	1,443,870
23	9-10-70	1-25-71	2,695,700	1,232	92	5.9	5.7	899,000	1,517,000
24	1-28-71	5-10-71	2,054,600	948	61	5.8	5.7	1,116,000	1,693,000
25	5-11-71	7-29-71	1,638,900	780	61	6.1	5.9	939,000	1,623,000
26	8-3-71	10-5-71	1,261,800	1,426	139	5.9	5.8	1,204,000	1,855,000
27	10-8-71	1-19-72	1,308,600	1,903	129	5.8	5.7	818,000	1,663,000
28	1-20-72	3-28-72	1,840,600	1,778	117	5.8	5.8	874,000	1,301,000
29	3-29-72	In service	68,120			5.8	6.0	900,000	1,750,000

[d]The demineralizer was removed from service to regenerate the anion column after adding 3.6 cu ft of Ionac 540 resin.

Primary Water System

A routine ionic analysis was made on a sample of BSR pool water. The results are compared in Table 13 with similar data from a sample taken in June, 1970.

Table 13. Ionic Analysis

Material	June 26, 1970 (ppm)	March 10, 1972 (ppm)
Al	0.010	≤0.010
Ca	0.090	0.016
Cl	1.000	1.800
Cr	0.005	<0.010
Cu	0.005	<0.010
F	1.700	<0.200
Fe	1.070	<0.020
Mg	0.030	<0.005
Na	0.050	0.019
Ni	0.020	<0.010
NO_3	0.100	0.029
SO_4	0.500	<1.000
U	0.005	<0.010
Co_3 as $CaCO_3$	-----	<1.000
HCO_3 as $CaCO_3$	-----	<1.000
Alkalinity as $CaCO_3$	-----	<1.000
Dissolved Co_2	-----	40.000
Ca hardness as $CaCO_3$	-----	<0.100
Total hardness as $CaCO_3$	-----	<0.200
Non-volatile matter (NVM)	-----	<1.800
Total solids	-----	1.800
Po_4	0.070	<0.030 μg/ml
Si	0.200	<0.400 μg/ml

Secondary Water System

Table 14 gives information on a corrosion sample that was removed last quarter.

Table 14. Corrosion Sample Data on the Secondary Cooling System

Sample Material	Date Removed	Holder Location	Date Inserted	Rate of Loss (mil/yr)
Mild steel	9-28-71	Tower riser	8-18-70	0.5

Special Tests

Efficiency Tests

Tests were performed by Inspection Engineering on the charcoal filters. Details are given in Table 15.

East D_2O Tank

A summary of information which has been collected on the east D_2O tank since its present usage began is presented in Tables 16 and 17. Table 16 relates the production of ^3H to accumulated power on the reactor and the contamination level (purity) of the D_2O, while Table 17 contains chemical-analysis-type information.

Table 15. Efficiency Test Results, Filters

Date	Unit	Remarks
		Cell-Ventilation System
2-11-72	Center bank	An elemental iodine retention efficiency test was performed on the center filter bank (following installation of new charcoal) with results as follows: 99.995%.
3-28-72	South bank	An elemental iodine retention efficiency test was performed on the south filter bank (following installation of new charcoal) with results as follows: 99.983%.

Table 16. D_2O (East) Irradiation Facility

Date	Accumulated Power on Reactor (MWhr)	^3H (μc/ml)	^3H/MWhr	D_2O Content (%)
December, 1965	0.37×10^3	3	0.8×10^{-2}	99.27
August, 1968	7.68×10^3	85	1.1×10^{-2}	99.68
May, 1969	15.82×10^3	160	1.0×10^{-2}	Not reported
February, 1972	37.32×10^3	342	0.92×10^{-2}	99.47

Table 17. Data on D_2O (East) Irradiation Facility

Date	Gas Analysis (volume %)					pD	Specific Resistance (ohms-cm)	Al (mg/ml or ppm)	^{210}Po (counts min^{-1} ml^{-1})
	D_2	H_2	O_2	N_2	CO_2				
December, 1965	67.17	NR*	6.73	29.99	NR*	NR*	NR*	NR*	NR*
May, 1969	57.34	NR*	4.99	32.29	NR*	8.02	3.16×10^5	0.40	<1
						6.83	2.49×10^5	0.2	
						7.71	1.08×10^5	0.3	
						6.69	1.16×10^5	0.4	
January, 1970	NR*	<1.5	22	78	<0.2	NR*	NR*	NR*	NR*
February, 1972	NR*	NR*	NR*	NR*	NR*	8.70	NR*	<1	∿0

*NR = Not reported.

Shim Rod Calibrations

The BSR shim rods were calibrated after core loading 21 had been established. The results are shown in Appendix A. The total worth of all six rods is 11.512% $\Delta k/k$. 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$10.91 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 9.52 in. to comply with the same operating limit. Appendix A also shows the comparison of rod worths for January, 1970, January, 1971, October, 1971, and January, 1972.

Special Programs

The BSR was used as an experiment facility to aid the TVA trainees from the Browns Ferry nuclear power reactor in conducting experiments and gaining reactor startup training.

These experiments were three of a series of six performed by the TVA trainees. The remaining experiments were performed at the Pool Critical Assembly and are described elsewhere in this report.

Xenon Buildup and Decay Experiment

Following operation at 2 Mw to achieve xenon equilibrium, the power level of the BSR was reduced to 4 kw to begin the experiment for the TVA trainees to study the buildup and decay of xenon in the BSR core. The trainees 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) startup of the reactor, maintaining the reactor critical at 4 kw, and shutdown of the reactor at 15- to 30-minute intervals; (2) determining the reactivity worth of the shim rods (rods 1-4 ganged with rods 5 and 6 at 23 in. withdrawn) under varying concentrations of xenon following each reactor startup; and (3) determining the reactivity worth of xenon in the core as a function of time.

Measurement of Half Life of Simple Radioactive Decay

The BSR was operated at a power level of 100 kw to irradiate five aluminum samples at the east face of the east D_2O tank. The samples were irradiated for 10, 8, 6, 4, and 2 minutes, respectively. The TVA trainees performed all activities associated with the experiment under the direct supervision of an Operations Division supervisor. The experiment was an exercise in: (1) handling of radioactive materials; (2) measuring the half-life of a radioactive sample; and (3) determining the saturated activity for the neutron source used for activation.

Chamber Classes

The exercise was conducted in the north end of the BSR pool. A counting-rate channel was set up ready for use. A Sb-Be source was used as a source of neutrons. The class was conducted by an engineer of the Instrumentation and Controls Division and was an exercise in: (1) instrumentation used in the counting-rate channel; (2) behavior of the fission chamber; (3) counting rate versus PHS with the neutron source withdrawn; (4) counting rate versus PHS with the neutron source present; (5) uncompensated ionization chamber; and (6) compensated ionization chambers.

POOL CRITICAL ASSEMBLY

Operations

The PCA was used 111.8 hrs as an experiment facility for the benefit of the University of Tennessee nuclear engineering students (30 hrs) and trainees from the TVA Browns Ferry nuclear power reactor (81.8 hrs). 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 18 (Usage of Pool Critical Facility). The PCA maintenance is listed in Table 19.

Table 18. Usage of Pool Critical Facility

Date	Operational Activity	Purpose
January 11 and 12	Checkout of reactor instrumentation	Preparing for the approach-to-critical experiment for TVA
January 18	To demonstrate use of the PCA	TVA Browns Ferry nuclear power reactor trainee familiarization
January 19, February 2 and 16	Established cores Nos. 118, 119, and 120 to obtain a critical mass following the standard approach-to-critical procedure	Conducting experiments for the TVA trainees from the Browns Ferry nuclear power reactor
January 20 and 21, February 3, 4, 17, and 18	Established core No. 77 to permit calibration of the regulating rod and the performance of the importance function experiment	Conducting experiments for the TVA trainees from the Browns Ferry nuclear power reactor
February 29, March 1 and 2	Established cores Nos. 121, 122, and 123 to obtain a critical mass following the standard approach-to-critical procedure	Conducting experiments for the University of Tennessee nuclear engineering students
March 28	Check of reactor instrumentation started	Preparing for experiments for the University of Tennessee nuclear engineering students in April

Table 19. PCA Maintenance

Date	Trouble or Condition	Action
1-19-72	Unstable signal in primary fission chamber channel	Replaced tubes in the A-1 amplifier
2-2-72	Unstable signal in primary fission chamber channel	Replaced the counting-rate meter
2-25-72	No. 2 coarse selsyn motor failure	Replaced the coarse selsyn motor with a spare unit

Experiments

Experiments were conducted at the PCA by students from the Nuclear Engineering Department of the University of Tennessee and trainees from the TVA Browns Ferry nuclear power reactor as indicated in Table 18. 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 and the TVA trainees 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 TVA trainees.

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 TVA trainees.

APPENDIX A

INTRA-LABORATORY CORRESPONDENCE

OAK RIDGE NATIONAL LABORATORY

January 17, 1972

To: Distribution

Subject: Calibration of BSR Shim Rods

The BSR shim rods were calibrated following the refueling operation to establish BSR loading No. 21. The resulting reactivity worth curves are attached, along with a plot of excess reactivity versus the ganged rod position of rods 1-4. Loading 21 resulted in a net gain in total worth of the six shim rods, i.e., a change from a total of 10.618% $\Delta k/k$ to 11.512% $\Delta k/k$. The increase was expected, as the fuel content of the reactor was increased, particularly the fuel content of the shim-rod elements.

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

1. all six rods ganged at 10.91 inches withdrawn; and
2. rods 5 and 6 at 23 inches withdrawn, rods 1-4 ganged at 9.52 inches withdrawn.

Rod worths determined during the four most recent calibrations are compared in Table 1 below.

Table 1. Comparison of BSR Rod Worths (% $\Delta k/k$)

Rod No.	January, 1970	January, 1971	October, 1971	January, 1972
1	1.773	1.762	1.710	1.944
2	1.810	1.914	1.690	1.864
3	3.089	3.011	2.716	3.018
4	3.203	3.010	2.714	2.962
5	1.005	0.910	0.922	0.852
6	1.056	0.928	0.866	0.872
1-4	9.875	9.697	8.830	9.788
5-6	2.061	1.829	1.788	1.724
Total	11.936	11.526	10.618	11.512

S. S. Hurt III

S. S. Hurt, III

SSH:kmh

Distribution: C. B. Gaither, T. P. Hamrick, E. D. Lance, W. H. Tabor, BSR Control Room

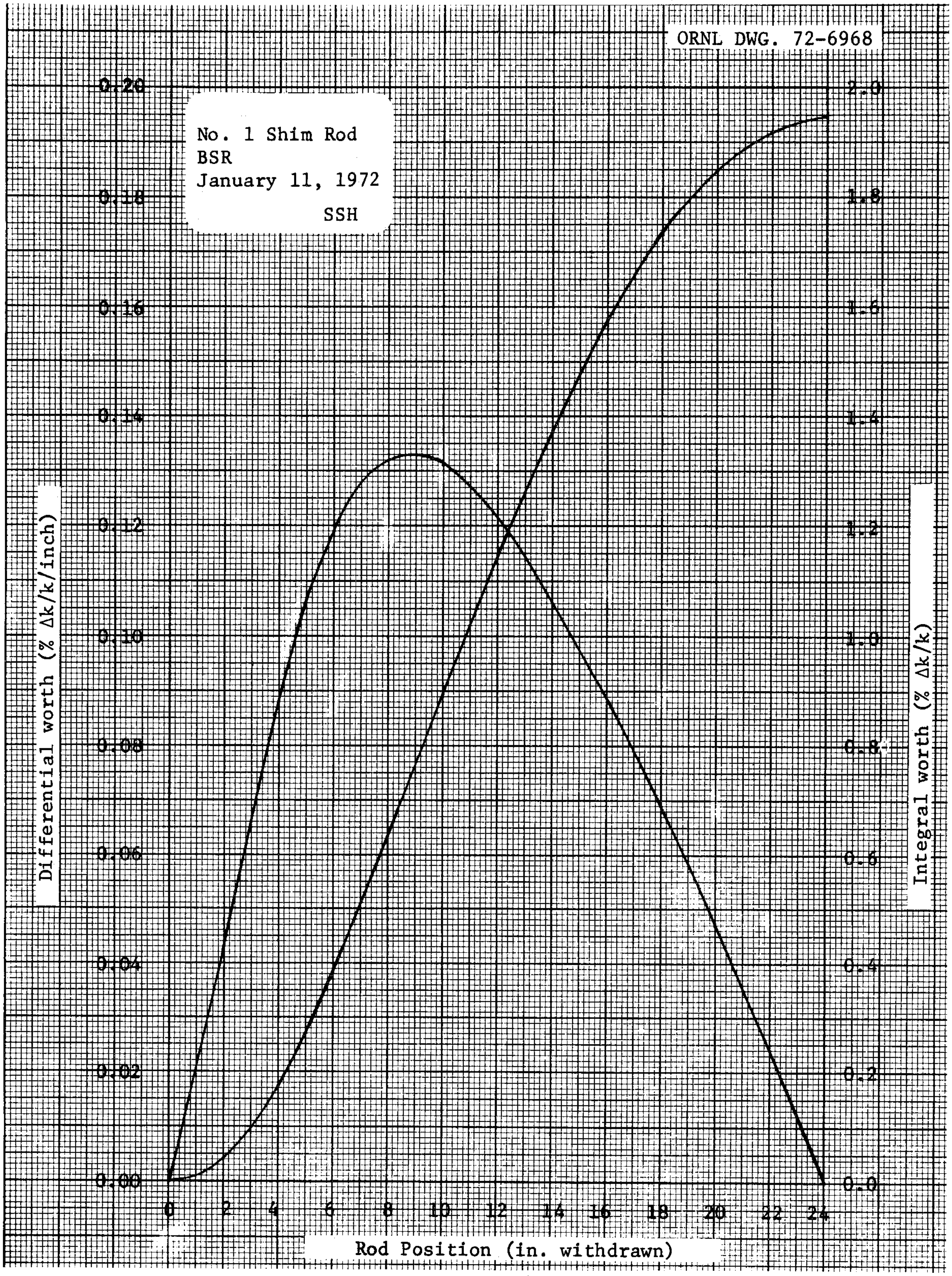

ORNL DWG. 72-6968
No. 1 Shim Rod
BSR
January 11, 1972
SSH
Differential worth (% Δk/k/inch)
Integral worth (% Δk/k)
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
2
4
6
8
10
12
14
16
18
20
22
24
Rod Position (in. withdrawn)

Figure 1

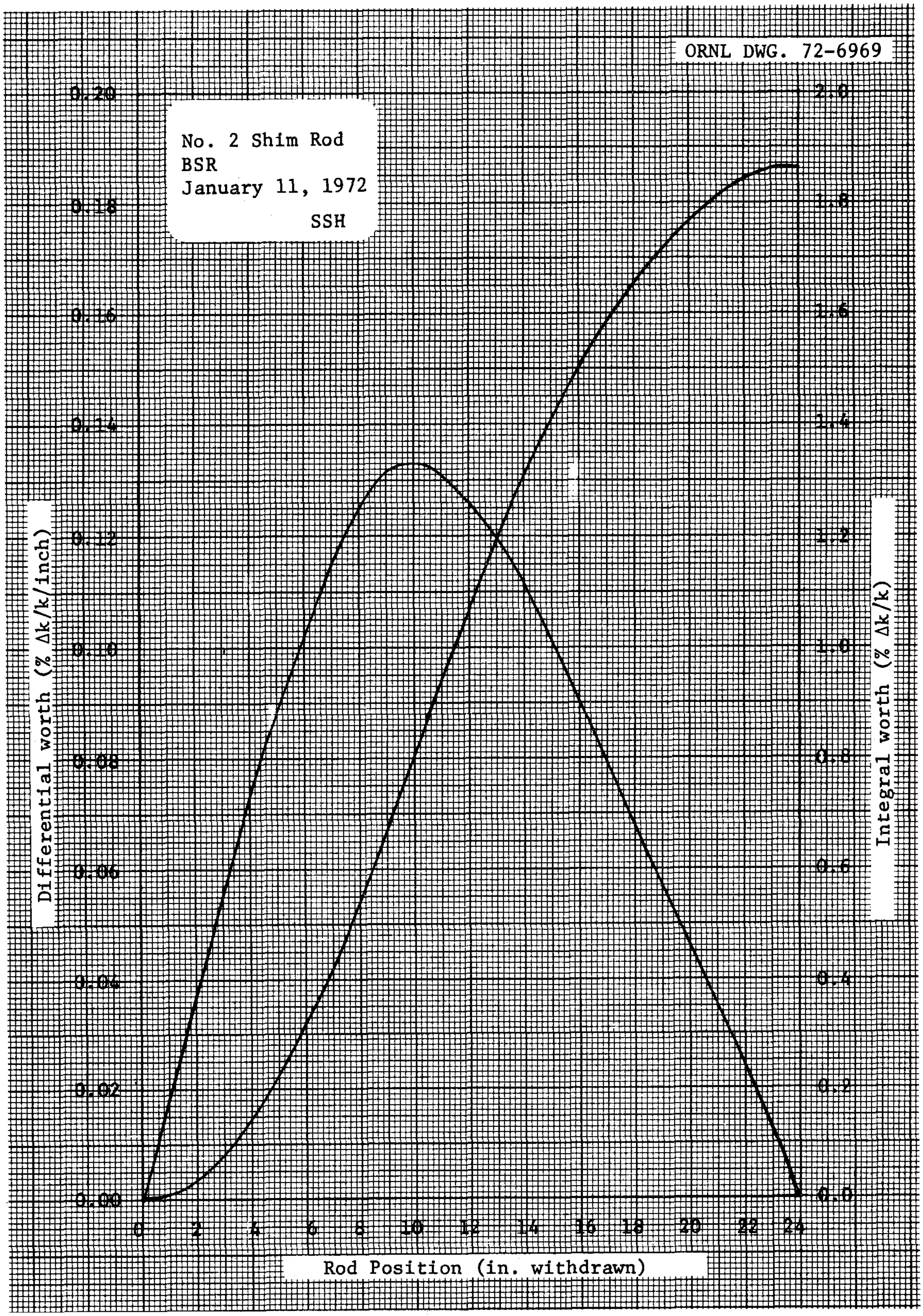

ORNL DWG. 72-6969
No. 2 Shim Rod
BSR
January 11, 1972
SSH
Differential worth (% Δk/k/inch)
Integral worth (% Δk/k)
Rod Position (in. withdrawn)
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
2
4
6
8
10
12
14
16
18
20
22
24

Figure 2

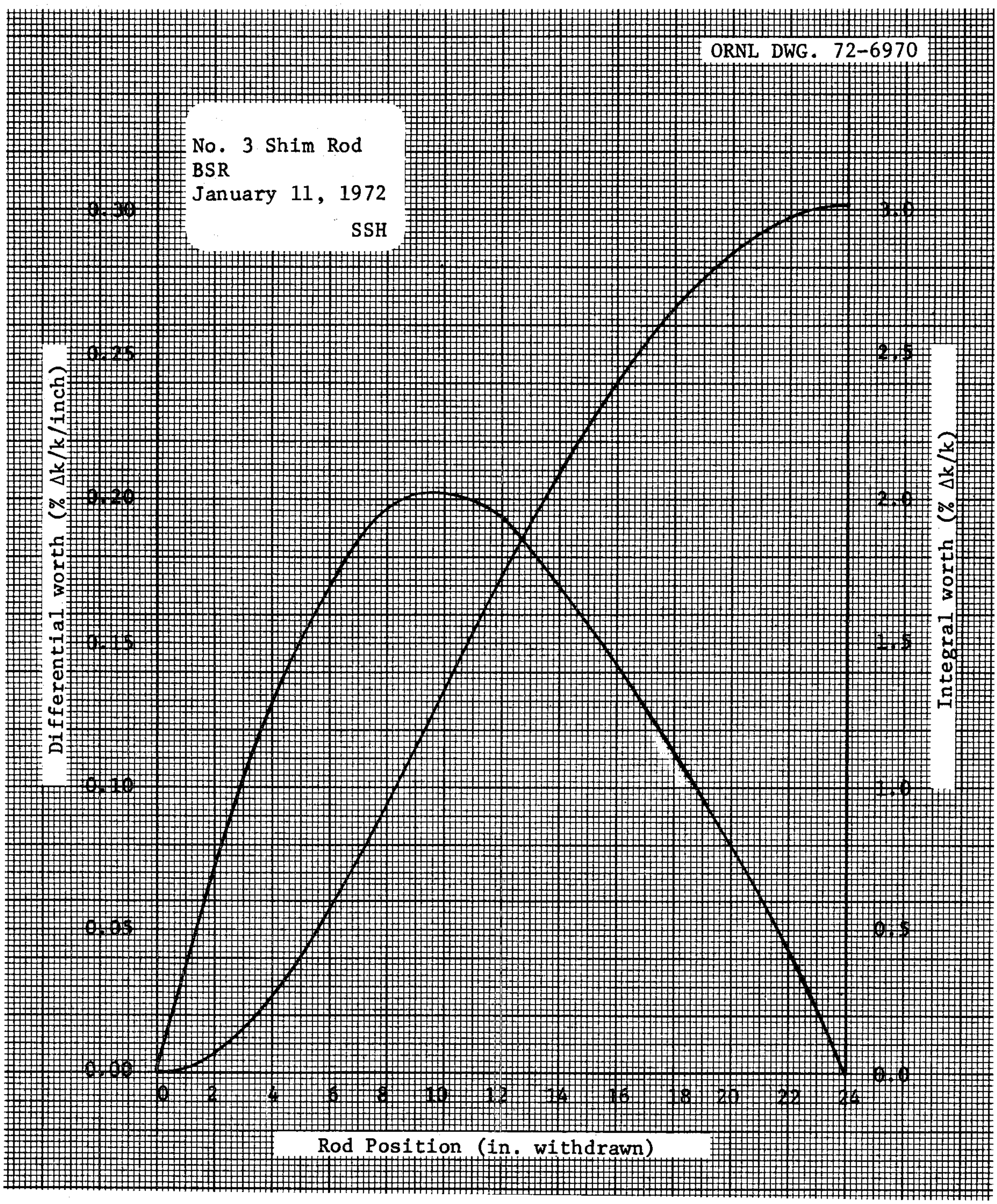

ORNL DWG. 72-6970
No. 3 Shim Rod
BSR
January 11, 1972
SSH
Differential worth (% Δk/k/inch)
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Integral worth (% Δk/k)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
2
4
6
8
10
12
14
16
18
20
22
24
Rod Position (in. withdrawn)

Figure 3

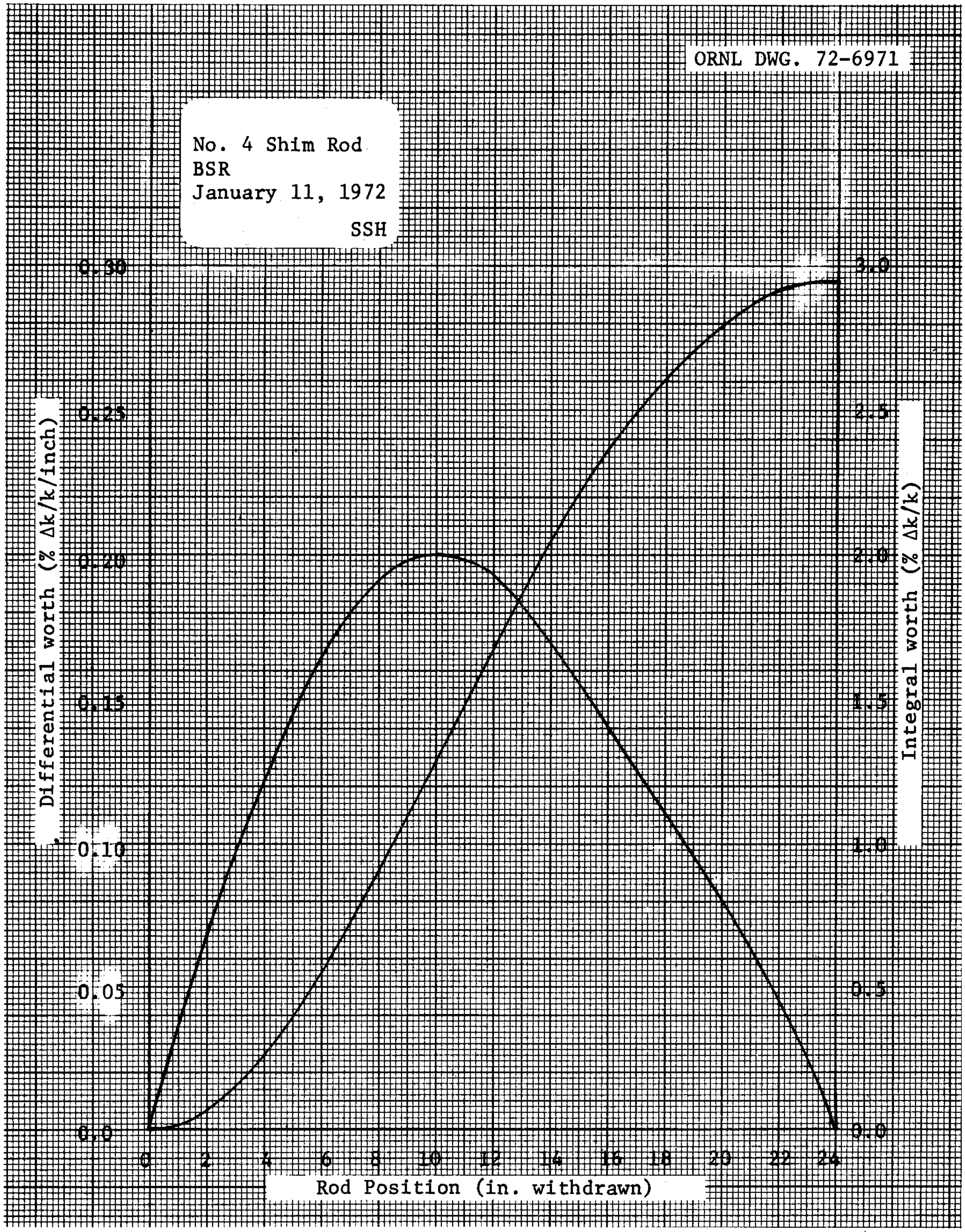

ORNL DWG. 72-6971
No. 4 Shim Rod
BSR
January 11, 1972
SSH
Differential worth (% Δk/k/inch)
0.30
0.25
0.20
0.15
0.10
0.05
0.0
Integral worth (% Δk/k)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
2
4
6
8
10
12
14
16
18
20
22
24
Rod Position (in. withdrawn)

Figure 4

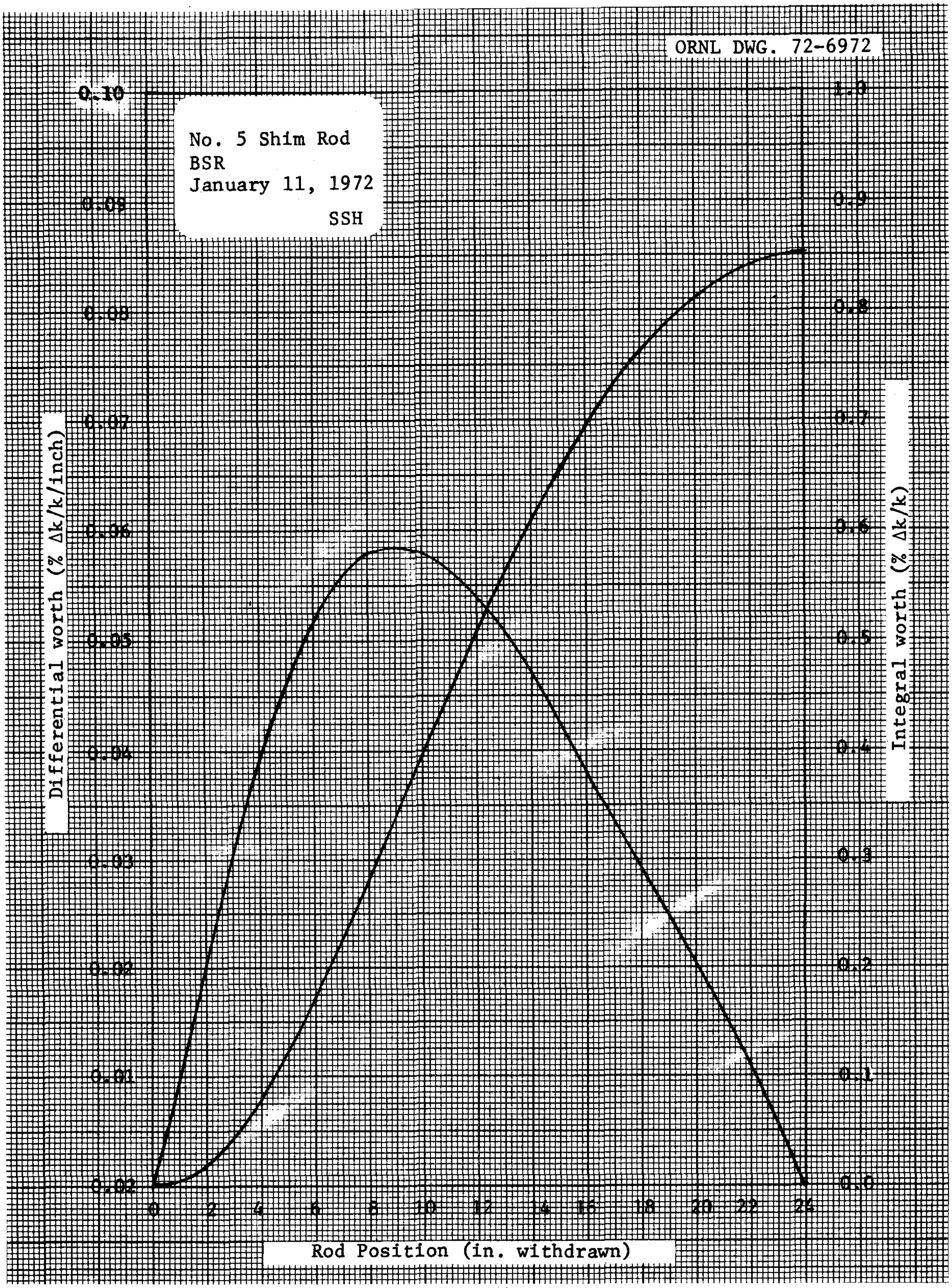

ORNL DWG. 72-6972
No. 5 Shim Rod
BSR
January 11, 1972
SSH
Differential worth (% Δk/k/inch)
Integral worth (% Δk/k)
Rod Position (in. withdrawn)
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.02
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
2
4
6
8
10
12
14
16
18
20
22
24

Figure 5

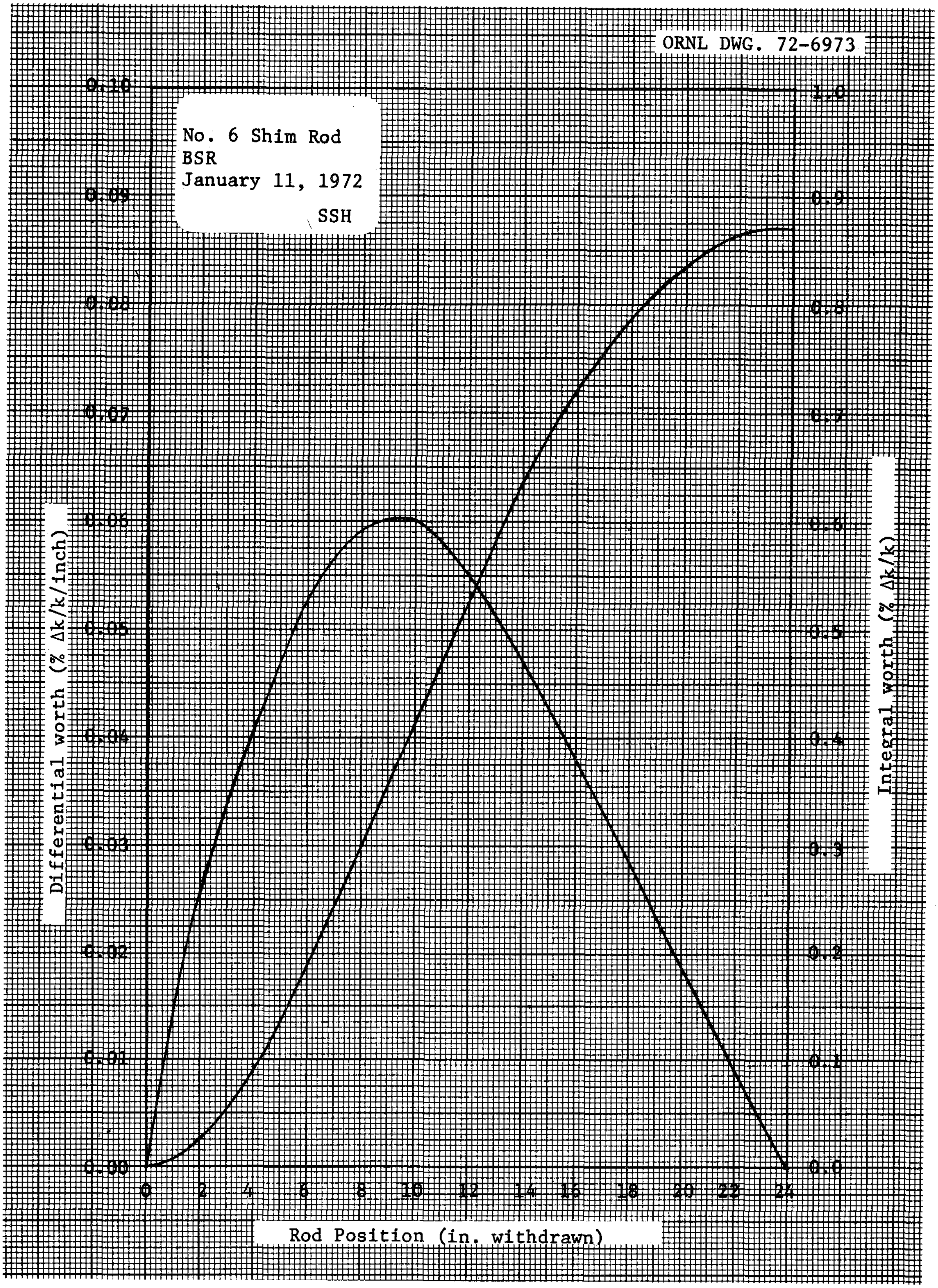

ORNL DWG. 72-6973
No. 6 Shim Rod
BSR
January 11, 1972
SSH
Differential worth (% Δk/k/inch)
Integral worth (% Δk/k)
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0 2 4 6 8 10 12 14 16 18 20 22 24
Rod Position (in. withdrawn)

Figure 6

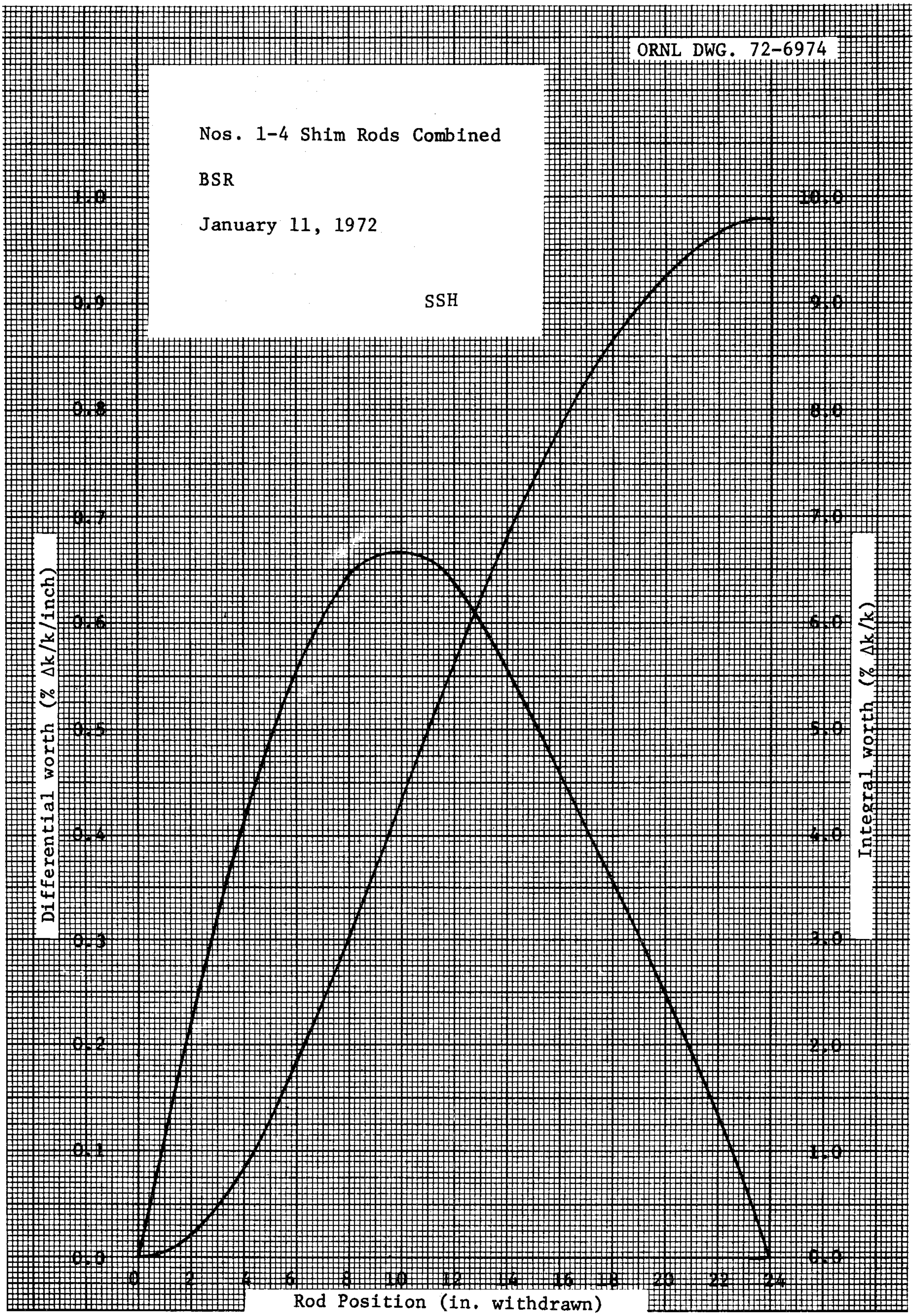

ORNL DWG. 72-6974
Nos. 1-4 Shim Rods Combined
BSR
January 11, 1972
SSH
Differential worth (% Δk/k/inch)
Integral worth (% Δk/k)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0
2
4
6
8
10
12
14
16
18
20
22
24
Rod Position (in. withdrawn)

Figure 7

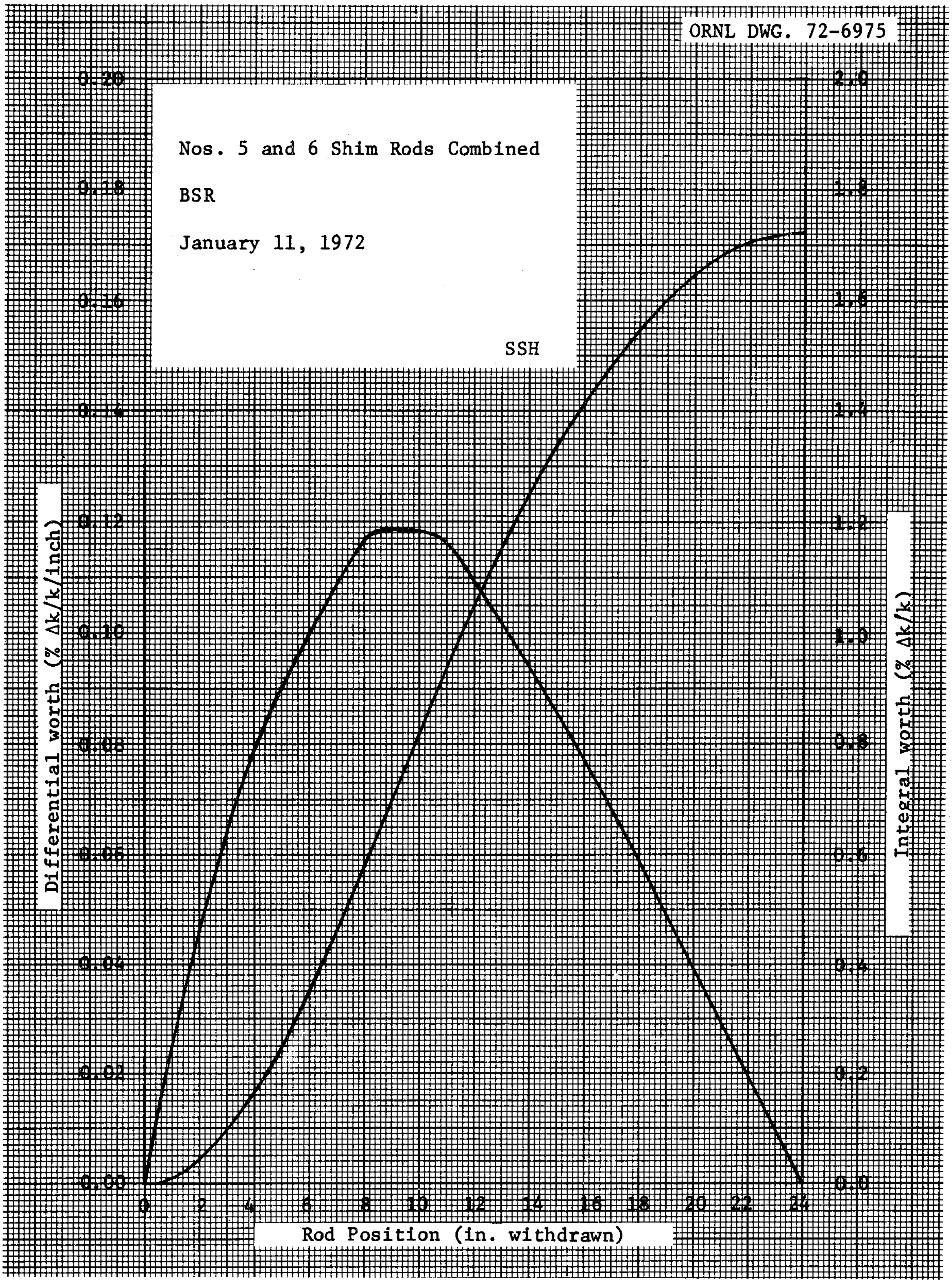

ORNL DWG. 72-6975
Nos. 5 and 6 Shim Rods Combined
BSR
January 11, 1972
SSH
Differential worth (% Δk/k/inch)
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
0.16
0.18
0.20
Integral worth (% Δk/k)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
0
2
4
6
8
10
12
14
16
18
20
22
24
Rod Position (in. withdrawn)

Figure 8

ORNL DWG. 72-6976

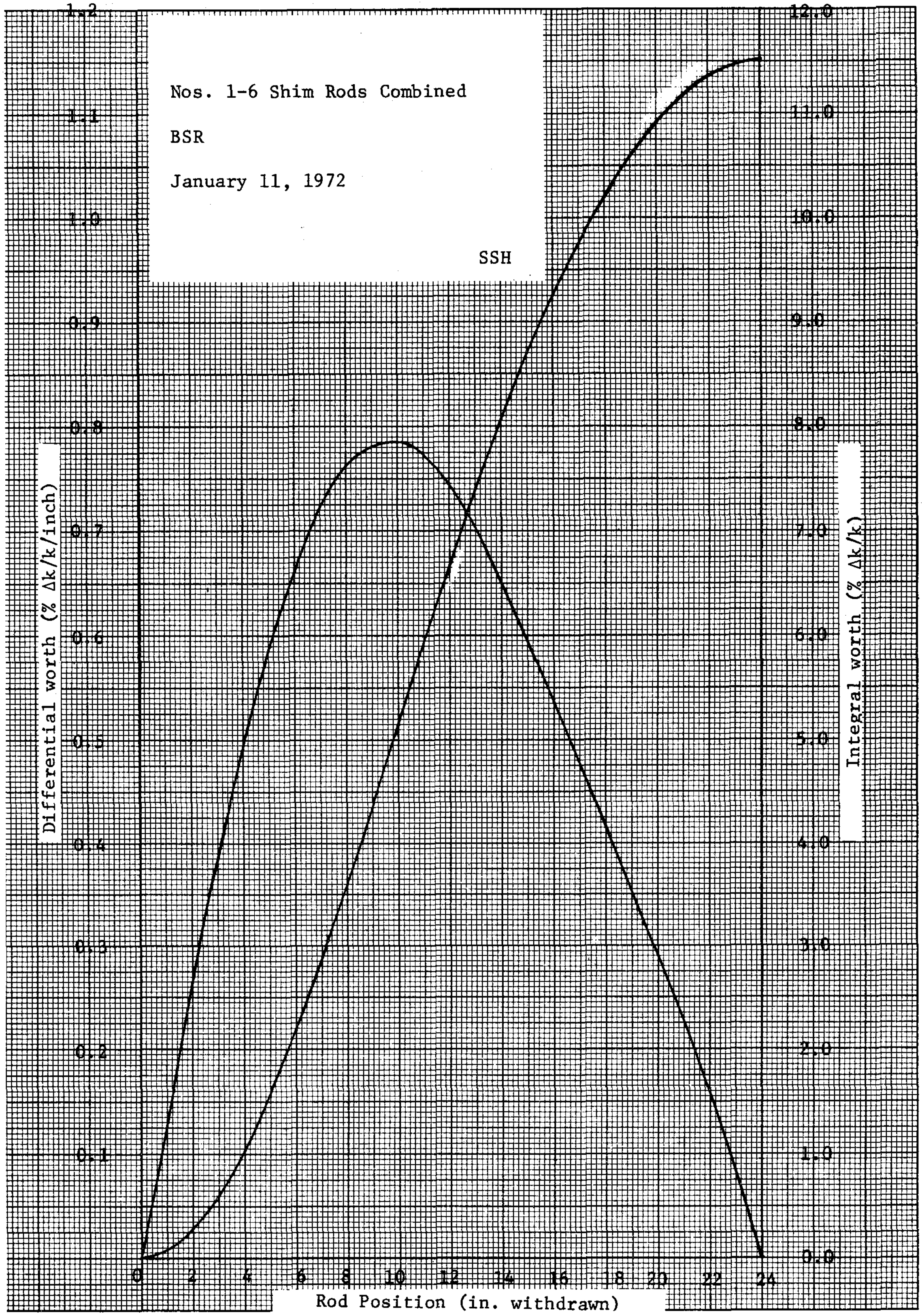
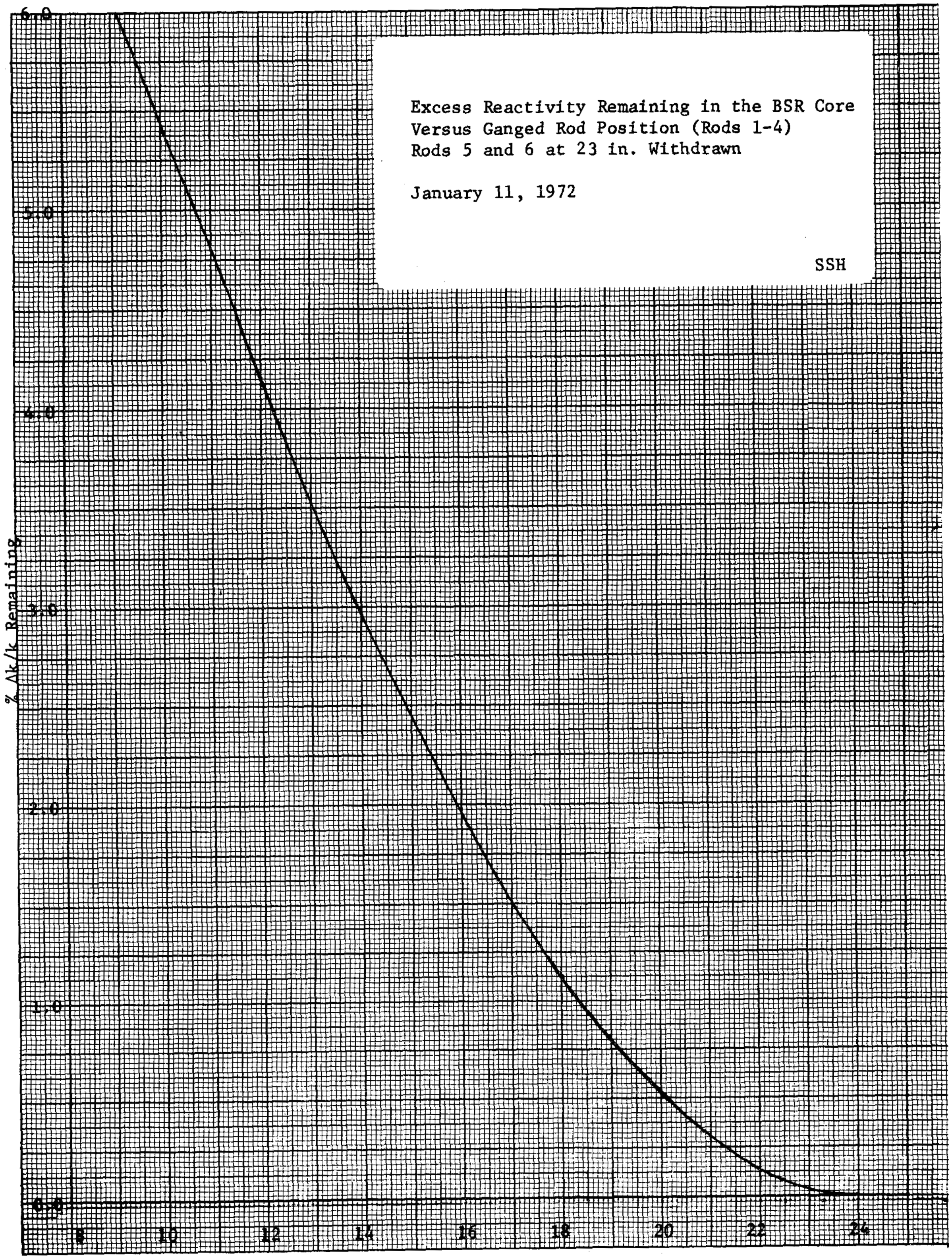


Figure 9

ORNL DWG. 72-6977



Ganged Position of Rods 1-4 (inches withdrawn)

Figure 10

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