BuMines OFR 68-86

PB86-216587

A mining research contract report
SEPTEMBER 1982

INSTRUMENTED IN-MINE TESTING OF THE BUREAU OF MINES LOW-RPM DEEP-CUTTING CONTINUOUS MINING MACHINE

Contract H0282029
Southwest Research Institute

Bureau of Mines Open File Report 68-86

BUREAU OF MINES
UNITED STATES DEPARTMENT OF THE INTERIOR

50272-101

REPORT DOCUMENTATION PAGE	1. REPORT NO. BuMines OFR 68-86	2.	3. Recipient's Accession No. PB86 216587/AS

4. Title and Subtitle
Instrumented In-Mine Testing of the Bureau of Mines Low-RPM, Deep-Cutting Continuous Mining Machine

5. Report Date
Sept. 1982

6.

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10. Project/Task/Work Unit No.
05-5473

11. Contract(C) or Grant(G) No.
(C) H0282029
(G)

12. Sponsoring Organization Name and Address
Office of Assistant Director--Mining Research
Bureau of Mines
U.S. Department of the Interior
Washington, DC 20241

13. Type of Report & Period Covered
Contract research
9-29-78--8-31-82

14.

15. Supplementary Notes
Approved for release Oct. 17, 1983.

16. Abstract (Limit: 200 words)

The Federal Coal Mine Health and Safety Act of 1969 established maximum airborne respirable dust exposure levels for underground coal mines. In an effort to provide the knowledge needed to achieve compliance without reducing productivity, the Bureau of Mines has sponsored research oriented toward improving mining machines. This work has consistently shown that a deep-cutting, low-rpm (revolutions per minute) continuous miner can reduce respirable dust levels without production penalties. To provide the design data by manufacturers to produce production versions of the deep-cutting machine, a prototype miner was instrumented and in-mine tests were conducted. The data acquisition system developed for this testing allowed real-time monitoring of selected machine parameters to include cutterhead bit forces, power levels, structural loads, and pressures. During the in-mine tests, these parameters were recorded for a wide range of operating conditions. Test variables were advance rate, bit lacing, and head rotary speed. Analysis of the test data was performed to quantify the characteristics in terms useful to the designers of continuous mining equipment. Peak, average, and root-mean=square values for power, torque, RPM, boom loads, and bit loads were computed.

17. Document Analysis a. Descriptors
Mining research
Underground testing
Deep cutting
Continuous mining machine
Instrumentation
Respirable dust

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report)	21. No. of Pages
Release unlimited by NTIS	Unclassified	125
	20. Security Class (This Page)	22. Price
	Unclassified	

(See ANSI-Z39.18) See Instructions on Reverse OPTIONAL FORM 272 (4-77) (Formerly NTIS-35) Department of Commerce

FOREWORD

This report was prepared by Southwest Research Institute (SwRI), located in San Antonio, Texas. Work described herein was authorized and funded under USBM Contract Number H0282029. The contract was initiated under the Coal Mine Health and Safety Program. It was administered under the technical direction of Twin Cities Research Center, with Mr. Kelly Strebig acting as the Technical Project Officer. Mr. Larry Rock was the Contract Administrator for the Bureau of Mines.

Submitted by the author on 21 September 1982, this report is a summary of work recently completed as part of this contract during the period of 29 September 1978 to 31 August 1982.

ACKNOWLEDGMENTS

Testing programs intended to coexist with mine production put a heavy burden on project personnel. These programs require the utmost in communication, cooperation, and hard work from all parties. Accordingly, the author wishes to recognize the important contributions made to this project by the following organizations and individuals:

- The U. S. Bureau of Mines, particularly Kelly Strebig, Linda Dahl, and Larry Rock, for expediting instrumentation approvals, test agreements, and contract continuations

- United Coal Company, particularly Dick Wolfe, Wes Blakely, and Gary Mullins, for their hard work in coordinating the underground testing with the mine

- The people of Bluestar No. 3 for their patience and help in dealing with our special needs

- The SwRI Test Crew, particularly Jim Grothues, John Prudhomme, David Wilkinson, Jim Sealy, and Tim Duncan, for their enthusiasm and hard work in spite of many personal sacrifices

All persons involved with this contract would like to express their condolences and extend a special acknowledgment to the family and friends of Jim Grothues, who was killed in an automobile accident on December 5, 1981, while en route to the mine.

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1.0 INTRODUCTION

The major objective of the program was to collect design data so that the manufacturers of continuous mining machines could have the information needed to produce *production* machines capable of generating less airborne dust. This objective is part of the Bureau's goal to provide the mining industry with the technology needed to implement safe mining practices without unduly compromising production. The deep-cutting, low-RPM type of continuous mining machine represents such a mechanism, if it were available as a standard product.

To attain the project objective, the program was performed in three phases. The first phase was devoted to defining the data requirements of the manufacturers and designing the associated data acquisition system (DAS). The second phase was devoted to the adaptation/installation of the data system on the USBM's machine, a Lee Norse Hard Head Model 456 (Figure 1). The third and final phase was devoted to testing the outfitted machine under representative mining conditions.

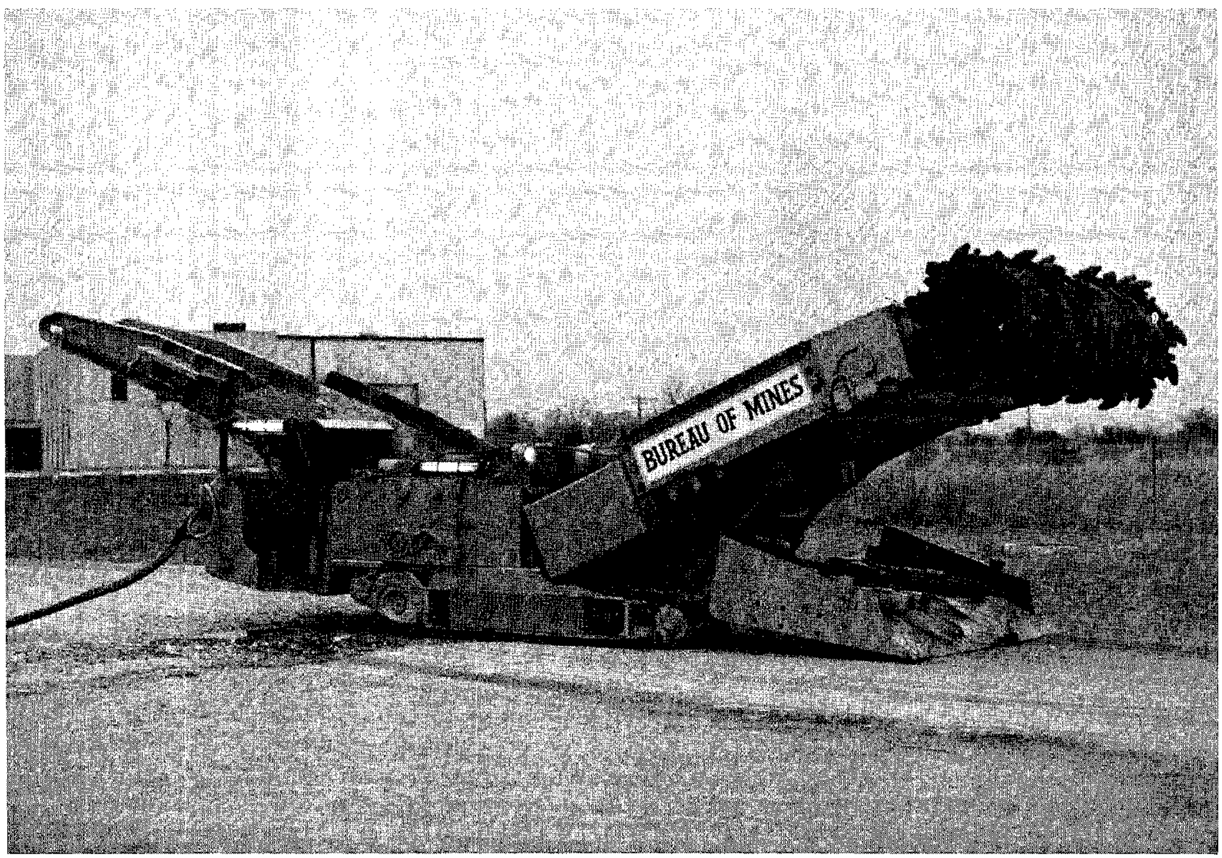


Figure 1. The USBM Continuous Mining Machine Used for the In-mine Testing

2.0 SUMMARY OF RESULTS

In-mine testing of the HH456 was conducted in a United Coal Company drift mine located near Grundy, Virginia. The seam, designated the "Splash Dam" was 6 to 8 feet in thickness and had a consistent middle rock band. The rock varied from 12 to 24 inches in thickness. The mine operated one conventional section, two shifts per day.

Preparations for the testing were initiated in September 1981 and completed in late October. Testing began shortly thereafter and was completed in early February 1982. During the test period, the machine ran at two different head rotary speeds: 18 and 51 RPM. For each head speed, the machine advance rate and bit spacing were varied incrementally. At each test condition, certain machine parameters were recorded to include head motor torques, head RPM, boom loads, and bit loads. Test data were analyzed to quantify the operational characteristics in terms useful to the designers of continuous mining equipment. Each recorded parameter was processed to provide average, root-mean-squared (RMS), and peak values for given cutting conditions. Additionally, certain parameters were combined to calculate quantities that could not be measured directly. These calculated quantities included horsepower and machine reactive forces at the face (horizontal and vertical) for each portion of the cutting cycle. A summary sheet for each test is included in Appendix A.

In general, the instrumentation system utilized in the mine performed well, considering the test environment. The transducers installed on the machine boom and chassis worked reliably and without failure. Problems, however, were encountered with the bit load measurement systems that were mounted on the cutterhead. Although the approach to measurement of the bit loads proved to be feasible, the effective life of the transducers (i.e., strain gages and thrust washers) employed was far less than originally expected. This short life was due in large part to the impact loading from the rock taken during the shear cycle and the corrosive effects of wetted coal dust in proximity to the strain gages. As a result, we quickly depleted our spare parts inventory and were not able to acquire replacement components within the time contraints of the program. Rather than postpone the program and jeopardize mine cooperation, we decided to continue with fewer bit load channels being recorded.

The cutting of the rock band not only contributed to the difficulties in measuring bit loads but also required some adjustment in the test plan. Originally, the test plan called for three incremental changes in face bit spacing—2 inches, 4 inches, and 8 inches. Although no difficulties were encountered at the lesser spacings, the 8-inch spacing induced severe machine displacement and vibration while cutting the rock. After two sump/shear cycles, it was clear that continued operation at the 8-inch spacing was overly abusive and, if continued, would result in machine failure. Consequently, the 8-inch configuration was discontinued and the cutterhead reconfigured to the 4-inch spacing for the remaining tests in the 8-inch series.

After completion of the in-mine testing, the data base was analyzed to determine the effects of depth of cut and RPM on the monitored and calculated parameters. The results of our data analysis provided both expected and unexpected relationships. In regard to torque, horsepower, and specific energy, the results exhibited characteristics similar to those observed by other investigators. (1,2)* On the other hand, cutting loads (as derived from bit measurements) and boom reactive forces differed considerably from those reported in the literature. Although some of the discrepancy can be attributed to differences in the approaches used to measure and/or infer the relationships, we could find no good reasons for rejecting our data simply because it departed from expectation. We can only conclude that the non-uniformity in the coal seam, from top to bottom, affected the distribution and magnitude of the forces. A complete discussion of the results and their interpretation is included in Section 4 of this report.

* Underscored numerals in parentheses refer to references listed at the end of the report.

3.0 EXPERIMENTAL PLAN

3.1 Test Machine

The particular continuous mining machine used in the testing was manufactured by the Lee Norse Company under contract to the USBM. Designated the "Hard Head" 456, the machine was designed and built to serve as a test base for assessing the effects of head rotary speed and depth of cut on Airborne Respirable Dust (ARD) levels. (3) Though it was patterned after the Lee Norse production model HH455, the HH456 incorporated several features not found in standard moduc-tion model HH455, the HH456 incorporated several features not found in standard machines. These special features gave the machine not only the power and robustness needed to operate at high depth of cut but also provided a means of changing the cutterhead rotary speed in discrete increments. A comparison of the standard HH455 with HH456 is presented in Table 1. The dimensional features of the HH456 are illustrated in Figure 2.

TABLE 1. Comparison of the HH456 to the HH455 Production Model

	HH456	HH455
Cutterhead Drum Diameter (inches)	44.50	38.75
Cutterhead Rotary Speed (RPM)	9, 18, & 51	55
Cutterhead Drive Motors (Hp) (Continuous Rating)	2 at 225 ea.	2 at 150 ea.
Cutterhead Drum Width (inches)	124	124
Basic Machine Weight (pounds)	105,000	97,000
Gathering Head	Dual Arm	Dual Arm
Auto Cutting Cycle	Yes	No
Thrust Control	Yes	No

Aside from the ability to change the rotary speed, the cutterhead could also be fitted with various bit block configurations and spacing increments. Throughout the testing, 45-degree bit blocks (Figure 3) were used. The bit spacing, however, was varied over a range from 2 to 8 inches in increments of 2 inches. These spacing changes were confined to the "face" bits only. The bits used to cut clearance for the boom struts and the drum ends were not changed.

The original bit type designed for the HH456 had a 4.75-inch gauge length and represented a sizable replacement cost. Because it is primarily the carbide insert that wears, an insert was designed to permit the use of a conventional bit type that costs significantly less than the original bit. By so doing, the head could be frequently fitted with new bits and thus minimize the influence of dull tools on the measurements. The bit/insert configuration is compared to the original bit in Figure 4. As indicated, the insert served as an extension for the smaller bit so that the gauge length remained the same as the original bit.

Prior to its delivery to SwRI for installation of the data acquisition system, the HH456 underwent a complete inspection and rebuild of critical systems. It was during this period of rework that some of the special machine features were eliminated. For example, the auxiliary sump/shear mechanisms needed to achieve high depths of cut were eliminated; the automatic control for the sump/shear cycle was likewise eliminated. These changes were made to simplify the maintainability

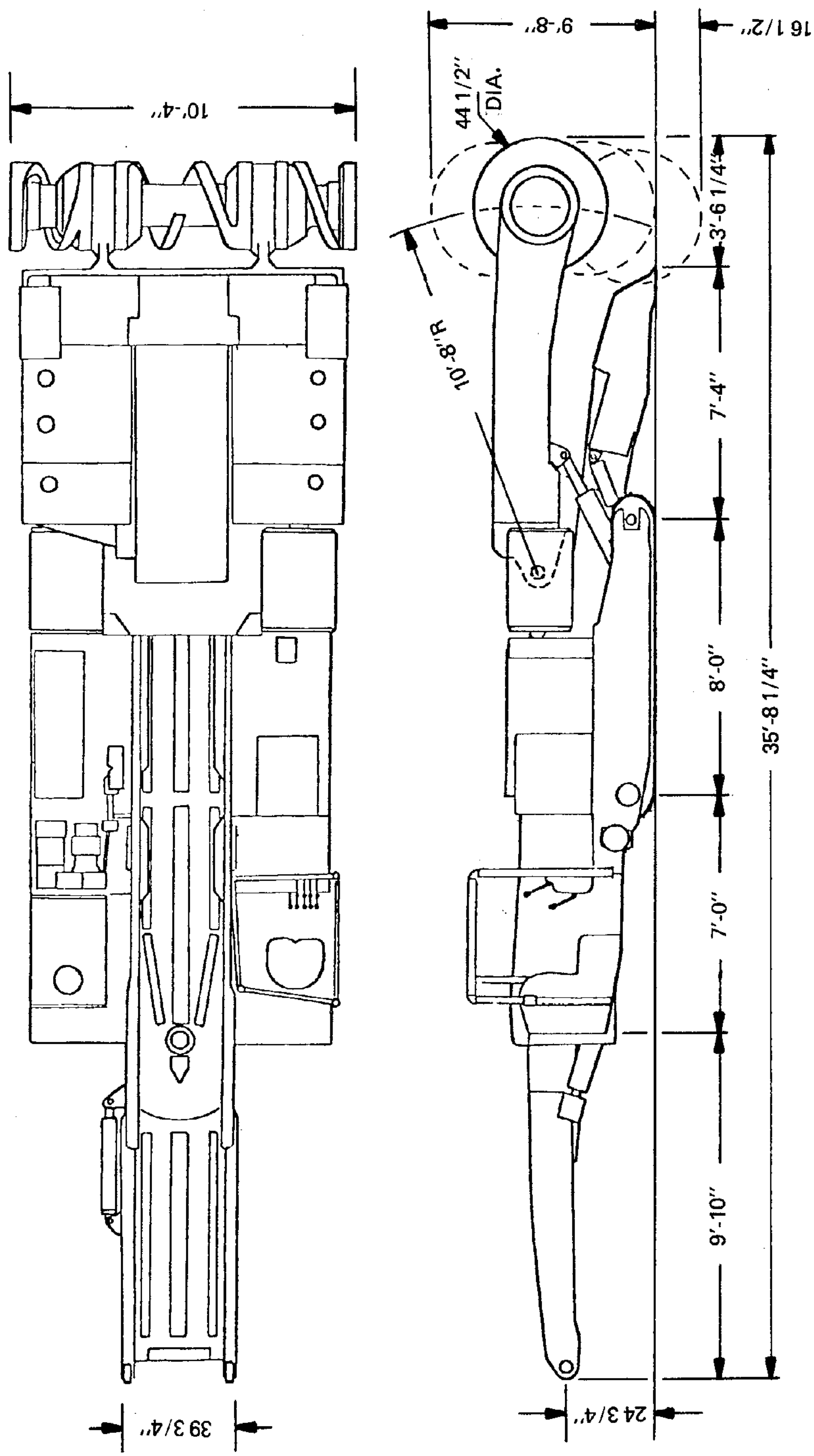


Figure 2. HH456 Dimensions

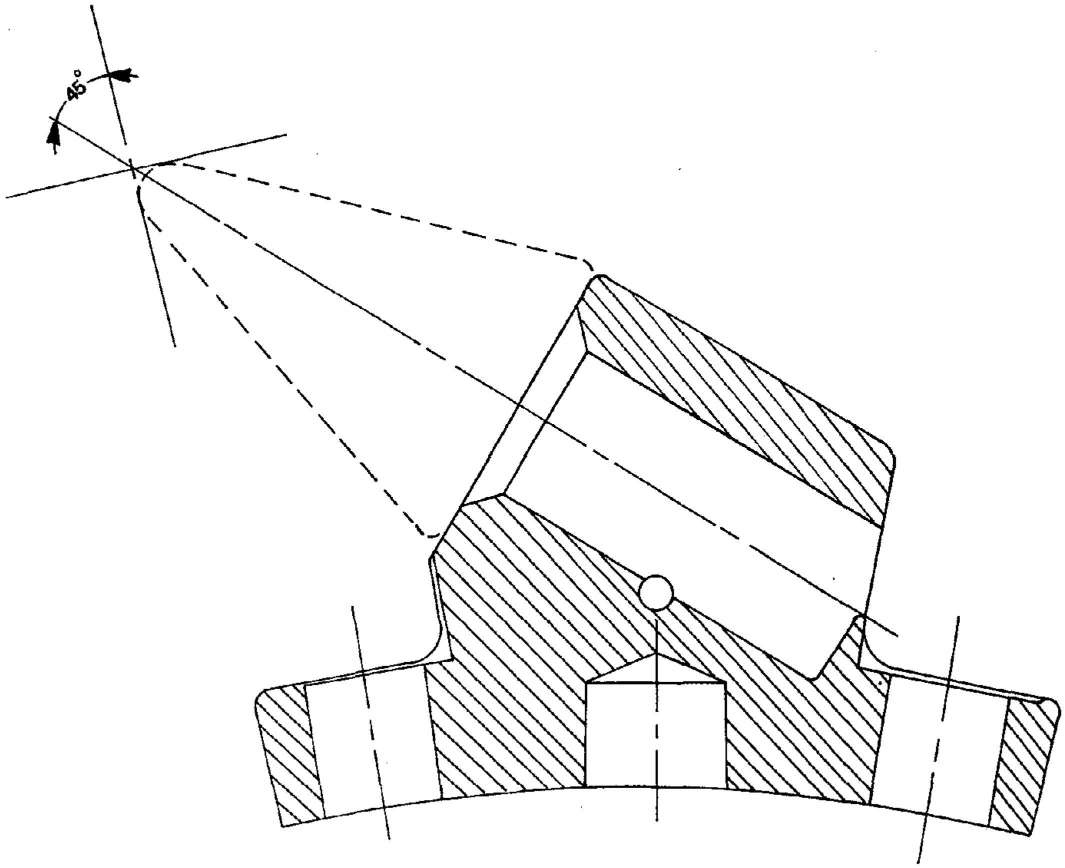


Figure 3. HH456 Bit Block—45 Degree Configuration

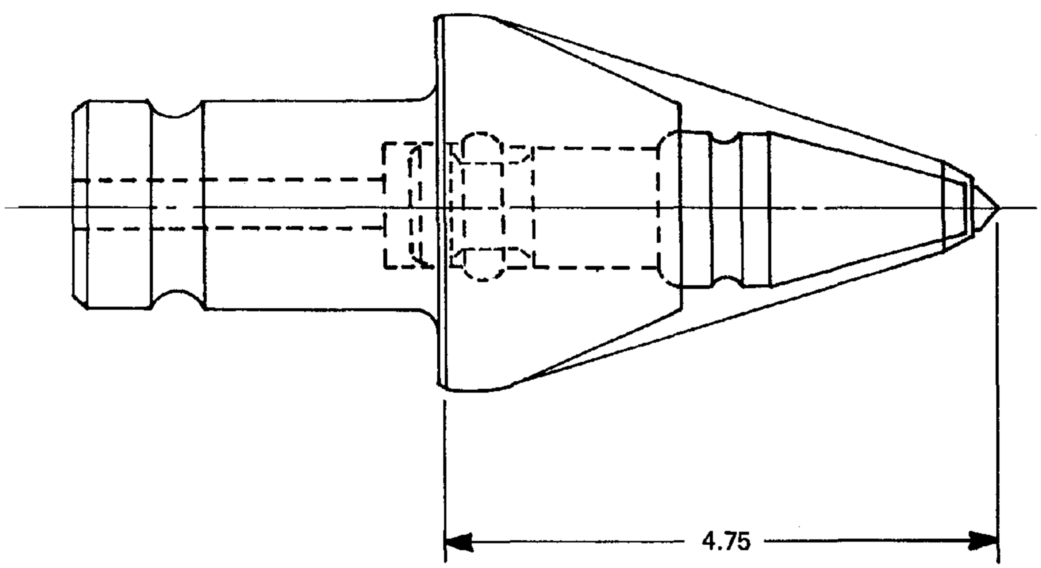


Figure 4. Geometric Comparison of the New Bit/Insert Configuration to the Original Plumb Bob Bit

aspects of the machine and enhance its appeal to mine operators who were being considered as participants in the testing. For all practical purposes, the HH456 was operationally no different than the HH455 at the time it was installed in the test mine.

3.2 Machine Design Data Requirements

To ensure that the experimental plan would yield the type of information most useful to the design of continuous mining machines, six manufacturers were consulted. The companies contacted were Fairchild Equipment, Jeffrey, Joy, Long-Airdox, National Mine Service, and Ingersoll-Rand. The following text presents a brief summary of the feedback received from the survey.

Collectively, the companies expressed interest in the deep-cutting concept and were encouraged to see the Bureau undertaking the effort. Some reservation was expressed, however, over the correlation of data derived from the HH456. These reservations arose from the fact that the HH456 is an experimental machine that does not necessarily reflect a common design philosophy. Consequently, the observed data would be unique, and the ability to apply the results to different machine designs would depend upon the completeness of supporting documentation—documentation in the form of test procedures, test logs, mine conditions, and data reduction techniques. Additionally, there was concern for the utility of data derived from a single mine.

Attempts to define criteria for selecting a "representative" mine were not overly successful. There is no standard set of parameters employed in building a machine for a customer. The design is largely dictated by the experience of the customer and/or the manufacturer, i.e., experience with bit life, maintenance, production, etc.; factors such a grindability, drillability, inclusions, etc., can provide insight but are not used as absolutes. All companies sited the mine floor to be particularly important because floor conditions affect the tramming rate/depth of cut and buoyancy of the machine.

To the companies contacted, 2 to 3-1/2 in./rev constitutes a deep cut. The problem in designing machines to operate at 2 to 3-1/2 in./rev is dictated primarily by the tractive force that can be generated and not so much by the packaging of the drive components. All recognize that the bit penetrations can be increased by reducing the number of bits in contact; however, in so doing, the spacing increases and coring may result. In exploring avenues of creating additional thrust, few people like the idea of auxiliary jacks or anchors interacting with the ribs or roof/floor. Often, conditions would prohibit their use—conditions such as a weak roof or interference with loading equipment. The practicality of jacks on production machines will have to be evaluated, eventually, because the trend is toward building smaller machines that will weigh proportionally less. The alternative would be to decrease the drum width.

The objective of the in-mine testing was to monitor those basic machine parameters needed to synthesize a design capability for future deep-cutting, low-RPM machines. Having talked to the manufacturers, an analysis network evolved. As shown in Figure 5, the process involved monitoring five parameters, with each parameter providing part of the information needed to assess the cutting conditions and design specifications/requirements.

3.3 Test Objectives and Variables

Although the manufacturers were instrumental in defining the kind of information desired, the Bureau specified the test conditions. The contract specified a systematic evaluation of the HH456, with the head rotary speed and depth of cut as the independent test variables. The head rotary speeds selected were 18 RPM and 51 RPM. Depth of cut was to be varied in three discrete

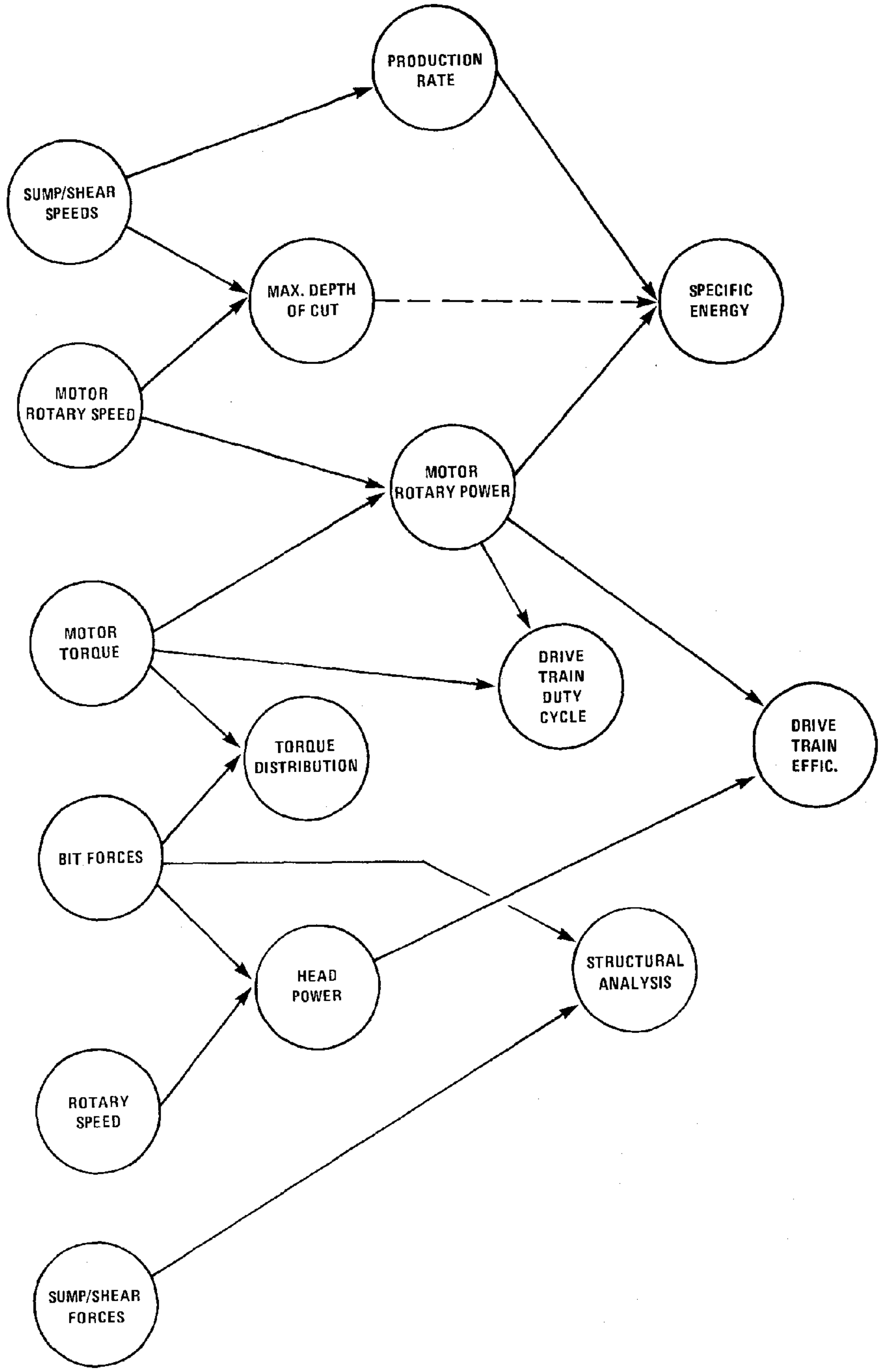


Figure 5. Design Data Network

levels—1, 2, and 3.5 inches per revolution—where depth of cut is defined as the maximum cutting depth a face bit achieves as it passes through the coal. The test design, as described, consisted of a two-factorial experiment with six combinations of rotary speed and depth of cut. Furthermore, each combination of machine's cutting parameters (RPM and depth of cut) was to be replicated five times. Accordingly, a total of thirty tests were required, as illustrated in Table 2.

TABLE 2. Test Matrix Layout*

HEAD ROTARY SPEED					
18 RPM			51 RPM		
DEPTH OF CUT			DEPTH OF CUT		
1 in./rev	2 in./rev	3-1/2 in./rev	1 in./rev	2 in./rev	3-1/2 in./rev
x	x	x	x	x	x
x	x	x	x	x	x
x	x	x	x	x	x
x	x	x	x	x	x
x	x	x	x	x	x

30 TESTS

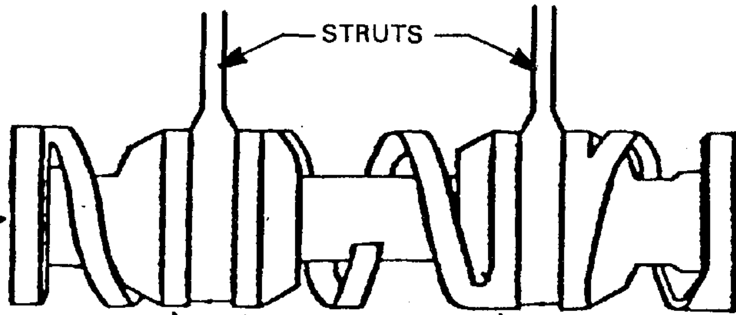
*Each "x" indicates a test, and each column represents the number of replicates.

The ratio of bit spacing to depth of cut was also constrained at a value of approximately 2.5 for each test cell. This constraint physically amounted to three different bit spacing combinations of 2, 4, and 8 inches as illustrated in Table 3. The resulting bit distributions for each of these spacings is shown in Figure 6.

TABLE 3. Face Bit Spacing for Each Depth of Cut

d[1], in.	S[2], in.	S/d
1	2	2
2	4	2
3.5	8	2.3

1. d = maximum depth of cut.
2. S = spacing between adjacent bits.



QUANTITY										TOTALS	
GAUGE BITS	9		2	2		2	2		9	26	2-INCH SPACING
'A' BITS		14			24			14		52	
										78	
GAUGE BITS	9		2	2		2	2		9	26	4-INCH SPACING
'A' BITS		7			12			7		26	
										52	
GAUGE BITS	9		2	2		2	2		9	26	8-INCH SPACING
'A' BITS		4			6			4		14	
										40	

Figure 6. Bit Distributions for Various Spacings

3.4 Data Acquisition System Design

The approach to the instrumentation design can be characterized by the following steps:

- Review of the permissibility requirements and discussions with MSHA and Bureau personnel
- Review of previous underground testing programs and identification of successful techniques and recommended practices (4)
- Review of the HH456 setup to see what could be salvaged
- With the parameters needed by the manufacturers and those needed for test control in mind, we reviewed available sources of MSHA approval components and systems.
- For those components or systems not available commercially in approved configurations, we defined the requirements to render them *intrinsically safe.*

From the beginning of the program, we felt that the most important piece of data acquisition was the bit loading. Because of the face environment and rotary motion of the head, it was also the most difficult measurement to make and involved novel techniques. Consequently, in Phases I and II, we designed, built, and tested a self-contained recording system that could be affixed to the cutterhead. Characteristics of the bit monitoring system are presented in Section 3.4.3.

3.4.1 Safety/Permissibility

To determine how the instrumentation system should be interfaced with the basic machine, we reviewed the typical sequence in terms of advancing the entry, the haulage system, and roof bolting. In conjunction, we reviewed the MSHA-enforced safety procedures that would effect access to the machine during the mining cycle. With this information, we could anticipate how best to power and lay out the signal conditioning/data acquisition system without jeopardizing the personal safety of site personnel.

Our approach to permissibility was to utilize approved equipment where possible. We found that various systems similar to that envisioned in this program had been approved, *but approval pertained to the entire system.* Thus, a subsystem approved as part of a total system did not mean it was approved as an item. Even with this limitation, we felt that there was advantage in using equipment that had been used successfully underground.

Fortunately, our selection of instrumentation did not require explosion-proof enclosures or testing. Certain parts of the system, however, were restricted to use in fresh air. In these instances, equipment interfaces were modified to incorporate barriers, thus providing the needed isolation under fault conditions. The machine-mounted instrumentation was made instrinsically safe by the use of (1) low-voltage, battery-operated circuitry; (2) current-limiting resistors; and (3) judicious design to eliminate inductors and large storage capacitances.

3.4.2 System Characteristics

The transducer arrangement used to monitor the parameters of interest is shown in Table 4. The physical location on the HH456 of each transducer is shown in Figure 7. It will be

TABLE 4. Summary of Transducer Characteristics

Measurement	Locations (Figure 11)	Transducer Type	Make/Model	Range (FS)	No. of Channels
Biaxial Acceleration of the Boom	1	Piezoresistive Accelerometer	Entran EGC-5000S-25	±25g	2
Motor Torque	2	Strain Gaged Shaft	LEBOW 1248-20K	20000 lbf-in	1
Boom Pivot Pin Load	3	Strain Gaged Pin	Strain Sert	100,000 lbf	1
Motor Rotary Speed	4	Magnetic Pickup	Action Sensor ASM 710	5000 RPM	1
Hydraulic Oil Temperature	5	Thermocouple	Action Sensor Type T AST-100	250°F	1
Bit Loading	6	Strain Gage	SwRI	5000 lbf	3
Electrical Power	7	Watt Transducer	Camille-Bauer 56-2P1-091	500 kW	1
Longitudinal Position & Velocity	8	Potentiometer DC Generator	Houston Scientific 1150-50	50 in (displ) 75 in/sec (vel)	2
Boom Angular Position & Velocity	9	Potentiometer DC Generator	Houston Scientific 1150-50	50 in (displ) 75 in/sec (vel)	2
Boom Cylinder Pressures	10	Strain Gaged Diaphragm	SENSOTEC A-5/767	±3000 psi	2

noted that the measurement system included those parameters designated by the manufacturers, as well as a biaxial accelerometer on the boom, sump/shear velocity transducers, a hydraulic oil temperature sensor, and an electrical power transducer. Although these additional parameters were not designated as being necessary by the manufacturers, they were included for the following reasons:

- *Biaxial Acceleration*—useful in characterizing the induced structural forces as a function of depth of cut
- *Sump/Shear Velocities*—mandatory for control of depth of cut
- *Hydraulic Oil Temperature*—useful as a test control parameter; i.e., functions are variant until control oil temperature stabilizes.
- *Electrical Power*—useful as an indication of motor efficiency and load sharing, as well as a backup means of calculating rotary horsepower and torque

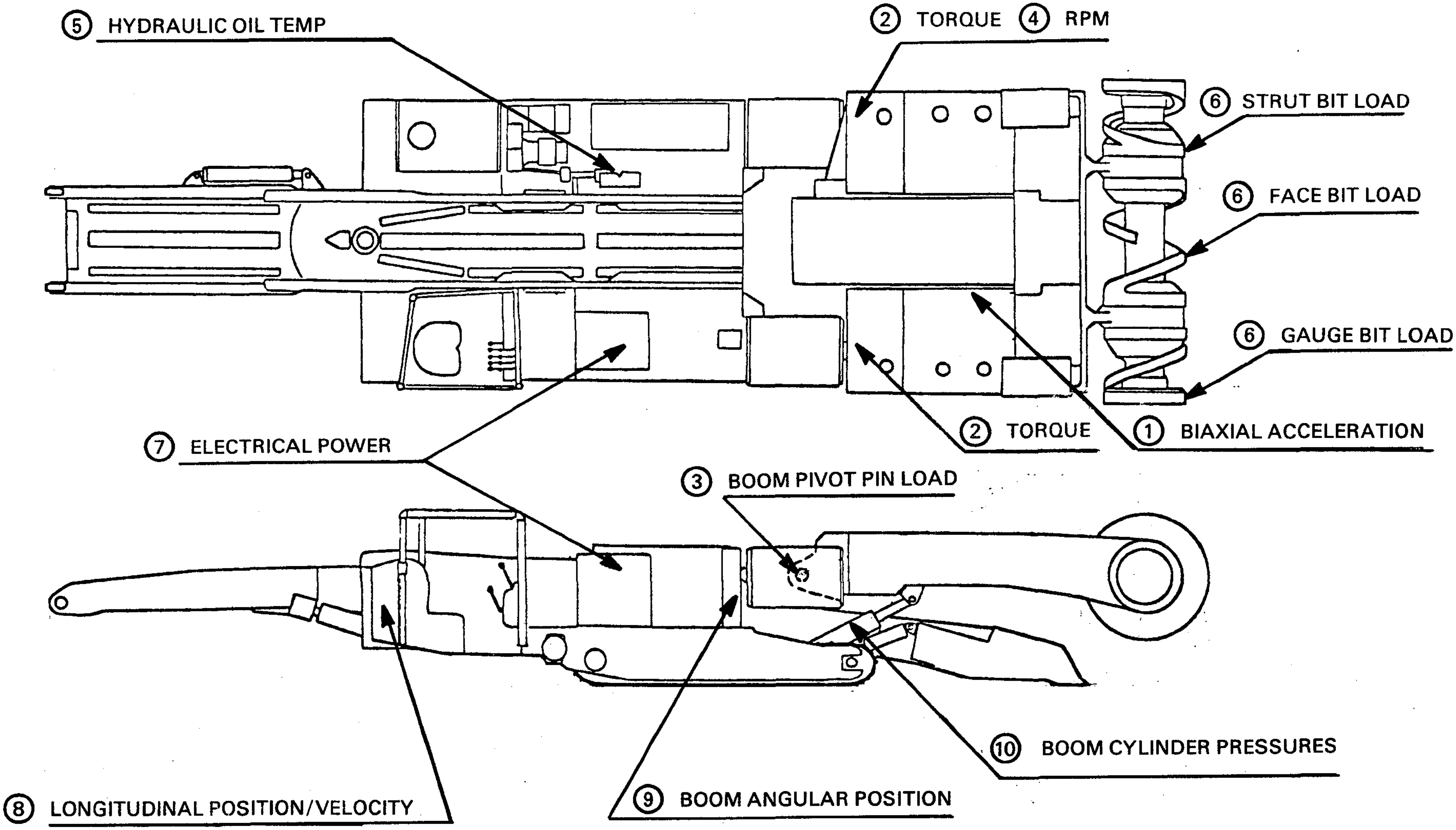


Figure 7. Transducer Locations

For each commercial transducer (Figure 8), certificates of calibration were obtained and checked prior to installation on the machine. The bit load transducers were also tested and evaluated. As a final checkout of the system prior to installing the machine in the test mine, simulated surface testing was conducted at SwRI (Figure 9).

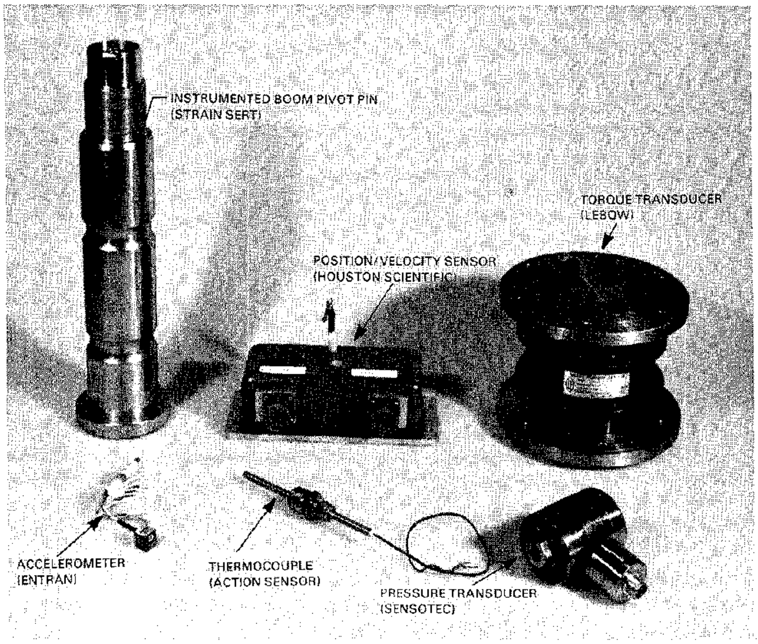


Figure 8. Transducer Types Used to Instrument the HH456

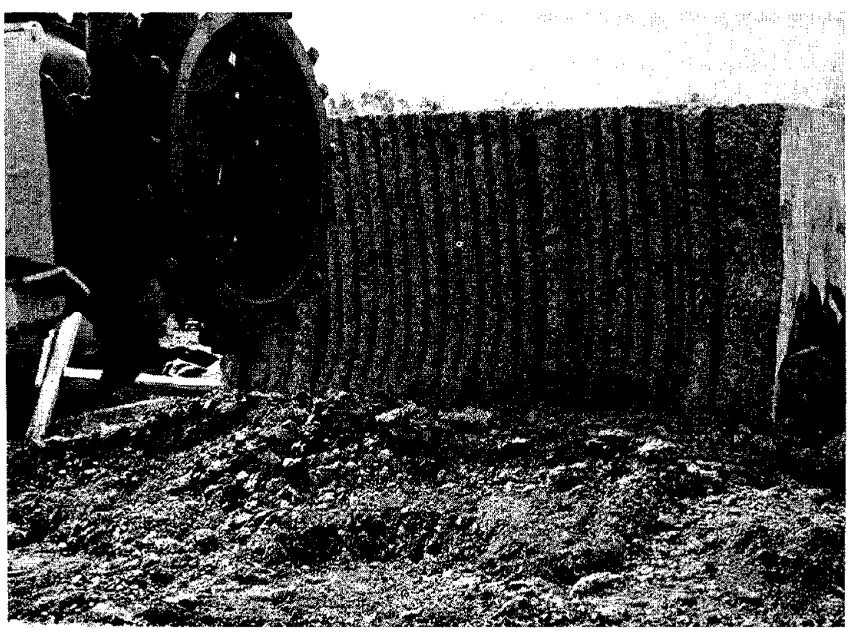


Figure 9. Simulated Coal Block Used for Check-out of Instrumentation

Block diagrams of the instrumentation system are shown in Figures 10 and 11. It should be noted that the bit recorder systems were separate from the main system because of their location on the cutterhead. At the end of a test, however, each bit recorder system was interfaced with the main system via an umbilical cable to permit transfer and recording of the bit load data onto the analog tape. With the exception of the bit load transducers, all other transducer signals were routed to conditioning systems mounted on the mining machine (Figure 12). Data was transmitted via the umbilical to the central control station located out-by the last open cross-cut on the fresh air side and installed in a dust-proof enclosure mounted on a wheeled cart (Figure 13). From the control station, each channel could be monitored and calibration levels applied. All data was recorded broadband on a multichannel magnetic tape recorder.

To ensure that the data were being recorded and were of proper quality, a six-pen chart recorder was used. Monitoring of the magnetic tape was accomplished by connecting the chart recorder to the playback side of the tape recorder. The data signal to the chart was thus delayed only slightly from real time by the interval required for the tape to move from the record head to the reproduce head.

3.4.3 Bit Load Monitoring System

Design of the bit load acquisition system has involved defining:

- Physical constraints
- Operational requirements
- Fidelity of the measurement required

Once these factors were defined, the process required various tradeoffs to obtain the optimum configuration in terms of size, power, and running time. The following disucssion presents the rationale utilized.

For this program, we were interested in three bit-load components: the axial load, the tangential load, and the lateral load. To measure each of these components and satisfy the constraint of using *conventional* bits, we designed a system of strain gage bridges to indicate the tangential and lateral loads and a load washer to measure axial load. The assembly is shown in Figure 14; the individual pieces are shown in Figure 15.

Efforts were made in the design and fabrication of this assembly to minimize the "cross talk" between channels (i.e., signals coupled into the unloaded channels from a loaded channel) and to minimize the effect of cross forces on the sensitivity of other channels. Besides single-axis loading tests conducted on an Instron testing machine, cutting tests in simulated coal and actual coal were performed to evaluate system performance. Comparison of the measurement techniques with that of the test stands indicated acceptable correlation (within 5 percent) for depths of cut greater than 1 inch. The discrepancies at the lower depths of cut were due to the measurement error in association with the strain gage bridge sensitivities and reduced cutting loads.

The nature of the application imposed a number of unique requirements on the bit recorder. The location of the recording units on the cutterhead placed them in a potentially hazardous area, where high concentrations of methane and dust can exist. For electrical equipment used at the face, MSHA regulations require either an explosive-proof enclosure or circuits that are instrinsically safe; the latter method was selected for the bit recorder. Current-limiting resistors were included in the

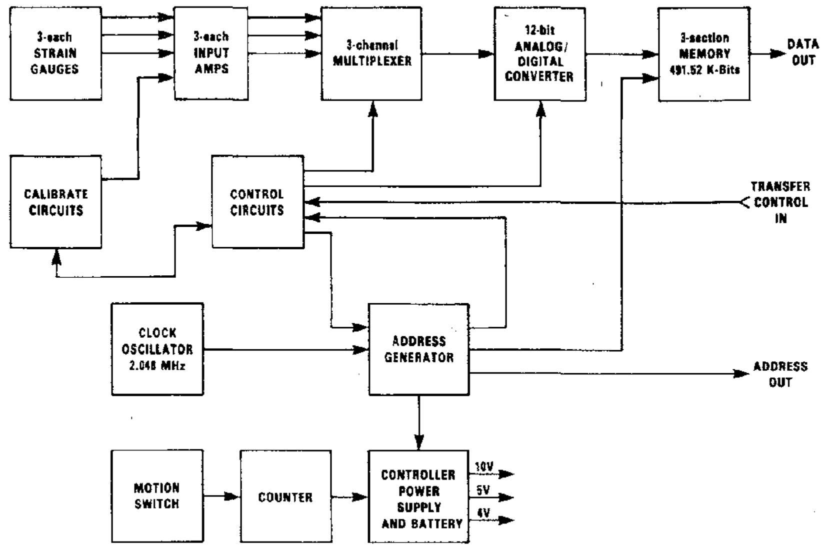


Figure 10. Bit Recorder Block Diagram

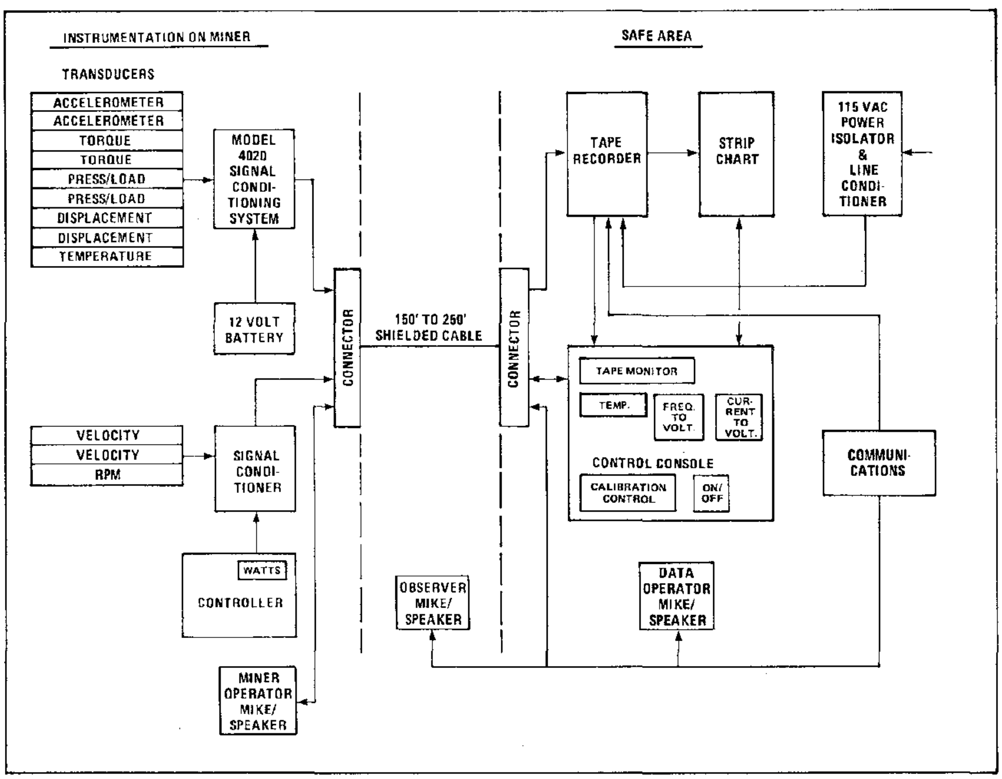


Figure 11. Block Diagram of HH456 Data Acquisition System

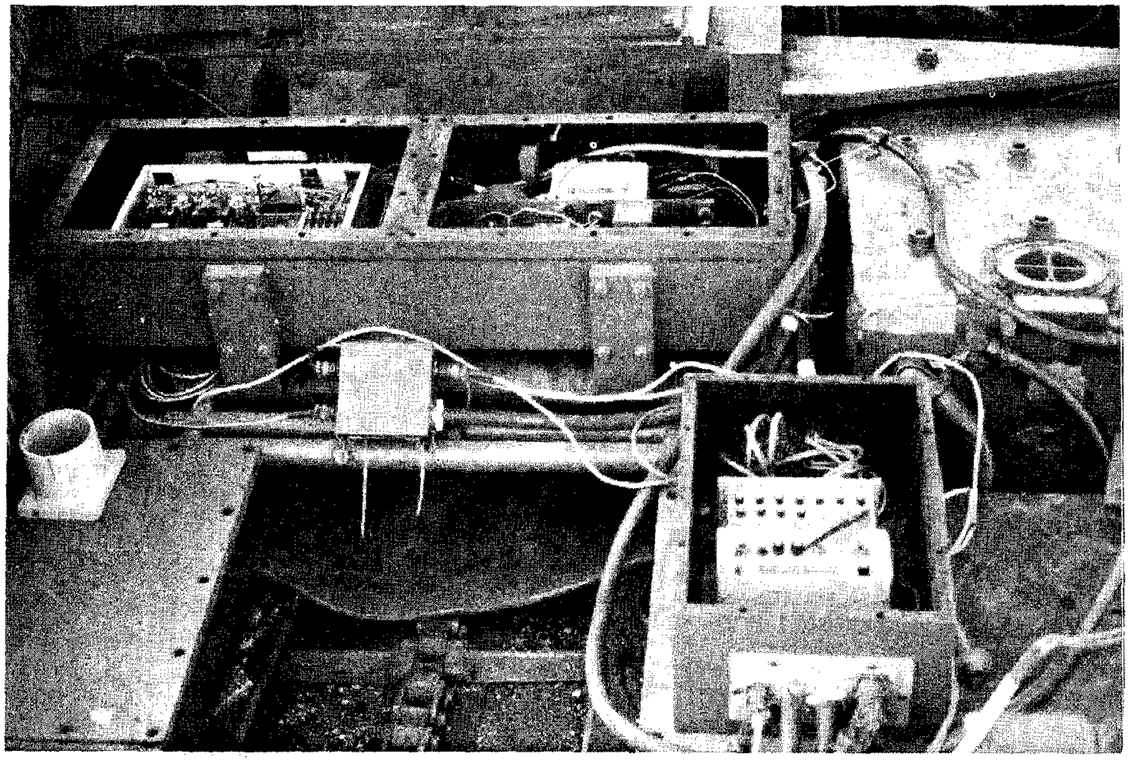


Figure 12. Signal Conditioning System Mounted on the HH456

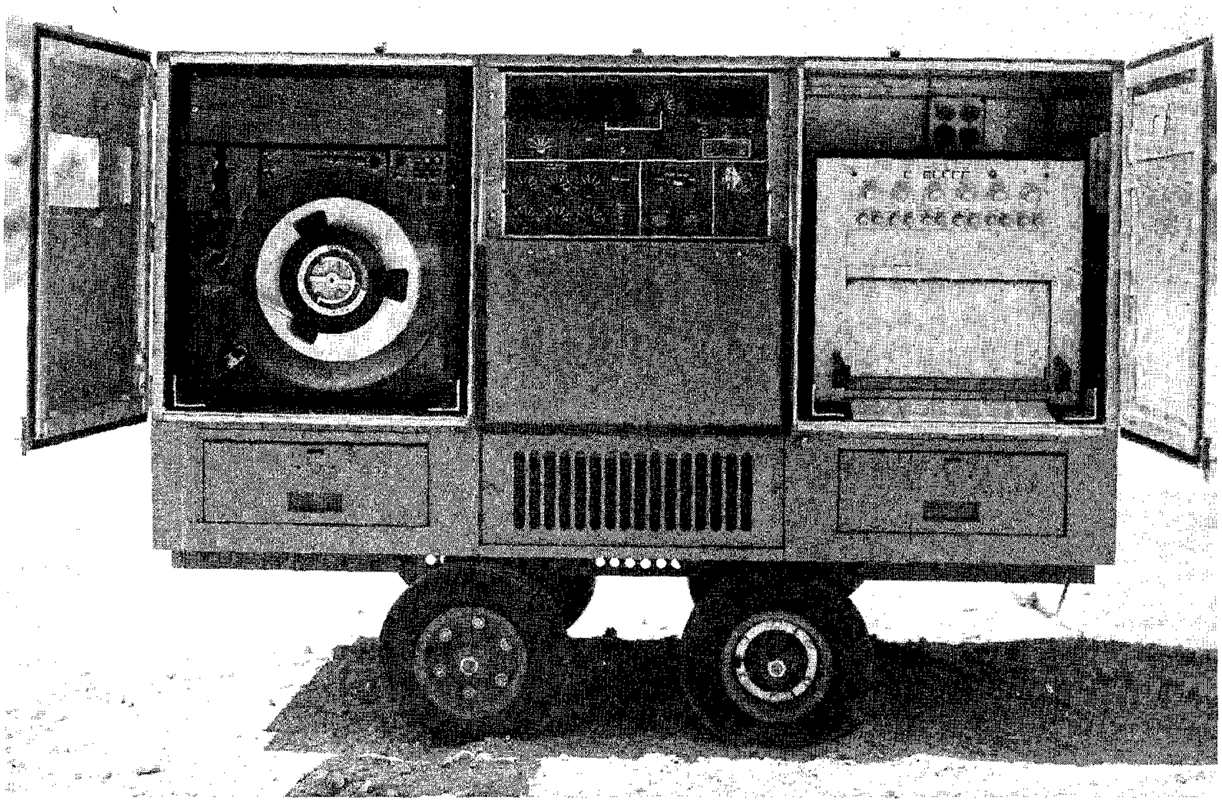


Figure 13. Central Control Cart Used to Monitor Machine Instrumentation

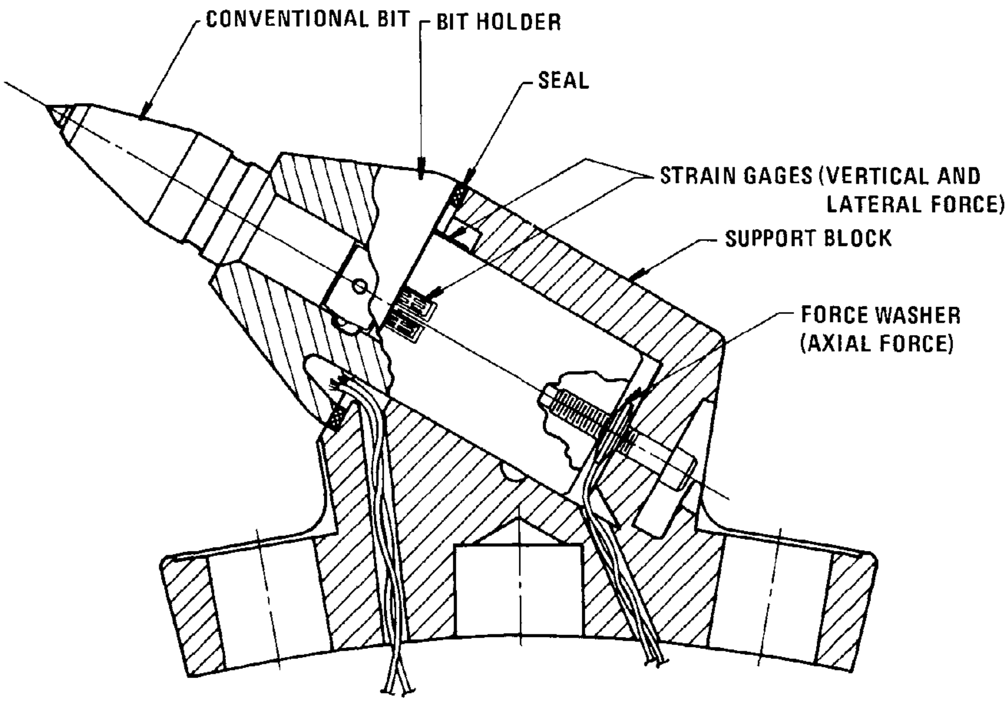


Figure 14. Instrumented Bit Assembly

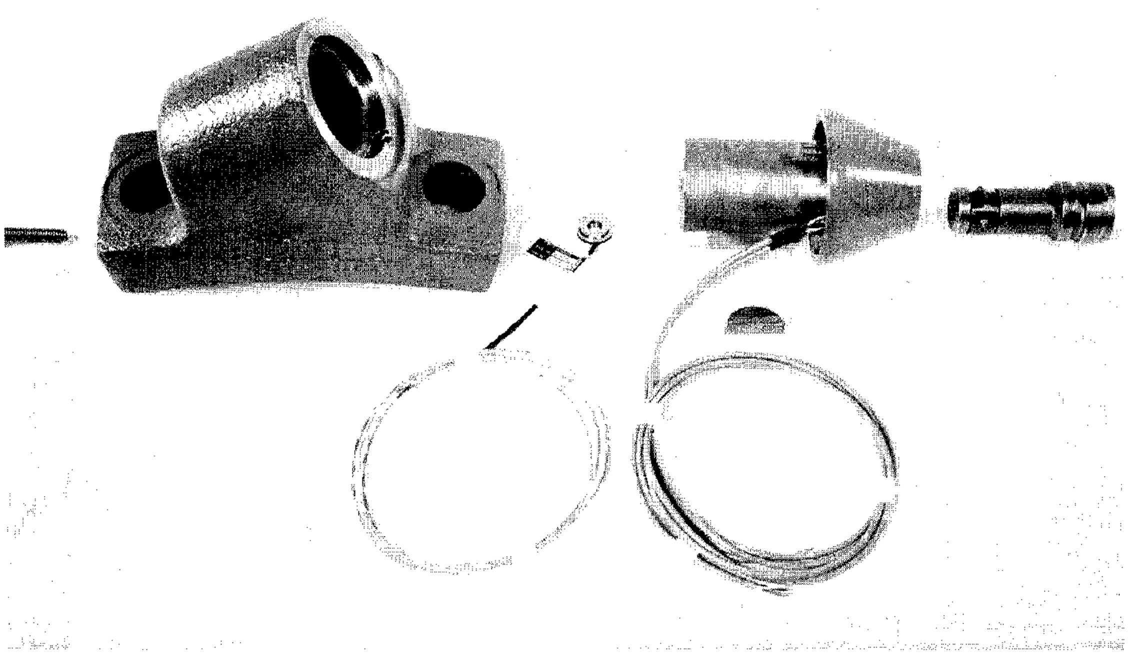


Figure 15. Instrumented Bit Assembly—Exploded View

battery pack to reduce the available current to values well below the level needed to ignite methane. Furthermore, no inductors and no capacitors greater than 1 microfarad were used in the system so that stored energy was also well below the ignition level. Finally, all batteries, current-limiting resistors, and series fuses were encapsulated in a urethane foam to ensure the integrity of the circuit.

Limited space available for mounting the recorders on the rotating head also placed restrictions on the assembly size and on the space available for batteries, for the electronic signal circuits, and for the memory. Because operating periods of up to several hours duration were necessary, the electronics were designed for minimum current drain by using low-power CMOS logic circuits where applicable, low-power analog amplifiers, and analog-to-digital converter memory devices with low standby power requirements and by energizing circuits only when needed.

Remote and inaccessible location of the bit recorders also imposed the requirement for automatic initiation of the recording cycle. The finite recording time, which is available along with the limited battery capacity, prevented the continuous operation of the unit over long time periods. However, it was also considered essential that the majority, if not all, of the recording be of data obtained while the machine was cutting. To meet this goal, means were incorporated to automatically turn on the recorder at a preset time after the cutting bits first strike the surface of the coal (or rock) and to then continue to record until the memory is filled (either 61 or 491 seconds, as preselected). After saturation, the memory switched to a low power mode to retain the data, and other circuits were automatically turned off to conserve battery power.

The size of the memory in the bit recorder (491,520 bits) was selected to be the largest that could fit into the available space. For flexibility, the option of dedicating the memory to one strain gage channel or splitting it between the three gages was incorporated. The data sampling rate was selected to be as low as possible, yet consistent with the measurement resolution or frequency response required for the bit force data. For additional flexibility, a choice of two sampling rates, 125 and 1000 per second, were provided. With either single- or three-channel operation, the available recording time was 491.5 and 61.45 seconds for the high and the low sample rates, respectively. In the three-channel mode, the resolution was approximately 10 Hz at the low rate and 83 Hz at the high rate. In the single-channel mode, the corresponding frequency responses were 31 Hz and 250 Hz. To put these numbers into the perspective of the test program, the maximum speed of a cutting bit was approximately 600 feet per minute (51 RPM configuration) and the minimum speed approximately 210 feet per minute (18 RPM configuration). Thus, for the highest speed, sampling at a rate of 1000 Hz for three channels provides 2.77 load points for each channel per inch of travel. This corresponds to angular rotation of 2.58 degrees or approximately 1 sample per degree of rotation.

The bit recorder and enclosure, as shown in Figure 16, were designed to permit reliable operation when installed on the cutterhead and subjected to rock/coal fragments, dust, water spray, accelerations, and vibration resulting from the mining process. The enclosure was built of 3/8-in. welded steel and contained two compartments. The smaller compartment contained the battery pack, programming plug, motion switch, and the interface connector. The larger compartments, as shown in Figure 17, contained the circuit boards and the strain gage connector. The sealed cover of the second compartment was not normally removed except for maintenance; however, the gasketed cover of the first compartment was opened periodically for battery replacement or programming changes. The interface connector was protected by a single pipe plug that was removed for the data transfer. The strain gage connections were made through a flexible conduit connected to the instrumented bits.

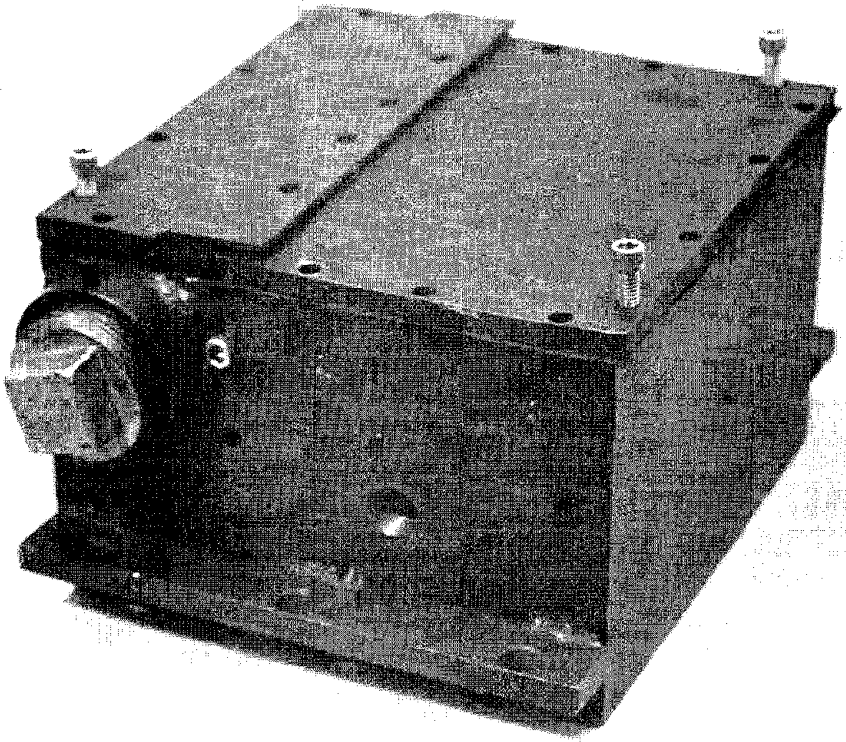


Figure 16. Bit Recorder Unit

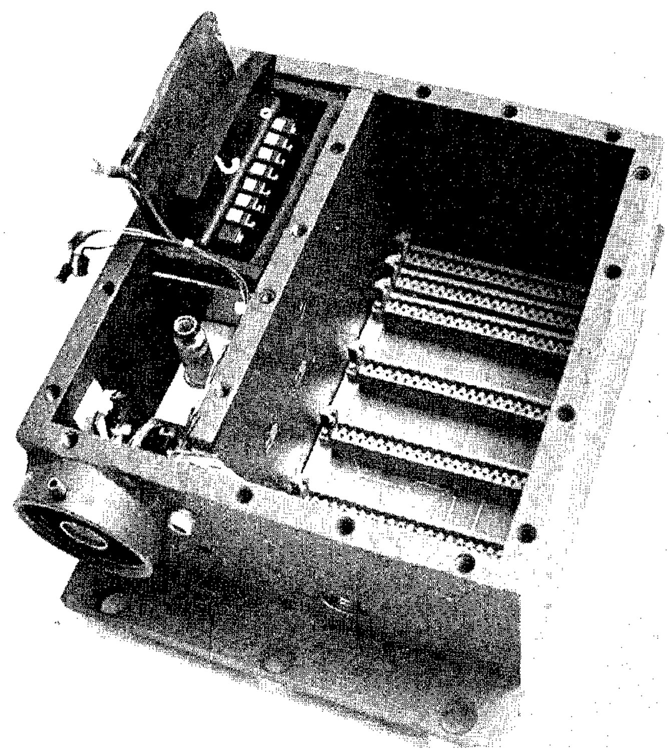


Figure 17. Bit Recorder Unit with Covers Removed

Seven, 4 × 5-in. circuit boards, Figure 18, were rigidly held in place by connectors on the bottom edge and card retainers on the top edge. Memory boards were encapsulated in foam to reduce damage due to vibration, and all components were bonded to the circuit boards.

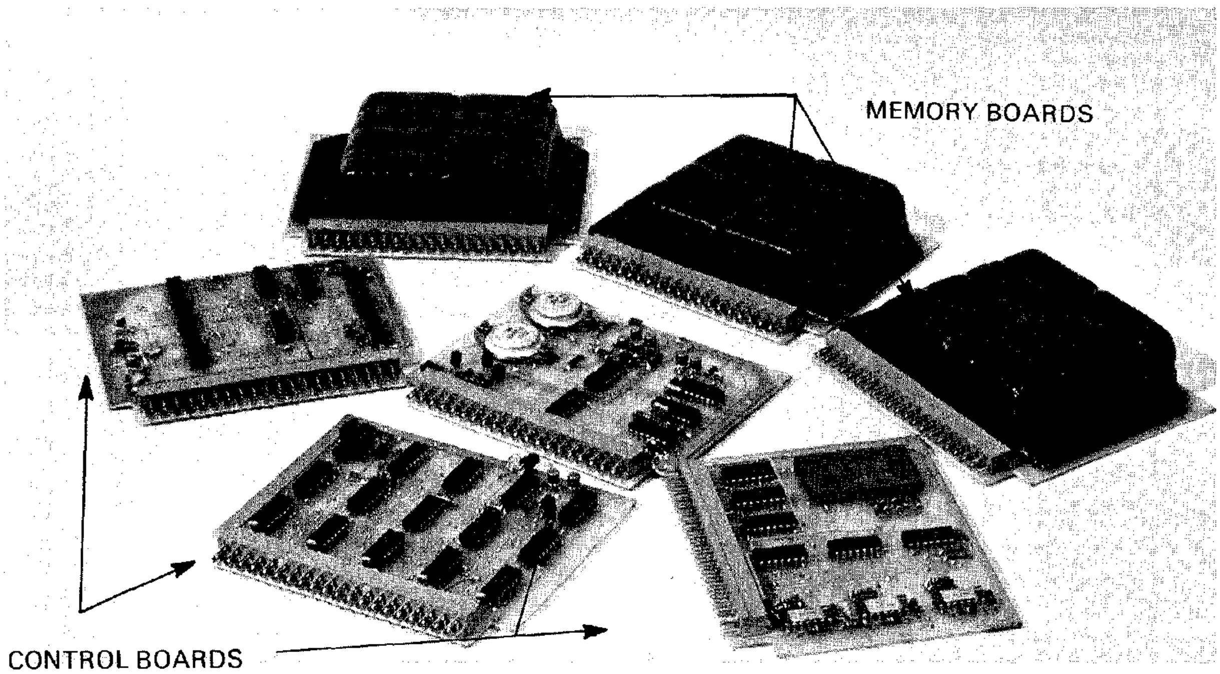


Figure 18. Printed Circuit Boards for Bit Recorder

Three bit recorders were installed on the cutterhead to obtain data from three instrumented bits. One unit was installed at each end of the head, as shown in Figure 19, to monitor a gauge bit and a strut bit, respectively. The third recorder was installed on the center section of the head and monitored a face bit as shown in Figure 20.

3.5 Mine Selection

Selection of a test mine was based on the following factors:

- A seam height, entry width, and floor condition compatible with the HH456
- A seam grind of less than 60, as expressed by Hardgrove number
- Operator interest in the program

Although there were a multitude of mines and seams capable of satisfying the first two considerations, few operators were found that were willing to cooperate without severe production penalties imposed upon the program. After many dead ends, a cooperative agreement was obtained with United Coal Company that had interest in the program from the standpoint of reducing the fines in their run-of-mine product.

The particular mine selected for the testing was a drift operation near Grundy, Virginia. The mine was under development and typically operated one conventional section, two shifts per day. The mine layout, as it existed during the test program, is shown in Figure 21.

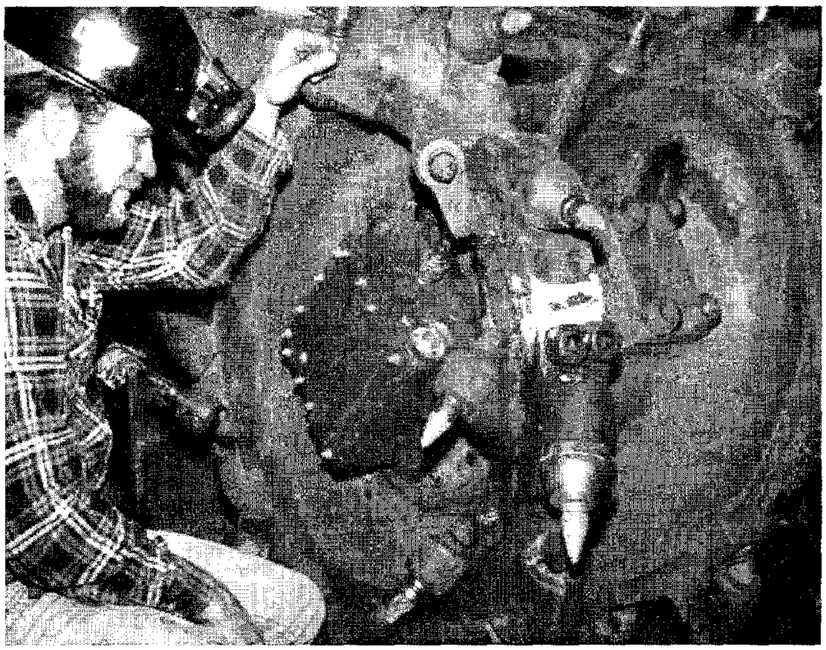


Figure 19. Gauge Bit Recorder Installation

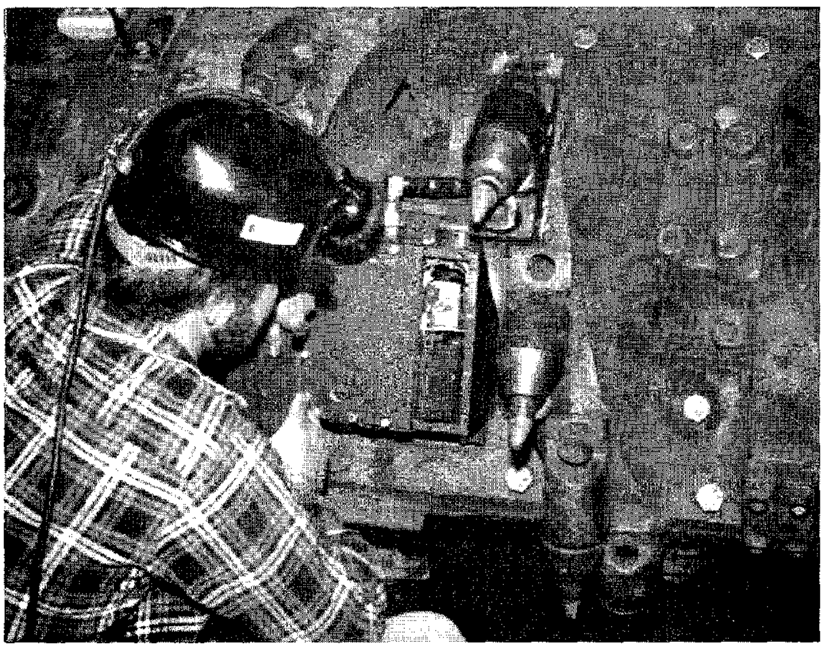


Figure 20. Face Bit Recorder Installation

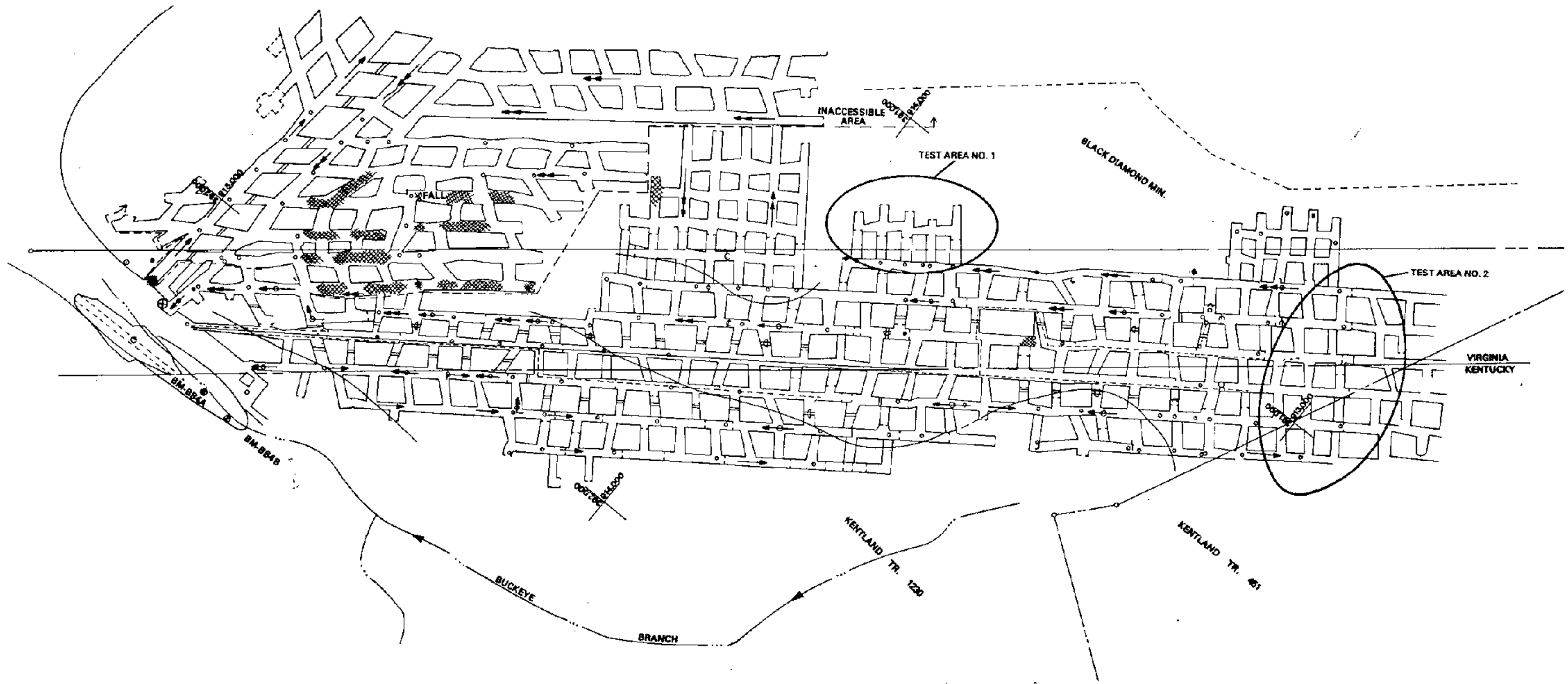


Figure 21. Mine Plan

The seam, designated the "Splash Dam", had a Hardgrove index of 49 to 50 and ranged in height from 6 to 8 feet. Near the middle of the seam, there was a rock band that varied from 12 to 24 inches in thickness (Figure 22).

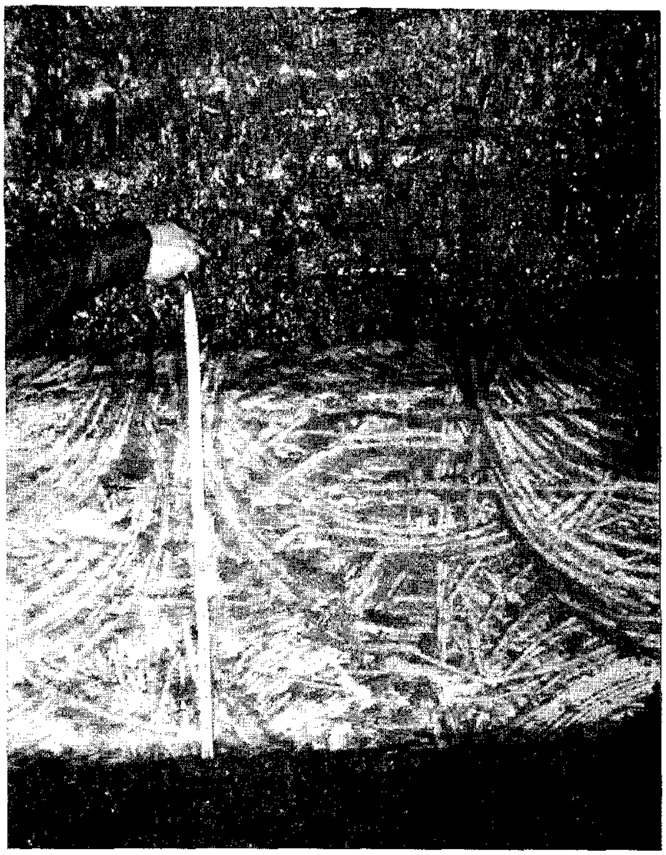


Figure 22. Typical Thickness of the Middle Rock Band

3.6 Test Procedures

Test procedures used during the test were divided into three parts. The first part was related to pretest preparations of the machine and check-out of the instrumentation. The second part pertained to the actual test events and the third part to the post-test evaluation.

Each of these procedures had a definite sequence and associated check list to ensure that steps were not overlooked. Samples of the protocols are contained in Appendix B, with the major features presented in the text that follows.

3.6.1 Machine Preparation and Test Sequence

To configure the machine for each set of test conditions, it was necessary to change the cutterhead rotary speed and/or bit lacing and to set the desired sump/shear rate. Changes in the cutterhead rotary speed were accomplished by changing two of the three speed reducers between each motor and the final drive gear box, which was an integral part of the boom.

Bit lacing was accomplished by adding or removing bit blocks—each block being secured to the head by bolts. Because the rock in the seam put a severe load on the blocks, bolts wre judiciously torqued to rated capacity and, in some instances, welded to the head.

The sump/shear rates for each cell were established through the setting of throttle valve stroke. Two different positions were required, one for sump and one for shear. So that the operator could reasonably replicate the desired rates, mechanical "stops" were used. Prior to each test, a trial-and-error process of measuring displacement and time was used to determine the appropirate valve position. Inasmuch as it was difficult to determine the rate at which the machine would cut through the rock band, the actual rates achieved by this method were subject to considerable variability.

Initially, the test plan called for a confounded variation in test conditions consisting of five speed changes and twelve lacing changes, as indicated in Table 5A. After the machine was first installed in the mine (July '81), the mine operator welded all bit blocks to the head. Because the welding operation represented a considerable investment and made rapid removal difficult, as well as unpopular, the test sequence was modified to follow a progressive removal of bit blocks with associated speed changes, as indicated in Table 5B.

3.6.2 Test Operations

Prior to each test, transducer continuity and response were checked through the entire data acquisition system. Upon receipt of acceptable calibration signals from each device, the bit recorders were made ready by selecting the desired time delay and turning on battery power. Although the units had adjustable features in terms of delay time, sampling frequency, and record channels, only one configuration was used during the program. For the duration of the testing, the

TABLE 5A. Test Sequence — Planned

HEAD ROTARY SPEED					
18 RPM			51 RPM		
DEPTH OF CUT			DEPTH OF CUT		
1 in./rev	2 in./rev	3.5 in./rev	1 in./rev	2 in./rev	3.5 in./rev
7	9	11	5	3	1
8	10	12	6	4	2
19	21	23	17	15	13
20	22	24	18	16	14
28	29	30	27	26	25

TABLE 5B. Test Sequence — Actual

HEAD ROTARY SPEED					
18 RPM			51 RPM		
DEPTH OF CUT			DEPTH OF CUT		
1 in./rev	2 in./rev	3.5 in./rev	1 in./rev	2 in./rev	3.5 in./rev
6	11	26	1	16	21
7	12	27	2	17	22
8	13	28	3	18	23
9	14	29	4	19	24
10	15	30	5	20	25

setup was maintained at 15-second time delay, 1000-Hz sample rate (per channel), and three-channel record.

After the above mentioned preparations, the instrumentation cart operator and machine observer took their positions, and the test was initiated. Each man had an assigned responsibility: the cart operator selectively monitored incoming transducer signals (Figure 23) while the

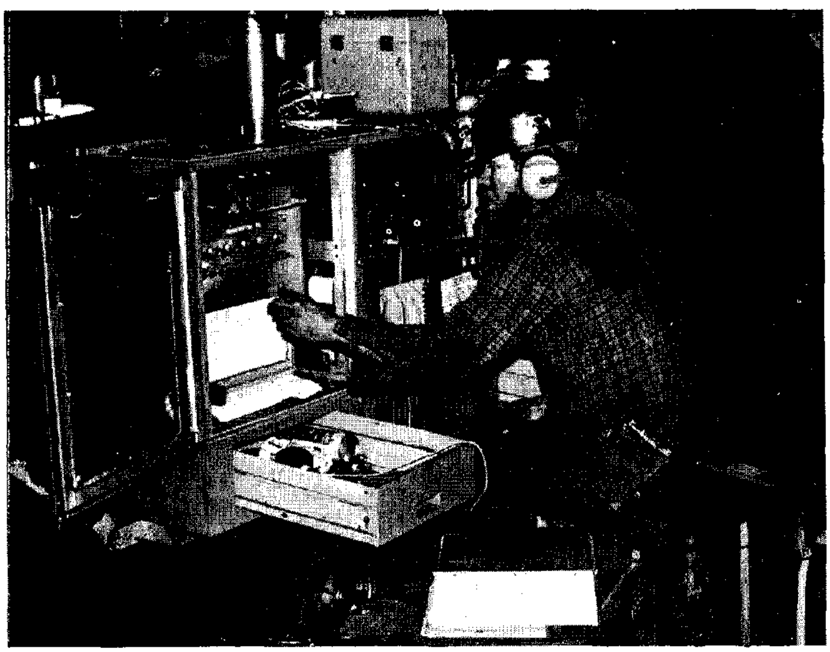


Figure 23. Instrumentation Cart Operator—Test Underway

machine observer noted the operator action and repositioned the sump stroke pole between sump cycles (Figure 24). Both men had headsets and microphones to permit verbal communication during the testing. As with the transducer data, the voice transmissions were recorded.

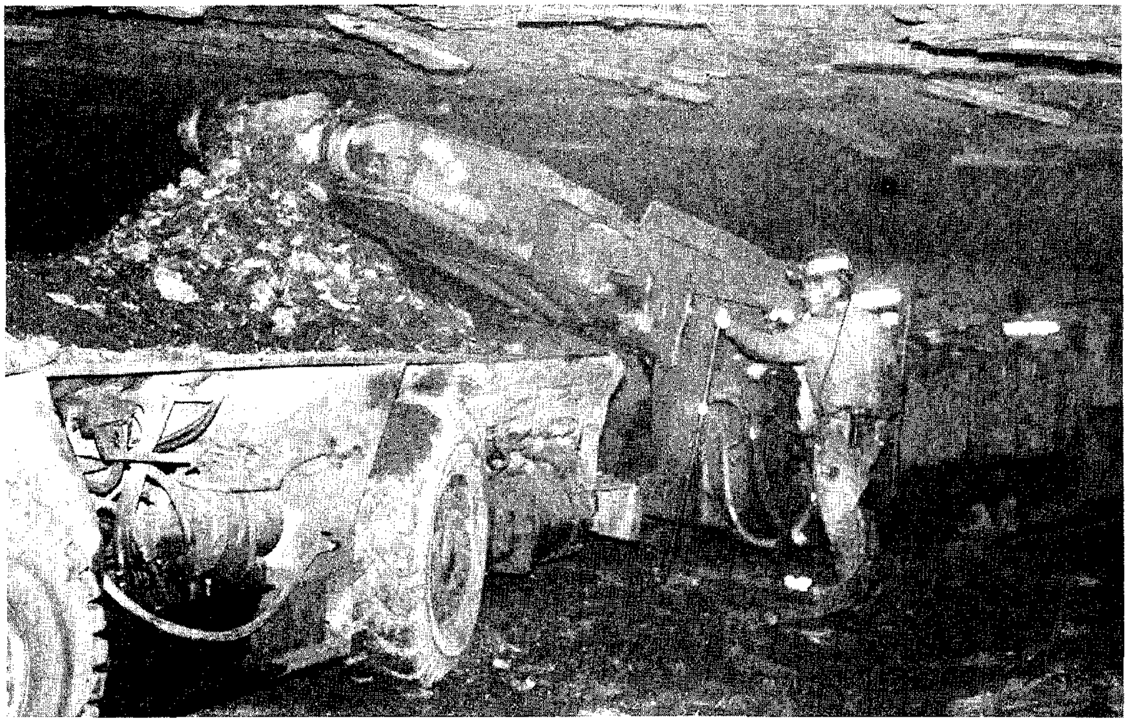


Figure 24. Machine Observer—Test Underway

3.6.3 Post-Test Evaluations

After the machine had completed a "place", a post-test calibration of the transducers was performed, and preparations were made to dump the bit recorders. Each bit recorder executed a playback of its memory when accessed with control box/cable link shown in Figure 25.

Figure 25. Playback of Bit Recorder

At this point, all data was reviewed, the machine inspected, and decisions made for test continuation. Figures 26 and 27 exemplify the type of data available from each test.

3.7 Data Reduction

3.7.1 Initial Considerations

Once the magnetic tape reel had been exhausted, it was returned to SwRI. At SwRI, the tape was played back to extract the voice documentation and to obtain complete hard-copy records of each tape channel. The transcribed communications were used to interpret/diagnose certain events and artifacts in the data, as well as provide a general time correlation. The hard-copy records were also checked for the presence of the proper calibration levels. Additionally, "timing" information was extracted from the traces to refine the time base. The preliminary information thus collected provided the adjustments for the computer reduction to follow.

3.7.2 Digitization

The next step in the data reduction was to transform the analog data recorded on magnetic tape to digital records. These records were written on tape and then used to analyze certain data channels in greater detail, as well as to compute selected parameters.

Recorded data on the analog magnetic tape was played back, with each channel passing through an active amplifier filter with adjustable gain. With the adjustable amplification feature, the magnitude of the calibration signal and peak values of each channel were adjusted to fit within the permissible values of the analog-to-digital (A/D) data acquisition system. Each channel was sampled at a rate of 1000 times per second and the digitized data written on digital magnetic tape. Once the raw digitizd data was stored on tape, the RMS and average value for each channel were immediately calculated and printed on a teletype to ensure that the data on each channel had been successfully captured. At this point, the digital tape was ready for further processing on a larger computer, where residing software programs were used to complete the data reduction.

3.7.3 Basic Calculations

Four basic calculations were performed to determine:

- Maximum depth of cut (sump and shear)
- Cutting horsepower
- Sump and shear forces
- Resultant bit loads

Algorithms that were used are developed mathematically in Figures 28 through 31, respectively.

Using the computer software, a summary of each test was prepared. The summary included a print-out of each portion of the cycle (sump and shear), as shown in Tables 6 and 7. The notation for each channel number is given in Table 8.

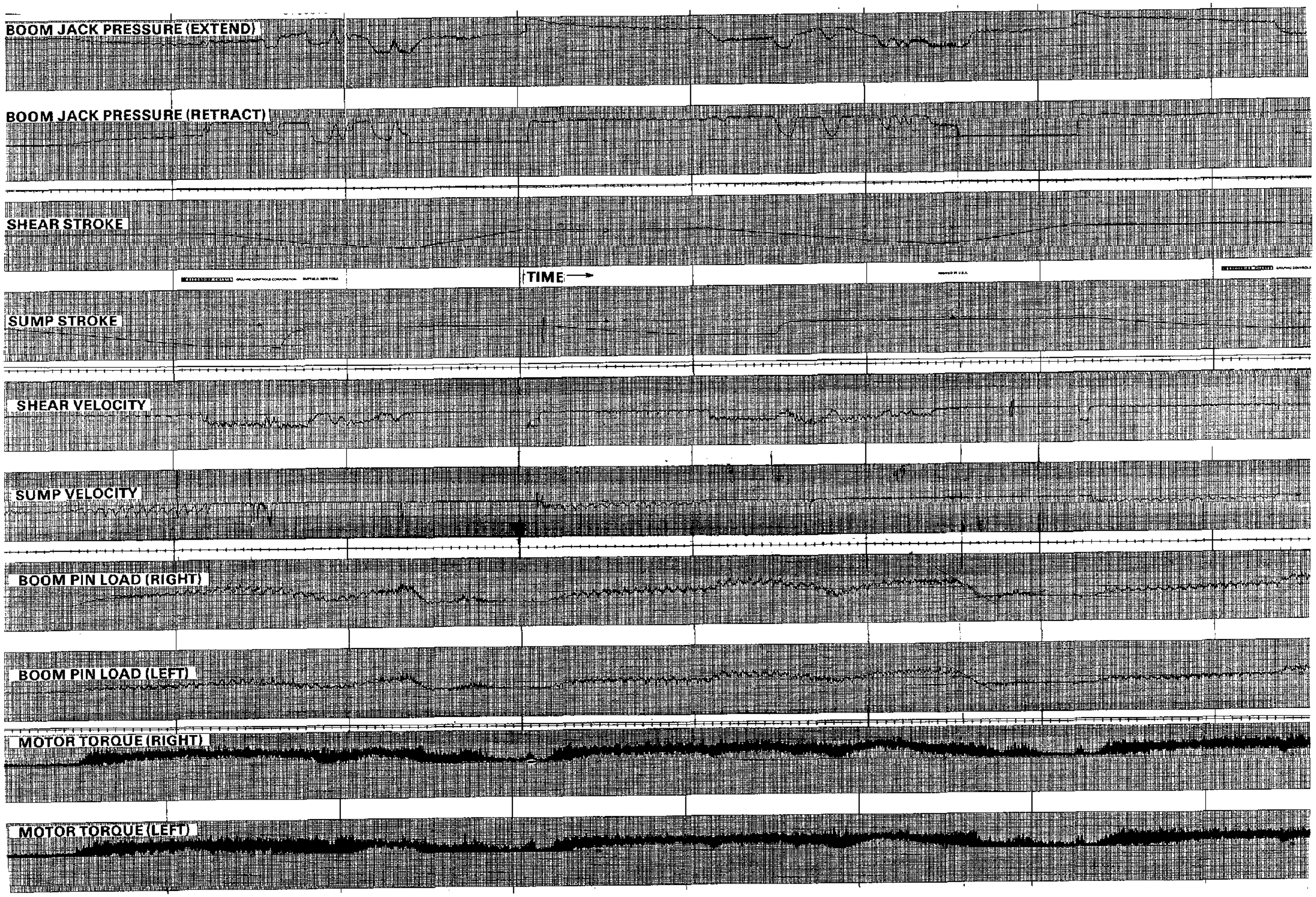


Figure 26. Analog Data Summary for Typical Test—51RPM, 2-inch Bit Spacing

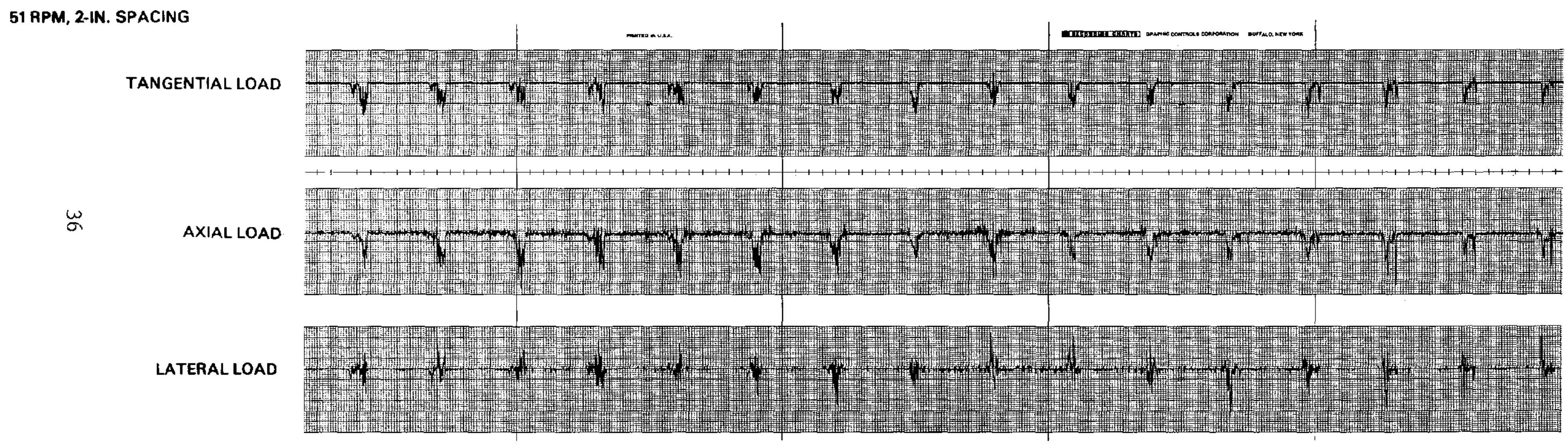
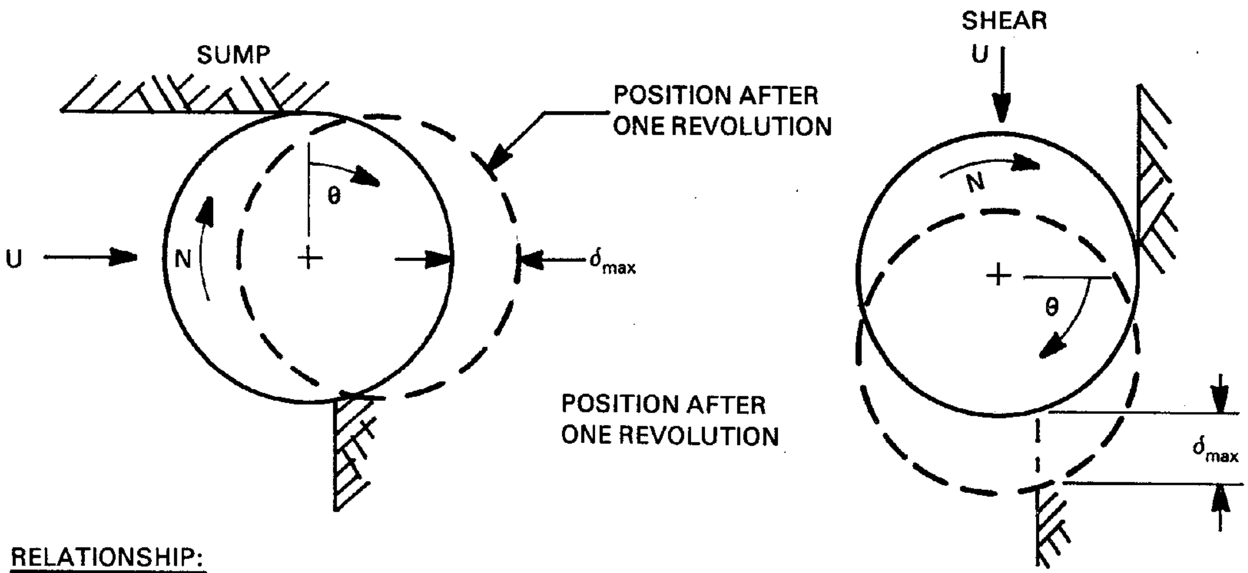


Figure 27. Typical Bit Load Data

NOTATION:



RELATIONSHIP:

$\delta = \frac{U}{fN} \sin \Theta$

U	=	Velocity of Cutterhead ℄
N	=	Cutterhead Rotary Speed
f	=	Number of Tracking Cutters (f = 1 for face bits)

KNOWN QUANTITIES:

For Sump,

δ	=	δ_{max} @ = 90°
U	—	Measured Directly (use Avg. Value)
N	—	Measured Directly (use Avg. Value)

$\therefore \quad \delta_{max}, \text{ sump} = \frac{U}{N}$

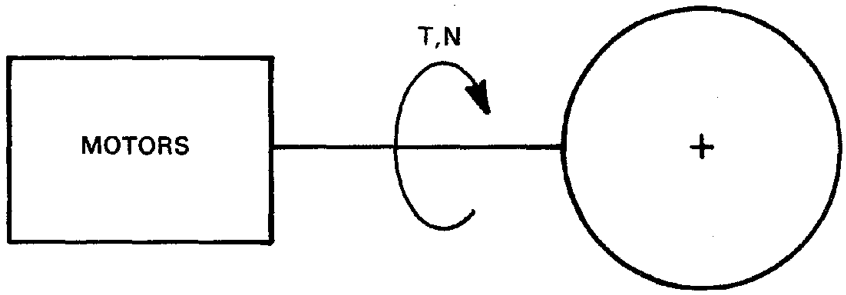
For Shear, know the duration of the cutting pass, "t", from the bit load data

U	—	Measured Directly (use Avg. Value)
N	—	Measured Directly (use Avg. Value)

$\therefore \quad \delta_{max}, \text{ shear} = \frac{U}{N} \sin \Theta$ where $\Theta = 2\pi N \cdot t$ (radians)

Figure 28. Calculation Scheme—Depth of Cut

NOTATION:



T = Indicated Torque
N = Indicated RPM

RELATIONSHIP:

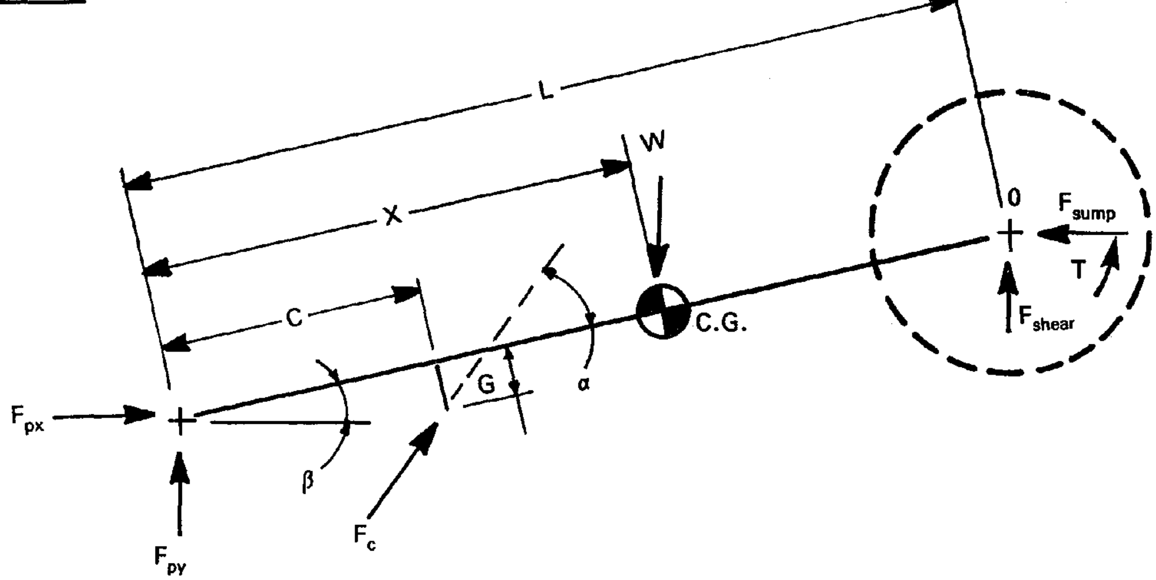
$$Hp = \frac{T \times N}{5252}$$ where T has units of lbf-ft

KNOWN QUANTITIES:

T — Measured Directly (Avg. Value of Both Motors)
N — Measured Directly

Figure 29. Calculation Scheme—Cutting Horsepower

NOTATION:



RELATIONSHIPS:

1. $\Sigma M_o = 0 = F_{px} L \sin\beta - F_{py} L \cos\beta \ - F_c \ L - C - \frac{G}{\tan\alpha} \ \sin\alpha + W(L - X)\cos\beta + T$
2. $\Sigma F_x = 0 = F_{px} + F_c \cos(\alpha + \beta) - F_{sump}$
3. $\Sigma F_y = 0 = F_{py} + F_c \sin(\alpha + \beta) - W + F_{shear}$

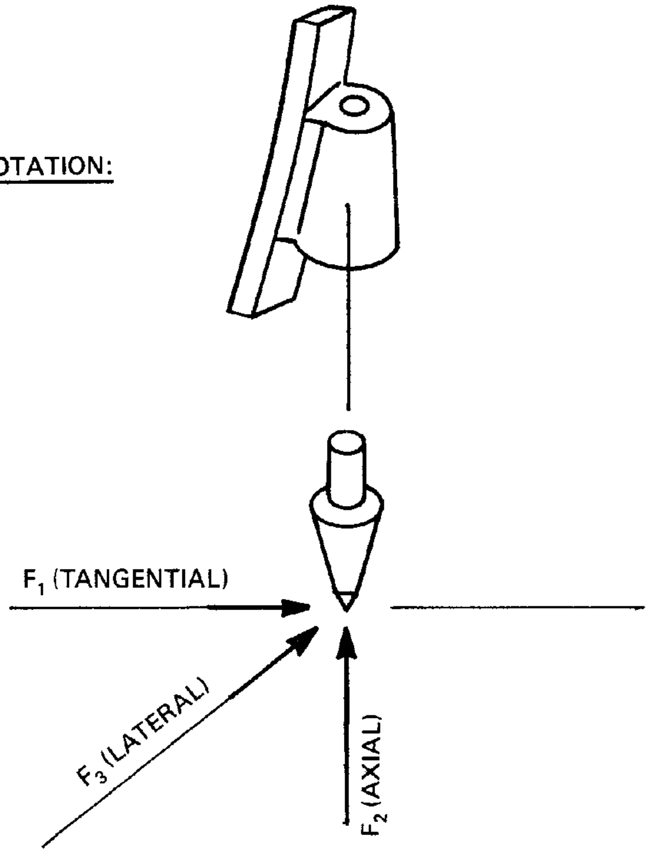
Solve Eqn. 1) for F_{py} and Subst into Eqn. 3)
Solve Eqn. 2) for F_{sump}
Solve Eqn. 3) for F_{shear}

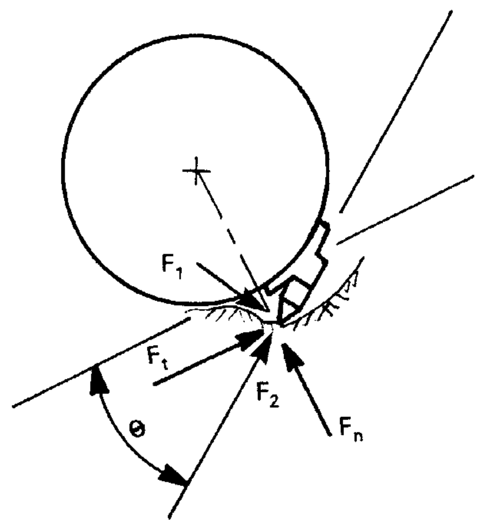
KNOWN QUANTITIES:

T	—	Cutterhead Torque — Calculated from Motor Torques and Reduction Ratios
W	—	Boom Weight—Measured (Constant, Neglecting Block Changes)
X	—	Boom C.G.—Measured (Constant, Neglecting Block Changes)
F_{px}	—	Measured Directly from Boom Pins (Average of Both Sides)
F_c	—	Measured Directly from Boom Lift Pressure Transducers (Average of Both Sides)
G,C,L	—	Boom Geometry (Constants)
β,α	—	Measured Directly from Boom Angular Position Transducer

Figure 30. Calculation Scheme—Sump/Shear Forces

NOTATION:





RELATIONSHIPS:

$$R = \sqrt{F_1^2 + F_2^2 + F_3^2}$$

$$F_t = F_1 \sin \Theta + F_2 \cos \Theta$$

$$F_n = F_2 \sin \Theta - F_1 \cos \Theta$$

KNOWN QUANTITIES:

F_1, F_2, F_3—Measured Directly

Θ—Bit attack angle (Constant @ 45°)

Figure 31. Calculation Scheme — Resultant Bit Forces

TEST NO. 5 — TABLE 6. Sump Cycle — SUMP CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3

HEAD SPEED: 51 RPM — BIT SPACING: 2 INCHES

LOCATION: 5-129 — DEPTH OF CUT: 1.0 IN/REV

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	391.8	373.3	671.7	12.69	1.9	.35
2	TORQUE RHS	423.9	360.3	1100.2	3.59	-8.7	3.22
3	SHAFT RPM	1586.9	1592.8	1722.6	.58	1541.1	9.42
4	X-LOAD LHS	12366.5	3656.8	24619.9	11.79	-37463.5	.03
5	X-LOAD RHS	13851.3	-2790.8	17425.4	12.60	-45854.8	0.00
6	F-CYLD DWN	42680.7	42659.6	47137.4	9.13	18910.9	15.07
7	F-CYLD UP	43393.9	43262.1	55782.5	.00	18600.2	15.07
8	SUMP RATE	.8	.7	2.3	.24	.1	2.10
9	SHEAR RATE	.1	.0	.7	15.03	-.1	3.50
10	SUMP STK	39.3	39.2	45.7	14.80	30.0	.03
11	VERT STK	35.5	35.6	36.4	.68	34.6	13.45
12	BOOM G-Y	.3	.1	1.5	.73	-1.2	.75
13	BOOM G-Z	.0	.0	.0	.73	-.0	9.13
~~14~~	~~E POWER~~	~~36.0~~	~~34.1~~	~~49.3~~	~~11.63~~	~~-6.0~~	~~.05~~
15	X-LOAD AVG	12080.4	433.0	14158.9	15.02	-40244.0	.00
16	F-CYLD	7186.6	602.5	25095.0	.00	-7485.3	13.04
17	TORQUE AVG	395.1	366.8	808.9	14.47	2.0	.36
18	DELTA	1.0	.9	2.7	.24	.1	2.10
19	F-SUMP	12952.0	1850.9	25442.9	15.02	-40433.5	.05
20	Y-LOAD	24593.4	23256.9	31281.9	14.81	-4909.6	.00
21	F-SHEAR	17314.3	17358.9	20187.1	13.04	12887.3	15.07
22	ALPHA	24.0	24.1	24.1	.68	23.8	13.45
23	M POWER	182.4	169.6	370.1	14.47	.9	.36
~~24~~	~~EFF~~	~~4825.3~~	~~356.6~~	~~372819.7~~	~~.66~~	~~-24044.8~~	~~.24~~
25	HEAD RPM	50.5	50.7	54.8	.58	49.0	9.42
26	BETA	12.1	12.1	12.4	13.45	11.5	.68
27	RATIO	.5	.4	1.3	.24	.0	2.10

TEST NO. 5 — TABLE 7. Shear Cycle — SHEAR CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3

HEAD SPEED: 51 RPM — BIT SPACING: 2 INCHES

LOCATION: S-129 — DEPTH OF CUT: 1.0 IN/REV

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	414.5	390.8	915.2	49.09	55.5	3.80
2	TORQUE RHS	434.4	377.8	1136.4	42.96	-11.0	8.59
3	SHAFT RPM	1578.2	1578.0	1711.4	13.27	1476.9	19.60
4	X-LOAD LHS	37350.7	34307.3	78866.9	31.07	3100.1	1.36
5	X-LOAD RHS	28854.3	26987.4	60979.8	38.06	-3789.5	.41
6	F-CYLD DWN	28656.7	27167.0	43007.6	64.99	421.5	.74
7	F-CYLD UP	8932.2	8434.8	18474.9	.01	2562.0	33.15
8	SUMP RATE	.1	.0	.8	10.47	-.0	45.97
9	SHEAR RATE	.9	.8	1.5	38.31	-.1	34.45
10	SUMP STK	44.5	44.5	46.4	11.82	41.6	49.10
11	VERT STK	62.4	61.1	86.7	51.29	21.4	21.25
12	BOOM G-Y	.3	.1	1.6	33.51	-1.4	29.99
13	BOOM G-Z	.0	.0	.0	33.51	-.0	29.99
~~14~~	~~E POWER~~	~~38.4~~	~~36.6~~	~~68.8~~	~~50.92~~	~~10.6~~	~~3.72~~
15	X-LOAD AVG	32535.0	30647.4	57058.5	32.02	6260.4	.76
16	F-CYLD	20802.1	-18732.2	7232.3	.79	-38991.6	64.92
17	TORQUE AVG	411.5	384.3	868.4	49.18	36.4	3.80
18	DELTA	1.0	.9	1.9	38.31	-.1	34.45
19	F-SUMP	32361.1	28199.4	57930.0	42.84	-7369.5	56.81
20	Y-LOAD	33922.5	33537.6	47126.8	21.26	19960.4	46.97
21	F-SHEAR	25436.7	24893.6	34652.9	64.93	7240.2	21.25
22	ALPHA	28.2	28.1	32.0	51.29	21.4	21.25
23	M POWER	189.2	177.3	397.5	34.98	17.2	3.80
~~24~~	~~EFF~~	~~260.8~~	~~248.2~~	~~753.0~~	~~4.88~~	~~41.2~~	~~1.83~~
25	HEAD RPM	50.2	50.2	54.5	13.27	47.0	19.60
26	BETA	5.8	.4	18.5	21.25	-11.1	51.29
27	RATIO	.5	.5	.9	38.31	-.0	34.45

TABLE 8. Channel Notation

Channel No.	Label	Parameter*	Units	Sign Convention*
1	TORQUE LHS	Motor Torque—Left Hand Side	lbf-ft	Scaler
2	TORQUE RHS	Motor Torque—Right Hand Side	lbs-ft	Scaler
3	SHAFT RPM	Shaft Rotary Speed, #3 Box	RPM	Scaler
4	XLOAD LHS	Horizontal Boom Pin Load—Left Hand Side	lbf	Positive toward head
5	XLOAD RHS	Horizontal Boom Pin Load—Right Hand Side	lbf	Positive toward head
6	FCYLD—DWN	Boom Jack Force—RETRACT Side	lbf	Scaler
7	FCYLD—UP	Boom Jack Force—EXTEND Side	lbf	Scaler
8	SMP RATE	Sump Rate	in./sec	Scaler
9	SHR RATE	Shear Rate	in./sec	Scaler
10	SMP STK	Sump Stroke	in.	Scaler
11	VER STK	Head Position, WRT "Full-Up"	in.	Scaler
12	BOOM GY	Boom Accel—Vertical	g's	Positive up
13	BOOM GZ	Boom Accel—Lateral	g's	Positive to right
14	E POWER	Electrical Power	kw	Scaler
15	XLOAD AVG	Avg. Horizontal Boom Pin Load—Left & Right Hand Side	lbf	Positive toward head
16	FCYLD	Effective Boom Lift Jack Force	lbf	Positive to raise head
17	TORQUE AVG	Average Torque—Left & Right Hand Side	lbf-ft	Scaler
18	DELTA	Maximum Depth of Cut	in./rev	Scaler
19	F-SUMP	Sump Force(Total)	lbf	Positive toward tail piece
20	YLOAD	Avg. Vertical Boom Pin Load—Calculated Total Load	lbf	Positive—up
21	F-SHEAR	Shear Force (Total)	lbf	Positive—up
22	ALPHA	Angle Between Boom & Lift Jack	degrees	Scaler
23	M POWER	Mechanical Power Delivered to Cutterhead	kw	Scaler
24	EFF	Conversion Efficiency—Elec. Power to Mech. Power	percent	Scaler
25	HEAD RPM	Cutterhead Rotary Speed—Calcuated from Red. Ratios	rpm	Scaler
26	BETA	Angle Between Horizontal & Boom	degrees	Scaler
27	RATIO	Ratio of Max. Depth of Cut to Bit Spacing	—	Scaler

*Reference to right/left hand side is defined from the operator's compartment looking toward the head.

3.7.4 Analysis

Analysis of the computer-generated results initially consisted of plotting the parameter values as a function of RPM, depth of cut, and cutting cycle (sump or shear). Later, an analysis of covariance was performed to normalize computer values to an average depth of cut. Quantities could then be averaged and examined for sensitivity to head rotary speed.

4.0 EXPERIMENTAL RESULTS

4.1 System performance

Adjustments to the experimental plan as described in Section 3.0 were made as a consequence of unanticipated problems with the HH456 and the DAS.

4.1.1 Test Machine

The rock in the seam represented very difficult cutting conditions that took their toll on the HH456. The problem that manifested itself most often was the loss of the bit blocks. Although proper tightening and monitoring of the block bolts reduced the problem, welding was often required. Welding of the blocks to the head, in turn, reduced the ability to alter bit spacing in a timely manner. Consequently, once a spacing was established, all testing (at both head speed conditions) was conducted before going to the next bit spacing arrangement.

The presence of rock in the seam dictated not only a change in test sequence but also a change in bit spacing test objectives. Only one test was attempted at the 8-inch bit spacing. As shown in Figure 34, the 8-inch spacing worked well for the sump cycle, but once the rock band was encountered on shear, the machine began to "buck" and experience large lateral displacements, as evidenced by the bit marks shown in Figure 32. Rather than risk damage to the machine, the deci-

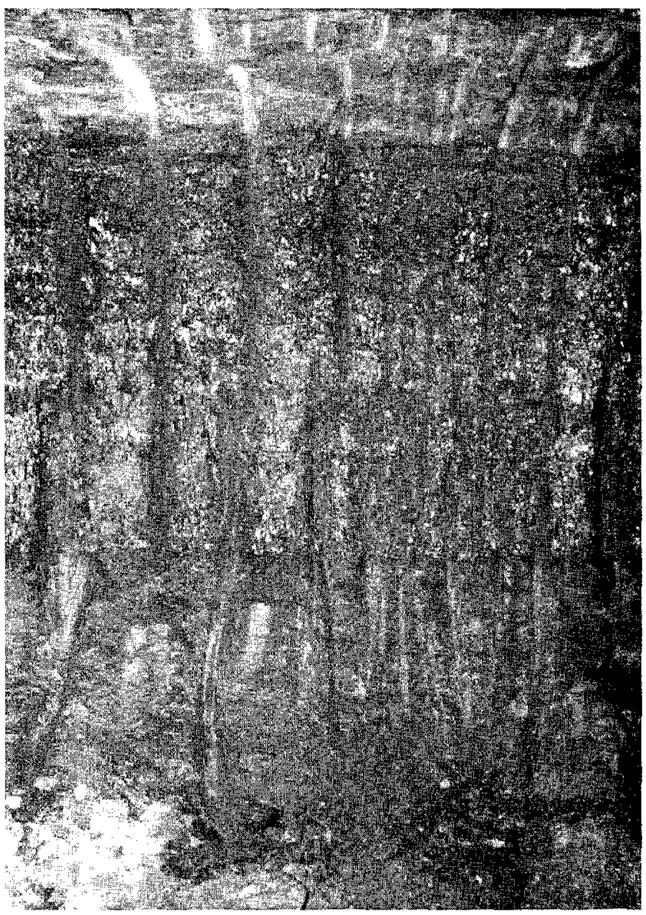


Figure 32. Coal Face Using 8-inch Bit Spacing

sion was made to discontinue testing at the 8-inch spacing. The spacing was reduced to 4 inches, and testing resumed, with the same depth of cut objectives for the 8-inch spacing (3.5 in./rev).

As the testing progressed to the higher advance rates, the machine began to experience speed box coupling failures, either with the coupling spline or the coupling key. Additionally, the machine did not have the thrust capacity to consistently cut at the desired rate on sump. The highest average sump rate attained was 2.8 inches per revolution.

4.1.2 Data Acquisition System

With the exception of the bit load recording system, the DAS worked very well, considering the environment. Persistent problems were encountered with only two of the transducers—the watt transducer and one of the instrumented load pins. The signal conditioning for the watt transducer was damaged early in the testing. Despite several attempts to repair the unit, its response level was never again consistent with calibrated levels; therefore, no power data was obtained.

The right side load pin used to monitor horizontal forces developed an unusual characteristic midway through the testing. The signal would invert itself during a test; however, during static load situations, its response was normal and consistent with the left side pin. No explanation of an electronic nature could be found. Although it was never verified, the instrumented pin could have been rotating with the boom.

The bit load recording system did not perform as expected. Initially, the problems were of a "quality control" nature, in that certain components were not properly matched, and printed circuit boards were not properly protected against corrosion. After these initial problems were resolved, other problems were encountered with the instrumented bits. Both the strain gages and the load cell used in each assembly had a very limited life. Only after the testing was near completion was an acceptable adhesive/coating procedure found for the strain gages. Unfortunately, this was at a time when the machine advance rates were at their highest, and the high loads in cutting the rock caused permanent deformation of the insert and/or damage to the load cell. Out of three instrumented positions, we could get only one system to consistently perform, and it was at great cost in terms of expended inserts and load cells.

4.2 Analysis of Test Data

The computer summary sheets for each test are contained in Appendix A. The average and RMS values for sump/shear forces, cutting horsepower, and bit loads for each test are summarized in Tables 9 and 10.

As indicated in the Experimental Plan, depth of cut was to be varied in three discrete increments—1, 2, and 3.5 inches per revolution for each head speed. In actuality, however, the machine advance rate during a given test series varied considerably. Because of the variability within each test cell, comparison of data across cells purely on the basis of "planned depth of cut" was meaningless. To analyze the data, it was therefore necessary to regroup the tests by actual depth of cut and bit spacing. With the tests regrouped, as shown in Tables 11 and 12, the cell averages for the various parameters (forces, torques, etc.) were computed and plotted using linear regression and power curve routines.

TABLE 9. Summary of Test Results

Run No.	RPM	SUMP CYCLE Delta Avg	Ratio Avg	F-Sump RMS	F-Sump Avg	F-Shear RMS	F-Shear Avg	M-Power RMS	M-Power Avg	SHEAR CYCLE Delta Avg	Ratio Avg	F-Sump RMS	F-Sump Avg	F-Shear RMS	F-Shear Avg	M-Power RMS	M-Power Avg
1	51	1.9	1.0	18009	11092	10391	10278	198	177	1.2	0.6	18612	8955	23197	22382	170	160
2	51	1.2	0.6	29827	-28711	23261	23184	204	196	1.4	0.7	26218	-23906	22125	21407	187	173
3	51	0.9	0.5	16263	-13561	21042	21070	193	183	1.6	0.8	15736	-10235	26482	25995	214	206
4	51	1.2	0.6	37364	-37229	10951	10968	58	50	1.0	0.5	44006	-42939	9416	8344	60	50
5	51	0.9	0.4	12952	1851	17314	17359	182	170	0.9	0.5	32361	28199	25437	24894	189	177
6	18	2.7	1.4	19305	12776	21655	21582	136	131	1.9	1.0	19205	-12211	20235	19817	79	73
7	18	2.1	1.0	20112	2317	18548	18223	146	136	1.9	1.0	18738	-11963	26238	26094	120	115
8	18	1.9	0.9	17614	-5343	25804	25768	132	127	2.0	1.0	13764	-5155	26362	25756	100	94
9	18	1.2	0.6	29052	-20605	26116	25933	97	88	2.9	1.4	24657	-20779	28770	28252	92	87
10	18	2.1	1.1	32017	-25953	20425	20223	71	59	2.5	1.3	17995	-2055	17346	16706	69	63
11	18	1.0	0.3	16501	-15114	14791	25805	51	48	2.5	0.6	23589	-19141	14257	13506	50	44
12	18	2.6	0.6	31678	-13369	14515	25730	93	82	1.5	0.4	28034	9977	22317	21996	77	73
13	18	2.0	0.5	23976	-13889	25362	25373	84	79	1.8	0.5	21433	3721	22990	22514	79	76
14	18	2.1	1.0	19686	-7037	26402	26281	188	178	1.8	0.9	22880	14751	25524	23723	155	149
15	18	1.9	1.0	90322	-69226	44428	41176	125	101	2.3	1.1	50821	-7971	18573	17941	117	108
16	51	0.7	0.2	50045	-49174	22982	22976	140	126	1.1	0.3	33191	-10811	19060	18469	188	168
17	51	0.7	0.2	54062	-52264	24162	24165	150	132	1.3	0.3	26320	-9811	23112	21886	189	167
18	51	0.8	0.2	51453	-49793	22643	22632	145	126	1.3	0.3	25090	-4653	24590	24131	223	204
19	51	0.8	0.2	37063	-30530	21339	21317	179	158	1.2	0.3	26269	-5758	27602	27155	234	213
20	51	0.6	0.1	41639	-39653	21545	21528	179	157	1.2	0.3	30473	-12885	27590	27173	234	210
21	51	0.3	0.0	67706	-67392	24468	24459	57	50	2.2	0.3	62361	-54066	24108	23123	154	128
22	51	1.4	0.2	31890	-13349	25976	25118	231	209	-1.7	-0.2	27851	-26631	26526	26502		
23	51	0.5	0.1	56138	37159	15787	7377	166	125	1.8	0.5	73164	-58759	31005	29645	271	257
24	51	2.5	0.6	39065	-17052	26364	25027	265	253	1.5	0.4	75204	-62082	28969	28074	246	234
25	51	1.2	0.3	52625	-51804	21252	21185	189	160	1.6	0.4	77689	-42179	23619	22891	240	226
26	18	1.6	0.4	29374	-25549	17188	16987	72	61	4.3	1.1	21357	-18481	26180	26044	106	99
27	18	2.1	0.5	29887	-27683	22577	22569	88	75	3.8	1.0	17583	-14617	29013	28804	113	105
28	18	2.3	0.6	21931	-18777	15935	15878	146	130	6.2	1.5	43773	-42609	19038	18434	95	79
29	18	2.0	0.5	18159	-16321	17895	17632	150	141	3.5	0.9	20110	-17260	30600	30282	208	201
30	18	2.8	0.7	22004	-18659	24631	24621	214	199	3.1	0.8	20103	-17894	31060	30568	202	194

TABLE 10. Bit Load Data Summary

Run No.	RPM	Bit Location	SUMP Delta Avg	SUMP Ratio Avg	SUMP F-Bit 1 RMS	SUMP F-Bit 1 Avg	SUMP F-Bit 2 RMS	SUMP F-Bit 2 Avg	SUMP F-Bit 3 RMS	SUMP F-Bit 3 Avg	SHEAR Delta Avg	SHEAR Ratio Avg	SHEAR F-Bit 1 RMS	SHEAR F-Bit 1 Avg	SHEAR F-Bit 2 RMS	SHEAR F-Bit 2 Avg	SHEAR F-Bit 3 RMS	SHEAR F-Bit 3 Avg
1	51	Face	1.9	1.0	295	130	1314	908	335	-100	1.2	0.6	433	275	1244	872	394	42
1	51	Strut	1.9	1.0	392	-64	1126	840	790	286	1.2	0.6	583	211	932	636	900	195
2	51	Strut	1.2	0.6	420	305	ND**	ND	826	656	1.4	0.7	487	271	ND	ND	973	642
5	51	Face	0.9	0.9	ND	ND	1328	1109	535	-240	0.9	0.5	ND	ND	1263	1027	460	-152
6	18	Gauge	2.7	1.9	443	260	ND	ND	886	473	1.9	1.0	253	175	ND	ND	303	190
6	18	Face	2.7	1.9	221	51	1383	910	325	-114	1.9	1.0	350	-132	1731	985	446	-17
7	18	Gauge	2.1	1.0	—*	—	—	—	—	—	1.9	1.0	320	165	ND	ND	561	248
7	18	Face	2.1	1.0	—	—	—	—	—	—	1.9	1.0	228	101	ND	ND	295	-62
8	18	Gauge	1.9	0.9	420	262	ND	ND	777	442	2.0	1.0	390	204	ND	ND	764	345
9	18	Gauge	1.2	0.6	466	247	ND	ND	827	436	2.9	1.4	667	433	ND	ND	737	329
10	18	Face	2.1	1.1	—	—	—	—	—	—	2.5	1.3	ND	ND	1904	951	817	-241
11	18	Gauge	1.0	0.3	—	—	—	—	—	—	2.5	0.6	557	287	3391	1635	1355	654
16	51	Face	0.7	0.2	—	—	—	—	—	—	1.1	0.3	628	-166	ND	ND	936	333
17	51	Face	0.7	0.2	—	—	—	—	—	—	1.3	0.3	826	-234	ND	ND	1049	186
18	51	Face	0.8	0.2	731	-574	ND	ND	811	573	1.3	0.3	624	-407	ND	ND	637	394
19	51	Face	0.8	0.2	629	-429	ND	ND	638	426	1.2	0.3	848	-164	ND	ND	1308	529
22	51	Face	1.4	0.2	—	—	—	—	—	—	ND	ND	448	-220	2009	1599	ND	ND
23	51	Face	0.5	0.1	—	—	—	—	—	—	1.8	0.5	565	-350	4205	2657	ND	ND
25	51	Face	1.2	0.3	1619	1399	4048	3498	1619	1399	1.6	0.4	2043	1656	5108	4140	2043	1656
26	18	Face	1.6	0.4	ND	ND	1990	1215	311	3	4.3	1.1	ND	ND	2133	1155	403	51
27	18	Face	2.1	0.5	ND	ND	2935	1832	453	-167	3.8	1.0	ND	ND	2961	1559	578	-74

* Blank entries indicate that no data was recorded during the sump cycle. Recorder "delay" longer than sump time.

**"ND" designates channel malfunction.

Table 11. Test Distribution by Depth of Cut, Bit Spacing, and Cutting Cycle - 18 RPM

SUMP

S = 2 in.*

Test No.	Average ℓ_{max}**
9	1.2
8	1.9
7	2.1
0	2.1
	2.03 (mean)
6	2.7

S = 4 in.

Test No.	Average ℓ_{max}
11	1.0
26	1.6
15	1.9
13	2.0
29	2.0
14	2.1
27	2.1
28	2.3
	2.07 (mean)
12	2.8
30	2.6
	2.7 (mean)

SHEAR

S = 2 in.

Test No.	Average ℓ_{max}
6	1.9
7	1.9
8	2.0
	1.93 (mean)
10	2.5
9	2.9
	2.7 (mean)

S = 4 in.

Test No.	Average ℓ_{max}
12	1.5
13	1.8
14	1.8
	1.7 (mean)
15	2.3
11	2.5
	2.4 (mean)
30	3.1
29	3.5
27	3.8
	3.65 (mean)
26	4.3

*S = bit spacing
**ℓ = depth of cut

Table 12. Test Distribution by Depth of Cut, Bit Spacing, and Cutting Cycle - 51 RPM

SUMP

S = 2 in.*

Test No.	Average ℓ_{max}**
3	0.9
5	0.9
2	1.2
4	1.2
	1.05 (mean)
1	1.9

S = 4 in.*

Test No.	Average ℓ_{max}
23	0.5
20	0.6
16	0.7
17	0.7
	0.625 (mean)
18	0.8
19	0.8
	0.8 (mean)
25	1.2
24	2.5

SHEAR

S = 2 in.

Test No.	Average ℓ_{max}
5	0.9
4	1.0
1	1.2
	1.03 (mean)
2	1.4
3	1.6
	1.5 (mean)

S = 4 in.

Test No.	Average ℓ_{max}
16	1.1
19	1.2
20	1.2
17	1.3
18	1.3
	1.22 (mean)
24	1.5
25	1.5
23	1.8
	1.63 (mean)

*S = bit spacing
**ℓ = depth of cut

4.2.1 Bit Loads

Because of various operational problems, we were not able to keep the recording systems working consistently. Furthermore, we had to dedicate available resources to recording face bit loads. Consequently, we obtained very limited data from the instrumented strut bit and gage bit. Although there was not sufficient data to establish the relationship between load and depth of cut at the strut and gage positions, the data did indicate that the load components were not drastically different in terms of magnitude than those of a face bit for any given machine advance rate.

With the emphasis on measuring face bit loads, we obtained considerably more loading data than would otherwise have been possible. Despite the emphasis, however, the data set was far from complete in the sense we did not get the repetition needed to perform a complete statistical evaluation. Thus, our analysis merely exhibits the trends associated with the measurements.

Since we did not expect cutting speed to have any significant influence on the face bit loads, the 18-RPM bit data were combined with the 51-RPM bit data to produce the data sets shown in Table 13. Linear regression curve fits were then done for each load component, with the results shown in Figures 33, 34, and 35.

Table 13. Test Distribution for Face Bit Data

SUMP

S = 2 in.*

Test No.	Average ℓ_{max}**
5	0.9
1	1.9
6	2.7

S = 4 in.

Test No.	Average ℓ_{max}
17	0.7
18	0.8
19	0.8
26	2.1
27	2.1

SHEAR

S = 2 in.

Test No.	Average ℓ_{max}
5	0.9
1	1.2
6	1.9
7	1.9
10	2.5

S = 4 in.

Test No.	Average ℓ_{max}
16	1.1
19	1.2
17	1.3
18	1.3
23	1.8
27	3.8
26	4.3

*S = bit spacing.
**ℓ = depth of cut.

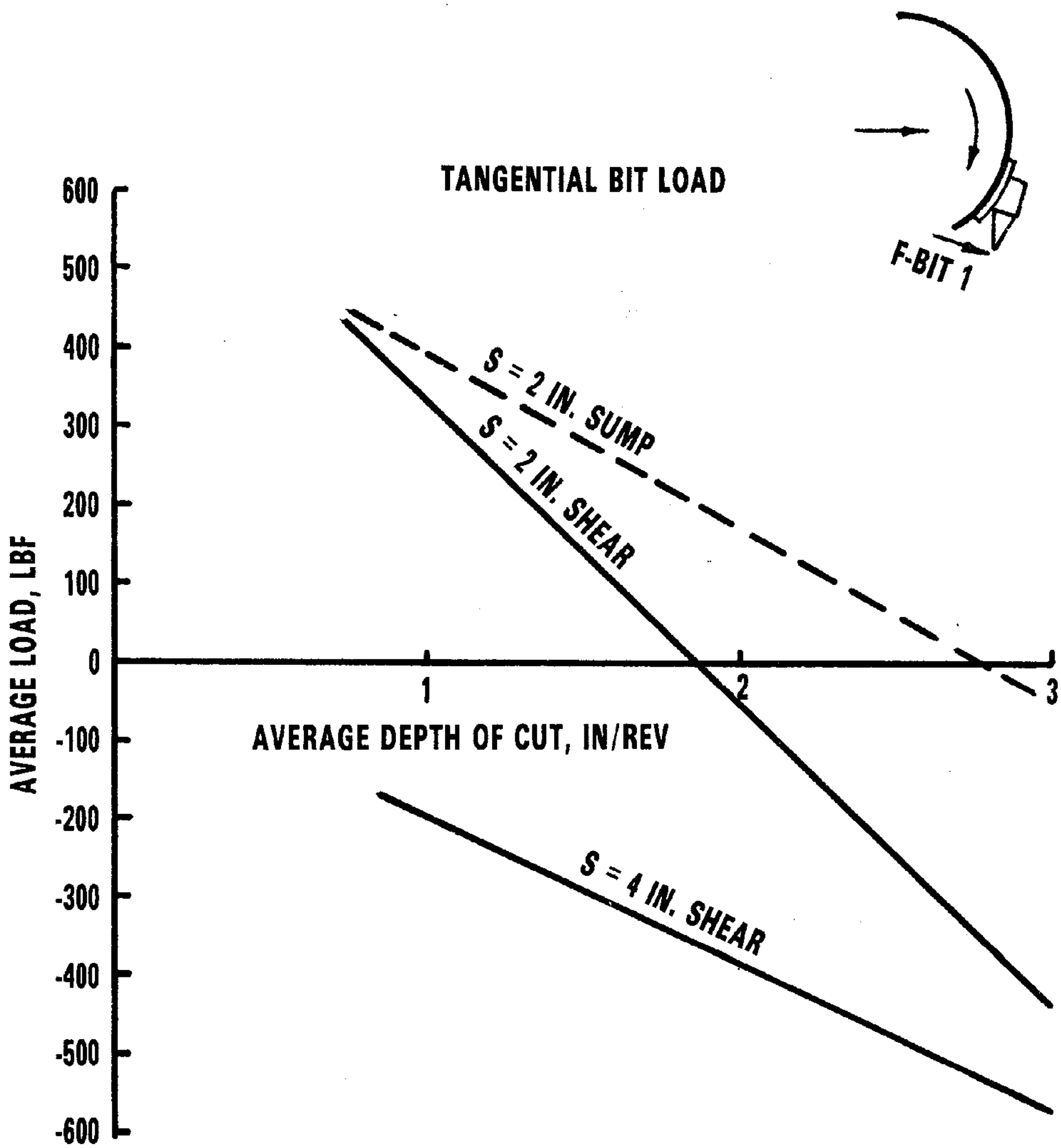


Figure 33. Average Tangential Bit Load vs. Depth of Cut (both RPMs)

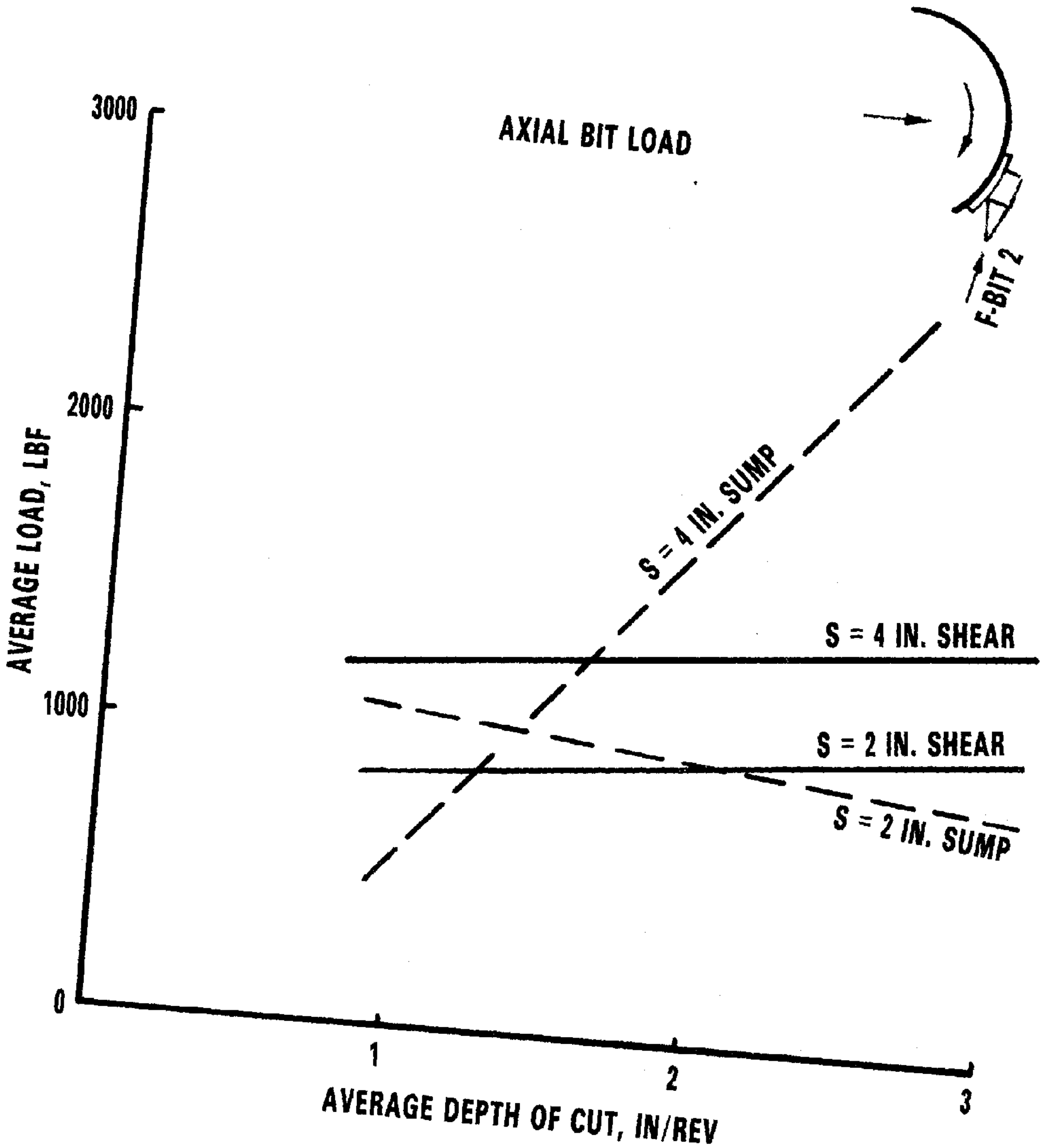


Figure 34. Average Axial Bit Load vs, Depth of Cut (both RPMs)

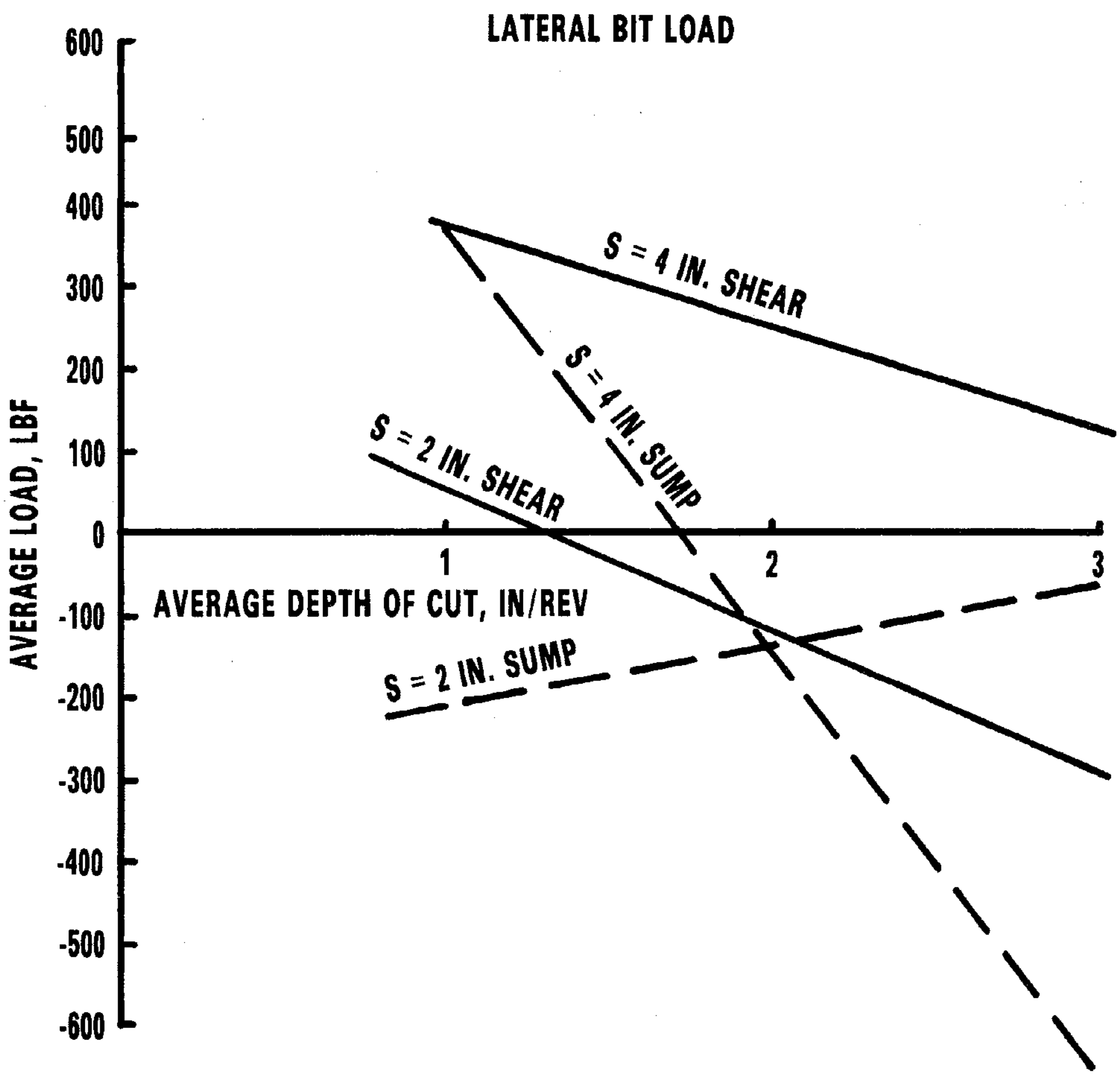


Figure 35. Average Lateral Bit Load vs. Depth of Cut (both RPMs)

4.2.1.1 Tangential Bit Load

The average load tangential to the bit axis (Figure 33) shows a negative gradient with respect to increasing depth of cut. Unlike the 2-in. spacing configuration, which starts positive and goes through zero load between 2-3 in/rev, the 4 in. spacing configuration started at a negative level. The negative values in both cases imply that the load is opposite to the direction assumed; i.e., instead of tending to lift the bit block away from the front bolt hole, the load actually tries to lift the block at the back bolt hole when negative.

The negative gradient associated with the tangential bit load came from a reversal in load direction as the machine advance rate was increased. Accordingly, as the testing progressed to higher depth of cut, the negative portion of the load history subtracted from the positive portion, thereby reducing the average value for the cycle. A typical load history is shown in Figure 36 to illustrate the characteristics of the reversal.

There are three possible explanations for the observed tangential load:

(1) The negative load is due to "self-loading"; i.e., after a chip is created, the bit "springs back" in response to the reduced load.

(2) The negative load is due to the cutting of the rock band, which was considerably harder than the coal.

(3) The instantaneous advance rate and rotary speed combine to reduce the velocity of the bit with respect to the face during rotation through the lower quadrant such that the bit is forced into the face.

Of these three possibilities, the duration of the negative load tends to discount the first possibility. Furthermore, if the rock were the primary factor, then one would expect to see the load reversal primarily on shear, as it was during the shear cycle that most of the rock was taken. Since the average decreased for both sump and shear cycles, only the last possibility is left to explain the result. We suspect, however, that the non-uniformity in the seam had an effect, and additional research is needed to fully understand the data.

4.2.1.2 Axial Bit Load

Generally speaking, the average values of the axial bit load increased with increasing depth of cut. The one excpetion occurred with the 2-in. bit spacing. On sump, the axial bit load had a small negative slope with increasing depth of cut. The observed axial loads did not show the expected rate of increase. Possible reasons for the slightness in slope include

(1) dirt in the transducer that increased the friction between the bore and the insert, thereby reducing the axial response, and

(2) the limitation of the data itself in that the curves were fitted to relatively few points.

4.2.1.3 Lateral Bit Load

For a face bit, one would expect the lateral bit load to be very near zero for non-interacting grooves. As shown in Figure 35, however, the data would suggest that the side relief created by the adjacent bit causes a significant side load for the shallower depths of cut with the effect of the side relief decreasing with increasing depth of cut.

4.2.1.4 Cutting Force

Besides providing insight to the load history, our intent in measuring bit load components was to ultimately resolve the coal cutting forces acting tangentially and normal to the bit trajectory. The transformation would then allow the data collected from the mine to be more easily compared with data derived from linear cutting experiments, as well as serve as a means of correlation with other machine parameters, such as boom forces and cutterhead torque. The results of the coordinate transformation for the face bit data are shown in Figure 37.

As would be expected, the tangential force (or cutting force) decreases with increasing depth of cut because of the change in directional sense of the load normal to the bit axis (F-Bit 1) previously discussed. On the other hand, the force normal to the cutterhead orbit increases due to the contribution of F-Bit 1 with increasing depth of cut.

4.2.1.5 Maximum Bit Loads

The maximum value observed for a given bit load component was between 4—5 times greater than the respective average value. The same proportion was true of the relationship between the load normal to the bit axis and the bit axial load; i.e., the maximum axial load (F-Bit 2) was approximately five times greater than the maximum normal (F-Bit 1) load.

4.2.2 Cutterhead Torque

Because the bit forces that create the cutterhead torque requirement are independent of RPM, the motor torque measurements for each test were combined in one data set. The appropriate torque ratios were, of course, applied to each RPM set (18 and 51) to convert motor torque to cutterhead torque. The approach of converting motor torque to head torque, while straightforward, inherently assumes that clutch slippage is zero. This assumption did not always apply. During the larger depths of cut (particularly at 18 RPM), the clutches became hot, which was indicative of some slippage.

As shown in Figure 38, there was not a consistent difference between sump vs. shear torque. At the 2-in. spacing, sump torque was higher than shear torque. At the 4-in. spacing, shear torque was generally higher than sump torque. With both sump and shear, the torque increased with depth of cut.

4.2.3 Cutterhead Power

Because the torque data did not consistently show a difference between cutting cycles (sump vs. shear), the cycle data sets were combined to analyze cutterhead power. The discrimination between RPM (18 RPM vs. 51 RPM), however, was maintained.

As shown in Figures 39 and 40, the horsepower for both RPM configurations increased with depth of cut. Furthermore, the 51-RPM configuration required about 2—3 times more power than the 18-RPM configuration, as would be expected.

The effect of bit spacing on power requirement was most pronounced at 51 RPM. For 51 RPM, the 4-in. spacing required about 20 percent more power than the 2-in. spacing.

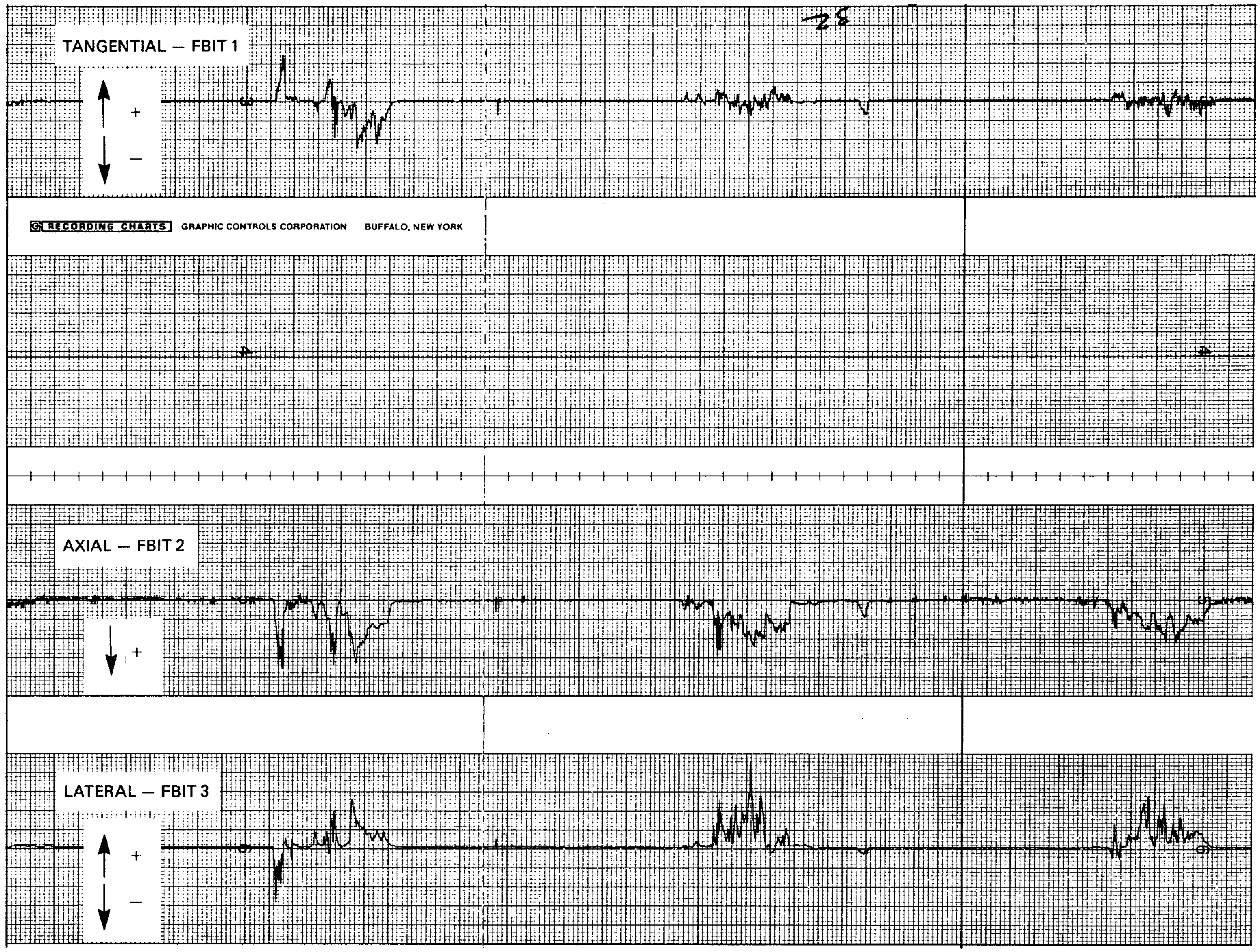


Figure 36. Face Bit Load History with Load Reversal on Tangential Axis

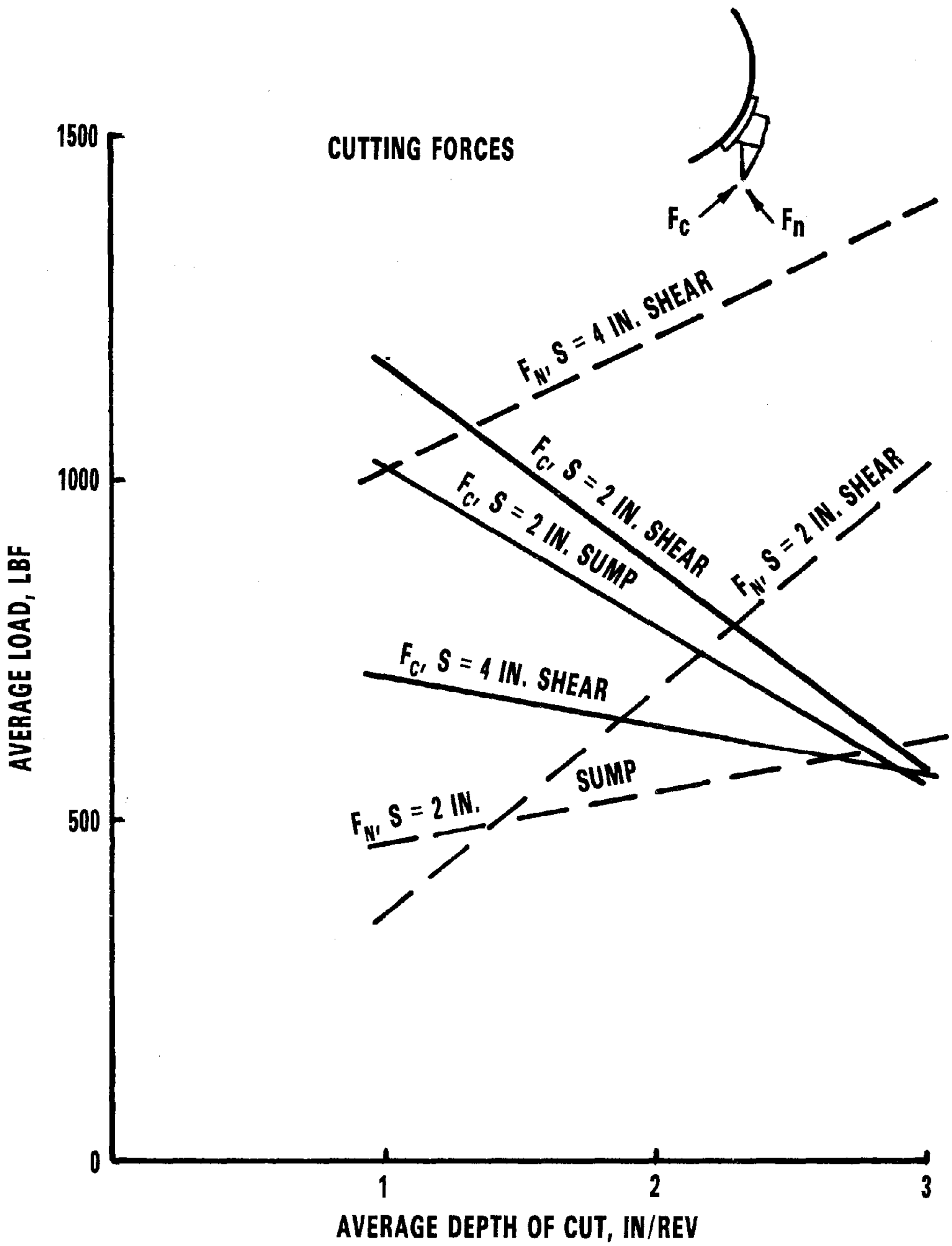


Figure 37. Average Face Bit Cutting Forces vs. Depth of Cut (both RPMs)

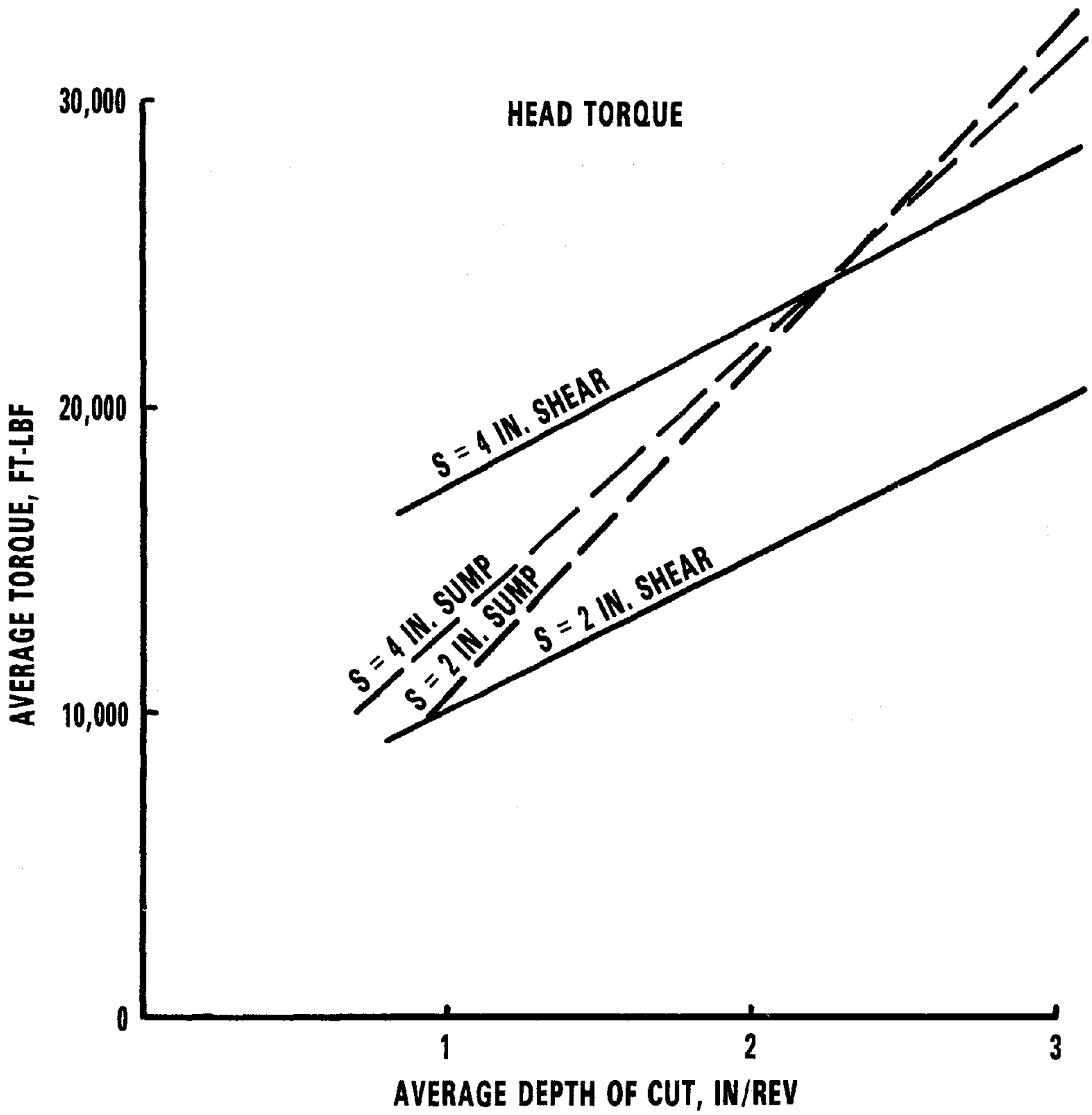


Figure 38. Average Head Torque vs. Depth of Cut (both RPMs)

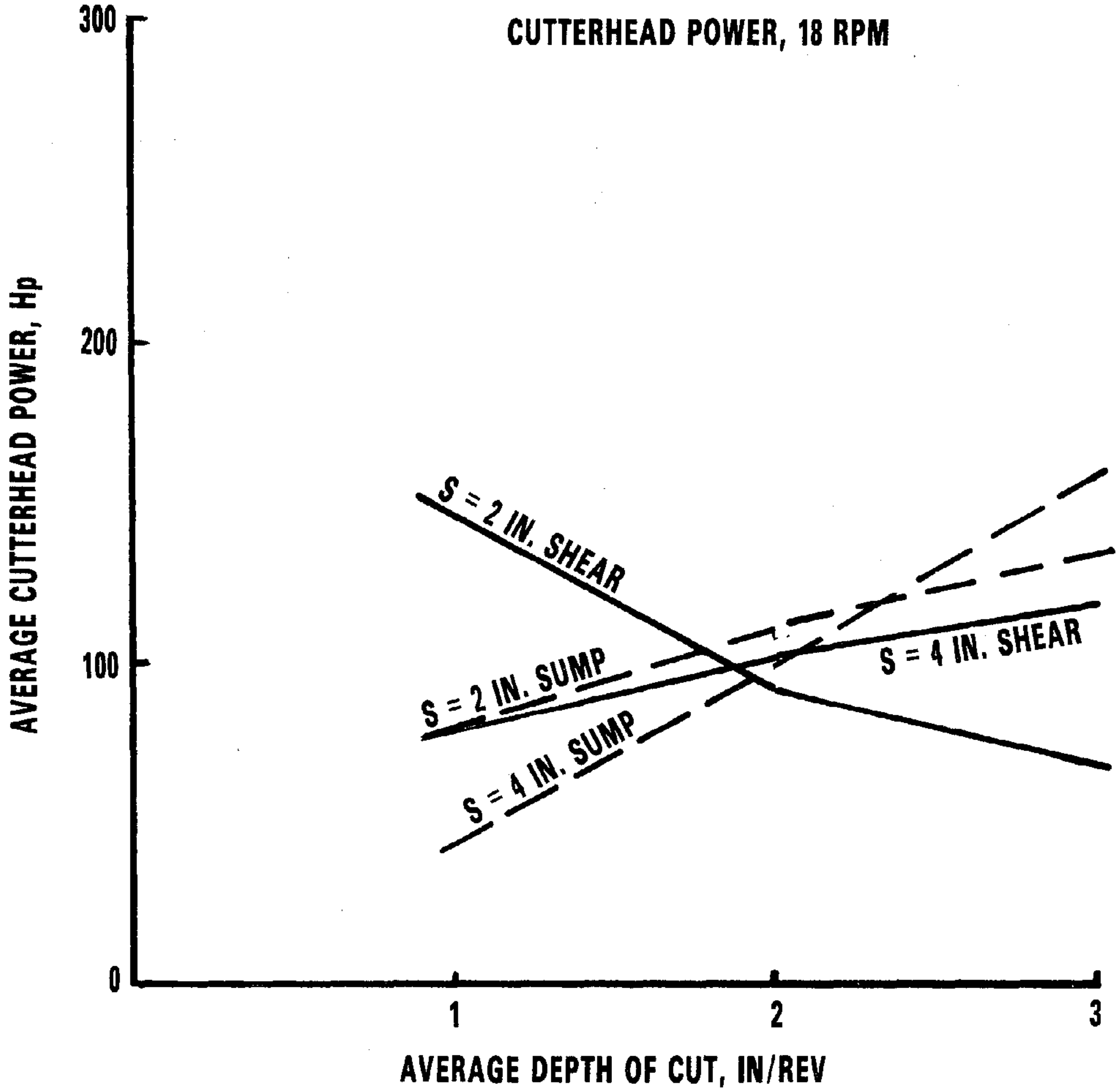


Figure 39. Average Cutterhead Power vs. Depth of Cut, 18 RPM

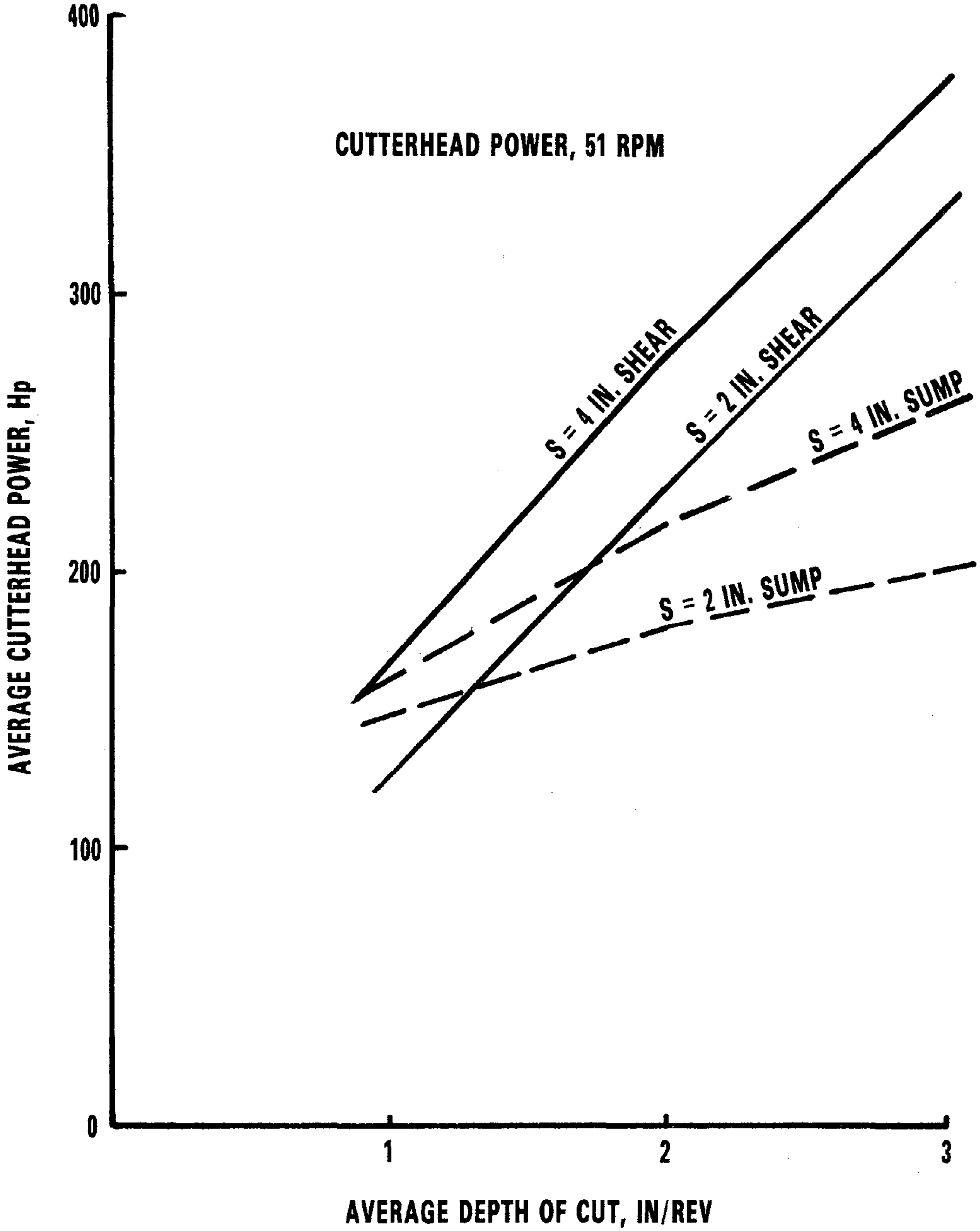


Figure 40. Average Cutterhead Power vs. Depth of Cut, 51 RPM

4.2.4 Specific Energy

Specific energy, as commonly used in evaluating mining machinery, is the ratio of power to production rate. Inasmuch as we did not measure tonnage on a cut-cycle basis, specific energy based on predicted tonnage of the machine for a given cut cycle introduces an artificial aspect to the data. The difficulty can be overcome by using the actual advance rate of the machine, which is directly proportional to production rate, as the geometry of the cutterhead did not change during the test program. Calculating specific energy in this manner precludes a direct comparison between machines. One must first know the production per foot of advance for each machine in order to make comparisons.

The specific energy relationships for both the 18-RPM and the 51-RPM data sets (Figures 41 and 42) reveal a significant decrease in specific energy when the depth of cut exceeds 2 in./rev.—a result consistent with previous field testing of the HH456.

A comparison of the data sets purely on the basis of the RPM does not provide any distinctive characteristics. This is so because of the apparent lack of "order" associated with the 18-RPM data set.

Although the 18-RPM result (Figure 41) is hard to interpret, the 51-RPM configuration (Figure 42) indicates the shear specific energy to be higher than the sump specific energy. In light of the seam characteristics, this would be expected as the rock in the seam was typically taken during the shear cycle. If, however, the RPM data sets are combined, the result is totally different. As shown in Figure 43, combining the sump data for both RPMs and the shear data for both RPMs produces just the opposite result;, i.e., sump specific energy is higher than shear specific energy. The inconsistency comes from the sump data for the 18-RPM data set, which was typically higher than the shear.

The 4-in. bit spacing typically produced a higher specific energy than did the 2-in. spacing.

4.2.5 Horizontal Boom Force

The horizontal boom force was derived from boom pin measurements and pressure values on the boom jacks. Because these forces are primarily dependent on the depth of cut and bit spacing, not RPM, the data sets for 18 and 51 RPM were combined. The results are shown in Figure 44.

As shown in Figure 44, the horizontal boom force during sump has a positive gradient. The more interesting aspect, however, is the variation in sense of direction of the force as depth of cut increases. At shallow depths of cut, the horizontal force is negative, indicating that the machine is being pulled toward the face. Near a cutting depth of 2 in./rev., the load direction reverses, indicating that the machine must then provide a forward thrust in order to cut.

The only explanation, other than instrumentation malfunction, available for the observed effect resides in the seam characteristics. The coal in the uppermost part of the seam was highly cleated and friable. On sump, the upper coal was taken and usually a small portion of the rock bank, depending on the total advance of the machine. The low resistance of the top coal, combined with the cutting of rock by the lower quadrant of the cutterhead, could induce a self-engaging effect.

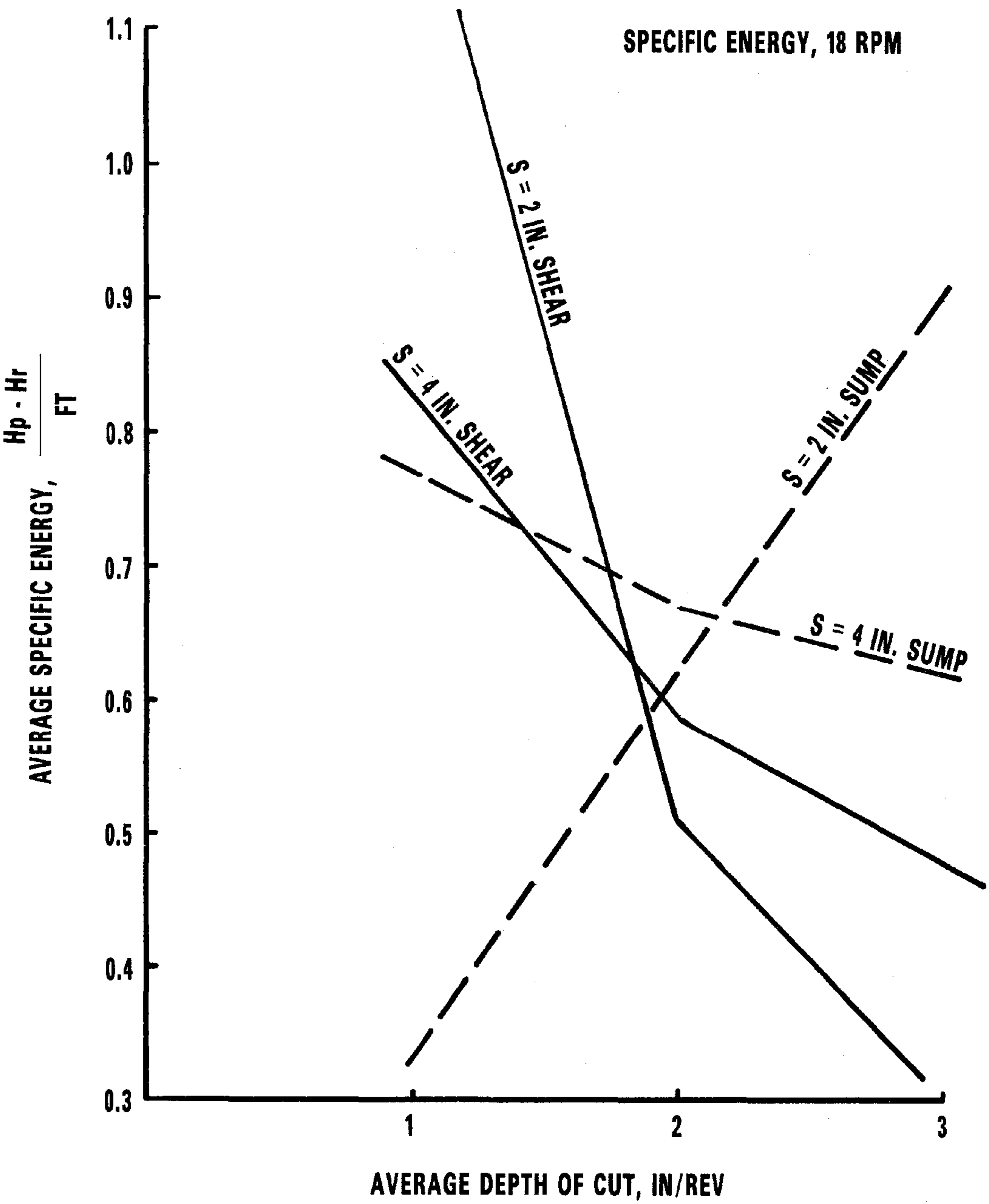


Figure 41. Average Specific Energy vs. Depth of Cut, 18 RPM

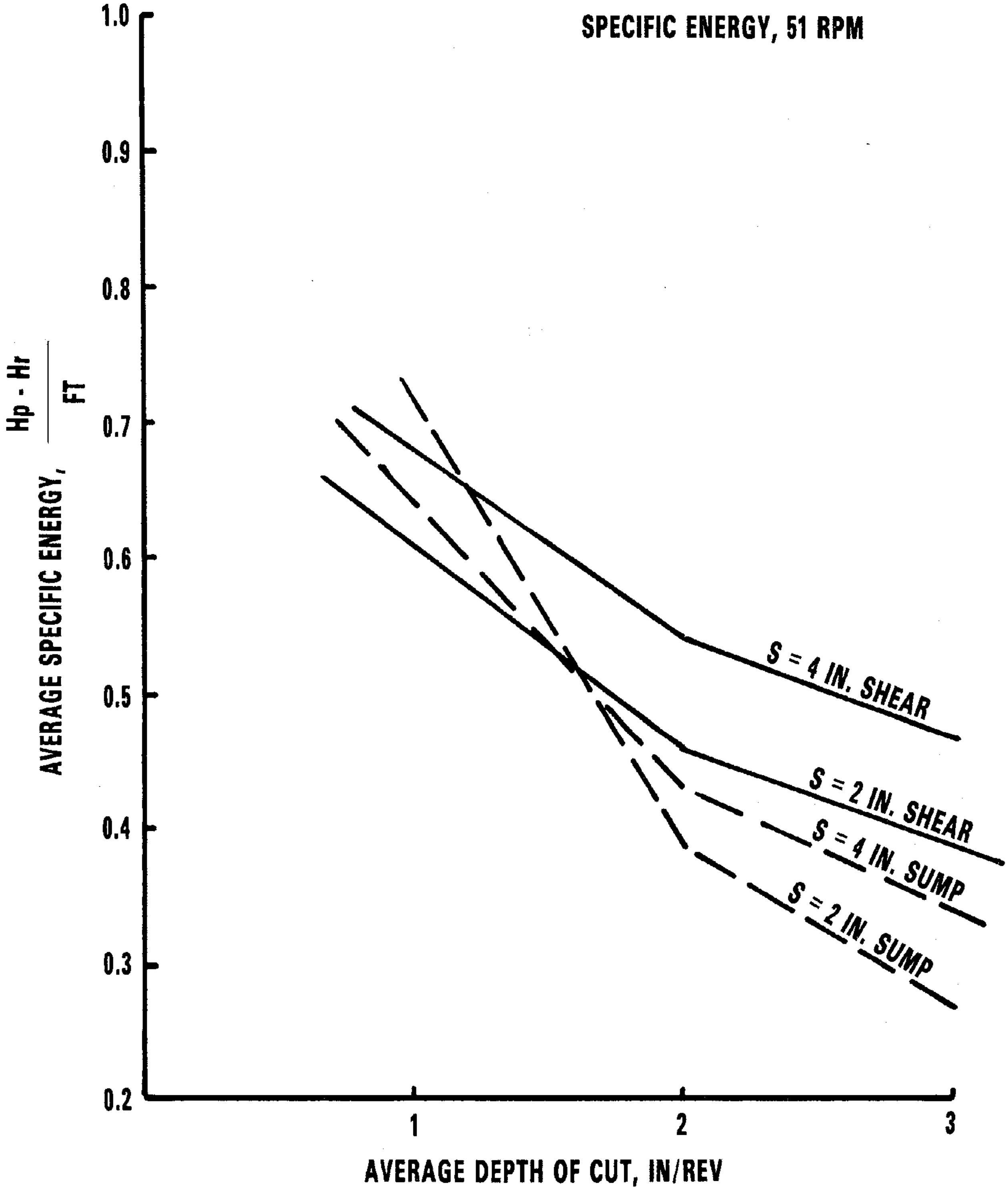


Figure 42. Average Specific Energy vs. Depth of Cut, 51 RPM

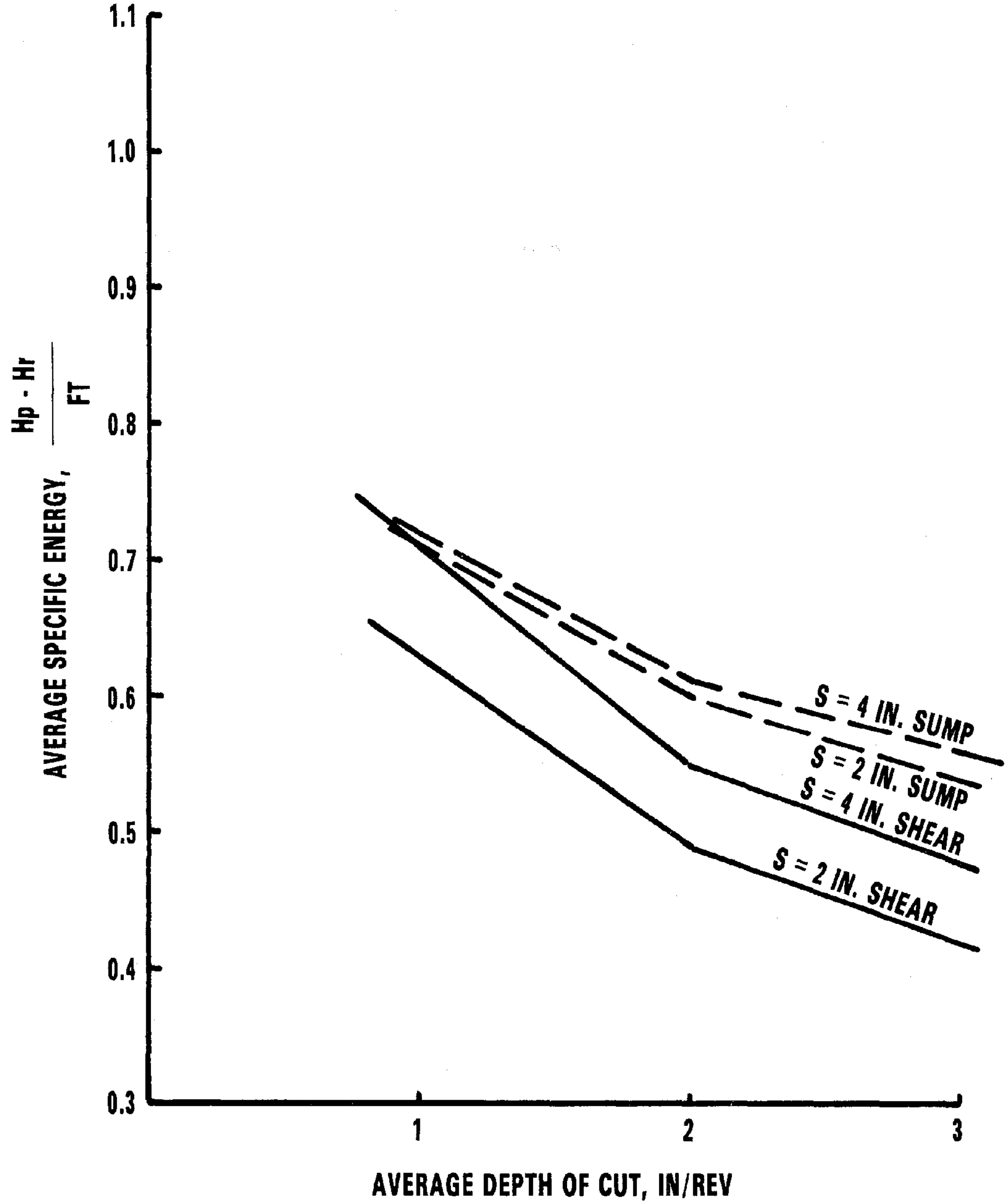


Figure 43. Average Specific Energy vs. Depth of Cut (both RPMs)

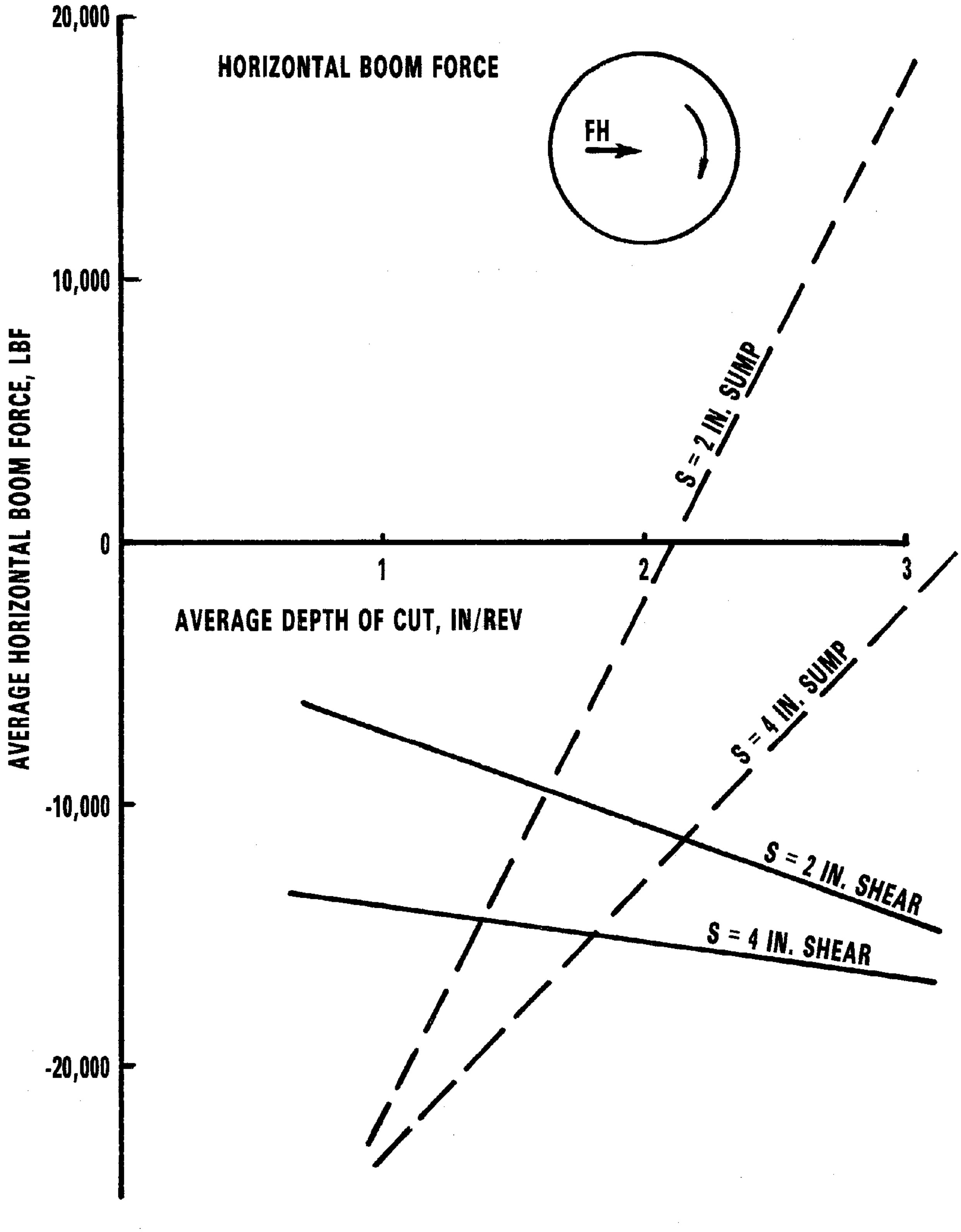


Figure 44. Average Horizontal Boom Force vs. Depth of Cut (both RPMs)

The self-engaging effect on shear is also indicated in Figure 44. In the case of shear, however, the gradient is negative, meaning that the self-engaging force increases with increasing depth of cut.

Bit spacing most directly effects the gradient of the force; i.e., the 2-in. spacing had a greater gradient than the 4-in. spacing. In addition, the force levels for the 4-in. spacing were typically higher than the 2-in. spacing for the same portion of the cut cycle and depth of cut.

4.2.6 Vertical Boom Force

The vertical boom force was also derived from boom pin measurements and boom jack pressures. The data sets for both RPMs were combined as was done for the horizontal boom force evaluation.

The vertical boom force (Figure 45) increases with depth of cut for both sump and shear. The shear load, however, is consistently greater than sump load for a given bit spacing and depth of cut.

As with the horizontal force, the 4-in. spacing typically generated higher vertical force levels than did the 2-in. spacing for similar cut cycles.

5.0 CONCLUSIONS

When operating at the same depth of cut and head lacing, the differences between the 18-RPM and 51-RPM machine configuration reside only in the power requirement to cut. There is no difference in boom forces or cutterhead torque. If compared on an equal production rate basis, however, there is considerable difference in force and torque. For example, to replace a typical 51-RPM machine operating at 1 in./rev. in the test mine with an 18-RPM machine that produces at the same rate would require a low-speed machine to operate at 3 in./rev. Using the test data, the higher advance rate of the low-speed machine implies the following:

- The head torque requirement would increase by 200 percent.
- The power requirement ($\approx$ 150 hp) would be the same.
- A 20,000-lb_f increase in the thrust requirement.

Ordinarily, the increase in thrust requirement would dictate an increase in machine weight or the use of auxiliary thrust rigs. Because of the nature of test data, however, a weight increase would not be necessary, assuming the basic machine weight was on the order of 100,000 pounds.

In light of the differences indicated and the operational experience with the HH456 18-RPM configuration tested in the mine, it is feasible to make the substitution without sacrificing production. The substitution could be in the form of new machines specifically designed for low-speed operations or in the form of reworked conventional machines.

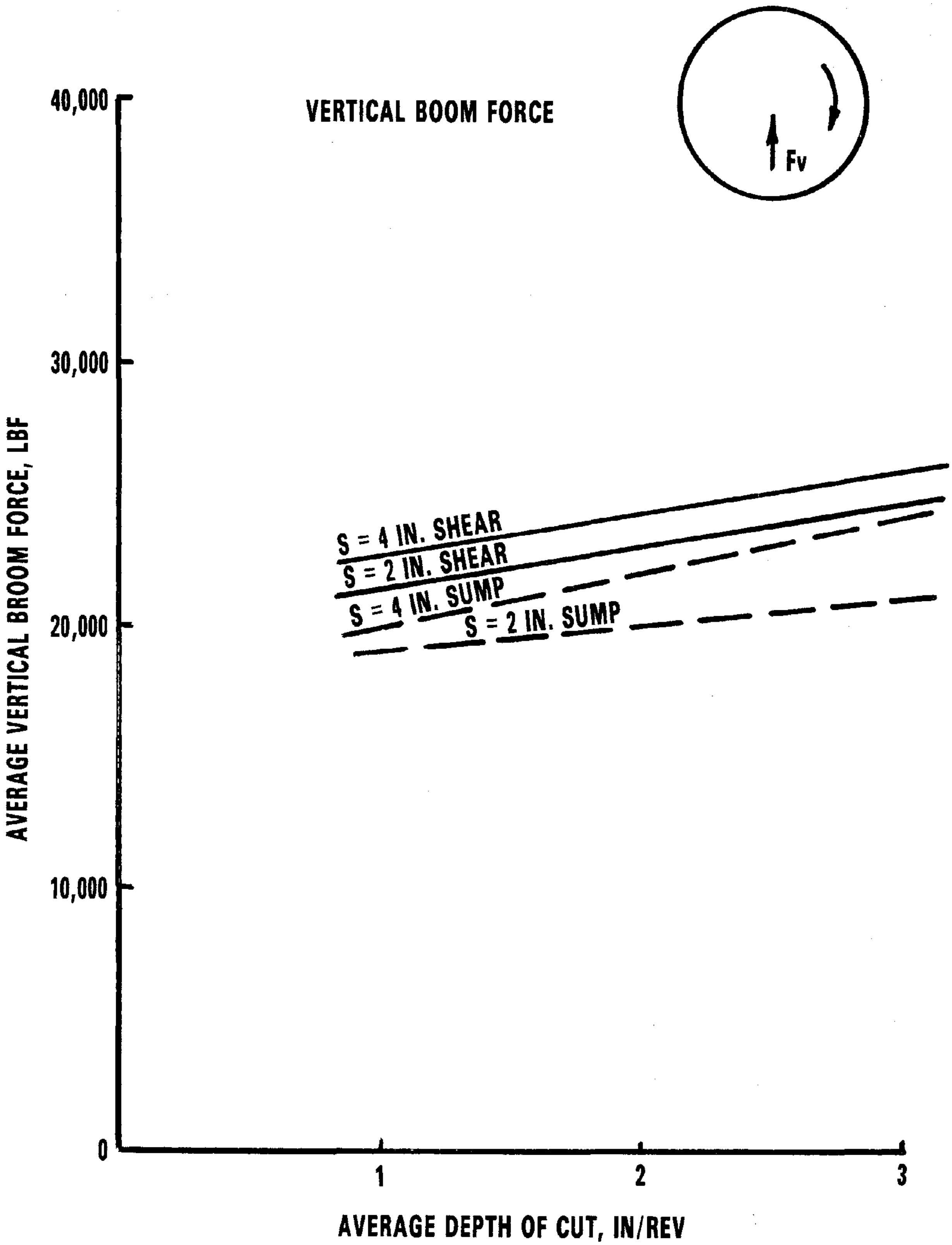


Figure 45. Average Vertical Boom Force vs. Depth of Cut (both RPMs)

REFERENCES

1. P.A. Boardman and E.J. Pedroncelli, "Investigations into Coal Cutting Using a Continuous Miner", summary of Progress Report No. 1, Chamber of Mines of South Africa, Coal Mining Laboratory, Research Report: 8/80; Project No. CT2T30

2. S. Black and J. Rounds, *Deep Cutting Continuous Miner (Effect of Drum Rotational Speed and Depth of Cut on Airborne Respirable Dust and Specific Energy),* NTIS Report No. PB-274345, 1977

3. S. Black and R.L. Schmidt, *Reduced Generation of Airborne Dust Through Deep-Cutting Continuous Miners,* U.S. Department of Interior, Bureau of Mines Information Circular 8753

4. R. Spencer, P. O'Brien, and H. Pastan, *Environmental and Functional Design Requirements for Supervisory Control Equipment Used in Underground Continuous Coal Mining,* USBM Contract Report, Contract No. JO166007, 1977

APPENDIX A. TEST SUMMARY SHEETS

APPENDIX A. TEST SUMMARY SHEETS

Explanation of Computer Sheet Headings

At the top of each summary page, the test number, cutting cycle, and test conditions are listed. The notation for the column headings is as follows:

CHAN ____ Chanel number; 1 through 14 refer to parameters actually measured and recorded; 15 through 27 refer to computed parameters.

LABEL ____ Parameter name (ref. Table 8)

RMS ____ The root mean squared value as calculated over the duration of the cycle

AVG ____ The average value as calculated over the duration of the cycle

MAX ____ The maximum value during the cycle

TMAX ____ The time (in seconds) at which the maximum occurred

MIN ____ The minimum value during the cycle

TMIN ____ The time (in seconds) at which the minimum occurred

MACHINE DATA SUMMARIES

TEST NO. 1 SUMP CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3

HEAD SPEED: 51 RPM BIT SPACING: 2 INCHES

LOCATION: 1- 89 DEPTH OF CUT: 1.0 IN/REV

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	446.9	392.7	1085.7	9.85	-37.2	4.70
2	TORQUE RHS	440.5	388.1	1044.0	6.36	-20.7	4.61
3	SHAFT RPM	1559.5	1562.6	1654.7	15.08	1469.9	3.85
4	X-LOAD LHS	17742.2	-10843.8	33615.9	5.17	-38061.3	.35
5	X-LOAD RHS	16510.8	-1424.1	41859.1	5.15	-34102.8	.36
6	F-CYLD DWN	9061.1	7710.2	19806.3	6.40	53.1	2.87
7	F-CYLD UP	22569.6	22000.4	33717.9	.43	13285.4	6.41
8	SUMP RATE	2.1	1.6	5.4	.36	-.1	6.55
9	SHEAR RATE	.3	.2	1.5	4.08	-.1	3.09
10	SUMP STK	24.8	23.2	34.7	14.83	-.1	.00
11	VERT STK	37.9	38.0	39.2	1.91	37.0	5.18
12	BOOM G-Y	1.2	-.0	3.5	5.86	-3.4	2.45
13	BOOM G-Z	.0	-.0	.0	5.86	-.0	2.45
~~14~~	~~E POWER~~	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	X-LOAD AVG	16112.9	-6134.0	27970.6	5.17	-36082.1	.35
16	F-CYLD	17356.3	14290.2	33408.0	.42	-6113.5	6.40
17	TORQUE AVG	439.0	390.4	1038.8	6.36	-8.5	4.70
18	DELTA	2.5	1.9	6.4	.36	-.1	6.55
19	F-SUMP	18008.5	11091.5	53067.6	5.17	-18455.1	.35
20	Y-LOAD	17611.7	14433.3	35806.1	6.40	-5524.2	.42
21	F-SHEAR	10391.3	10278.4	15437.9	14.69	4472.3	3.51
22	ALPHA	24.4	24.4	24.6	1.91	24.2	5.18
23	M POWER	198.1	176.8	474.3	6.36	-4.0	4.70
~~24~~	~~EFF~~	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	HEAD RPM	49.6	49.7	52.7	15.08	46.8	3.85
26	BETA	10.9	10.9	11.3	5.18	10.2	1.91
27	RATIO	1.3	1.0	3.2	.36	-.0	6.55

TEST NO. 1 SHEAR CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3

HEAD SPEED: 51 RPM BIT SPACING: 2 INCHES

LOCATION: 1- 89 DEPTH OF CUT: 1.0 IN/REV

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	391.9	349.0	1054.7	23.97	-24.6	10.71
2	TORQUE RHS	379.5	346.3	891.8	20.85	-28.4	7.56
3	SHAFT RPM	1567.1	1567.0	1673.5	11.61	1511.6	21.95
4	X-LOAD LHS	15484.2	5803.5	37293.4	26.66	-34685.3	11.67
5	X-LOAD RHS	29011.1	21715.8	55846.5	26.50	-19211.1	10.85
6	F-CYLD DWN	29999.0	24608.8	56020.5	27.90	362.4	11.84
7	F-CYLD UP	16637.4	14118.2	43620.7	.80	938.2	29.39
8	SUMP RATE	.1	.0	.2	33.74	-.1	19.65
9	SHEAR RATE	1.2	1.0	3.4	34.05	-.1	10.48
10	SUMP STK	34.0	34.0	35.0	11.86	32.5	33.56
11	VERT STK	56.7	55.8	75.7	35.03	38.0	.01
12	BOOM G-Y	1.1	-.0	3.5	12.17	-3.2	11.54
13	BOOM G-Z	.0	-.0	.0	12.17	-.0	11.54
~~14~~	~~E POWER~~	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	X-LOAD AVG	21063.0	13759.7	41656.4	28.19	-20316.4	11.84
16	F-CYLD	17544.8	-10490.6	18838.7	11.84	-38339.7	28.19
17	TORQUE AVG	371.0	347.6	763.0	23.97	-.3	10.21
18	DELTA	1.5	1.2	4.1	34.05	-.1	10.48
19	F-SUMP	18612.4	8955.0	48697.6	29.20	-43441.6	34.78
20	Y-LOAD	29495.7	28390.5	43582.3	14.60	9279.0	11.84
21	F-SHEAR	23196.9	22381.5	34585.2	28.19	10523.2	11.29
22	ALPHA	27.3	27.3	30.4	35.03	24.4	.01
23	M POWER	170.1	159.6	353.6	23.97	-.1	10.21
~~24~~	~~EFF~~	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	HEAD RPM	49.9	49.9	53.3	11.61	48.1	21.95
26	BETA	5.3	2.8	10.8	.01	-6.2	35.03
27	RATIO	.7	.6	2.1	34.05	-.1	10.48

TEST NO, 2 SUMP CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO,3

HEAD SPEED: 51 RPM BIT SPACING: 2 INCHES

LOCATION: 3- 91 DEPTH OF CUT: 1,0 IN/REV

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	456,5	429,7	1512,0	,00	-179,2	,01
2	TORQUE RHS	454,1	430,6	774,8	13,03	-17,9	,80
3	SHAFT RPM	1554,9	1554,9	1603,9	,08	1525,7	12,72
4	X-LOAD LHS	16826,5	-14853,0	9296,5	10,99	-34243,5	,20
5	X-LOAD RHS	12654,0	-7329,8	17175,6	11,57	-38484,8	,02
6	F-CYLD DWN	47473,5	47413,8	52035,3	12,39	40207,3	,24
7	F-CYLD UP	43687,3	43514,4	53457,3	,11	36430,2	12,39
8	SUMP RATE	1,0	1,0	1,6	4,77	,5	5,46
9	SHEAR RATE	,1	,0	,3	12,61	-,1	11,93
10	SUMP STK	13,7	12,6	21,2	13,08	2,4	,00
11	VERT STK	45,3	45,3	45,9	,40	44,6	9,50
12	BOOM G-Y	,8	-,0	2,8	9,79	-2,6	9,68
13	BOOM G-Z	,0	-,0	,0	9,79	-,0	9,68
~~14~~	~~E POWER~~	~~1,0~~	~~,8~~	~~1,6~~	~~3,02~~	~~-3,6~~	~~9,50~~
15	X-LOAD AVG	14069,3	-11091,4	6191,7	12,90	-35914,3	,01
16	F-CYLD	7424,8	-3899,4	13144,4	,21	-15573,9	12,39
17	TORQUE AVG	447,7	430,2	774,0	,00	-56,8	,01
18	DELTA	1,2	1,2	1,9	4,77	,6	5,46
19	F-SUMP	29827,3	-28710,9	-6530,0	11,55	-51472,4	,01
20	Y-LOAD	22690,6	22088,5	31129,9	12,89	7753,5	,10
21	F-SHEAR	23261,2	23184,4	28266,6	9,90	18208,8	2,94
22	ALPHA	25,6	25,6	25,7	,40	25,5	9,50
23	M POWER	203,5	195,8	362,4	,00	-26,6	,01
~~24~~	~~EFF~~	~~38426,5~~	~~-6945,0~~	~~152653,3~~	~~12,40~~	~~-150253,4~~	~~12,40~~
25	HEAD RPM	49,5	49,5	51,0	,08	48,6	12,72
26	BETA	7,5	7,5	7,8	9,50	7,2	,40
27	RATIO	,6	,6	1,0	4,77	,3	5,46

TEST NO, 2 SHEAR CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO,3

HEAD SPEED: 51 RPM BIT SPACING: 2 INCHES

LOCATION: 3- 91 DEPTH OF CUT: 1,0 IN/REV

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	419,4	379,0	940,7	11,84	-20,4	19,09
2	TORQUE RHS	418,4	380,8	940,1	5,32	-27,4	18,94
3	SHAFT RPM	1560,3	1560,2	1603,9	18,85	1504,4	32,51
4	X-LOAD LHS	13374,8	-7964,1	34367,2	33,45	-33043,9	21,44
5	X-LOAD RHS	13494,4	1998,4	37487,9	6,85	-34590,1	22,41
6	F-CYLD DWN	31268,4	28168,4	50882,3	,53	4165,3	19,84
7	F-CYLD UP	20812,0	17978,4	41085,3	1,86	-154,6	35,04
8	SUMP RATE	,2	,0	2,1	5,20	-,1	34,36
9	SHEAR RATE	1,3	1,1	2,5	10,80	-,1	35,00
10	SUMP STK	7,1	3,9	22,2	2,16	,4	4,89
11	VERT STK	67,3	66,1	87,9	34,78	44,7	,04
12	BOOM G-Y	,8	-,0	3,3	23,23	-3,2	5,92
13	BOOM G-Z	,0	-,0	,0	23,23	-,0	5,92
~~14~~	~~E POWER~~	~~1,0~~	~~,7~~	~~1,8~~	~~33,09~~	~~-4,7~~	~~1,20~~
15	X-LOAD AVG	11002,6	-2982,9	28495,3	31,87	-29169,7	22,37
16	F-CYLD	14426,9	-10190,0	8956,4	28,47	-33933,6	31,87
17	TORQUE AVG	411,3	379,9	871,1	32,47	-8,3	16,57
18	DELTA	1,6	1,4	3,0	10,80	-,1	,59
19	F-SUMP	26219,2	-23906,4	13711,2	33,16	-57555,3	10,09
20	Y-LOAD	29500,6	29127,7	40926,3	4,66	19189,0	1,87
21	F-SHEAR	22125,0	21407,3	33420,1	4,09	10015,2	28,56
22	ALPHA	29,0	28,9	32,2	34,78	25,5	,04
23	M POWER	187,0	173,2	386,9	32,47	-3,9	16,57
~~24~~	~~EFF~~	~~37040,9~~	~~-5232,6~~	~~173007,6~~	~~8,34~~	~~-173408,0~~	~~33,63~~
25	HEAD RPM	49,7	49,6	51,0	18,85	47,9	32,51
26	BETA	6,1	-1,8	7,8	,04	-11,7	34,78
27	RATIO	,8	,7	1,5	10,80	-,0	,59

TEST NO. 3 SUMP CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3

HEAD SPEED: 51 RPM BIT SPACING: 2 INCHES

LOCATION: 5- 93 DEPTH OF CUT: 1.0 IN/REV

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	428.1	397.6	881.0	13.55	-10.3	1.46
2	TORQUE RHS	415.8	389.7	829.7	18.88	-10.6	1.03
3	SHAFT RPM	1592.6	1597.7	1633.9	.18	1543.5	12.37
4	X-LOAD LHS	8835.8	-1709.3	17476.4	10.11	-27849.0	.59
5	X-LOAD RHS	14266.1	-6490.6	29363.3	12.36	-40189.2	.17
6	F-CYLD DWN	46830.2	46947.6	53253.8	6.14	41076.9	19.00
7	F-CYLD UP	43843.6	43742.4	55847.0	.20	35980.7	16.11
8	SUMP RATE	.8	.8	1.7	2.63	.0	10.82
9	SHEAR RATE	.1	.1	.7	15.05	-.1	17.03
10	SUMP STK	18.8	17.9	27.3	18.86	5.8	.16
11	VERT STK	45.1	45.2	45.6	1.96	44.2	11.11
12	BOOM G-Y	1.0	-.0	3.7	.72	-3.9	.76
13	BOOM G-Z	.0	-.0	.0	.72	-.0	.76
~~14~~	~~E POWER~~	~~1.1~~	~~-.1~~	~~7.4~~	~~6.34~~	~~-7.1~~	~~11.83~~
15	X-LOAD AVG	9695.3	-4099.9	12718.1	13.21	-31761.7	0.00
16	F-CYLD	6375.4	-3205.2	12956.6	.23	-16676.3	12.36
17	TORQUE AVG	416.4	393.6	809.7	13.55	-2.0	1.03
18	DELTA	1.0	.9	2.1	2.63	.0	10.82
19	F-SUMP	16263.2	-13561.3	4566.7	15.51	-44235.8	0.00
20	Y-LOAD	24146.2	23713.4	33848.1	11.10	8705.5	.24
21	F-SHEAR	21042.1	21070.3	26881.1	12.36	17364.1	.86
22	ALPHA	25.6	25.7	25.6	1.96	25.4	11.11
23	M POWER	193.2	182.9	372.6	13.55	-.9	1.03
~~24~~	~~EFF~~	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	HEAD RPM	50.7	50.8	52.0	.18	49.1	12.37
26	BETA	7.7	7.7	8.0	11.11	7.4	1.96
27	RATIO	.5	.5	1.0	2.63	.0	10.82

TEST NO. 3 SHEAR CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3

HEAD SPEED: 51 RPM BIT SPACING: 2 INCHES

LOCATION: 5- 93 DEPTH OF CUT: 1.0 IN/REV

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	473.0	447.9	1048.9	16.69	-5.8	15.93
2	TORQUE RHS	461.0	440.8	876.2	23.03	-5.0	15.87
3	SHAFT RPM	1578.6	1578.5	1622.6	15.87	1532.2	23.11
4	X-LOAD LHS	17330.2	12459.3	41403.5	7.48	-24542.5	15.24
5	X-LOAD RHS	21551.2	15356.4	50178.2	5.25	-35737.2	15.76
6	F-CYLD DWN	41739.6	39516.5	53439.9	4.05	1083.0	15.70
7	F-CYLD UP	21175.4	18282.5	41220.2	.01	-508.4	29.22
8	SUMP RATE	.1	.0	1.6	12.75	-.1	29.02
9	SHEAR RATE	1.5	1.3	2.9	13.43	-.1	29.94
10	SUMP STK	15.2	10.9	27.7	7.25	2.8	12.48
11	VERT STK	70.1	68.7	88.0	28.95	44.3	.70
12	BOOM G-Y	1.0	.0	4.7	3.80	-3.5	30.07
13	BOOM G-Z	.0	-.0	.0	3.80	-.0	30.07
~~14~~	~~E POWER~~	~~1.1~~	[illegible]	[illegible]	~~31.71~~	[illegible]	[illegible]
15	X-LOAD AVG	18341.4	13907.9	30915.0	5.25	-23938.0	15.90
16	F-CYLD	24398.4	-21233.9	19860.3	15.71	-42607.3	25.41
17	TORQUE AVG	462.4	444.4	836.0	11.66	-1.2	15.50
18	DELTA	1.8	1.6	3.4	13.43	-.1	.49
19	F-SUMP	15736.4	-10234.7	31343.0	10.18	-39687.9	18.01
20	Y-LOAD	34141.5	33571.6	47810.0	4.04	14910.1	15.71
21	F-SHEAR	26482.1	25994.9	34365.2	4.38	8699.2	15.71
22	ALPHA	29.4	29.3	32.2	28.95	25.4	.70
23	M POWER	213.5	205.5	389.4	11.66	-.6	15.50
~~24~~	~~EFF~~	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	HEAD RPM	50.2	50.2	51.6	15.87	48.8	23.11
26	BETA	6.9	-3.0	7.9	.70	-11.7	28.95
27	RATIO	.9	.8	1.7	13.43	-.0	.49

TEST NO, 4 SUMP CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO,3

HEAD SPEED: 51 RPM BIT SPACING: 2 INCHES

LOCATION: 2- 90 DEPTH OF CUT: 1,0 IN/REV

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	142,2	108,5	541,7	10,79	-10,2	8,88
2	TORQUE RHS	141,4	104,5	576,1	12,19	-14,6	9,63
3	SHAFT RPM	1605,7	1614,3	1615,2	5,88	1577,2	9,76
4	X-LOAD LHS	4958,1	4101,5	12734,0	8,60	-8405,5	8,50
5	X-LOAD RHS	42763,1	-42892,9	-30412,3	9,18	-50277,4	,15
6	F-CYLD DWN	3801,5	3610,6	9226,9	8,53	439,8	,56
7	F-CYLD UP	32237,2	32401,3	33999,1	7,70	27810,6	8,53
8	SUMP RATE	1,1	1,0	1,7	8,81	,1	9,64
9	SHEAR RATE	,1	,0	,2	6,54	-,1	11,73
10	SUMP STK	11,9	10,5	19,9	13,11	,3	,00
11	VERT STK	47,6	47,9	47,9	11,31	47,0	11,81
12	BOOM G-Y	,4	-,0	1,5	11,00	-1,5	3,65
13	BOOM G-Z	,0	-,0	,0	11,00	-,0	3,65
~~14~~	~~E-POWER~~	~~47,3~~	~~-36,0~~	~~3,6~~	~~8,88~~	~~-100,5~~	~~10,79~~
15	X-LOAD AVG	42763,1	-42892,9	-30412,3	9,18	-50277,4	,15
16	F-CYLD	28698,6	28790,7	33035,3	,54	18869,6	8,53
17	TORQUE AVG	123,8	106,5	489,2	8,52	-5,3	3,73
18	DELTA	1,3	1,2	2,0	8,81	,1	9,64
19	F-SUMP	37364,4	-37229,4	-12677,2	9,18	-54773,8	8,72
20	Y-LOAD	1474,8	-478,3	5095,0	8,51	-4040,3	,53
21	F-SHEAR	10951,2	10968,3	15849,4	8,53	7920,2	8,95
22	ALPHA	26,1	26,2	26,0	11,31	25,9	11,81
23	M POWER	58,0	49,9	228,3	8,52	-2,5	3,73
~~24~~	~~EFF~~	~~3972,2~~	~~-314,0~~	~~17440,1~~	~~4,86~~	~~104649,8~~	~~[illegible]~~
25	HEAD RPM	51,1	51,4	51,4	5,88	50,2	9,76
26	BETA	6,6	6,6	6,7	11,81	6,3	11,31
27	RATIO	,6	,6	1,0	8,81	,1	9,64

TEST NO, 4 SHEAR CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO,3

HEAD SPEED: 51 RPM BIT SPACING: 2 INCHES

LOCATION: 2- 90 DEPTH OF CUT: 1,0 IN/REV

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	145,4	107,7	583,6	28,68	-16,1	31,37
2	TORQUE RHS	142,3	105,8	617,1	14,30	-16,0	1,60
3	SHAFT RPM	1597,2	1597,2	1695,5	38,96	1577,2	11,42
4	X-LOAD LHS	11788,4	-7592,8	8589,4	,28	-45886,6	41,00
5	X-LOAD RHS	38469,2	-37410,7	-10667,3	40,56	-55198,6	14,98
6	F-CYLD DWN	9259,3	9071,9	15705,5	40,89	1259,0	2,32
7	F-CYLD UP	27906,7	27048,8	34999,3	5,50	3431,6	40,91
8	SUMP RATE	,2	,0	1,4	,32	-,1	36,82
9	SHEAR RATE	,9	,9	1,7	7,94	-,1	1,56
10	SUMP STK	7,4	3,4	21,3	2,71	-,1	7,82
11	VERT STK	69,0	67,9	87,1	40,99	47,0	2,34
12	BOOM G-Y	,4	,0	1,7	30,14	-1,4	6,58
13	BOOM G-Z	,0	,0	,0	30,14	-,0	6,58
~~14~~	~~E-POWER~~	~~49,3~~	~~-35,7~~	~~5,1~~	~~31,37~~	~~-194,2~~	~~28,68~~
15	X-LOAD AVG	38469,2	-37410,7	-10667,3	40,56	-55198,6	14,98
16	F-CYLD	19582,3	17976,8	29430,2	,51	-11550,4	40,91
17	TORQUE AVG	127,6	106,8	510,7	20,48	-8,8	,36
18	DELTA	1,1	1,0	1,9	7,94	-,1	1,56
19	F-SUMP	44006,3	-42939,4	-9142,9	9,75	-76394,3	14,94
20	Y-LOAD	18237,3	16172,7	35727,5	40,91	-2352,9	1,68
21	F-SHEAR	9416,3	8344,3	15536,0	8,21	-1301,6	35,67
22	ALPHA	29,2	29,2	32,1	40,99	25,9	2,34
23	M POWER	59,7	50,0	238,3	20,48	-4,1	,36
~~24~~	~~EFF~~	~~4607,8~~	~~-342,1~~	~~22633,5~~	~~5,39~~	~~-216583,9~~	~~8,69~~
25	HEAD RPM	50,8	50,8	54,0	38,96	50,2	11,42
26	BETA	6,2	-2,7	6,7	2,34	-11,3	40,99
27	RATIO	,5	,5	1,0	7,94	-,1	1,56

TEST NO. 5 SUMP CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3

HEAD SPEED: 51 RPM BIT SPACING: 2 INCHES

LOCATION: 5-129 DEPTH OF CUT: 1.0 IN/REV

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	391.8	373.3	671.7	12.69	1.9	.35
2	TORQUE RHS	423.9	360.3	1100.2	3.59	-8.7	3.22
3	SHAFT RPM	1586.9	1592.8	1722.6	.58	1541.1	9.42
4	X-LOAD LHS	12366.5	3656.8	24619.9	11.79	-37463.6	.03
5	X-LOAD RHS	13851.3	-2790.8	17425.4	12.60	-45854.8	0.00
6	F-CYLD DWN	42680.7	42659.6	47137.4	9.13	18910.9	15.07
7	F-CYLD UP	43393.9	43262.1	55782.5	.00	18600.2	15.07
8	SUMP RATE	.8	.7	2.3	.24	.1	2.10
9	SHEAR RATE	.1	.0	.7	15.03	-.1	3.50
10	SUMP STK	39.3	39.2	45.7	14.80	30.0	.03
11	VERT STK	35.5	35.6	36.4	.68	34.6	13.45
12	BOOM G-Y	.3	.1	1.5	.73	-1.2	.75
13	BOOM G-Z	.0	.0	.0	.73	-.0	9.13
14	E POWER	[illegible]	34.1	48.3	11.63	-6.0	.05
15	X-LOAD AVG	12080.4	433.0	14168.9	15.02	-40244.0	.00
16	F-CYLD	7186.6	602.5	25095.0	.00	-7485.3	13.04
17	TORQUE AVG	395.1	366.8	808.9	14.47	2.0	.36
18	DELTA	1.0	.9	2.7	.24	.1	2.10
19	F-SUMP	12952.0	1850.9	25442.9	15.02	-40433.5	.05
20	Y-LOAD	24593.4	23256.9	31281.9	14.81	-4909.6	.00
21	F-SHEAR	17314.3	17358.9	20187.1	13.04	12887.3	15.07
22	ALPHA	24.0	24.1	24.1	.68	23.8	13.45
23	M POWER	182.4	169.6	370.1	14.47	.9	.36
24	EFF	[illegible]	[illegible]	[illegible]	.66	-24044.0	.24
25	HEAD RPM	50.5	50.7	54.8	.58	49.0	9.42
26	BETA	12.1	12.1	12.4	13.45	11.5	.68
27	RATIO	.5	.4	1.3	.24	.0	2.10

TEST NO. 5 SHEAR CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3

HEAD SPEED: 51 RPM BIT SPACING: 2 INCHES

LOCATION: 5-129 DEPTH OF CUT: 1.0 IN/REV

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	414.5	390.8	915.2	49.09	55.6	3.80
2	TORQUE RHS	434.4	377.8	1136.4	42.96	-11.0	8.59
3	SHAFT RPM	1578.2	1578.0	1711.4	13.27	1476.9	19.60
4	X-LOAD LHS	37350.7	34307.3	78866.9	31.07	3100.1	1.36
5	X-LOAD RHS	28854.3	26982.4	60979.8	38.06	-3789.6	.41
6	F-CYLD DWN	28656.7	27167.0	43007.6	64.99	421.6	.74
7	F-CYLD UP	8932.2	8434.8	18474.9	.01	2562.0	33.15
8	SUMP RATE	.1	.0	.8	10.47	-.0	45.97
9	SHEAR RATE	.9	.8	1.5	38.31	-.1	34.45
10	SUMP STK	44.5	44.5	46.4	11.82	41.6	49.10
11	VERT STK	62.4	61.1	86.7	51.29	31.4	21.25
12	BOOM G-Y	.3	.1	1.6	33.51	-1.4	29.99
13	BOOM G-Z	.0	.0	.0	33.51	-.0	29.99
14	E POWER	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	X-LOAD AVG	32535.0	30647.4	57058.5	32.02	6260.4	.76
16	F-CYLD	20802.1	-18732.2	7232.3	.79	-38991.6	64.92
17	TORQUE AVG	411.5	384.3	868.4	49.18	36.4	3.80
18	DELTA	1.0	.9	1.9	38.31	-.1	34.45
19	F-SUMP	32361.1	28199.4	57930.0	42.84	-7369.5	56.81
20	Y-LOAD	33922.5	33537.6	47126.8	21.26	19960.4	46.97
21	F-SHEAR	25436.7	24893.6	34652.9	64.93	7240.2	21.25
22	ALPHA	28.2	28.1	32.0	51.29	21.4	21.25
23	M POWER	189.2	177.3	397.5	34.98	17.2	3.80
24	EFF	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	HEAD RPM	50.2	50.2	54.5	13.27	47.0	19.60
26	BETA	5.8	.4	18.5	21.25	-11.1	51.29
27	RATIO	.5	.5	.9	38.31	-.0	34.45

TEST NO. 6 SUMP CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3

HEAD SPEED: 18 RPM BIT SPACING: 2 INCHES

LOCATION: 1- 89 DEPTH OF CUT: 1.0 IN/REV

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	325.6	314.9	612.6	11.50	46.7	9.80
2	TORQUE RHS	313.6	294.5	871.0	1.41	-6.9	2.88
3	SHAFT RPM	506.1	506.2	506.0	16.05	506.0	16.05
4	X-LOAD LHS	292.6	137.6	1115.2	9.81	-860.9	11.12
5	X-LOAD RHS	17552.9	15929.2	34640.9	7.21	-10488.3	6.05
6	F-CYLD DWN	20620.2	20541.0	27119.5	16.05	11978.3	.03
7	F-CYLD UP	9639.5	9463.5	18553.3	.03	3951.1	16.05
8	SUMP RATE	.9	.7	2.6	.37	-.1	4.91
9	SHEAR RATE	.1	.0	.8	2.75	-.1	6.53
10	SUMP STK	9.9	8.9	15.7	16.00	.3	.02
11	VERT STK	54.3	54.3	55.3	.03	53.7	15.53
12	BOOM G-Y	3.3	-3.3	-1.9	.03	-4.3	16.05
13	BOOM G-Z	.0	-.0	-.0	16.04	-.0	.03
~~14~~	~~E POWER~~	~~70.2~~	~~-63.7~~	~~43.1~~	~~6.05~~	~~-130.0~~	~~7.21~~
15	X-LOAD AVG	17552.9	15929.2	34640.9	7.21	-10488.3	6.05
16	F-CYLD	11668.2	-11077.5	6261.7	.03	-22980.4	16.05
17	TORQUE AVG	316.3	304.7	583.6	10.59	39.8	.26
18	DELTA	3.4	2.7	9.5	.37	-.2	4.91
19	F-SUMP	19305.0	12776.3	47804.9	7.38	-42642.7	6.10
20	Y-LOAD	30772.1	30695.2	36589.5	14.73	19261.6	0.00
21	F-SHEAR	21655.2	21582.3	28129.8	16.05	14946.1	.03
22	ALPHA	27.1	27.1	27.2	.03	27.0	15.53
23	M POWER	136.0	131.0	251.0	10.59	17.1	.26
~~24~~	~~EFF~~	~~1782.7~~	~~-106.2~~	~~62384.3~~	~~4.83~~	~~-72896.8~~	~~9.64~~
25	HEAD RPM	16.1	16.1	16.1	16.05	16.1	16.05
26	BETA	3.5	3.5	3.7	15.53	3.0	.03
27	RATIO	1.7	1.4	4.8	.37	-.1	4.91

TEST NO. 6 SHEAR CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3

HEAD SPEED: 18 RPM BIT SPACING: 2 INCHES

LOCATION: 1- 89 DEPTH OF CUT: 1.0 IN/REV

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	183.9	172.9	531.5	19.14	7.0	11.26
2	TORQUE RHS	197.8	164.1	941.5	18.10	-12.3	33.63
3	SHAFT RPM	506.0	506.0	506.0	41.03	506.0	41.03
4	X-LOAD LHS	290.9	127.8	1355.1	1.91	-980.9	30.94
5	X-LOAD RHS	11044.7	-2044.3	29693.2	19.30	-31848.0	34.12
6	F-CYLD DWN	16437.5	14683.0	54605.0	16.37	6123.2	32.33
7	F-CYLD UP	11029.4	9974.9	32340.8	15.92	-308.6	22.77
8	SUMP RATE	.0	-.0	.1	28.89	-.1	9.04
9	SHEAR RATE	.7	.5	2.1	16.00	-.1	4.32
10	SUMP STK	4.7	2.0	15.8	.03	-.4	16.21
11	VERT STK	61.9	61.5	77.2	41.00	53.7	.53
12	BOOM G-Y	2.6	-2.3	-1.0	32.33	-8.7	16.37
13	BOOM G-Z	.0	-.0	.0	22.77	-.0	15.92
~~14~~	~~E POWER~~	~~44.2~~	~~8.2~~	~~127.3~~	~~34.12~~	~~-115.9~~	~~10.30~~
15	X-LOAD AVG	11044.7	-2044.3	29693.2	19.30	-31848.0	34.12
16	F-CYLD	9475.2	-4708.1	10877.3	36.32	-31241.1	16.37
17	TORQUE AVG	182.8	168.5	623.8	18.10	10.5	9.78
18	DELTA	2.5	1.9	7.9	16.00	-.4	4.32
19	F-SUMP	19204.8	-12211.4	35220.7	25.96	-58489.2	.40
20	Y-LOAD	26305.9	25955.6	41031.7	.67	17047.0	11.66
21	F-SHEAR	20234.9	19817.0	33380.1	.40	9909.6	37.76
22	ALPHA	28.2	28.2	30.6	41.00	27.0	.53
23	M POWER	78.6	72.5	268.2	18.10	4.5	9.78
~~24~~	~~EFF~~	~~2143.9~~	~~-31.2~~	~~63155.2~~	~~4.29~~	~~-61264.7~~	~~3.98~~
25	HEAD RPM	16.1	16.1	16.1	41.03	16.1	41.03
26	BETA	3.3	.2	3.7	.53	-6.8	41.00
27	RATIO	1.2	1.0	4.0	16.00	-.2	4.32

TEST NO, 7 SUMP CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO,3

HEAD SPEED: 18 RPM BIT SPACING: 2 INCHES

LOCATION: 1- 89 DEPTH OF CUT: 1,0 IN/REV

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	296,9	277,4	602,3	13,80	-3,5	1,42
2	TORQUE RHS	286,2	259,4	694,8	15,15	-10,8	2,78
3	SHAFT RPM	598,2	598,5	599,0	22,90	597,9	23,04
4	X-LOAD LHS	274,4	57,7	1041,4	19,53	-1230,8	21,62
5	X-LOAD RHS	18871,0	2369,6	32924,4	13,48	-50954,6	1,10
6	F-CYLD DWN	28471,9	26788,5	49573,7	2,95	-391,5	,69
7	F-CYLD UP	25831,3	25364,7	51726,8	2,89	17875,2	21,81
8	SUMP RATE	,9	,7	3,6	,57	-,1	7,57
9	SHEAR RATE	,4	,1	3,4	2,94	-,1	7,60
10	SUMP STK	12,3	11,2	19,9	22,53	-,0	,02
11	VERT STK	46,7	46,7	47,6	5,98	44,8	2,35
12	BOOM G-Y	4,5	-4,3	,1	,69	-7,9	2,95
13	BOOM G-Z	,0	-,0	-,0	21,81	-,0	2,88
~~14~~	~~E POWER~~	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	X-LOAD AVG	18871,0	2369,6	32924,4	13,48	-50954,6	1,10
16	F-CYLD	12397,2	-1423,8	34428,4	,72	-14035,4	14,95
17	TORQUE AVG	288,1	268,4	624,2	15,09	-5,1	1,23
18	DELTA	2,9	2,1	11,3	,57	-,3	7,57
19	F-SUMP	20112,1	2317,1	52541,8	19,49	-48268,2	1,09
20	Y-LOAD	26476,7	24321,3	36104,3	18,21	-6497,4	,71
21	F-SHEAR	18548,3	18223,4	26030,8	15,07	4222,5	2,34
22	ALPHA	25,8	25,9	26,0	5,98	25,5	2,35
23	M POWER	146,4	136,4	317,2	15,09	-2,6	1,23
~~24~~	~~EFF~~	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	HEAD RPM	19,0	19,0	19,1	22,90	19,0	23,04
26	BETA	6,9	6,9	7,7	2,35	6,5	5,98
27	RATIO	1,4	1,0	5,6	,57	-,1	7,57

TEST NO, 7 SHEAR CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO,3

HEAD SPEED: 18 RPM BIT SPACING: 2 INCHES

LOCATION: 1- 89 DEPTH OF CUT: 1,0 IN/REV

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	242,7	232,9	510,3	,06	13,4	11,88
2	TORQUE RHS	239,3	219,0	770,8	14,17	-6,7	32,15
3	SHAFT RPM	597,9	597,9	599,0	34,23	597,9	57,09
4	X-LOAD LHS	267,3	48,1	1161,2	54,21	-991,3	52,14
5	X-LOAD RHS	14777,1	12532,5	36852,6	41,30	-11068,0	24,34
6	F-CYLD DWN	26500,6	25322,1	41519,3	54,41	6206,3	1,53
7	F-CYLD UP	5569,6	4555,4	22388,7	,18	-615,9	55,37
8	SUMP RATE	,0	-,0	,6	,01	-,1	7,20
9	SHEAR RATE	,7	,6	1,9	32,78	-,1	24,61
10	SUMP STK	3,0	-,1	20,0	,25	-1,0	56,01
11	VERT STK	65,5	64,3	86,9	57,03	46,2	,76
12	BOOM G-Y	4,2	-4,0	-1,0	1,53	-6,6	54,41
13	BOOM G-Z	,0	-,0	,0	55,37	-,0	,18
~~14~~	~~E POWER~~	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	X-LOAD AVG	14777,1	12532,5	36852,6	41,30	-11068,0	24,34
16	F-CYLD	21926,3	-20766,7	-2526,6	,17	-38865,5	52,32
17	TORQUE AVG	236,3	225,9	562,9	14,17	12,2	11,88
18	DELTA	2,2	1,9	5,9	32,78	-,3	24,61
19	F-SUMP	18738,2	-11963,2	35092,5	,05	-61309,9	49,74
20	Y-LOAD	33651,0	33514,6	43041,2	49,74	25174,0	24,38
21	F-SHEAR	26238,0	26093,7	32908,1	12,45	15816,8	1,43
22	ALPHA	28,7	28,6	32,0	57,03	25,8	,76
23	M POWER	120,1	114,8	286,0	14,17	6,2	11,88
~~24~~	~~EFF~~	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	HEAD RPM	19,0	19,0	19,1	34,23	19,0	57,09
26	BETA	5,7	-1,0	7,1	,76	-11,2	57,03
27	RATIO	1,1	1,0	2,9	32,78	-,1	24,61

TEST NO. 8 SUMP CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3

HEAD SPEED: 18 RPM BIT SPACING: 2 INCHES

LOCATION: 1- 89 DEPTH OF CUT: 1.0 IN/REV

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	285.8	274.0	553.3	6.41	5.1	.05
2	TORQUE RHS	275.8	267.0	728.5	18.80	-10.6	.81
3	SHAFT RPM	560.6	560.9	561.3	27.10	560.2	27.13
4	X-LOAD LHS	260.6	-36.8	1044.5	16.54	-986.9	23.04
5	X-LOAD RHS	17178.9	13199.3	38469.1	15.57	-35358.4	.07
6	F-CYLD DWN	44496.2	44344.0	57078.3	.45	37993.0	25.66
7	F-CYLD UP	26638.7	25842.5	51674.3	.00	18539.2	20.66
8	SUMP RATE	.7	.6	2.4	.16	-.0	8.92
9	SHEAR RATE	.4	.1	2.7	4.87	-.1	18.94
10	SUMP STK	10.7	8.7	18.8	27.08	-3.5	0.00
11	VERT STK	52.8	52.9	53.8	15.72	50.6	3.97
12	BOOM G-Y	7.1	-7.1	-6.1	25.66	-9.1	.45
13	BOOM G-Z	.0	-.0	-.0	20.66	-.0	.00
~~14~~	~~E POWER~~	~~[illegible]~~	~~-52.7~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~
15	X-LOAD AVG	17178.9	13199.3	38469.1	15.57	-35358.4	.07
16	F-CYLD	19076.9	-18501.5	9431.8	.00	-29058.2	4.89
17	TORQUE AVG	277.9	265.5	580.9	18.80	7.7	.02
18	DELTA	2.3	1.9	8.0	.16	-.2	8.92
19	F-SUMP	17613.9	-5342.7	37612.9	22.67	-66264.7	1.56
20	Y-LOAD	34482.5	34292.6	42288.9	5.31	12844.9	0.00
21	F-SHEAR	25803.9	25767.8	30352.2	7.45	18165.5	.00
22	ALPHA	26.9	26.9	27.0	15.72	26.5	3.97
23	M POWER	132.3	126.5	276.6	18.80	3.7	.02
~~24~~	~~EFF~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~
25	HEAD RPM	17.8	17.8	17.9	27.10	17.8	27.13
26	BETA	4.1	4.1	5.1	3.97	3.7	15.72
27	RATIO	1.1	.9	4.0	.16	-.1	8.92

TEST NO. 8 SHEAR CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3

HEAD SPEED: 18 RPM BIT SPACING: 2 INCHES

LOCATION: 1- 89 DEPTH OF CUT: 1.0 IN/REV

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	215.8	201.9	503.3	10.88	-3.0	43.05
2	TORQUE RHS	214.8	192.0	690.2	5.93	-14.7	37.84
3	SHAFT RPM	560.5	560.5	561.3	43.07	560.2	43.07
4	X-LOAD LHS	261.5	-37.2	1044.5	41.85	-1166.5	18.79
5	X-LOAD RHS	19335.7	14760.0	46625.6	42.26	-15722.4	24.19
6	F-CYLD DWN	27126.4	23778.0	55438.2	1.27	5078.4	25.43
7	F-CYLD UP	5732.6	4408.8	23371.4	.91	-473.8	23.31
8	SUMP RATE	.0	.0	.5	24.56	-.1	27.13
9	SHEAR RATE	.7	.6	2.2	1.02	-.1	.56
10	SUMP STK	16.5	13.7	19.3	15.16	-5.6	43.04
11	VERT STK	70.8	70.2	83.3	42.68	52.7	.31
12	BOOM G-Y	4.3	-3.8	-.8	25.43	-8.9	1.27
13	BOOM G-Z	.0	-.0	.0	23.31	-.0	.91
~~14~~	~~E POWER~~	~~77.3~~	~~[illegible]~~	~~[illegible]~~	~~24.19~~	~~[illegible]~~	~~[illegible]~~
15	X-LOAD AVG	19335.7	14760.0	46625.6	42.26	-15722.4	24.19
16	F-CYLD	23089.6	-19369.2	447.8	29.56	-49622.3	42.28
17	TORQUE AVG	209.6	196.9	548.5	5.93	-3.4	42.52
18	DELTA	2.3	2.0	7.4	1.02	-.3	.56
19	F-SUMP	13764.0	-5155.3	40614.9	15.93	-57819.9	3.35
20	Y-LOAD	32918.3	32390.9	47319.5	1.71	21556.2	29.54
21	F-SHEAR	26362.2	25756.4	40041.7	42.26	16140.1	24.19
22	ALPHA	29.6	29.5	31.5	42.68	26.8	.31
23	M POWER	99.8	93.8	261.2	5.93	-1.6	42.52
~~24~~	~~EFF~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~
25	HEAD RPM	17.8	17.8	17.9	43.07	17.8	43.07
26	BETA	5.5	-3.7	4.2	.31	-9.6	42.68
27	RATIO	1.2	1.0	3.7	1.02	-.2	.56

TEST NO. 9 — SUMP CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3

HEAD SPEED: 18 RPM — BIT SPACING: 2 INCHES

LOCATION: 5- 93 — DEPTH OF CUT: 1.0 IN/REV

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	214.8	194.1	638.5	4.00	-4.4	1.34
2	TORQUE RHS	204.5	177.0	812.4	1.87	-11.6	4.98
3	SHAFT RPM	557.1	558.7	555.5	22.07	555.5	22.07
4	X-LOAD LHS	266.1	.5	1272.6	3.86	-1352.3	3.50
5	X-LOAD RHS	16200.1	-4128.2	47761.7	3.97	-56873.4	.70
6	F-CYLD DWN	40746.9	40353.3	60568.7	4.02	27950.1	.12
7	F-CYLD UP	32717.7	32612.6	47385.3	.11	26108.2	4.02
8	SUMP RATE	.6	.4	3.9	15.99	-.1	13.49
9	SHEAR RATE	.3	.2	1.7	4.39	-.1	2.03
10	SUMP STK	6.5	6.1	9.8	20.99	.5	.06
11	VERT STK	31.6	31.7	32.5	.81	30.5	3.51
12	BOOM G-Y	6.5	-6.4	-4.5	.12	-9.7	4.02
13	BOOM G-Z	.0	-.0	-.0	4.02	-.0	.13
~~14~~	~~F POWER~~	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	X-LOAD AVG	16200.1	-4128.2	47761.7	3.97	-56873.4	.70
16	F-CYLD	11446.6	-7740.7	19215.5	.12	-34143.4	4.02
17	TORQUE AVG	205.0	185.6	687.6	4.00	1.3	.27
18	DELTA	2.1	1.2	13.1	15.99	-.3	13.49
19	F-SUMP	29051.7	-20604.7	58389.7	3.97	-99312.9	.70
20	Y-LOAD	26907.2	24638.9	58333.2	4.02	-9134.1	.09
21	F-SHEAR	26115.6	25932.8	41616.9	.57	12186.7	3.97
22	ALPHA	23.3	23.4	23.4	.81	23.1	3.51
23	M POWER	96.8	87.6	324.6	4.00	.6	.27
~~24~~	~~EFF~~	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	HEAD RPM	17.7	17.8	17.7	22.07	17.7	22.07
26	BETA	13.8	13.9	14.3	3.51	13.3	.81
27	RATIO	1.1	.6	6.6	15.99	-.2	13.49

TEST NO. 9 — SHEAR CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3

HEAD SPEED: 18 RPM — BIT SPACING: 2 INCHES

LOCATION: 5- 93 — DEPTH OF CUT: 1.0 IN/REV

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	206.1	192.1	549.5	11.36	1.5	48.66
2	TORQUE RHS	194.2	174.8	1403.7	16.08	-26.6	16.07
3	SHAFT RPM	555.5	555.5	556.6	14.89	555.5	53.14
4	X-LOAD LHS	263.4	2.4	1272.8	2.69	-1232.8	40.62
5	X-LOAD RHS	19097.1	12383.2	37195.2	47.61	-19316.9	30.19
6	F-CYLD DWN	34836.6	32690.9	53584.3	.37	6253.9	26.18
7	F-CYLD UP	9996.9	7356.3	42018.9	.69	-533.2	16.32
8	SUMP RATE	.1	-.0	.8	40.17	-.1	42.12
9	SHEAR RATE	1.0	.8	3.2	.73	-.1	16.36
10	SUMP STK	3.8	.3	9.8	1.36	-48.6	6.33
11	VERT STK	67.2	65.3	85.3	52.71	32.0	.02
12	BOOM G-Y	5.6	-5.2	-1.0	26.18	-8.6	.37
13	BOOM G-Z	.0	-.0	.0	16.32	-.0	.69
~~14~~	~~F POWER~~	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	X-LOAD AVG	19097.1	12383.2	37195.2	47.61	-19316.9	30.19
16	F-CYLD	29003.1	-25334.6	-823.9	26.12	-49857.5	53.05
17	TORQUE AVG	195.4	183.4	866.6	16.08	10.3	50.80
18	DELTA	3.4	2.9	10.9	.73	-.4	16.36
19	F-SUMP	24657.4	-20778.7	30716.4	8.21	-75596.6	23.42
20	Y-LOAD	34972.9	34583.5	45479.0	15.48	20171.5	.69
21	F-SHEAR	28769.7	28252.1	38723.3	2.70	16984.1	30.19
22	ALPHA	28.9	28.7	31.6	52.71	23.3	.02
23	M POWER	92.2	86.6	409.2	16.08	4.9	50.80
~~24~~	~~EFF~~	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	HEAD RPM	17.7	17.7	17.7	14.89	17.7	53.14
26	BETA	7.2	-1.5	13.6	.02	-10.5	52.71
27	RATIO	1.7	1.4	5.5	.73	-.2	16.36

TEST NO, 10 SUMP CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO,3

HEAD SPEED: 18 RPM BIT SPACING: 2 INCHES

LOCATION: 5-129 DEPTH OF CUT: 1,0 IN/REV

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	287,5	234,1	841,0	27,12	-9,2	19,27
2	TORQUE RHS	62,5	33,2	346,5	1,71	-16,1	14,14
3	SHAFT RPM	522,5	523,0	565,5	24,06	16,2	23,25
4	X-LOAD LHS	22346,7	-22100,8	-8629,3	26,43	-34011,5	23,47
5	X-LOAD RHS	27038,9	-20482,9	26339,3	27,84	-52026,1	5,92
6	F-CYLD DWN	18043,3	16555,1	31153,8	27,93	2073,1	,26
7	F-CYLD UP	26247,1	25870,1	33452,3	,24	13029,6	27,94
8	SUMP RATE	,7	,6	2,2	,46	-,1	18,03
9	SHEAR RATE	,1	,0	,9	17,27	-,1	14,66
10	SUMP STK	12,5	11,2	22,0	28,01	-,1	0,00
11	VERT STK	33,7	33,8	34,4	19,39	32,1	27,77
12	BOOM G-Y	,2	,0	,8	24,22	-,7	23,63
13	BOOM G-Z	,0	,0	,0	24,22	-,0	23,63
~~14~~	~~E POWER~~	~~5,5~~	~~-4,6~~	~~6,8~~	~~17,90~~	~~-12,2~~	~~12,04~~
15	X-LOAD AVG	27038,9	-20482,9	26339,3	27,84	-52026,1	5,92
16	F-CYLD	14993,1	9315,1	31158,7	,25	-17964,6	27,94
17	TORQUE AVG	159,4	133,6	477,7	27,12	-7,3	,61
18	DELTA	2,7	2,1	59,6	23,25	-,2	18,03
19	F-SUMP	32017,3	-25953,2	32820,8	24,95	-69657,6	8,49
20	Y-LOAD	16312,2	9861,1	43217,6	27,84	-11058,5	5,92
21	F-SHEAR	20425,0	20223,5	31480,7	17,00	8977,1	,24
22	ALPHA	23,7	23,7	23,8	19,39	23,3	27,77
23	M POWER	70,6	59,2	213,1	27,12	-3,2	,61
~~24~~	~~EFF~~	~~6396,4~~	~~-1068,0~~	~~68906,0~~	~~24,66~~	~~-86789,1~~	[illegible]
25	HEAD RPM	16,6	16,6	18,0	24,06	,5	23,25
26	BETA	12,8	12,8	13,5	27,77	12,4	19,39
27	RATIO	1,3	1,1	29,8	23,25	-,1	18,03

TEST NO, 10 SHEAR CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO,3

HEAD SPEED: 18 RPM BIT SPACING: 2 INCHES

LOCATION: 5-129 DEPTH OF CUT: 1,0 IN/REV

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	277,1	252,6	750,4	,20	-10,7	54,34
2	TORQUE RHS	56,4	32,8	321,3	12,54	-16,1	12,58
3	SHAFT RPM	522,0	521,8	564,3	13,81	-6,4	40,02
4	X-LOAD LHS	25429,3	-24427,9	356,9	6,36	-46808,4	37,46
5	X-LOAD RHS	15190,3	-2294,4	48063,6	26,79	-35530,5	49,17
6	F-CYLD DWN	9729,6	9212,6	31194,1	,13	2716,6	39,60
7	F-CYLD UP	13037,2	10378,3	27092,6	46,91	-344,9	26,80
8	SUMP RATE	,1	,0	,9	,00	-,1	24,44
9	SHEAR RATE	,8	,7	2,2	10,67	-4,7	7,78
10	SUMP STK	21,7	21,7	23,5	5,20	19,6	61,48
11	VERT STK	55,4	53,9	77,8	62,02	9,8	25,31
12	BOOM G-Y	,2	,0	1,4	38,80	-1,5	38,81
13	BOOM G-Z	,0	,0	,0	38,80	-,0	38,81
~~14~~	~~F POWER~~	~~5,5~~	~~-4,7~~	~~5,1~~	[illegible]	~~-12,3~~	[illegible]
15	X-LOAD AVG	15190,3	-2294,4	48063,6	26,79	-35530,5	49,17
16	F-CYLD	9853,4	1165,7	22606,2	46,90	-25330,1	10,16
17	TORQUE AVG	155,4	142,7	393,1	,20	-6,4	56,33
18	DELTA	22,6	2,5	4978,5	40,02	-1114,1	40,02
19	F-SUMP	17995,0	-2055,3	68061,5	26,78	-52414,8	6,37
20	Y-LOAD	24676,4	24031,9	44272,6	10,14	11507,7	39,60
21	F-SHEAR	17346,0	16705,5	31749,0	9,87	6681,4	52,61
22	ALPHA	27,0	27,0	30,7	62,02	19,2	25,31
23	M POWER	68,9	63,3	173,8	,20	-2,8	56,33
~~24~~	~~EFF~~	~~5023,3~~	~~-1129,1~~	~~53203,8~~	~~21,64~~	[illegible]	~~,18~~
25	HEAD RPM	16,6	16,6	18,0	13,81	-,2	40,02
26	BETA	6,9	3,7	24,1	25,31	-7,1	62,02
27	RATIO	11,3	1,3	2489,2	40,02	-557,0	40,02

TEST NO. 11 SUMP CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3

HEAD SPEED: 18 RPM BIT SPACING: 4 INCHES

LOCATION: 5-129 DEPTH OF CUT: 2.0 IN/REV

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	61.2	44.4	317.6	6.67	-10.4	1.64
2	TORQUE RHS	204.1	189.1	629.1	34.56	-.4	1.53
3	SHAFT RPM	481.9	482.4	494.7	34.72	466.8	36.07
4	X-LOAD LHS	29421.0	-26649.4	14612.0	34.62	-53815.6	2.80
5	X-LOAD RHS	17322.4	-14428.9	33019.1	34.30	-38886.3	15.31
6	F-CYLD DWN	7224.2	3596.8	37452.5	33.15	-176.1	30.56
7	F-CYLD UP	19992.1	19460.2	30831.2	1.57	-932.3	34.63
8	SUMP RATE	.4	.3	1.2	16.80	-.2	15.00
9	SHEAR RATE	.5	.1	3.0	33.09	-.2	21.32
10	SUMP STK	26.8	26.3	33.5	33.88	17.0	.42
11	VERT STK	38.9	38.8	42.7	.03	33.2	30.83
12	BOOM G-Y	.1	.1	.1	35.11	.1	36.11
13	BOOM G-Z	.0	.0	.0	34.12	.0	36.11
~~14~~	~~F POWER~~	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	X-LOAD AVG	22045.1	-20564.1	14865.3	34.30	-41577.3	1.56
16	F-CYLD	17593.5	15863.3	29124.6	1.57	-16172.1	32.88
17	TORQUE AVG	124.6	116.7	337.8	34.56	2.6	1.64
18	DELTA	1.5	1.0	4.8	16.80	-.6	15.00
19	F-SUMP	16500.7	-15113.5	9351.6	34.90	-36860.2	1.56
20	Y-LOAD	10403.5	8448.3	35291.2	34.32	-3434.3	1.56
21	F-SHEAR	14791.1	14515.3	29705.1	32.88	10694.0	28.73
22	ALPHA	24.5	24.6	25.2	.03	23.5	30.83
23	M POWER	50.9	47.7	140.0	34.56	1.1	1.64
~~24~~	~~FSE~~	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	HEAD RPM	15.3	15.4	15.7	34.72	14.9	36.07
26	BETA	10.6	10.5	13.0	30.83	8.7	.03
27	RATIO	.4	.3	1.2	16.80	-.2	15.00

TEST NO. 11 SHEAR CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3

HEAD SPEED: 18 RPM BIT SPACING: 4 INCHES

LOCATION: 5-129 DEPTH OF CUT: 2.0 IN/REV

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	66.3	41.7	372.3	15.80	-15.0	24.65
2	TORQUE RHS	199.5	174.8	540.5	15.53	-5.0	41.69
3	SHAFT RPM	481.4	481.3	495.7	33.72	466.8	45.65
4	X-LOAD LHS	25683.4	-19401.4	47653.1	21.61	-67595.8	28.25
5	X-LOAD RHS	25193.1	-18092.1	35354.6	15.48	-55849.5	25.16
6	F-CYLD DWN	6936.3	6640.7	15672.2	20.77	56.4	17.24
7	F-CYLD UP	18625.6	17058.1	32424.0	28.24	-120.2	15.52
8	SUMP RATE	.1	-.1	.1	45.60	-.2	10.47
9	SHEAR RATE	.8	.6	2.7	20.70	-.2	21.78
10	SUMP STK	31.4	31.4	33.4	.20	30.3	44.35
11	VERT STK	57.1	56.2	74.8	49.05	39.5	.10
12	BOOM G-Y	.1	.1	.1	49.05	.1	49.06
13	BOOM G-Z	.0	.0	.0	49.05	.0	49.06
~~14~~	~~F POWER~~	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	X-LOAD AVG	23692.9	-12746.7	14545.5	15.48	-49199.2	31.32
16	F-CYLD	13670.7	10417.4	31041.1	28.24	-12187.8	18.84
17	TORQUE AVG	121.4	108.3	362.2	18.74	-3.5	42.86
18	DELTA	3.1	2.5	10.5	20.70	-.7	21.78
19	F-SUMP	23585.4	-19141.4	14596.3	15.18	-46671.3	31.31
20	Y-LOAD	18255.9	17673.5	31466.3	18.84	2534.4	24.05
21	F-SHEAR	14257.3	13596.1	22328.4	18.94	3888.6	48.64
22	ALPHA	27.4	27.4	30.3	49.05	24.6	.10
23	M POWER	45.6	44.3	147.3	15.29	-1.5	42.86
~~24~~	~~FSE~~	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	HEAD RPM	15.3	15.3	15.8	33.72	14.9	45.85
26	BETA	5.2	2.8	10.1	.11	-5.7	49.05
27	RATIO	.7	.6	2.6	20.70	-.2	21.78

TEST NO. 12 SUMP CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3

HEAD SPEED: 18 RPM BIT SPACING: 4 INCHES

LOCATION: 5-129 DEPTH OF CUT: 2.0 IN/REV

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	64.4	33.6	383.4	5.69	-28.0	5.63
2	TORQUE RHS	407.6	355.9	837.1	5.58	-9.0	.77
3	SHAFT RPM	497.6	500.3	510.1	5.60	479.2	4.95
4	X-LOAD LHS	8070.3	1675.1	14306.3	5.28	-15168.9	.11
5	X-LOAD RHS	25124.0	4323.8	132509.5	.13	-58417.5	.14
6	F-CYLD DWN	48888.3	48590.4	57459.1	10.01	32331.4	.13
7	F-CYLD UP	35562.7	35102.9	48268.5	.15	26463.3	11.90
8	SUMP RATE	.7	.7	1.4	1.66	-.1	8.80
9	SHEAR RATE	.1	-.0	.5	9.92	-.2	4.67
10	SUMP STK	8.6	7.9	12.9	12.10	.9	.08
11	VERT STK	38.3	38.5	39.3	.06	37.2	12.12
12	BOOM G-Y	.3	-.1	1.6	10.25	-1.9	10.00
13	BOOM G-Z	.0	-.0	.0	10.25	-.0	10.00
~~14~~	~~E POWER~~	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	X-LOAD AVG	25124.0	4323.8	132509.5	.13	-58417.5	.14
16	F-CYLD	19543.2	-13487.5	15727.8	.15	-30405.7	10.00
17	TORQUE AVG	220.1	194.8	583.7	5.58	-9.7	1.94
18	DELTA	2.8	2.6	5.5	1.67	-.4	8.78
19	F-SUMP	31678.1	-13368.9	290529.9	.13	-91141.2	.14
20	Y-LOAD	34792.8	31326.2	65020.6	.11	-5441.6	.14
21	F-SHEAR	25805.1	25730.0	32742.6	9.75	-41434.7	.11
22	ALPHA	24.5	24.7	24.6	.06	24.2	12.12
23	M POWER	92.5	81.9	248.5	5.58	-4.1	1.94
~~24~~	~~EFF~~	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	HEAD RPM	15.8	15.9	16.2	5.60	15.3	4.95
26	BETA	10.8	10.9	11.2	12.12	10.2	.06
27	RATIO	.7	.6	1.4	1.67	-.1	8.78

TEST NO. 12 SHEAR CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3

HEAD SPEED: 18 RPM BIT SPACING: 4 INCHES

LOCATION: 5-129 DEPTH OF CUT: 2.0 IN/REV

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	75.3	32.2	538.0	66.27	-228.7	51.04
2	TORQUE RHS	327.8	314.2	719.9	60.44	7.8	68.35
3	SHAFT RPM	494.8	494.7	512.4	69.65	45.6	12.96
4	X-LOAD LHS	7403.0	4543.7	26389.3	61.07	-15533.4	75.49
5	X-LOAD RHS	22163.7	14821.3	71803.3	61.63	-40425.9	75.12
6	F-CYLD DWN	14469.2	13258.0	53979.9	0.00	2874.0	71.61
7	F-CYLD UP	4532.2	1912.9	30755.9	.15	-3271.9	67.36
8	SUMP RATE	.2	-.0	1.7	68.09	-.3	13.58
9	SHEAR RATE	.6	.4	3.3	68.40	-.2	41.09
10	SUMP STK	12.9	12.9	14.2	13.59	11.5	13.58
11	VERT STK	56.6	55.9	80.4	56.50	18.3	56.49
12	BOOM G-Y	.4	-.0	3.1	68.40	-3.0	34.59
13	BOOM G-Z	.0	-.0	.0	68.40	-.0	34.59
~~14~~	~~E POWER~~	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	X-LOAD AVG	22163.7	14821.3	71803.3	61.63	-40425.9	75.12
16	F-CYLD	14031.8	-11345.1	12901.5	78.05	-36620.0	60.46
17	TORQUE AVG	182.6	173.2	505.1	62.83	3.9	68.35
18	DELTA	2.2	1.5	12.7	12.96	-.6	41.09
19	F-SUMP	28033.7	9976.9	95591.4	61.63	-83454.8	73.87
20	Y-LOAD	30710.0	30301.7	45628.0	.02	15805.1	2.21
21	F-SHEAR	22316.6	21995.9	36025.0	.33	8605.4	76.94
22	ALPHA	27.3	27.3	31.1	56.50	20.9	56.49
23	M POWER	76.8	72.8	213.1	62.83	1.7	68.35
~~24~~	~~EFF~~	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	HEAD RPM	15.7	15.7	16.3	69.65	1.5	12.96
26	BETA	4.9	2.7	20.0	56.49	-8.3	56.50
27	RATIO	.5	.4	3.2	12.96	-.2	41.09

TEST NO. 13 SUMP CYCLE

IN MINE TESTING OF HH456, BLUE STAR NO.3

HEAD SPEED: 18 RPM BIT SPACING: 4 INCHES

LOCATION: 5-129 DEPTH OF CUT: 2.0 IN/REV

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	59.8	32.1	409.7	14.20	-31.3	14.15
2	TORQUE RHS	367.0	345.3	727.9	4.28	-5.9	.10
3	SHAFT RPM	496.7	498.2	509.4	14.11	480.8	18.08
4	X-LOAD LHS	4515.7	160.2	10928.5	4.19	-14171.1	.06
5	X-LOAD RHS	16309.1	3665.3	31005.1	9.64	-47049.1	.33
6	F-CYLD DWN	49451.5	49456.3	57950.9	4.31	38856.1	.73
7	F-CYLD UP	36941.0	36550.0	52707.9	.05	27476.3	16.78
8	SUMP RATE	.7	.5	2.5	6.53	-.1	17.96
9	SHEAR RATE	.1	-.0	.5	6.12	-.2	16.22
10	SUMP STK	9.4	8.3	14.3	17.37	.1	.00
11	VERT STK	40.0	40.1	41.2	.06	38.8	16.21
12	BOOM G-Y	.3	-.1	1.4	3.65	-1.9	5.87
13	BOOM G-Z	.0	-.0	.0	3.65	-.0	5.87
14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	X-LOAD AVG	16309.1	3665.3	31005.1	9.64	-47049.1	.33
16	F-CYLD	15251.6	-12906.3	12731.8	.73	-22929.5	9.85
17	TORQUE AVG	200.2	186.7	459.2	14.20	-8.0	.06
18	DELTA	2.6	2.0	9.7	6.53	-.5	17.96
19	F-SUMP	23975.5	-13889.0	29768.9	13.03	-76517.9	.69
20	Y-LOAD	31815.8	30586.2	43232.8	9.64	1991.7	.33
21	F-SHEAR	25362.2	25373.4	30752.9	4.49	19616.8	13.03
22	ALPHA	24.8	24.8	24.[illegible]	.06	24.5	16.21
23	M POWER	84.2	79.4	188.9	14.20	-3.4	.06
24	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	HEAD RPM	15.8	15.9	16.2	14.11	15.3	18.08
26	BETA	10.0	10.0	10.4	16.21	9.4	.06
27	RATIO	.7	.5	2.4	6.53	-.1	17.96

TEST NO. 13 SHEAR CYCLE

IN MINE TESTING OF HH456, BLUE STAR NO.3

HEAD SPEED: 18 RPM BIT SPACING: 4 INCHES

LOCATION: 5-129 DEPTH OF CUT: 2.0 IN/REV

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	53.7	32.3	395.3	6.45	-19.9	2.30
2	TORQUE RHS	341.0	327.7	864.9	49.19	48.9	1.73
3	SHAFT RPM	495.2	495.1	510.6	10.60	321.6	54.74
4	X-LOAD LHS	6919.8	3999.3	25511.0	36.12	-9588.0	62.90
5	X-LOAD RHS	20808.8	12582.2	67554.6	46.86	-31743.6	65.04
6	F-CYLD DWN	18303.3	16277.8	53312.5	2.35	3140.5	5.29
7	F-CYLD UP	7751.5	3897.4	61170.3	14.34	-6838.0	14.32
8	SUMP RATE	.1	-.0	2.0	45.28	-.1	49.07
9	SHEAR RATE	.6	.5	3.0	50.13	-.2	37.80
10	SUMP STK	13.1	13.1	14.4	8.31	11.5	49.15
11	VERT STK	60.5	59.3	83.9	69.38	2.1	69.36
12	BOOM G-Y	.5	-.1	4.7	51.26	-4.3	51.27
13	BOOM G-Z	.0	-.0	.0	51.26	-.0	51.27
14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	X-LOAD AVG	20808.8	12582.2	67554.6	46.86	-31743.6	65.04
16	F-CYLD	15686.2	-12380.4	52154.5	14.34	-43274.9	39.65
17	TORQUE AVG	187.6	180.0	466.4	49.19	24.0	1.73
18	DELTA	2.3	1.8	11.5	50.13	-.7	37.80
19	F-SUMP	21432.8	3720.5	98901.3	14.34	-50806.5	2.34
20	Y-LOAD	31282.1	30834.6	46830.2	39.65	-1172.4	14.31
21	F-SHEAR	22990.1	22513.9	35516.8	39.65	-13547.3	14.34
22	ALPHA	27.9	27.8	31.6	69.38	17.7	69.36
23	M POWER	78.9	75.7	199.7	49.19	10.2	1.73
24	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	HEAD RPM	15.8	15.8	16.2	10.60	10.2	54.74
26	BETA	5.3	1.2	27.9	69.36	-9.8	69.38
27	RATIO	.6	.5	2.9	50.13	-.2	37.80

TEST NO. 14 SUMP CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO. 3

HEAD SPEED: 18 RPM BIT SPACING: 4 INCHES

LOCATION: 5-129 DEPTH OF CUT: 2.0 IN/REV

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	435.0	412.3	793.2	13.48	-13.2	.29
2	TORQUE RHS	434.7	412.0	794.1	13.48	-12.9	.29
3	SHAFT RPM	510.2	511.1	545.4	19.49	469.1	20.38
4	X-LOAD LHS	27149.0	-26753.7	-11920.2	14.41	-44091.6	18.83
5	X-LOAD RHS	19200.5	10683.8	41991.7	15.13	-37733.5	.08
6	F-CYLD DWN	50604.9	50464.3	58634.1	14.11	26917.5	23.11
7	F-CYLD UP	33287.4	32746.4	50133.8	.99	10462.3	23.13
8	SUMP RATE	.6	.6	1.8	.45	-.1	7.75
9	SHEAR RATE	.1	.0	1.1	5.45	-.2	5.26
10	SUMP STK	11.2	10.2	17.9	22.70	.1	.06
11	VERT STK	32.8	32.9	34.3	.38	31.7	21.41
12	BOOM G-Y	.3	.0	2.0	19.46	-1.7	16.82
13	BOOM G-Z	.0	.0	.0	19.46	-.0	16.82
[redacted]							
15	X-LOAD AVG	19200.5	10683.8	41991.7	15.13	-37733.5	.08
16	F-CYLD	20260.5	-17717.9	17317.4	.99	-32082.3	14.11
17	TORQUE AVG	434.8	412.2	793.7	13.48	-13.1	.29
18	DELTA	2.4	2.1	6.6	.45	-.2	7.75
19	F-SUMP	19685.9	-7037.2	43829.5	15.13	-66559.6	5.41
20	Y-LOAD	37794.6	36055.9	54037.0	15.13	113.3	.08
21	F-SHEAR	26402.0	26280.9	37941.5	5.41	15909.3	21.92
22	ALPHA	23.5	23.6	23.7	.38	23.3	21.41
23	M POWER	188.2	178.4	337.4	14.45	-5.6	.29
[redacted]							
25	HEAD RPM	16.2	16.3	17.4	19.49	14.9	20.38
26	BETA	13.2	13.2	13.7	21.41	12.5	.38
27	RATIO	1.2	1.0	3.3	.45	-.1	7.75

TEST NO. 14 SHEAR CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO. 3

HEAD SPEED: 18 RPM BIT SPACING: 4 INCHES

LOCATION: 5-129 DEPTH OF CUT: 2.0 IN/REV

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	358.5	343.7	779.6	48.47	-4.2	56.74
2	TORQUE RHS	358.3	343.4	779.7	48.47	-3.9	56.74
3	SHAFT RPM	509.7	509.6	603.8	26.20	-5.3	81.73
4	X-LOAD LHS	32898.7	-32411.7	-12766.9	56.00	-53933.5	16.80
5	X-LOAD RHS	30655.7	23410.8	127077.5	32.23	-23158.0	65.57
6	F-CYLD DWN	27413.2	23465.8	49790.4	23.83	5612.3	59.49
7	F-CYLD UP	6092.1	4444.1	19895.1	63.83	-520.9	83.40
8	SUMP RATE	.1	.0	.7	15.67	-.1	8.46
9	SHEAR RATE	.6	.5	1.9	51.56	-.1	10.14
10	SUMP STK	18.1	18.1	19.5	35.38	16.1	86.15
11	VERT STK	57.9	55.9	82.3	86.43	1.2	8.09
12	BOOM G-Y	.4	.0	2.3	24.51	-2.6	24.51
13	BOOM G-Z	.0	.0	.0	24.51	-.0	24.51
[redacted]							
15	X-LOAD AVG	30655.7	23410.8	127077.5	32.23	-23158.0	65.57
16	F-CYLD	25579.4	-19021.7	12917.2	63.83	-49833.7	23.83
17	TORQUE AVG	358.4	343.5	779.7	48.47	-4.0	56.74
18	DELTA	3.2	1.8	112.2	81.73	-674.9	81.73
19	F-SUMP	22880.5	14751.3	182262.0	32.23	-36599.8	65.57
20	Y-LOAD	39922.8	37655.2	74846.2	32.23	17690.6	64.28
21	F-SHEAR	24524.4	23722.8	39099.2	17.18	9869.0	46.93
22	ALPHA	27.4	27.3	31.4	86.43	17.5	8.09
23	M POWER	155.1	148.7	340.0	48.47	-1.8	56.74
[redacted]							
25	HEAD RPM	16.2	16.2	19.2	26.20	-.2	81.73
26	BETA	7.3	2.7	28.4	8.09	-9.1	86.43
27	RATIO	1.6	.9	56.1	81.73	-337.4	81.73

TEST NO. 15 — SUMP CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3

HEAD SPEED: 18 RPM — BIT SPACING: 4 INCHES

LOCATION: S-129 — DEPTH OF CUT: 2.0 IN/REV

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	309.4	243.7	1540.1	.04	-68.0	.04
2	TORQUE RHS	309.2	243.5	1539.0	.04	-68.3	.04
3	SHAFT RPM	504.6	502.5	549.2	23.72	-61.7	.17
4	X-LOAD LHS	23506.8	-21523.4	108504.4	.04	-34183.7	23.15
5	X-LOAD RHS	28081.5	-19145.4	126758.4	.03	-51870.5	6.05
6	F-CYLD DWN	33304.4	32576.2	77597.5	.03	-10648.7	.03
7	F-CYLD UP	14918.9	13365.1	64837.0	.03	-1061.9	.03
8	SUMP RATE	.8	.6	2.2	.73	-5.1	.04
9	SHEAR RATE	.4	-.0	.9	17.11	-5.7	.03
10	SUMP STK	13.2	11.0	22.5	28.05	-56.8	.03
11	VERT STK	34.0	34.0	62.0	.17	.6	.03
12	BOOM G-Y	1.0	-.0	1.4	11.45	-13.7	.03
13	BOOM G-Z	.0	-.0	.0	11.45	-.0	.03
14	E POWER	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	X-LOAD AVG	28081.5	-19145.4	126758.4	.03	-51870.5	6.05
16	F-CYLD	22556.0	-19211.1	9586.9	.03	-40484.7	.52
17	TORQUE AVG	309.3	243.6	1539.5	.04	-68.2	.04
18	DELTA	66.0	1.9	3489.3	.03	-4969.5	.03
19	F-SUMP	90322.4	-69226.1	237863.7	.03	-158950.5	6.05
20	Y-LOAD	23061.0	22784.9	74783.0	.03	12234.2	.03
21	F-SHEAR	44427.5	41175.9	66995.4	4.05	-46761.0	.03
22	ALPHA	23.7	23.7	28.3	.17	17.4	.03
23	M POWER	125.1	101.4	361.8	26.70	-53.0	.01
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	HEAD RPM	16.1	16.0	17.5	23.72	-2.0	.17
26	BETA	12.8	12.8	28.7	.03	0.0	.17
27	RATIO	33.0	1.0	1744.6	.03	-2484.8	.03

TEST NO. 15 — SHEAR CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3

HEAD SPEED: 18 RPM — BIT SPACING: 4 INCHES

LOCATION: S-129 — DEPTH OF CUT: 2.0 IN/REV

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	273.2	251.4	661.1	9.45	-9.0	54.29
2	TORQUE RHS	272.9	251.2	660.5	9.45	-9.4	54.29
3	SHAFT RPM	506.2	506.1	547.6	32.37	6.7	38.59
4	X-LOAD LHS	26685.9	-25654.3	348.7	5.79	-48146.1	63.22
5	X-LOAD RHS	15213.9	-460.1	48381.3	25.70	-35088.7	47.51
6	F-CYLD DWN	15381.0	11799.7	34398.4	45.30	-641.9	71.04
7	F-CYLD UP	8603.0	7911.6	26500.4	70.64	805.4	71.10
8	SUMP RATE	.1	-.0	.9	.06	-.1	23.41
9	SHEAR RATE	.7	.6	2.2	9.99	-5.7	7.18
10	SUMP STK	21.4	21.4	23.6	7.83	19.2	67.70
11	VERT STK	59.8	57.9	81.6	70.84	16.8	24.26
12	BOOM G-Y	.3	.0	2.3	27.06	-2.6	13.09
13	BOOM G-Z	.0	.0	.0	27.06	-.0	13.09
14	E POWER	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	X-LOAD AVG	15213.9	-460.1	48381.3	25.70	-35088.7	47.51
16	F-CYLD	12626.0	-3888.1	23614.3	70.73	-30729.3	45.29
17	TORQUE AVG	273.1	251.3	660.8	9.45	-9.2	54.29
18	DELTA	3.2	2.3	291.6	38.59	-21.3	7.18
19	F-SUMP	50821.3	-7970.8	119386.4	25.70	-122213.8	50.66
20	Y-LOAD	27677.4	26388.6	44373.1	50.86	97.5	70.24
21	F-SHEAR	18573.3	17941.3	31030.8	38.19	-5322.4	9.48
22	ALPHA	27.7	27.6	31.3	70.84	20.6	24.26
23	M POWER	117.4	108.1	281.3	9.45	-4.0	54.29
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	HEAD RPM	16.1	16.1	19.0	32.37	.2	38.59
26	BETA	7.0	1.9	20.7	24.26	-8.8	70.84
27	RATIO	1.6	1.1	145.8	38.59	-10.7	7.18

TEST NO. 16 SUMP CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3

HEAD SPEED: 51 RPM BIT SPACING: 4 INCHES

LOCATION: 4-130 DEPTH OF CUT: 2.0 IN/REV

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	326.5	270.9	1047.8	7.43	-11.8	1.57
2	TORQUE RHS	322.0	269.8	946.2	9.19	-10.7	8.53
3	SHAFT RPM	1596.3	1599.5	1606.4	4.75	1577.3	9.40
4	X-LOAD LHS	10333.9	9426.9	27174.9	3.70	-3965.1	10.75
5	X-LOAD RHS	30689.8	-30094.6	-5157.6	3.68	-45899.5	4.62
6	F-CYLD DWN	34731.9	34763.0	40832.8	10.45	30131.0	4.22
7	F-CYLD UP	41345.0	41400.1	44648.4	.25	36010.5	10.45
8	SUMP RATE	.7	.6	2.0	.70	-.0	2.93
9	SHEAR RATE	.1	.0	.3	10.00	-.0	6.60
10	SUMP STK	5.2	4.6	8.8	11.04	.1	0.00
11	VERT STK	42.5	42.6	42.8	1.51	41.9	3.49
12	BOOM G-Y	.9	-.1	3.7	3.32	-3.4	.61
13	BOOM G-Z	.0	-.0	.0	3.32	-.0	.61
14	E POWER	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	X-LOAD AVG	30689.8	-30094.6	-5157.6	3.68	-45899.5	4.62
16	F-CYLD	7288.7	6637.2	13678.4	4.22	-4635.9	10.45
17	TORQUE AVG	300.2	270.3	794.6	3.52	4.3	2.11
18	DELTA	.8	.7	2.4	.70	-.0	2.93
19	F-SUMP	50045.2	-49174.3	10473.9	3.68	-76480.9	3.72
20	Y-LOAD	11198.5	10778.6	21522.6	10.45	3157.1	4.22
21	F-SHEAR	22982.0	22976.4	29156.0	3.73	11121.6	3.68
22	ALPHA	25.2	25.2	25.2	1.51	25.0	3.49
23	M POWER	140.1	126.3	371.4	3.52	2.0	2.11
24	EFF	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	HEAD RPM	50.8	50.9	51.1	4.75	50.2	9.40
26	BETA	8.8	8.8	9.0	3.49	8.6	1.51
27	RATIO	.2	.2	.6	.70	-.0	2.93

TEST NO. 16 SHEAR CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3

HEAD SPEED: 51 RPM BIT SPACING: 4 INCHES

LOCATION: 4-130 DEPTH OF CUT: 2.0 IN/REV

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	456.9	363.6	1543.1	31.78	-16.4	28.15
2	TORQUE RHS	412.8	361.7	1157.6	12.88	-13.7	3.92
3	SHAFT RPM	1580.6	1580.5	1610.9	8.35	1527.9	28.71
4	X-LOAD LHS	12460.8	7421.2	34527.5	19.77	-44404.2	32.77
5	X-LOAD RHS	21111.8	-4188.8	89699.2	25.98	-54389.9	32.77
6	F-CYLD DWN	15104.4	14108.9	38330.6	.00	-201.1	6.77
7	F-CYLD UP	14108.4	12760.2	41914.1	.08	-403.5	28.68
8	SUMP RATE	.1	.0	.4	13.81	-.1	38.72
9	SHEAR RATE	1.1	.9	3.2	24.17	-.0	13.29
10	SUMP STK	9.1	9.1	9.7	18.10	8.4	34.96
11	VERT STK	61.4	60.3	81.4	39.09	42.2	.44
12	BOOM G-Y	.9	-.1	3.7	35.13	-3.9	1.40
13	BOOM G-Z	.0	-.0	.0	35.13	-.0	1.40
14	E POWER	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	X-LOAD AVG	21111.8	-4188.8	89699.2	25.98	-54389.9	32.77
16	F-CYLD	8991.0	-1348.7	19986.2	6.77	-29892.2	28.70
17	TORQUE AVG	407.0	362.6	1186.1	27.77	9.2	3.53
18	DELTA	1.3	1.1	3.9	24.17	-.1	5.21
19	F-SUMP	33191.1	-10811.3	136567.5	25.98	-116884.5	28.92
20	Y-LOAD	24565.0	23735.7	37253.7	18.56	4915.2	5.95
21	F-SHEAR	19060.3	18469.2	33290.0	25.99	2982.5	34.80
22	ALPHA	28.1	28.0	31.2	39.09	25.1	.44
23	M POWER	187.8	167.7	541.9	27.77	4.3	3.53
24	EFF	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	HEAD RPM	50.3	50.3	51.3	8.35	48.6	28.71
26	BETA	5.3	.8	8.9	.44	-8.7	39.09
27	RATIO	.3	.3	1.0	24.17	-.0	5.21

TEST NO. 17 SUMP CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3

HEAD SPEED: 51 RPM BIT SPACING: 4 INCHES

LOCATION: 4-130 DEPTH OF CUT: 2.0 IN/REV

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	353.0	284.3	1167.7	15.28	-17.2	6.96
2	TORQUE RHS	348.1	282.0	1152.2	16.26	-12.1	4.33
3	SHAFT RPM	1595.9	1599.3	1609.2	.01	1562.2	19.03
4	X-LOAD LHS	8621.4	6335.4	27467.4	17.93	-21272.7	18.04
5	X-LOAD RHS	32367.6	-30659.8	15648.9	19.04	-53816.5	2.80
6	F-CYLD DWN	37548.7	37495.9	44917.8	15.75	23012.5	18.94
7	F-CYLD UP	43149.4	42840.2	50301.7	1.44	14354.9	19.04
8	SUMP RATE	.6	.6	1.0	17.63	.0	19.01
9	SHEAR RATE	.4	.2	2.3	19.00	-.1	14.34
10	SUMP STK	9.3	8.2	15.7	18.96	.3	.20
11	VERT STK	42.1	42.2	44.0	19.02	41.3	15.13
12	BOOM G-Y	.9	-.1	3.6	12.40	-3.6	12.40
13	BOOM G-Z	.0	-.0	.0	12.40	-.0	12.40
14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	X-LOAD AVG	32367.6	-30659.8	15648.9	19.04	-53816.5	2.80
16	F-CYLD	7646.9	5344.4	16570.4	14.64	-10765.9	19.04
17	TORQUE AVG	322.3	283.2	952.4	13.47	-.6	1.70
18	DELTA	.7	.7	1.2	17.63	.0	19.01
19	F-SUMP	54061.6	-52463.5	15619.8	19.04	-85628.1	2.78
20	Y-LOAD	12424.6	11028.7	32341.7	19.04	-1256.4	14.63
21	F-SHEAR	24161.6	24165.1	29658.1	16.92	18960.3	15.65
22	ALPHA	25.1	25.2	25.4	19.02	24.9	15.13
23	M POWER	150.2	132.1	441.9	13.47	-.3	1.70
24	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	HEAD RPM	50.8	50.9	51.2	.01	49.7	19.03
26	BETA	9.0	9.0	9.3	15.13	8.1	19.02
27	RATIO	.2	.2	.3	17.63	.0	19.01

TEST NO. 17 SHEAR CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3

HEAD SPEED: 51 RPM BIT SPACING: 4 INCHES

LOCATION: 4-130 DEPTH OF CUT: 2.0 IN/REV

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	459.0	362.4	1543.5	19.98	-15.6	15.02
2	TORQUE RHS	415.3	359.9	1325.6	30.51	-15.1	24.29
3	SHAFT RPM	1579.9	1579.3	1609.2	41.75	8.2	15.69
4	X-LOAD LHS	9994.7	4476.1	42962.3	21.15	-28521.2	11.36
5	X-LOAD RHS	22343.5	5810.8	76571.7	15.48	-58944.2	24.94
6	F-CYLD DWN	25504.7	22990.6	53464.4	41.22	183.2	41.97
7	F-CYLD UP	12529.7	11144.1	31331.5	25.63	-470.4	41.70
8	SUMP RATE	.3	.1	1.8	33.59	-.1	27.24
9	SHEAR RATE	1.1	1.0	2.9	18.94	-.0	41.92
10	SUMP STK	15.4	15.4	16.5	9.27	13.1	31.54
11	VERT STK	69.6	68.2	85.3	42.05	43.6	.04
12	BOOM G-Y	.9	-.1	4.4	11.97	-4.3	20.24
13	BOOM G-Z	.0	-.0	.0	11.97	-.0	20.24
14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	X-LOAD AVG	22343.5	5810.8	76571.7	15.48	-58944.2	24.94
16	F-CYLD	19273.9	-11846.4	22404.0	25.62	-42799.2	41.20
17	TORQUE AVG	410.7	361.1	1231.9	19.04	4.7	26.35
18	DELTA	5.7	1.3	572.5	15.69	-.1	41.92
19	F-SUMP	26319.7	-9810.7	102551.8	15.47	-89081.3	24.94
20	Y-LOAD	29576.2	29068.2	40274.0	15.49	8745.1	1.35
21	F-SHEAR	23112.0	21886.3	34577.4	39.70	1382.7	24.95
22	ALPHA	29.3	29.2	31.8	42.05	25.3	.04
23	M POWER	189.1	166.7	568.4	2.26	.7	15.69
24	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	HEAD RPM	50.3	50.3	51.2	41.75	.3	15.69
26	BETA	6.7	-2.8	8.3	.04	-10.5	42.05
27	RATIO	1.4	.3	143.1	15.69	-.0	41.92

TEST NO. 18 SUMP CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3

HEAD SPEED: 51 RPM BIT SPACING: 4 INCHES

LOCATION: 4-130 DEPTH OF CUT: 2.0 IN/REV

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	339.1	274.7	1159.8	16.86	-14.2	6.43
2	TORQUE RHS	341.6	271.7	1138.5	13.42	-17.9	13.43
3	SHAFT RPM	1579.5	1582.2	1597.8	.60	350.0	10.77
4	X-LOAD LHS	7947.7	5981.4	23586.0	15.24	-16303.6	15.32
5	X-LOAD RHS	30885.5	-29142.5	-2405.7	15.23	-52605.6	.29
6	F-CYLD DWN	36613.2	36590.9	43999.0	11.05	29361.7	15.33
7	F-CYLD UP	41717.4	41664.4	48947.3	2.10	32836.5	16.65
8	SUMP RATE	.7	.7	1.5	8.04	-.0	7.25
9	SHEAR RATE	.2	.1	.9	15.39	-.0	14.91
10	SUMP STK	9.4	8.6	15.2	16.99	.3	.00
11	VERT STK	45.0	45.1	45.5	3.02	44.4	3.01
12	BOOM G-Y	1.0	-.1	3.8	6.36	-4.1	.48
13	BOOM G-Z	.0	-.0	.0	6.36	-.0	.48
~~14~~	~~E-POWER~~	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	X-LOAD AVG	30885.5	-29142.5	-2405.7	15.23	-52605.6	.29
16	F-CYLD	7433.3	5073.5	18043.2	2.07	-10315.0	16.65
17	TORQUE AVG	314.0	273.2	1008.8	16.52	3.6	2.14
18	DELTA	.9	.8	3.1	10.77	-.0	7.25
19	F-SUMP	51452.8	-49792.5	-6520.3	11.11	-80869.3	.30
20	Y-LOAD	13960.4	12970.9	26508.4	11.05	787.3	2.09
21	F-SHEAR	22642.6	22632.3	28311.8	14.23	17606.4	11.11
22	ALPHA	25.6	25.6	25.6	3.02	25.4	3.01
23	M POWER	144.7	126.1	462.8	16.52	1.7	2.14
~~24~~	~~EFF~~	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	HEAD RPM	50.3	50.3	50.8	.60	11.1	10.77
26	BETA	7.7	7.7	7.9	3.01	7.4	3.02
27	RATIO	.2	.2	.8	10.77	-.0	7.25

TEST NO. 18 SHEAR CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3

HEAD SPEED: 51 RPM BIT SPACING: 4 INCHES

LOCATION: 4-130 DEPTH OF CUT: 2.0 IN/REV

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	551.7	450.5	1541.1	20.90	-20.3	12.21
2	TORQUE RHS	477.1	447.0	1062.6	.30	-7.3	.61
3	SHAFT RPM	1552.8	1552.7	1594.5	25.11	1507.8	17.91
4	X-LOAD LHS	9613.6	633.7	33506.8	24.89	-35620.2	16.41
5	X-LOAD RHS	21215.6	10187.9	68930.4	14.83	-60038.1	25.09
6	F-CYLD DWN	26837.4	24988.6	39607.8	.02	-180.2	24.35
7	F-CYLD UP	11873.0	10851.7	38165.5	.10	-591.3	24.09
8	SUMP RATE	.2	.1	2.0	15.21	-.0	21.03
9	SHEAR RATE	1.1	1.1	2.4	4.32	-.0	24.23
10	SUMP STK	15.9	15.9	17.0	16.66	14.9	.25
11	VERT STK	60.6	60.0	74.5	24.05	44.7	.07
12	BOOM G-Y	.9	-.1	4.6	13.56	-4.4	13.57
13	BOOM G-Z	.0	-.0	.0	13.56	-.0	13.57
~~14~~	~~E-POWER~~	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	X-LOAD AVG	21215.6	10187.9	68930.4	14.83	-60038.1	25.09
16	F-CYLD	18373.5	-14137.0	26862.0	25.04	-34988.5	15.50
17	TORQUE AVG	491.7	448.7	1233.5	17.50	-1.7	.61
18	DELTA	1.4	1.3	2.9	15.86	-.1	24.23
19	F-SUMP	25089.6	-4653.4	84412.5	14.83	-81792.0	17.71
20	Y-LOAD	30728.3	29991.3	41371.8	14.44	6175.7	1.16
21	F-SHEAR	24589.6	24130.8	33742.4	20.52	3473.8	24.83
22	ALPHA	28.0	28.0	30.2	24.05	25.5	.07
23	M POWER	222.8	203.6	551.5	17.50	-.8	.61
~~24~~	~~EFF~~	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	HEAD RPM	49.4	49.4	50.7	25.11	48.0	17.91
26	BETA	4.1	.9	7.8	.07	-5.6	24.05
27	RATIO	.3	.3	.7	15.86	-.0	24.23

TEST NO. 19 — SUMP CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3

HEAD SPEED: 51 RPM — BIT SPACING: 4 INCHES

LOCATION: 4-130 — DEPTH OF CUT: 2.0 IN/REV

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	433.1	341.8	1362.4	21.76	-10.8	8.41
2	TORQUE RHS	405.5	336.5	1248.5	21.29	-17.1	8.91
3	SHAFT RPM	1589.2	1592.0	1612.0	.04	1559.3	22.58
4	X-LOAD LHS	11725.1	10231.9	31749.3	23.16	-12474.1	23.88
5	X-LOAD RHS	20839.2	-15235.9	26086.1	22.81	-47684.6	2.06
6	F-CYLD DWN	34309.0	33334.3	48750.0	.74	17426.2	23.70
7	F-CYLD UP	35342.2	33314.4	49792.0	.01	13045.9	24.01
8	SUMP RATE	.8	.7	2.7	.65	.1	22.96
9	SHEAR RATE	.4	.2	2.3	14.18	-.0	15.87
10	SUMP STK	14.0	12.9	21.4	23.98	.1	.02
11	VERT STK	48.8	48.8	50.9	23.97	46.9	.75
12	BOOM G-Y	.9	-.1	3.8	5.73	-3.9	4.16
13	BOOM G-Z	.0	-.0	.0	5.73	-.0	4.16
~~14~~	~~L POWER~~	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	X-LOAD AVG	20839.2	-15235.9	26086.1	22.81	-47684.6	2.06
16	F-CYLD	5329.5	-19.9	13525.2	.00	-13626.9	13.60
17	TORQUE AVG	384.7	339.2	1194.2	21.15	5.0	7.06
18	DELTA	.9	.8	3.2	.65	.2	22.96
19	F-SUMP	37063.1	-30529.8	36517.7	22.81	-82487.5	1.04
20	Y-LOAD	20566.6	19807.1	32554.0	22.81	6273.9	2.06
21	F-SHEAR	21338.6	21317.0	27501.6	.98	15461.7	21.50
22	ALPHA	26.2	26.3	26.5	23.97	25.9	.75
23	M POWER	178.6	157.6	547.5	21.15	2.3	7.06
~~24~~	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	HEAD RPM	50.6	50.7	51.3	.04	49.6	22.58
26	BETA	6.0	6.0	6.6	.75	5.0	23.97
27	RATIO	.2	.2	.8	.65	.0	22.96

TEST NO. 19 — SHEAR CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3

HEAD SPEED: 51 RPM — BIT SPACING: 4 INCHES

LOCATION: 4-130 — DEPTH OF CUT: 2.0 IN/REV

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	577.7	468.1	1540.9	30.33	-11.6	30.89
2	TORQUE RHS	502.3	460.7	1240.9	4.15	-12.5	35.65
3	SHAFT RPM	1566.4	1566.3	1609.7	38.72	1522.2	23.58
4	X-LOAD LHS	10868.1	4531.2	44535.2	22.00	-44176.9	21.21
5	X-LOAD RHS	24154.8	18417.8	82924.8	14.67	-36414.4	19.98
6	F-CYLD DWN	32823.0	31468.5	50439.0	38.94	12128.7	3.66
7	F-CYLD UP	8808.1	7966.0	19898.9	24.55	-565.3	16.20
8	SUMP RATE	.1	.0	.8	14.70	-.0	9.32
9	SHEAR RATE	1.0	1.0	2.7	24.59	-.0	17.56
10	SUMP STK	20.5	20.5	21.5	.92	19.6	38.22
11	VERT STK	72.3	71.4	85.2	39.13	50.2	.02
12	BOOM G-Y	.8	-.1	4.1	8.59	-3.5	38.78
13	BOOM G-Z	.0	-.0	.0	8.59	-.0	38.78
~~14~~	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	X-LOAD AVG	24154.8	18417.8	82924.8	14.67	-36414.4	19.98
16	F-CYLD	25704.0	-23502.6	-3050.1	.47	-49641.9	38.94
17	TORQUE AVG	511.8	464.4	1299.2	7.93	5.7	36.33
18	DELTA	1.3	1.2	3.2	24.61	-.0	17.56
19	F-SUMP	26269.0	-5757.5	97626.1	16.13	-132006.2	21.21
20	Y-LOAD	33830.2	33556.0	49671.0	21.21	18316.5	29.26
21	F-SHEAR	27602.4	27155.3	39806.4	14.67	8790.5	29.44
22	ALPHA	29.8	29.7	31.8	39.13	26.4	.02
23	M POWER	233.9	212.7	590.5	7.93	2.7	36.33
~~24~~	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	HEAD RPM	49.8	49.8	51.2	38.72	48.4	23.58
26	BETA	6.6	-4.2	5.3	.02	-10.4	39.13
27	RATIO	.3	.3	.8	24.61	-.0	17.56

TEST NO. 20 SUMP CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3

HEAD SPEED: 51 RPM BIT SPACING: 4 INCHES

LOCATION: 4-130 DEPTH OF CUT: 2.0 IN/REV

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	434.4	338.2	1511.1	21.55	-13.9	8.67
2	TORQUE RHS	408.5	335.6	1199.7	14.53	-9.6	5.60
3	SHAFT RPM	1589.4	1591.9	1608.1	.15	1562.1	22.07
4	X-LOAD LHS	14338.2	13260.3	32013.4	11.03	-5069.9	15.10
5	X-LOAD RHS	22142.7	-20423.5	-353.8	21.90	-41342.2	3.02
6	F-CYLD DWN	38601.8	38638.5	42761.6	12.97	33958.3	16.85
7	F-CYLD UP	39416.7	39341.4	47633.0	.57	32159.5	21.94
8	SUMP RATE	.5	.5	1.6	22.12	-.0	7.77
9	SHEAR RATE	.1	.1	.5	15.70	-.1	8.68
10	SUMP STK	8.9	8.1	14.8	22.10	.2	.05
11	VERT STK	49.6	49.7	50.1	4.48	49.1	21.78
12	BOOM G-Y	.9	-.1	3.7	8.87	-3.9	.57
13	BOOM G-Z	.0	-.0	.0	8.87	-.0	.57
~~14~~	~~E-POWER~~	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	X-LOAD AVG	22142.7	-20423.5	-353.8	21.90	-41342.2	3.02
16	F-CYLD	4069.7	702.9	11435.9	.57	-9626.1	18.95
17	TORQUE AVG	384.3	336.9	1162.3	21.55	.7	14.62
18	DELTA	.6	.6	2.0	22.12	-.0	7.67
19	F-SUMP	41638.9	-39652.5	-1478.8	16.84	-72062.0	3.18
20	Y-LOAD	19140.7	18862.3	27212.0	18.95	10042.8	.18
21	F-SHEAR	21545.0	21528.1	25818.5	21.66	15628.5	16.84
22	ALPHA	26.3	26.4	26.4	4.48	26.2	21.78
23	M POWER	178.5	156.6	536.2	21.55	.3	14.62
~~24~~	~~EFF~~	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	~~14.62~~
25	HEAD RPM	50.6	50.7	51.2	.15	49.7	22.07
26	BETA	5.6	5.6	5.8	21.78	5.3	4.48
27	RATIO	.2	.1	.5	22.12	-.0	7.67

TEST NO. 20 SHEAR CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3

HEAD SPEED: 51 RPM BIT SPACING: 4 INCHES

LOCATION: 4-130 DEPTH OF CUT: 2.0 IN/REV

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	570.3	460.4	1542.1	31.63	-10.1	16.44
2	TORQUE RHS	501.0	456.7	1183.7	4.70	-3.5	36.34
3	SHAFT RPM	1568.9	1568.8	1609.2	37.96	1517.2	27.08
4	X-LOAD LHS	12091.9	4480.3	48747.0	25.02	-40582.8	18.14
5	X-LOAD RHS	22217.7	14006.9	67905.5	22.10	-40000.2	18.05
6	F-CYLD DWN	34118.3	32995.7	49219.9	37.87	7087.1	2.09
7	F-CYLD UP	11963.8	10435.9	36611.6	.35	-373.6	24.49
8	SUMP RATE	.6	.2	4.6	3.32	-.0	34.00
9	SHEAR RATE	1.1	1.0	2.9	27.92	-4.6	28.74
10	SUMP STK	16.4	16.3	23.3	3.33	14.6	.00
11	VERT STK	71.5	70.4	85.3	38.11	6.4	20.89
12	BOOM G-Y	.8	-.1	3.6	15.16	-3.6	12.23
13	BOOM G-Z	.0	-.0	.0	15.16	-.0	12.23
~~14~~	~~E-POWER~~	[illegible]	[illegible]	~~70.4~~	[illegible]	[illegible]	~~37.52~~
15	X-LOAD AVG	22217.7	14006.9	67905.5	22.10	-40000.2	18.05
16	F-CYLD	24815.2	-22559.8	3765.9	1.99	-48167.1	37.87
17	TORQUE AVG	511.3	458.6	1290.5	25.76	8.7	36.84
18	DELTA	1.3	1.2	3.5	27.93	-5.6	28.74
19	F-SUMP	30473.1	-12885.2	86414.4	25.02	-133297.8	18.05
20	Y-LOAD	33170.3	32712.9	51836.4	23.86	17234.1	29.85
21	F-SHEAR	27589.8	27173.1	59554.6	20.89	9573.6	28.75
22	ALPHA	29.6	29.6	31.8	38.11	18.6	20.89
23	M POWER	233.9	210.3	584.3	25.76	4.1	36.84
~~24~~	~~EFF~~	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	HEAD RPM	49.9	49.9	51.2	37.96	48.3	27.08
26	BETA	6.7	-3.8	25.7	20.89	-10.5	38.11
27	RATIO	.3	.3	.9	27.93	-1.4	28.74

TEST NO, 21 SUMP CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO,3

HEAD SPEED: 51 PPM BIT SPACING: 8 INCHES

LOCATION: 4-130 DEPTH OF CUT: 3,5 IN/REV

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	149,7	127,6	580,5	1,02	-5,8	6,00
2	TORQUE RHS	156,2	126,4	522,6	1,43	-11,3	3,71
3	SHAFT RPM	1371,1	1377,9	1617,4	5,37	1034,9	3,58
4	X-LOAD LHS	23539,7	23552,1	38733,9	5,98	14986,6	5,28
5	X-LOAD RHS	53944,7	-54106,2	-18956,7	5,98	-72035,1	5,89
6	F-CYLD DWN	9859,4	6078,9	34665,6	5,17	-228,6	,24
7	F-CYLD UP	31525,1	31560,3	47123,8	5,31	26950,1	1,26
8	SUMP RATE	,4	,3	1,5	,36	-,1	3,00
9	SHEAR RATE	,8	,4	2,8	5,36	-,2	3,37
10	SUMP STK	,7	,6	1,4	5,51	-,2	3,65
11	VERT STK	32,8	33,0	34,9	6,00	31,8	3,96
12	BOOM G-Y	,8	-,0	3,1	3,89	-2,7	4,26
13	BOOM G-Z	,0	-,0	,0	3,89	-,0	4,26
~~14~~	~~E-POWER~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~
15	X-LOAD AVG	53944,7	-54106,2	-18956,7	5,98	-72035,1	5,89
16	F-CYLD	25701,7	25481,5	31981,7	,20	7267,1	5,17
17	TORQUE AVG	141,8	127,0	468,9	1,02	6,6	,64
18	DELTA	,6	,3	2,2	,36	-,2	3,00
19	F-SUMP	67705,6	-67391,5	-10371,4	5,98	-107139,4	5,89
20	Y-LOAD	13823,4	-13247,1	7275,3	5,98	-20389,3	,01
21	F-SHEAR	24468,3	24458,6	36351,7	5,27	13621,0	5,98
22	ALPHA	23,6	23,8	23,8	6,00	23,3	3,96
23	M POWER	56,5	50,4	194,1	1,02	2,4	,64
~~24~~	~~EFF~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~
25	HEAD RPM	43,6	43,8	51,5	5,37	32,9	3,58
26	BETA	13,5	13,6	13,6	3,96	12,2	6,00
27	RATIO	,1	,0	,3	,36	-,0	3,00

TEST NO, 21 SHEAR CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO,3

HEAD SPEED: 51 RPM BIT SPACING: 8 INCHES

LOCATION: 4-130 DEPTH OF CUT: 3,5 IN/REV

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	458,7	353,5	1275,9	23,61	-12,6	10,34
2	TORQUE RHS	437,6	353,3	1244,6	11,54	-14,4	9,90
3	SHAFT RPM	1285,5	1276,0	1628,7	8,43	797,8	16,18
4	X-LOAD LHS	27669,9	22851,2	108181,6	17,14	-52769,2	13,60
5	X-LOAD RHS	34380,2	-24345,7	80508,3	18,28	-78175,8	7,69
6	F-CYLD DWN	36978,7	29712,2	68405,3	12,37	-614,1	6,91
7	F-CYLD UP	29363,0	26994,0	51258,1	2,03	1523,1	20,76
8	SUMP RATE	,3	,1	2,0	17,65	-,1	18,53
9	SHEAR RATE	1,9	1,5	6,1	15,96	-,3	12,83
10	SUMP STK	,6	,5	1,2	7,64	-,1	26,60
11	VERT STK	56,9	55,2	73,6	25,96	34,7	,02
12	BOOM G-Y	,8	-,0	6,2	11,18	-6,0	18,17
13	BOOM G-Z	,0	-,0	,0	11,18	-,0	18,17
~~14~~	~~E-POWER~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~
15	X-LOAD AVG	34380,2	-24345,7	80508,3	18,28	-78175,8	7,69
16	F-CYLD	18375,4	-2718,2	37453,7	8,11	-57777,3	14,92
17	TORQUE AVG	426,7	353,4	1242,4	14,46	,9	21,77
18	DELTA	2,8	2,2	9,9	12,99	-,6	12,83
19	F-SUMP	63360,6	-54065,5	128239,6	18,28	-193178,3	13,58
20	Y-LOAD	25696,9	19482,2	57622,6	14,92	-17596,7	7,69
21	F-SHEAR	24108,3	23122,8	49732,3	11,21	7649,3	22,64
22	ALPHA	27,3	27,2	30,1	25,96	23,8	,02
23	M POWER	153,6	128,2	481,6	21,79	,3	21,77
~~24~~	~~EFF~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~
25	HEAD RPM	40,9	40,6	51,8	8,43	25,4	16,18
26	BETA	6,8	3,0	12,3	,02	-5,2	25,96
27	RATIO	,4	,3	1,2	12,99	-,1	12,83

TEST NO. 22 SUMP CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3

HEAD SPEED: 51 RPM BIT SPACING: 8 INCHES

LOCATION: 4-130 DEPTH OF CUT: 3.5 IN/REV

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	522.6	477.9	1152.2	12.62	1.2	.03
2	TORQUE RHS	574.2	483.6	1544.7	10.69	-8.5	5.44
3	SHAFT RPM	1494.4	1473.3	1608.7	.20	-30.8	16.08
4	X-LOAD LHS	19926.5	13765.5	66984.5	4.36	-35432.8	8.97
5	X-LOAD RHS	18812.7	1142.4	61666.8	8.55	-55361.6	.37
6	F-CYLD DWN	30201.5	29766.5	45653.6	9.00	5602.8	.10
7	F-CYLD UP	20280.2	19918.2	35401.9	.11	11291.8	8.97
8	SUMP RATE	.9	.7	2.9	12.67	-.1	9.80
9	SHEAR RATE	.4	.1	1.8	12.24	-.3	15.19
10	SUMP STK	9.6	8.6	18.3	15.17	.9	.07
11	VERT STK	30.4	30.5	32.7	15.17	28.4	15.18
12	BOOM G-Y	.7	-.0	2.7	.08	-2.8	.08
13	BOOM G-Z	.0	-.0	.0	.08	-.0	.08
~~14~~	~~E-POWER~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~
15	X-LOAD AVG	18812.7	1142.4	61866.8	8.55	-55361.6	.37
16	F-CYLD	13811.8	-9848.3	29659.6	.11	-34050.2	8.97
17	TORQUE AVG	528.9	480.8	1144.1	4.73	14.2	1.83
18	DELTA	41.1	1.4	1939.6	16.06	-1286.9	16.05
19	F-SUMP	31889.7	-13349.3	92762.2	8.55	-98998.0	2.90
20	Y-LOAD	30874.5	28193.8	63490.4	8.55	-14988.5	.11
21	F-SHEAR	25976.2	25118.3	48463.9	2.90	1256.1	8.55
22	ALPHA	23.1	23.2	23.5	15.17	22.7	15.18
23	M POWER	231.3	208.6	519.9	4.73	-.6	16.08
~~24~~	~~EFF~~	~~22467.7~~	~~-254.1~~	~~50305.4~~	~~14.46~~	~~-1465420.1~~	~~[illegible]~~
25	HEAD RPM	47.6	46.9	51.2	.20	-1.0	16.08
26	BETA	14.4	14.5	15.2	15.18	13.2	15.17
27	RATIO	5.1	.2	242.5	16.06	-160.9	16.05

TEST NO. 22 SHEAR CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3

HEAD SPEED: 51 RPM BIT SPACING: 8 INCHES

LOCATION: 4-130 DEPTH OF CUT: 3.5 IN/REV

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	30.2	14.7	96.1	.14	-26.1	1.92
2	TORQUE RHS	31.3	13.5	109.8	.62	-13.0	2.09
3	SHAFT RPM	70.9	-70.4	-20.6	.20	-73.9	4.09
4	X-LOAD LHS	20986.7	20966.1	23482.2	.54	17358.0	.28
5	X-LOAD RHS	11328.9	-9535.5	11903.0	.12	-13197.0	2.40
6	F-CYLD DWN	24357.2	24298.5	30219.8	.02	22811.5	1.89
7	F-CYLD UP	19560.8	19538.8	20449.9	2.08	16400.4	.04
8	SUMP RATE	.6	.4	.9	.17	-.1	2.99
9	SHEAR RATE	.2	.1	.7	1.60	-.2	3.49
10	SUMP STK	16.2	16.2	17.0	.23	15.7	4.09
11	VERT STK	30.2	30.2	30.6	2.40	29.5	.30
12	BOOM G-Y	.1	-.0	.2	.00	-.2	2.42
13	BOOM G-Z	.0	-.0	.0	.00	-.0	2.42
~~14~~	~~E-POWER~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~3.05~~	~~[illegible]~~	~~[illegible]~~
15	X-LOAD AVG	11328.9	-9535.5	11903.0	.12	-13197.0	2.40
16	F-CYLD	5426.1	-4759.7	-3014.4	1.36	-13679.9	.03
17	TORQUE AVG	27.7	14.1	89.7	.04	-16.2	1.91
18	DELTA	6.5	-1.7	9.4	.19	-18.0	1.60
19	F-SUMP	27850.8	-26630.7	4203.9	.12	-32025.4	2.40
20	Y-LOAD	20725.5	20283.7	34972.0	.01	17757.3	1.36
21	F-SHEAR	26525.8	26501.5	27606.7	1.15	21447.5	.12
22	ALPHA	23.0	23.0	23.1	2.40	22.9	.30
23	M POWER	.5	-.3	.3	1.91	-1.8	.94
~~24~~	~~EFF~~	~~3.5~~	~~[illegible]~~	~~[illegible]~~	~~.93~~	~~-5.2~~	~~3.05~~
25	HEAD RPM	2.3	-2.2	-.7	.20	-2.4	4.09
26	BETA	14.4	14.4	14.7	.30	14.2	2.40
27	RATIO	.8	-.2	1.2	.19	-2.3	1.60

TEST NO, 23 SUMP CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO,3

HEAD SPEED: 51 RPM BIT SPACING: 4 INCHES

LOCATION: 4-130 DEPTH OF CUT: 3,5 IN/REV

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	366,9	274,2	1335,7	4,46	1,4	18,01
2	TORQUE RHS	364,8	271,7	1331,2	4,46	-,8	18,01
3	SHAFT RPM	1592,5	1594,2	1632,2	20,04	1415,7	10,47
4	X-LOAD LHS	19281,7	14302,0	36093,1	20,08	-35632,1	2,72
5	X-LOAD RHS	19280,3	14299,4	36092,2	20,08	-35631,2	2,72
6	F-CYLD DWN	33560,1	32295,1	53376,3	3,46	326,7	3,88
7	F-CYLD UP	38671,5	37619,4	49558,8	21,09	8756,7	3,61
8	SUMP RATE	,9	,4	3,5	2,22	-,1	19,96
9	SHEAR RATE	,7	,3	3,4	3,44	-,1	2,63
10	SUMP STK	11,2	10,7	12,9	22,06	,6	,60
11	VERT STK	33,3	33,3	34,6	3,44	29,2	5,34
12	BOOM G-Y	5,4	-5,2	-,1	3,88	-8,5	3,46
13	BOOM G-Z	,0	-,0	-,0	3,88	-,0	3,46
~~14~~	~~F-POWER~~	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	X-LOAD AVG	19281,0	14300,7	36092,7	20,08	-35631,7	2,72
16	F-CYLD	12866,4	5324,3	31854,5	4,14	-31806,7	3,52
17	TORQUE AVG	365,9	273,0	1333,5	4,46	,3	18,01
18	DELTA	1,0	,5	4,3	2,22	-,1	19,96
19	F-SUMP	56137,6	37159,4	109292,4	22,10	-105340,3	2,72
20	Y-LOAD	27618,9	27394,6	41649,8	5,90	9545,4	3,75
21	F-SHEAR	15787,0	7377,0	50837,1	2,72	-18663,1	4,46
22	ALPHA	23,6	23,6	23,8	3,44	22,8	5,34
23	M POWER	166,3	125,4	605,5	4,46	,1	18,01
~~24~~	~~EFF~~	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	HEAD RPM	50,7	50,7	51,9	20,04	45,0	10,47
26	BETA	13,0	13,0	14,8	5,34	12,3	3,44
27	RATIO	,3	,1	1,1	2,22	-,0	19,96

TEST NO, 23 SHEAR CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO,3

HEAD SPEED: 51 RPM BIT SPACING: 4 INCHES

LOCATION: 4-130 DEPTH OF CUT: 3,5 IN/REV

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	604,4	572,4	1185,9	15,21	9,0	1,39
2	TORQUE RHS	601,5	569,4	1182,4	15,21	6,8	1,39
3	SHAFT RPM	1542,0	1541,6	1628,8	1,38	1039,1	22,60
4	X-LOAD LHS	14136,3	-2031,7	36771,3	15,04	-66149,4	23,79
5	X-LOAD RHS	14137,5	-2034,4	36770,3	15,04	-66147,6	23,79
6	F-CYLD DWN	51502,1	51224,0	63105,9	21,23	21253,1	,17
7	F-CYLD UP	21858,8	20101,9	52223,2	1,41	1290,3	21,23
8	SUMP RATE	,2	,0	1,6	16,93	-,1	21,96
9	SHEAR RATE	1,6	1,5	4,9	12,99	-,1	,74
10	SUMP STK	12,0	12,0	13,1	16,93	10,3	29,97
11	VERT STK	60,5	58,7	82,3	30,07	33,6	,48
12	BOOM G-Y	8,2	-8,2	-3,4	,17	-10,1	21,23
13	BOOM G-Z	,0	-,0	-,0	,17	-,0	21,23
~~14~~	~~E-POWER~~	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	X-LOAD AVG	14136,9	-2033,1	36770,8	15,04	-66148,5	23,79
16	F-CYLD	33394,7	-31122,1	28150,7	,17	-61630,2	21,24
17	TORQUE AVG	602,9	570,9	1184,1	15,21	7,9	1,39
18	DELTA	2,0	1,8	5,9	12,99	-,1	,74
19	F-SUMP	77164,4	-58758,7	109344,9	,18	-223812,0	23,79
20	Y-LOAD	41172,6	40808,3	63453,9	23,80	20091,0	1,20
21	F-SHEAR	31004,9	29645,2	47672,7	7,92	-16682,0	,18
22	ALPHA	27,8	27,7	31,4	30,07	23,6	,48
23	M POWER	270,8	257,0	529,9	15,21	3,7	1,39
~~24~~	~~EFF~~	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	HEAD RPM	49,1	49,1	51,8	1,38	33,1	22,60
26	BETA	6,7	1,5	12,8	,48	-9,1	30,07
27	RATIO	,5	,5	1,5	12,99	-,0	,74

TEST NO. 24 SUMP CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3

HEAD SPEED: 51 RPM BIT SPACING: 4 INCHES

LOCATION: 4-130 DEPTH OF CUT: 3.5 IN/REV

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	587.4	560.3	1031.5	2.47	-5.9	.23
2	TORQUE RHS	586.9	559.8	1031.4	2.47	-6.4	.23
3	SHAFT RPM	1559.5	1572.2	1606.5	.17	1491.6	2.78
4	X-LOAD LHS	13832.3	-1073.9	39482.2	.44	-42131.1	1.46
5	X-LOAD RHS	13832.9	-1073.2	39484.9	.44	-42128.5	1.46
6	F-CYLD DWN	30200.6	29697.9	39277.6	1.47	667.8	3.97
7	F-CYLD UP	20744.1	20561.7	29714.2	.19	4731.4	4.02
8	SUMP RATE	2.5	2.1	5.1	.81	-.0	4.00
9	SHEAR RATE	.3	.1	1.2	1.67	-.1	1.22
10	SUMP STK	8.9	8.3	11.9	3.94	1.0	.03
11	VERT STK	38.1	38.4	38.7	.05	35.5	4.01
12	BOOM G-Y	4.8	-4.7	-.1	3.97	-6.3	1.47
13	BOOM G-Z	.0	-.0	-.0	3.97	-.0	1.47
~~14~~	~~F POWER~~	~~59.3~~	~~55.[illegible]~~	~~74.0~~	~~1.58~~	~~21.[illegible]~~	~~.88~~
15	X-LOAD AVG	13832.6	-1073.6	39483.6	.44	-42129.8	1.46
16	F-CYLD	11221.8	-9126.2	15038.6	3.85	-23394.3	1.47
17	TORQUE AVG	587.1	560.1	1031.4	2.47	-6.2	.23
18	DELTA	3.0	2.5	6.1	.79	-.0	3.80
19	F-SUMP	39065.3	-17051.8	88977.6	.20	-120752.1	1.46
20	Y-LOAD	27295.1	27192.3	38852.1	.98	16697.1	2.47
21	F-SHEAR	26363.9	25026.5	49995.2	1.46	-2367.2	.19
22	ALPHA	24.5	24.7	24.5	.05	23.9	4.01
23	M POWER	264.7	253.1	457.6	2.47	-2.9	.23
~~24~~	~~EFF~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~.05~~	~~-5.1~~	~~.23~~
25	HEAD RPM	49.6	50.0	51.1	.17	47.5	2.78
26	BETA	11.0	11.1	11.9	4.01	10.5	.05
27	RATIO	.7	.6	1.5	.79	-.0	3.80

TEST NO. 24 SHEAR CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3

HEAD SPEED: 51 RPM BIT SPACING: 4 INCHES

LOCATION: 4-130 DEPTH OF CUT: 3.5 IN/REV

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	539.4	511.9	1216.2	25.02	.2	1.38
2	TORQUE RHS	539.0	511.5	1216.0	25.02	-.3	1.38
3	SHAFT RPM	1557.9	1557.7	1606.5	.71	522.2	17.72
4	X-LOAD LHS	15101.2	-5174.6	59716.5	21.92	-59594.3	23.83
5	X-LOAD RHS	15102.5	-5174.6	59719.1	21.92	-59643.9	23.83
6	F-CYLD DWN	47090.8	44553.5	71387.9	39.01	203.6	.44
7	F-CYLD UP	18119.4	15391.8	63979.9	8.66	-437.7	16.35
8	SUMP RATE	.3	.1	2.4	21.80	-.1	28.06
9	SHEAR RATE	1.5	1.3	3.6	4.14	-.1	.35
10	SUMP STK	9.1	8.9	12.8	6.32	6.7	31.84
11	VERT STK	63.4	61.6	82.5	39.13	3.1	12.07
12	BOOM G-Y	7.5	-7.1	-.0	.44	-11.4	39.01
13	BOOM G-Z	.0	-.0	-.0	.44	-.0	39.01
~~14~~	~~F POWER~~	~~[illegible]~~	~~52.[illegible]~~	~~76.5~~	~~26.57~~	~~22.3~~	~~.77~~
15	X-LOAD AVG	15101.8	-5174.6	59717.8	21.92	-59619.1	23.83
16	F-CYLD	31629.6	-29161.7	16556.0	.46	-53187.3	38.37
17	TORQUE AVG	539.2	511.7	1216.1	25.02	-.1	1.38
18	DELTA	1.8	1.5	7.8	17.72	-.1	.35
19	F-SUMP	75003.8	-62081.6	68517.3	.33	-199144.7	21.67
20	Y-LOAD	40449.2	39497.7	61091.4	37.30	-4273.3	12.07
21	F-SHEAR	28969.2	28073.8	89437.8	12.07	-2397.2	.33
22	ALPHA	28.3	28.2	31.4	39.13	17.9	12.07
23	M POWER	245.8	233.5	544.8	23.84	-.0	1.38
~~24~~	~~EFF~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~
25	HEAD RPM	49.6	49.6	51.1	.71	16.6	17.72
26	BETA	6.7	.2	27.4	12.07	-9.2	39.13
27	RATIO	.4	.4	1.9	17.72	-.0	.35

TEST NO. 25 SUMP CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3

HEAD SPEED: 51 RPM BIT SPACING: 4 INCHES

LOCATION: 4-130 DEPTH OF CUT: 3.5 IN/REV

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	439.2	361.2	1215.3	5.14	-12.8	2.02
2	TORQUE RHS	502.1	369.4	1516.9	10.74	-399.3	1.81
3	SHAFT RPM	1501.1	1503.6	1607.7	1.65	939.1	1.34
4	X-LOAD LHS	35776.9	-35207.4	-13194.8	13.04	-55906.3	.09
5	X-LOAD RHS	35789.2	-35219.9	-13202.6	13.04	-55905.0	.09
6	F-CYLD DWN	37474.9	37475.1	47740.1	13.01	30520.8	.20
7	F-CYLD UP	48617.4	48659.6	64921.4	5.58	29078.1	5.57
8	SUMP RATE	1.1	.9	2.8	.89	-.0	.30
9	SHEAR RATE	.3	.1	2.2	13.02	-.1	.45
10	SUMP STK	10.9	9.9	17.1	12.75	.5	.31
11	VERT STK	43.5	43.6	62.0	7.93	8.8	7.93
12	BOOM G-Y	.7	-.2	2.5	4.87	-3.2	4.86
13	BOOM G-Z	.0	-.0	.0	4.87	-.0	4.86
~~14~~	~~F POWER~~	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	X-LOAD AVG	35783.0	-35213.7	-13198.7	13.04	-55905.6	.09
16	F-CYLD	12158.9	11184.5	26395.1	5.57	-9901.3	5.57
17	TORQUE AVG	431.3	365.3	1227.6	10.13	-180.8	1.81
18	DELTA	1.4	1.2	4.4	1.34	-.0	.30
19	F-SUMP	52625.0	-51803.8	-22971.8	7.43	-87679.0	5.57
20	Y-LOAD	8567.1	7618.7	21275.5	13.03	-12789.9	7.93
21	F-SHEAR	21252.0	21184.9	37639.2	7.93	11556.9	5.58
22	ALPHA	25.3	25.4	28.3	7.93	19.0	7.93
23	M POWER	188.6	159.9	540.0	10.13	-73.2	1.81
~~24~~	~~EFF~~	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	HEAD RPM	47.8	47.8	51.2	1.65	29.9	1.34
26	BETA	8.4	8.4	24.6	7.93	0.0	7.93
27	RATIO	.3	.3	1.1	1.34	-.0	.30

TEST NO. 25 SHEAR CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3

HEAD SPEED: 51 RPM BIT SPACING: 4 INCHES

LOCATION: 4-130 DEPTH OF CUT: 3.5 IN/REV

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	548.9	520.9	1175.3	.29	-9.1	.20
2	TORQUE RHS	609.0	536.2	1498.0	3.69	-9.5	29.66
3	SHAFT RPM	1466.7	1465.3	1604.3	.22	584.5	5.25
4	X-LOAD LHS	12116.4	-2418.4	48754.6	13.93	-43431.2	.85
5	X-LOAD RHS	12117.5	-2433.2	48733.7	13.93	-43432.5	.85
6	F-CYLD DWN	38962.5	37675.0	50307.9	5.25	-2933.7	31.09
7	F-CYLD UP	18557.5	16992.0	42019.8	.21	2243.3	30.94
8	SUMP RATE	.1	.0	.5	23.11	-.1	23.04
9	SHEAR RATE	1.4	1.3	3.2	14.16	-.1	30.98
10	SUMP STK	16.6	16.6	17.4	3.72	15.8	28.34
11	VERT STK	71.2	69.9	87.2	30.93	1.9	7.02
12	BOOM G-Y	.7	-.2	3.6	13.92	-3.4	13.92
13	BOOM G-Z	.0	-.0	.0	13.92	-.0	13.92
~~14~~	~~F POWER~~	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	X-LOAD AVG	12117.0	-2425.8	48744.1	13.93	-43431.8	.85
16	F-CYLD	22558.5	-20683.0	16740.4	1.04	-41137.6	29.89
17	TORQUE AVG	562.8	528.6	1135.6	18.28	2.2	.02
18	DELTA	1.8	1.6	7.7	5.25	-.2	30.98
19	F-SUMP	47688.5	-42178.9	42795.6	13.93	-99379.7	30.02
20	Y-LOAD	36712.4	35744.5	52786.0	30.02	6571.3	.85
21	F-SHEAR	23618.9	22891.4	48434.0	3.91	7492.3	30.92
22	ALPHA	29.5	29.5	32.1	30.93	17.6	7.02
23	M POWER	240.3	226.1	488.0	5.37	1.0	.02
~~24~~	~~EFF~~	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	HEAD RPM	46.7	46.6	51.1	.22	18.6	5.25
26	BETA	7.1	-3.5	28.0	7.02	-11.4	30.93
27	RATIO	.5	.4	1.9	5.25	-.0	30.98

TEST NO. 26 SUMP CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3

HEAD SPEED: 18 RPM BIT SPACING: 4 INCHES

LOCATION: 5-129 DEPTH OF CUT: 3.5 IN/REV

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	169.4	141.6	524.1	21.13	-14.4	7.48
2	TORQUE RHS	169.3	141.5	523.7	21.13	-14.7	7.48
3	SHAFT RPM	505.3	505.8	590.0	11.53	484.8	.18
4	X-LOAD LHS	54929.4	-51595.5	-3353.7	20.46	-90004.5	7.57
5	X-LOAD RHS	20248.4	780.2	53394.2	20.18	-36481.9	.12
6	F-CYLD DWN	14832.5	12309.6	28554.2	22.85	-1488.6	7.53
7	F-CYLD UP	28365.2	27801.6	37069.6	7.52	15534.5	22.86
8	SUMP RATE	.5	.4	1.8	22.77	-.1	14.14
9	SHEAR RATE	.2	.1	1.0	11.96	-.1	1.76
10	SUMP STK	9.5	8.9	16.6	23.00	2.6	.16
11	VERT STK	37.1	37.1	62.0	20.70	6.6	16.05
12	BOOM G-Y	.3	-.0	2.0	13.91	-2.7	13.96
13	BOOM G-Z	.0	.0	.0	13.91	-.0	13.96
~~14~~	~~F POWER~~	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	X-LOAD AVG	31449.4	-25407.6	15026.7	20.46	-54247.6	3.48
16	F-CYLD	20888.0	15492.0	38494.6	7.53	-12590.3	22.85
17	TORQUE AVG	169.4	141.5	523.9	21.13	-14.5	7.48
18	DELTA	2.0	1.6	6.6	22.77	-.4	14.14
19	F-SUMP	29373.8	-25549.3	12627.9	20.46	-48492.7	.10
20	Y-LOAD	14961.9	6164.1	34302.2	20.46	-15171.2	7.54
21	F-SHEAR	17188.2	16987.3	25454.1	16.05	11018.4	7.53
22	ALPHA	24.2	24.3	28.3	20.70	18.6	16.05
23	M POWER	72.4	60.6	222.4	21.13	-6.3	7.48
~~24~~	~~EFF~~	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	HEAD RPM	16.1	16.1	18.8	11.53	15.4	.18
26	BETA	11.3	11.3	25.6	16.05	0.0	20.70
27	RATIO	.5	.4	1.7	22.77	-.1	14.14

TEST NO. 26 SHEAR CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3

HEAD SPEED: 18 RPM BIT SPACING: 4 INCHES

LOCATION: 5-129 DEPTH OF CUT: 3.5 IN/REV

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	249.0	232.4	810.0	13.07	-8.4	13.05
2	TORQUE RHS	248.9	232.3	809.6	13.07	-7.2	13.05
3	SHAFT RPM	500.5	500.5	514.2	13.04	485.9	21.85
4	X-LOAD LHS	12068.4	-5363.4	39174.9	17.65	-33401.1	22.98
5	X-LOAD RHS	25415.2	23754.0	70463.9	31.61	-11653.2	31.61
6	F-CYLD DWN	35098.1	34429.9	48206.3	13.72	11320.8	3.22
7	F-CYLD UP	14083.7	13330.0	25444.5	16.29	2257.7	7.54
8	SUMP RATE	.2	.0	1.7	.08	-.1	25.49
9	SHEAR RATE	1.2	1.1	3.1	17.91	-.1	.54
10	SUMP STK	18.2	18.2	19.2	14.76	16.0	.08
11	VERT STK	61.1	59.5	85.9	32.54	1.1	1.88
12	BOOM G-Y	.4	.0	3.1	10.69	-3.5	10.68
13	BOOM G-Z	.0	.0	.0	10.69	-.0	10.68
~~14~~	~~F POWER~~	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	X-LOAD AVG	10542.0	9195.3	32920.3	31.61	-9090.5	31.61
16	F-CYLD	21886.3	-21049.9	-2175.3	6.41	-42772.3	13.72
17	TORQUE AVG	248.9	232.3	809.8	13.07	-7.8	13.05
18	DELTA	4.7	4.3	11.5	17.92	-.4	.54
19	F-SUMP	21356.8	-18480.6	12487.8	1.36	-76975.0	31.61
20	Y-LOAD	35214.8	35063.7	48451.5	13.72	24266.4	6.41
21	F-SHEAR	26180.4	26043.6	36123.5	13.72	17975.0	.20
22	ALPHA	27.9	27.9	31.9	32.54	17.5	1.88
23	M POWER	105.7	96.7	341.5	13.07	-3.3	13.05
~~24~~	~~EFF~~	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	HEAD RPM	15.9	15.9	16.4	13.04	15.5	21.85
26	BETA	[illegible]	1.1	28.4	1.88	-10.8	32.54
27	RATIO	1.2	1.1	2.9	17.92	-.1	.54

TEST NO. 27 SUMP CYCLE

IN MINE TESTING OF HH456, BLUE STAR NO.3

HEAD SPEED: 18 RPM BIT SPACING: 4 INCHES

LOCATION: 5-129 DEPTH OF CUT: 3.5 IN/REV

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	206.5	176.2	610.4	3.57	-13.2	.54
2	TORQUE RHS	206.2	175.8	609.7	3.57	-13.7	.54
3	SHAFT RPM	503.7	505.0	515.4	14.19	485.0	4.19
4	X-LOAD LHS	40892.3	-34597.7	-8690.1	3.00	-65138.2	5.57
5	X-LOAD RHS	18463.4	8656.1	78646.9	2.54	-37619.4	.04
6	F-CYLD DWN	41699.5	40645.0	55996.2	2.54	5732.1	14.19
7	F-CYLD UP	43447.0	42636.4	56602.9	.19	10463.1	14.13
8	SUMP RATE	.8	.6	2.8	1.05	-.1	14.68
9	SHEAR RATE	.6	.2	2.5	13.42	-.1	8.41
10	SUMP STK	8.4	7.9	11.6	15.00	.4	.11
11	VERT STK	37.8	37.9	41.6	15.08	36.3	2.84
12	BOOM G-Y	.4	-.0	1.7	14.12	-1.7	15.09
13	BOOM G-Z	.0	-.0	.0	14.12	-.0	15.09
~~14~~	~~C POWER~~	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	X-LOAD AVG	18760.5	-15470.8	9467.6	2.54	-48937.1	.04
16	F-CYLD	7142.0	1991.4	22241.2	.18	-15291.5	2.54
17	TORQUE AVG	206.3	176.0	610.0	3.57	-13.4	.54
18	DELTA	3.0	2.1	10.5	1.03	-.3	14.68
19	F-SUMP	29886.8	-27683.0	-533.0	2.76	-63964.6	.04
20	Y-LOAD	17812.7	16366.7	33642.0	2.54	-5321.2	.19
21	F-SHEAR	22572.3	22568.8	27297.8	13.37	15358.9	14.21
22	ALPHA	24.4	24.4	25.0	15.08	24.1	2.84
23	M POWER	87.7	74.9	256.7	3.57	-5.9	.54
~~24~~	~~EFF~~	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	HEAD RPM	16.0	16.1	16.4	14.19	15.4	4.19
26	BETA	11.0	11.0	11.6	2.84	9.2	15.08
27	RATIO	.7	.5	2.6	1.03	-.1	14.68

TEST NO. 27 SHEAR CYCLE

IN MINE TESTING OF HH456, BLUE STAR NO.3

HEAD SPEED: 18 RPM BIT SPACING: 4 INCHES

LOCATION: 5-129 DEPTH OF CUT: 3.5 IN/REV.

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	268.1	248.2	799.5	5.62	-8.7	6.25
2	TORQUE RHS	267.8	247.9	800.3	5.62	-9.2	6.25
3	SHAFT RPM	499.2	499.2	514.3	.41	412.8	14.63
4	X-LOAD LHS	13632.0	-1234.0	41294.4	19.29	-41627.0	1.16
5	X-LOAD RHS	37447.0	35192.7	83559.4	18.28	-8841.8	1.98
6	F-CYLD DWN	38966.4	38265.5	51376.6	16.18	12015.1	.67
7	F-CYLD UP	11819.4	10986.0	23318.6	26.12	2380.7	16.19
8	SUMP RATE	.1	.0	1.0	33.98	-.1	30.37
9	SHEAR RATE	1.1	1.0	2.6	.13	-5.7	30.83
10	SUMP STK	11.8	11.6	12.9	36.80	10.9	2.13
11	VERT STK	65.2	64.0	83.8	37.07	25.1	16.49
12	BOOM G-Y	.5	-.0	3.6	4.99	-4.1	4.99
13	BOOM G-Z	.0	-.0	.0	4.99	-.0	4.99
~~14~~	~~C POWER~~	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	X-LOAD AVG	19893.4	16979.4	44642.8	19.29	-13784.6	.67
16	F-CYLD	28981.4	-27279.5	5512.2	.67	-48807.0	16.18
17	TORQUE AVG	268.0	248.1	799.9	5.62	-8.9	6.25
18	DELTA	4.2	3.8	10.6	.13	-21.8	30.81
19	F-SUMP	17582.6	-14617.3	16069.9	22.71	-37753.9	32.43
20	Y-LOAD	37189.8	36839.7	51024.9	16.49	16454.1	.66
21	F-SHEAR	29012.8	28803.5	38003.9	16.18	17266.3	.71
22	ALPHA	28.6	28.6	31.6	37.07	22.1	16.49
23	M POWER	113.4	105.1	333.6	5.62	-3.8	6.00
~~24~~	~~EFF~~	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	HEAD RPM	16.9	15.9	16.4	.41	13.1	14.63
26	BETA	5.6	-.9	16.7	16.49	-3.8	37.07
27	RATIO	1.1	1.0	2.6	.13	-5.5	30.81

TEST NO. 28 SUMP CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3

HEAD SPEED: 18 RPM BIT SPACING: 4 INCHES

LOCATION: 5-129 DEPTH OF CUT: 3.5 IN/REV

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	333.6	297.9	769.3	4.59	-6.8	7.07
2	TORQUE RHS	333.5	297.8	768.9	4.59	-6.3	7.07
3	SHAFT RPM	517.6	520.6	550.0	5.52	478.9	2.88
4	X-LOAD LHS	49229.3	-47400.2	-13446.5	4.43	-87688.8	6.09
5	X-LOAD RHS	21110.7	-1268.7	46498.4	5.32	-37731.1	.27
6	F-CYLD DWN	14002.2	12015.2	28009.4	4.60	-2767.7	7.00
7	F-CYLD UP	30891.6	30872.3	37498.9	.23	22173.0	4.64
8	SUMP RATE	.8	.6	2.1	3.84	-.1	1.38
9	SHEAR RATE	.4	.2	1.8	5.64	-.1	.08
10	SUMP STK	7.3	7.1	9.7	6.62	3.6	1.38
11	VERT STK	29.6	29.8	30.3	6.70	28.4	4.67
12	BOOM G-Y	.4	-.0	3.2	4.41	-2.8	4.42
13	BOOM G-Z	.0	-.0	.0	4.41	-.0	4.42
14	E POWER	[illegible]	[illegible]	6.1	[illegible]	[illegible]	[illegible]
15	X-LOAD AVG	27904.2	-24334.5	13063.7	4.58	-49435.2	.23
16	F-CYLD	21576.3	18857.1	38115.2	.22	-5393.1	4.60
17	TORQUE AVG	333.5	297.8	769.1	4.59	-6.5	7.07
18	DELTA	3.1	2.3	7.6	3.85	-.3	1.38
19	F-SUMP	21930.5	-18777.0	19081.7	4.58	-42008.6	6.67
20	Y-LOAD	11919.6	2612.4	32116.7	4.58	-18636.9	.23
21	F-SHEAR	15935.4	15878.4	23417.1	5.38	8204.1	.72
22	ALPHA	23.0	23.2	23.0	6.70	22.7	4.67
23	M POWER	145.7	130.2	338.8	4.59	-2.8	7.07
24	EFF	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	HEAD RPM	16.5	16.6	17.5	5.52	15.2	2.88
26	BETA	14.8	14.9	15.2	4.67	14.3	6.70
27	RATIO	.8	.6	1.9	3.85	-.1	1.38

TEST NO. 26 SHEAR CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3

HEAD SPEED: 18 RPM BIT SPACING: 4 INCHES

LOCATION: 5-129 DEPTH OF CUT: 3.5 IN/REV

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	217.5	180.8	691.5	11.08	-12.0	7.42
2	TORQUE RHS	217.4	180.7	691.1	11.08	-12.3	7.42
3	SHAFT RPM	514.3	514.1	556.7	12.78	35.4	10.87
4	X-LOAD LHS	50281.1	-46251.6	8833.4	24.52	-106381.3	10.80
5	X-LOAD RHS	22468.7	-4789.2	125784.1	15.67	-43420.8	11.54
6	F-CYLD DWN	29539.7	27502.6	46039.6	26.12	-3673.0	.55
7	F-CYLD UP	34718.5	33068.5	64730.9	19.97	3553.9	26.11
8	SUMP RATE	.2	.0	2.5	.15	-.1	7.00
9	SHEAR RATE	1.9	1.7	5.6	10.83	-5.7	18.18
10	SUMP STK	7.7	7.6	9.9	.20	6.8	12.47
11	VERT STK	57.3	55.0	79.2	25.99	29.3	.65
12	BOOM G-Y	.5	-.0	2.2	15.50	-13.6	23.24
13	BOOM G-Z	.0	-.0	.0	15.50	-.0	23.24
14	E POWER	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	X-LOAD AVG	31462.2	-25520.4	39113.1	15.67	-67497.3	10.77
16	F-CYLD	19658.4	5565.9	41972.2	10.77	-42018.2	26.13
17	TORQUE AVG	217.5	180.8	691.3	11.08	-12.1	7.42
18	DELTA	7.8	6.2	236.9	10.87	-21.1	18.17
19	F-SUMP	43273.4	-42608.7	102479.8	5.67	-73569.1	14.10
20	Y-LOAD	21854.8	14933.6	42436.2	26.13	-18721.4	1.83
21	F-SHEAR	19076.4	18438.1	32260.0	26.12	-11299.8	5.67
22	ALPHA	27.2	27.1	30.9	25.99	22.9	.65
23	M POWER	95.0	79.0	302.6	11.08	-5.4	.47
24	EFF	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	HEAD RPM	16.4	16.4	17.7	12.78	1.1	10.87
26	BETA	7.8	3.1	14.8	.65	-7.7	25.99
27	RATIO	1.9	1.5	59.2	10.87	-5.3	18.17

TEST NO. 29 SUMP CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3

HEAD SPEED: 18 RPM BIT SPACING: 4 INCHES

LOCATION: 5-129 DEPTH OF CUT: 3.5 IN/REV

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	342.8	322.3	739.8	16.98	-2.7	14.34
2	TORQUE RHS	342.5	322.0	739.1	16.98	-1.6	14.34
3	SHAFT RPM	514.1	514.3	551.3	18.81	481.3	18.84
4	X-LOAD LHS	35972.9	-33897.6	11088.2	6.58	-64929.0	1.07
5	X-LOAD RHS	13647.5	-2535.1	126040.3	3.14	-41604.8	.07
6	F-CYLD DWN	18642.1	17415.2	42647.3	19.06	34.8	.97
7	F-CYLD UP	30318.8	30199.0	64812.6	16.05	22000.3	18.77
8	SUMP RATE	.8	.6	3.1	16.32	-.1	12.57
9	SHEAR RATE	.4	.2	2.6	19.10	-.1	13.53
10	SUMP STK	10.8	10.3	16.7	18.96	2.6	.03
11	VERT STK	27.6	27.6	29.9	19.08	26.7	10.18
12	BOOM G-Y	.4	-.0	1.7	18.67	-1.5	.78
13	BOOM G-Z	.0	-.0	.0	18.67	-.0	.78
~~14~~	~~C POWER~~	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	X-LOAD AVG	20593.3	-18216.3	42397.5	3.12	-47862.9	.97
16	F-CYLD	15665.7	12783.8	52161.9	16.04	-13576.7	18.95
17	TORQUE AVG	342.7	322.2	739.5	16.98	-2.2	14.34
18	DELTA	2.9	2.0	11.6	16.30	-.3	12.57
19	F-SUMP	18158.6	-16320.5	109205.7	2.08	-46605.3	3.12
20	Y-LOAD	11782.0	7629.1	42392.1	3.12	-19368.3	.97
21	F-SHEAR	17894.8	17631.8	30335.6	18.95	-22199.0	2.08
22	ALPHA	22.6	22.6	23.0	19.08	22.4	10.18
23	M POWER	149.5	140.6	318.1	16.98	-1.0	14.34
~~24~~	~~EFF~~	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	HEAD RPM	16.4	16.4	17.5	18.81	15.3	18.84
26	BETA	15.6	15.6	16.0	10.18	14.5	19.08
27	RATIO	.7	.5	2.9	16.30	-.1	12.57

TEST NO. 29 SHEAR CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3

HEAD SPEED: 18 RPM BIT SPACING: 4 INCHES

LOCATION: 5-129 DEPTH OF CUT: 3.5 IN/REV

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	476.1	460.9	919.7	10.11	1.9	1.56
2	TORQUE RHS	475.8	460.6	919.0	10.11	2.2	1.58
3	SHAFT RPM	513.9	513.8	560.3	10.16	467.8	19.88
4	X-LOAD LHS	17297.3	-6311.2	37626.7	15.08	-67889.5	2.86
5	X-LOAD RHS	42332.6	39724.3	126040.3	7.28	-8397.2	.89
6	F-CYLD DWN	40037.9	39149.9	54132.1	11.16	5737.1	.59
7	F-CYLD UP	11252.8	9978.1	64812.6	31.96	-1084.7	1.16
8	SUMP RATE	.1	.0	.7	21.21	-5.1	9.59
9	SHEAR RATE	1.1	.9	3.6	1.79	-.2	4.24
10	SUMP STK	17.7	17.7	18.9	32.49	15.9	.11
11	VERT STK	57.2	55.4	79.6	46.80	28.9	.05
12	BOOM G-Y	.5	-.0	2.9	8.00	-3.7	4.54
13	BOOM G-Z	.0	-.0	.0	8.00	-.0	4.54
~~14~~	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	X-LOAD AVG	20530.9	16706.5	59182.3	7.27	-23666.1	2.85
16	F-CYLD	31563.6	-29171.9	52161.9	1.15	-51484.1	11.15
17	TORQUE AVG	475.9	460.8	919.4	10.11	2.0	1.58
18	DELTA	4.1	3.5	13.3	1.80	-.5	4.24
19	F-SUMP	20109.9	-17260.2	103646.1	31.95	-57326.0	.18
20	Y-LOAD	40274.0	39393.8	58181.7	11.16	-7044.5	1.15
21	F-SHEAR	30600.0	30282.3	41964.8	.18	-15652.1	1.15
22	ALPHA	27.3	27.2	31.0	46.80	22.8	.05
23	M POWER	207.6	201.1	403.0	11.13	.9	1.58
~~24~~	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	HEAD RPM	16.4	16.4	17.6	10.16	14.9	19.88
26	BETA	7.0	3.0	15.0	.05	-7.9	46.80
27	RATIO	1.0	.3	3.3	1.80	-.1	4.24

TEST NO. 30 SUMP CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3

HEAD SPEED: 18 RPM BIT SPACING: 4 INCHES

LOCATION: 5-129 DEPTH OF CUT: 3.5 IN/REV

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	488.6	454.9	995.4	8.08	-7.0	.70
2	TORQUE RHS	488.5	454.9	995.1	8.08	-7.3	.70
3	SHAFT RPM	516.9	518.5	559.6	2.16	470.4	11.04
4	X-LOAD LHS	25169.5	-20371.7	25823.1	6.88	-57740.5	.04
5	X-LOAD RHS	19688.7	9721.3	59315.7	11.02	-41006.5	.46
6	F-CYLD DWN	46131.4	45772.8	60165.6	7.29	29941.4	.77
7	F-CYLD UP	40880.9	40725.0	54812.9	.46	33854.0	7.28
8	SUMP RATE	.9	.8	3.4	10.19	-.1	14.52
9	SHEAR RATE	.3	.1	1.4	7.78	-.1	.94
10	SUMP STK	11.2	10.6	16.4	17.08	2.2	.18
11	VERT STK	30.5	30.6	31.8	.39	29.3	7.38
12	BOOM G-Y	.4	-.0	3.6	9.36	-1.8	12.21
13	BOOM G-Z	.0	-.0	.0	9.36	-.0	12.21
~~14~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~
15	X-LOAD AVG	14942.8	-5325.2	21608.4	6.25	-45882.7	.46
16	F-CYLD	11819.5	-5047.8	24574.0	.45	-26089.6	7.29
17	TORQUE AVG	488.6	454.9	995.3	8.08	-7.1	.70
18	DELTA	3.4	2.8	12.7	10.19	-.3	14.52
19	F-SUMP	22003.6	-18658.5	15636.1	6.19	-54492.1	.40
20	Y-LOAD	25452.3	22777.7	43852.9	6.87	-9988.7	.46
21	F-SHEAR	24630.6	24621.2	30758.8	7.33	18796.3	1.13
22	ALPHA	23.1	23.2	23.3	.39	22.9	7.38
23	M POWER	213.8	199.1	439.9	8.08	-3.2	.70
~~24~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~
25	HEAD RPM	16.4	16.5	17.8	2.16	15.0	11.04
26	BETA	14.3	14.4	14.8	7.38	13.6	.39
27	RATIO	.9	.7	3.2	10.19	-.1	14.52

TEST NO. 30 SHEAR CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3

HEAD SPEED: 18 RPM BIT SPACING: 4 INCHES

LOCATION: 5-129 DEPTH OF CUT: 3.5 IN/REV

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	TORQUE LHS	462.0	444.3	892.6	31.43	-3.3	1.97
2	TORQUE RHS	462.0	444.2	892.3	31.43	-3.5	1.97
3	SHAFT RPM	515.4	515.3	561.9	31.66	469.2	31.30
4	X-LOAD LHS	18637.8	-7739.7	36507.0	31.35	-55942.2	1.07
5	X-LOAD RHS	42404.7	39278.0	78463.8	24.84	-18140.3	1.65
6	F-CYLD DWN	39814.8	38441.2	60845.6	27.78	321.6	39.19
7	F-CYLD UP	11797.7	9884.9	42193.2	.47	2114.5	37.86
8	SUMP RATE	.3	.1	3.3	19.84	-.1	44.35
9	SHEAR RATE	1.0	.8	2.9	2.76	-.1	38.43
10	SUMP STK	13.0	12.1	18.5	10.56	2.8	48.53
11	VERT STK	55.9	54.6	76.9	48.85	30.1	.53
12	BOOM G-Y	.5	-.0	3.4	9.79	-2.8	23.55
13	BOOM G-Z	.0	-.0	.0	9.79	-.0	23.55
~~14~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~
15	X-LOAD AVG	20817.1	15769.1	46145.3	31.35	-27507.2	1.67
16	F-CYLD	32052.3	-28556.4	16890.3	1.65	-58211.6	27.78
17	TORQUE AVG	462.0	444.3	892.4	31.43	-3.4	1.97
18	DELTA	3.8	3.1	10.7	2.76	-.4	38.43
19	F-SUMP	29102.9	-17893.5	23894.6	38.36	-46646.0	11.86
20	Y-LOAD	40069.2	38882.9	57810.1	10.34	3018.2	1.67
21	F-SHEAR	31059.8	30568.2	44865.1	12.86	11428.7	39.50
22	ALPHA	27.2	27.1	30.6	48.85	23.0	.53
23	M POWER	202.1	194.4	407.4	31.43	-1.5	1.97
~~24~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~
25	HEAD RPM	16.4	16.4	17.9	31.66	14.9	31.30
26	BETA	6.3	3.3	14.4	.53	-6.7	48.85
27	RATIO	.9	.6	2.7	2.76	-.1	38.43

BIT LOAD DATA SUMMARIES

TEST NO. 1 SUMP CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3 (STRUT BIT)

HEAD SPEED: 51 RPM BIT SPACING: 2 INCHES

LOCATION: 1-89 BIT POSITION: 3

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	F-BIT 1	392.2	-64.2	1377.6	9.64	-2375.1	3.77
2	F-BIT 2	1126.4	840.1	3895.4	4.98	-584.4	6.22
3	F-BIT 3	790.4	285.5	2369.5	3.91	-2950.1	8.52
4	F-RESULT	1434.9	1136.3	4358.1	4.98	320.1	3.68
5	THETA-1	69.0	4.0	90.0	7.47	-90.0	8.57
6	THETA-2	41.2	28.3	89.9	7.31	-89.9	9.42
7	THETA-3	52.0	22.8	90.0	7.39	-90.0	5.12
8	THETA-1,2	36.4	27.1	87.4	3.63	.0	7.39
9	THETA-1,3	47.3	37.8	89.5	5.12	.1	9.42
10	THETA-2,3	14.2	9.5	76.4	8.48	.0	8.57
11	F-TANGENT	740.8	548.5	3178.9	2.55	-686.0	.00
12	F-NORMAL	934.6	639.3	3652.4	4.98	-843.0	9.55

TEST NO. 1 SHEAR CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3 (STRUT BIT)

HEAD SPEED: 51 RPM BIT SPACING: 2 INCHES

LOCATION: 1-89 BIT POSITION: 3

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	F-BIT 1	583.3	211.1	2663.3	13.28	-3052.1	22.79
2	F-BIT 2	932.4	635.5	3888.5	14.49	-1673.2	6.08
3	F-BIT 3	299.7	195.0	2626.9	7.31	-2950.1	42.12
4	F-RESULT	1420.9	1110.4	4163.1	4.96	303.5	24.07
5	THETA-1	66.9	29.6	90.0	6.10	-90.0	6.10
6	THETA-2	51.2	32.5	89.9	1.37	-90.0	28.77
7	THETA-3	47.9	19.7	90.0	38.46	-89.7	44.14
8	THETA-1,2	42.3	33.9	89.6	14.52	.0	38.46
9	THETA-1,3	41.1	31.6	89.0	4.59	.1	28.77
10	THETA-2,3	20.4	14.3	89.4	1.33	.0	6.10
11	F-TANGENT	871.8	598.5	3448.3	14.49	-1526.2	14.45
12	F-NORMAL	667.6	300.1	3566.8	23.97	-1536.2	6.08

TEST NO. 1 SUMP CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3 (FACE BIT)

HEAD SPEED: 51 RPM BIT SPACING: 2 INCHES

LOCATION: 1-89 BIT POSITION: 2

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	F-BIT 1	294.8	130.2	931.4	.02	-1491.8	2.62
2	F-BIT 2	1314.1	908.4	4787.0	2.62	-56.3	2.78
3	F-BIT 3	335.4	-100.0	2554.9	2.59	-1952.3	2.62
4	F-RESULT	1387.9	973.6	5380.7	2.62	313.2	5.04
5	THETA-1	61.2	30.4	90.0	.14	-90.0	.14
6	THETA-2	19.5	12.2	87.5	2.78	-89.6	2.78
7	THETA-3	62.5	-16.1	90.0	.23	-89.9	.14
8	THETA-1,2	12.8	7.2	68.6	5.04	.1	.23
9	THETA-1,3	56.3	43.5	89.9	.14	.4	2.78
10	THETA-2,3	13.8	8.3	67.7	2.78	.0	.14
11	F-TANGENT	1053.6	734.3	2864.5	.08	59.3	.23
12	F-NORMAL	838.5	550.2	4439.1	2.62	-333.8	2.78

TEST NO. 1 SHEAR CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3 (FACE BIT)

HEAD SPEED: 51 RPM BIT SPACING: 2 INCHES

LOCATION: 1-89 BIT POSITION: 2

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	F-BIT 1	432.9	274.5	1662.7	22.83	-1255.0	49.13
2	F-BIT 2	1243.9	871.5	5704.8	9.74	-1659.0	16.89
3	F-BIT 3	393.7	41.6	2774.6	27.60	-2037.1	49.15
4	F-RESULT	1374.6	1019.0	5815.3	9.74	301.6	23.01
5	THETA-1	60.1	36.6	90.0	45.72	-90.0	25.33
6	THETA-2	32.0	21.5	90.0	32.37	-88.7	9.56
7	THETA-3	64.1	7.4	90.0	9.72	-90.0	28.78
8	THETA-1,2	20.0	12.2	83.7	18.13	.0	28.78
9	THETA-1,3	52.8	42.6	89.8	40.93	.0	32.37
10	THETA-2,3	22.3	15.5	88.7	24.19	.0	25.33
11	F-TANGENT	1114.6	810.2	4830.6	9.74	-814.2	16.89
12	F-NORMAL	701.1	422.1	3644.1	27.59	-1531.5	16.89

TEST NO. 2 SUMP CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3 (STRUT BIT)

HEAD SPEED: 51 RPM BIT SPACING: 2 INCHES

LOCATION: 3-91 BIT POSITION: 3

CHAN LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1 F-BIT 1	420.3	304.7	1449.5	10.64	-574.3	2.30
~~2 F-BIT 2~~	~~1051.9~~	~~762.1~~	~~3625.4~~	~~10.64~~	~~-1434.8~~	~~2.30~~
3 F-BIT 3	826.3	655.6	3186.5	8.21	-2257.1	13.59
~~4 F-RESULT~~	~~1461.4~~	~~1130.6~~	~~4659.3~~	~~8.21~~	~~336.5~~	~~4.82~~
~~5 THETA-1~~	~~71.0~~	~~58.2~~	~~89.8~~	~~3.53~~	~~-90.0~~	~~3.53~~
~~6 THETA-2~~	~~47.7~~	~~36.0~~	~~89.4~~	~~3.53~~	~~-89.3~~	~~5.90~~
~~7 THETA-3~~	~~47.7~~	~~40.8~~	~~89.9~~	~~.15~~	~~-90.0~~	~~4.85~~
~~8 THETA-1,2~~	~~44.2~~	~~38.4~~	~~89.9~~	~~3.53~~	~~.0~~	~~4.85~~
~~9 THETA-1,3~~	~~42.2~~	~~37.4~~	~~68.2~~	~~8.51~~	~~.1~~	~~3.53~~
~~10 THETA-2,3~~	~~14.9~~	~~13.4~~	~~21.9~~	~~4.85~~	~~.5~~	~~3.53~~
~~11 F-TANGENT~~	~~1944.2~~	~~754.3~~	~~3588.0~~	~~10.64~~	~~-1420.4~~	~~2.30~~
~~12 F-NORMAL~~	~~445.9~~	~~323.4~~	~~1630.4~~	~~10.64~~	~~-606.4~~	~~2.30~~

TEST NO. 2 SHEAR CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3 (STRUT BIT)

HEAD SPEED: 51 RPM BIT SPACING: 2 INCHES

LOCATION: 3-91 BIT POSITION: 3

CHAN LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1 F-BIT 1	487.2	271.4	2936.2	16.72	-1148.5	8.48
~~2 F-BIT 2~~	~~1218.2~~	~~678.7~~	~~7342.6~~	~~16.72~~	~~-2870.5~~	~~8.48~~
3 F-BIT 3	973.1	641.6	3370.2	10.83	-2678.8	16.68
~~4 F-RESULT~~	~~1833.4~~	~~1172.1~~	~~7953.4~~	~~16.72~~	~~328.1~~	~~21.49~~
~~5 THETA-1~~	~~67.9~~	~~40.4~~	~~89.9~~	~~20.38~~	~~-90.0~~	~~23.98~~
~~6 THETA-2~~	~~48.3~~	~~25.1~~	~~90.0~~	~~23.98~~	~~-89.7~~	~~26.43~~
~~7 THETA-3~~	~~42.6~~	~~30.0~~	~~89.9~~	~~10.61~~	~~-89.8~~	~~10.83~~
~~8 THETA-1,2~~	~~45.5~~	~~36.9~~	~~90.0~~	~~23.96~~	~~.1~~	~~10.81~~
~~9 THETA-1,3~~	~~37.8~~	~~30.5~~	~~60.2~~	~~10.81~~	~~.0~~	~~23.98~~
~~10 THETA-2,3~~	~~13.4~~	~~10.9~~	~~21.8~~	~~15.10~~	~~.0~~	~~23.96~~
~~11 F-TANGENT~~	~~1205.7~~	~~671.7~~	~~7262.1~~	~~16.72~~	~~-2841.4~~	~~8.48~~
~~12 F-NORMAL~~	~~516.8~~	~~258.0~~	~~3115.3~~	~~16.72~~	~~-1217.5~~	~~8.48~~

TEST NO. 5 SUMP CYCLE

IN MINE TESTIN G OF HH456, BLUE STAR NO.3 (FACE BIT)

HEAD SPEED: 51 RPM BIT SPACING: 2 INCHES

LOCATION: 5-129 BIT POSITION: 2

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	F-BIT 1	531.2	443.4	1578.7	4.97	204.1	4.99
~~2~~	~~F-BIT 2~~	~~1328.2~~	~~1108.7~~	~~3843.3~~	~~4.97~~	~~508.9~~	~~4.99~~
3	F-BIT 3	535.1	-239.7	1343.0	12.17	-2724.3	4.81
~~4~~	~~F-RESULT~~	~~1527.3~~	~~1277.2~~	~~4405.3~~	~~3.74~~	~~623.1~~	~~16.64~~
~~5~~	~~THETA-1~~	~~64.9~~	~~60.6~~	~~80.8~~	~~2.41~~	~~68.1~~	~~14.25~~
~~6~~	~~THETA-2~~	~~27.2~~	~~24.4~~	~~66.4~~	~~2.41~~	~~21.8~~	~~15.72~~
~~7~~	~~THETA-3~~	~~70.9~~	~~-22.9~~	~~90.0~~	~~9.79~~	~~-89.9~~	~~16.79~~
~~8~~	~~THETA-1,2~~	~~18.6~~	~~13.2~~	~~64.5~~	~~2.41~~	~~.0~~	~~9.79~~
~~9~~	~~THETA-1,3~~	~~58.3~~	~~54.0~~	~~68.2~~	~~16.72~~	~~23.6~~	~~2.41~~
~~10~~	~~THETA-2,3~~	~~19.2~~	~~17.8~~	~~21.9~~	~~14.25~~	~~9.2~~	~~2.41~~
~~11~~	~~F-TANGENT~~	~~1314.6~~	~~1097.4~~	~~3804.0~~	~~4.97~~	~~504.1~~	~~4.99~~
~~12~~	~~F-NORMAL~~	~~569.5~~	~~470.4~~	~~1671.8~~	~~4.97~~	~~215.5~~	~~4.99~~

TEST NO. 5 SHEAR CYCLE

IN MINE TESTIN G OF HH456, BLUE STAR NO.3 (FACE BIT)

HEAD SPEED: 51 RPM BIT SPACING: 2 INCHES

LOCATION: 5-129 BIT POSITION: 2

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	F-BIT 1	505.0	410.8	1540.3	8.55	153.3	3.56
~~2~~	~~F-BIT 2~~	~~1262.6~~	~~1027.2~~	~~3863.1~~	~~8.55~~	~~382.0~~	~~3.56~~
3	F-BIT 3	459.8	-151.9	1263.8	8.56	-2300.1	8.55
~~4~~	~~F-RESULT~~	~~1435.4~~	~~1165.5~~	~~4292.4~~	~~8.56~~	~~516.7~~	~~3.56~~
~~5~~	~~THETA-1~~	~~62.3~~	~~56.0~~	~~82.4~~	~~2.56~~	~~68.1~~	~~1.04~~
~~6~~	~~THETA-2~~	~~24.7~~	~~21.5~~	~~70.6~~	~~2.56~~	~~21.8~~	~~2.30~~
~~7~~	~~THETA-3~~	~~70.4~~	~~-10.0~~	~~90.0~~	~~3.04~~	~~-89.9~~	~~6.05~~
~~8~~	~~THETA-1,2~~	~~15.4~~	~~10.2~~	~~69.1~~	~~2.56~~	~~.0~~	~~3.04~~
~~9~~	~~THETA-1,3~~	~~57.5~~	~~51.4~~	~~68.3~~	~~2.30~~	~~19.4~~	~~2.56~~
~~10~~	~~THETA-2,3~~	~~18.8~~	~~16.9~~	~~21.9~~	~~1.04~~	~~7.6~~	~~2.56~~
~~11~~	~~F-TANGENT~~	~~1249.7~~	~~1016.7~~	~~3813.1~~	~~8.55~~	~~378.5~~	~~3.56~~
~~12~~	~~F-NORMAL~~	~~535.6~~	~~435.7~~	~~1635.1~~	~~8.56~~	~~161.7~~	~~3.56~~

TEST NO. 6 SUMP CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3 (FACE BIT)

HEAD SPEED: 18 RPM BIT SPACING: 2 INCHES

LOCATION: 1-89 BIT POSITION: 2

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	F-BIT 1	220.7	51.2	1603.1	17.85	-1499.0	3.44
2	F-BIT 2	1382.8	910.0	5460.6	4.07	273.2	3.37
3	F-BIT 3	325.2	-114.2	2160.3	3.39	-2625.3	7.40
4	F-RESULT	1437.6	942.2	5730.5	4.07	426.9	3.37
5	THETA-1	66.0	19.0	90.0	7.37	-90.0	10.97
6	THETA-2	10.8	6.9	62.2	3.39	.0	31.21
7	THETA-3	64.5	-30.3	90.0	18.03	-90.0	.05
8	THETA-1,2	8.3	5.0	62.1	3.39	.0	18.03
9	THETA-1,3	62.2	48.5	90.0	31.21	27.8	3.39
10	THETA-2,3	6.8	3.8	37.0	5.25	.0	10.97
11	F-TANGENT	1036.3	679.6	4933.7	4.07	227.0	3.37
12	F-NORMAL	941.5	607.2	4604.3	3.44	76.6	5.25

TEST NO. 6 SHEAR CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3 (FACE BIT)

HEAD SPEED: 18 RPM BIT SPACING: 2 INCHES

LOCATION: 1-89 BIT POSITION: 2

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	F-BIT 1	343.6	-132.3	1068.6	.22	-2172.0	10.61
2	F-BIT 2	1731.5	985.0	5774.7	17.30	304.3	13.62
3	F-BIT 3	445.0	-16.8	2413.2	13.64	-2608.2	10.64
4	F-RESULT	1820.9	1037.0	6115.9	17.23	486.0	13.62
5	THETA-1	55.5	-15.6	90.0	.23	-90.0	13.75
6	THETA-2	12.1	7.2	52.4	13.62	.3	20.99
7	THETA-3	54.7	-12.7	90.0	17.30	-90.0	.46
8	THETA-1,2	9.3	5.0	51.6	13.62	.0	17.30
9	THETA-1,3	51.4	35.0	89.7	20.99	37.6	13.62
10	THETA-2,3	7.6	4.3	34.5	13.82	.0	13.75
11	F-TANGENT	1041.6	602.9	4252.1	.45	157.1	13.62
12	F-NORMAL	1425.1	289.9	4697.3	17.30	166.9	.52

TEST NO. 6 SUMP CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3 (GAUGE BIT)

HEAD SPEED: 18 RPM BIT SPACING: 2 INCHES

LOCATION: 1- 89 BIT POSITION: 1

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	F-BIT 1	443.0	259.5	1305.6	3.68	-305.7	10.93
~~2~~	~~F-BIT 2~~	~~1107.3~~	~~648.7~~	~~4760.0~~	~~3.68~~	~~-764.9~~	~~10.93~~
3	F-BIT 3	886.0	472.7	4535.6	.09	-353.6	3.72
~~4~~	~~F-RESULT~~	~~1465.7~~	~~879.4~~	~~6273.3~~	~~.09~~	~~-436.9~~	[illegible]
~~5~~	~~THETA-1~~	~~51.6~~	~~34.1~~	~~86.8~~	~~7.50~~	~~-84.4~~	~~7.73~~
~~6~~	~~THETA-2~~	~~30.8~~	~~19.1~~	~~80.0~~	~~7.50~~	~~-89.8~~	~~7.73~~
~~7~~	~~THETA-3~~	~~41.2~~	~~24.8~~	~~88.8~~	~~3.71~~	~~-90.0~~	~~10.47~~
~~8~~	~~THETA-1,2~~	~~27.5~~	~~17.2~~	~~90.0~~	~~7.50~~	~~.0~~	~~10.47~~
~~9~~	~~THETA-1,3~~	~~36.1~~	~~24.4~~	~~68.2~~	~~10.47~~	~~.0~~	~~7.50~~
~~10~~	~~THETA-2,3~~	~~12.5~~	~~8.5~~	~~21.9~~	~~10.58~~	~~.0~~	~~7.50~~
~~11~~	~~F-TANGENT~~	~~1086.4~~	~~642.1~~	~~4212.6~~	~~3.68~~	~~-764.6~~	~~10.93~~
~~12~~	~~F-NORMAL~~	~~469.7~~	~~275.1~~	~~2016.1~~	~~3.68~~	~~-324.2~~	~~10.93~~

TEST NO. 7 SHEAR CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3 (FACE BIT)

HEAD SPEED: 18 RPM BIT SPACING: 2 INCHES

LOCATION: 1- 89 BIT POSITION: 2

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	F-BIT 1	227.5	100.6	1322.7	3.64	-163.2	17.14
~~2~~	~~F-BIT 2~~	~~5[illegible]~~	~~251.6~~	~~3366.6~~	~~3.64~~	~~-405.1~~	~~17.14~~
3	F-BIT 3	295.3	-61.5	404.0	17.14	-2330.0	.16
~~4~~	~~F-RESULT~~	~~62[illegible].1~~	~~341.8~~	~~3600.3~~	~~3.64~~	~~268.0~~	~~14.22~~
~~5~~	~~THETA-1~~	~~44.7~~	~~16.0~~	~~89.5~~	~~14.22~~	~~-82.3~~	~~14.31~~
~~6~~	~~THETA-2~~	~~24.3~~	~~5.6~~	~~87.2~~	~~14.22~~	~~-71.7~~	~~14.31~~
~~7~~	~~THETA-3~~	~~30.6~~	~~3.5~~	~~83.7~~	~~4.00~~	~~-80.7~~	~~14.16~~
~~8~~	~~THETA-1,2~~	~~20.0~~	~~10.1~~	~~87.2~~	~~14.22~~	~~.3~~	~~14.16~~
~~9~~	~~THETA-1,3~~	~~11.5~~	~~19.5~~	~~60.2~~	~~14.13~~	~~2.6~~	~~14.22~~
~~10~~	~~THETA-2,3~~	~~11.3~~	~~6.6~~	~~21.8~~	~~14.13~~	~~.6~~	~~14.22~~
~~11~~	~~F-TANGENT~~	~~55[illegible]~~	~~249.8~~	~~3274.4~~	~~3.64~~	~~-404.6~~	~~17.14~~
~~12~~	~~F-NORMAL~~	~~241.4~~	~~106.8~~	~~1404.6~~	~~3.64~~	~~133.0~~	~~17.14~~

TEST NO. 7 SHEAR CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3 (GAUGE BIT)

HEAD SPEED: 18 RPM BIT SPACING: 2 INCHES

LOCATION: 1- 89 BIT POSITION: 1

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	F-BIT 1	319.7	165.2	1856.2	6.65	52.1	16.64
~~2~~	~~F-BIT 2~~	~~700.0~~	~~412.8~~	~~4639.0~~	~~6.65~~	~~138.5~~	~~16.64~~
3	F-BIT 3	560.5	278.0	4410.9	6.65	-480.6	.03
~~4~~	~~F-RESULT~~	~~1227.0~~	~~523.0~~	~~6563.1~~	~~6.65~~	~~457.0~~	~~16.64~~
~~5~~	~~THETA-1~~	~~43.1~~	~~26.1~~	~~96.0~~	~~3.17~~	~~68.1~~	~~3.42~~
~~6~~	~~THETA-2~~	~~22.6~~	~~12.8~~	~~83.2~~	~~3.17~~	~~21.8~~	~~.00~~
~~7~~	~~THETA-3~~	~~30.1~~	~~22.1~~	~~89.0~~	~~.02~~	~~-40.0~~	~~.00~~
~~8~~	~~THETA-1,2~~	~~18.6~~	~~9.8~~	~~81.6~~	~~3.17~~	~~.0~~	~~.04~~
~~9~~	~~THETA-1,3~~	~~33.3~~	~~20.2~~	~~69.2~~	~~.00~~	~~7.8~~	~~3.19~~
~~10~~	~~THETA-2,3~~	~~11.5~~	~~6.9~~	~~21.9~~	~~3.42~~	~~3.1~~	~~3.17~~
~~11~~	~~F-TANGENT~~	~~231.0~~	~~408.2~~	~~4692.1~~	~~6.65~~	~~129.1~~	~~16.64~~
~~12~~	~~F-NORMAL~~	~~333.0~~	~~175.1~~	~~1967.5~~	~~6.65~~	~~56.4~~	~~16.64~~

TEST NO. 8 SUMP CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3 (GAUGE BIT)

HEAD SPEED: 18 RPM BIT SPACING: 2 INCHES

LOCATION: 1- 89 BIT POSITION: 1

CHAN LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1 F-BIT 1	425.1	262.4	2051.2	1.21	-200.5	4.57
2 F-BIT 2	1040.7	655.8	5130.6	1.21	-500.8	4.57
3 F-BIT 3	722.3	441.8	4375.9	4.56	-627.7	4.80
4 F-RESULT	1372.1	865.9	6305.8	1.21	613.9	4.37
5 THETA-1	53.8	32.8	89.8	4.57	-82.3	4.57
6 THETA-2	30.8	21.3	89.5	4.57	-84.2	4.57
7 THETA-3	41.9	28.7	83.2	4.82	-89.7	1.33
8 THETA-1,2	26.9	18.1	89.5	4.57	.3	1.37
9 THETA-1,3	30.4	27.7	58.2	1.37	.5	4.57
10 THETA-2,3	13.3	9.7	21.9	.44	.2	4.57
11 F-TANGENT	1039.1	643.2	5678.0	1.21	-486.9	4.57
12 F-NORMAL	444.2	278.1	2176.8	1.21	-212.3	4.57

TEST NO. 8 SHEAR CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3 (GAUGE BIT)

HEAD SPEED: 18 RPM BIT SPACING: 2 INCHES

LOCATION: 1- 89 BIT POSITION: 1

CHAN LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1 F-BIT 1	389.9	203.8	1947.2	27.30	-205.1	7.04
2 F-BIT 2	834.6	509.4	4869.5	27.30	-512.2	7.04
3 F-BIT 3	263.6	344.5	5434.0	10.46	-1186.7	21.35
4 F-RESULT	1224.0	673.3	6459.1	10.54	585.7	20.85
5 THETA-1	44.1	26.6	89.8	7.04	-80.0	21.98
6 THETA-2	21.3	13.9	89.4	7.64	-88.8	27.88
7 THETA-3	33.6	21.1	89.9	7.63	-90.0	.69
8 THETA-1,2	24.9	13.5	64.9	27.98	.0	.69
9 THETA-1,3	32.2	18.6	68.2	14.11	.1	27.98
10 THETA-2,3	11.2	6.8	21.8	10.97	.0	27.98
11 F-TANGENT	844.7	504.3	4819.4	27.30	-507.1	7.04
12 F-NORMAL	414.4	216.8	2066.6	27.30	-217.1	7.04

TEST NO. 9 SUMP CYCLE

IN MINE TESTING OF HH456, BLUE STAR NO.3 (GAUGE BIT)

HEAD SPEED: 18 RPM BIT SPACING: 2 INCHES

LOCATION: 5- 93 BIT POSITION: 1

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	F-BIT 1	465.5	242.4	2654.4	3.04	-1069.4	.18
~~2~~	~~F-BIT 2~~	~~1143.5~~	~~618.4~~	~~4637.1~~	~~3.04~~	~~-2472.8~~	~~.18~~
3	F-BIT 3	926.9	435.9	5441.8	.20	-700.7	14.39
~~4~~	~~F-RESULT~~	~~1541.4~~	~~913.6~~	~~7541.6~~	~~3.04~~	~~-558.1~~	~~.33~~
~~5~~	~~THETA-1~~	~~41.8~~	~~29.2~~	~~90.0~~	~~.24~~	~~-90.0~~	~~20.67~~
~~6~~	~~THETA-2~~	~~30.8~~	~~14.4~~	~~89.8~~	~~.13~~	~~-90.0~~	~~20.63~~
~~7~~	~~THETA-3~~	~~44.6~~	~~23.6~~	~~89.9~~	~~17.78~~	~~-89.9~~	~~14.35~~
~~8~~	~~THETA-1,2~~	~~27.4~~	~~15.8~~	~~90.0~~	~~20.67~~	~~.1~~	~~14.35~~
~~9~~	~~THETA-1,3~~	~~37.8~~	~~25.3~~	~~68.2~~	~~14.35~~	~~.0~~	~~20.67~~
~~10~~	~~THETA-2,3~~	~~12.8~~	~~8.7~~	~~21.8~~	~~.68~~	~~.0~~	~~.24~~
~~11~~	~~F-TANGENT~~	~~1141.7~~	~~612.1~~	~~4569.1~~	~~3.04~~	~~-2646.1~~	~~.18~~
~~12~~	~~F-NORMAL~~	~~494.5~~	~~262.3~~	~~2815.7~~	~~3.04~~	~~-1133.2~~	~~.18~~

TEST NO. 9 SHEAR CYCLE

IN MINE TESTING OF HH456, BLUE STAR NO.3 (GAUGE BIT)

HEAD SPEED: 18 RPM BIT SPACING: 2 INCHES

LOCATION: 5- 93 BIT POSITION: 1

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	F-BIT 1	666.5	433.3	2780.8	31.30	-492.2	17.41
~~2~~	~~F-BIT 2~~	~~1646.1~~	~~1083.1~~	~~6953.0~~	~~31.30~~	~~-1228.3~~	~~17.41~~
3	F-BIT 3	734.7	329.0	5441.8	14.14	-2004.6	31.29
~~4~~	~~F-RESULT~~	~~1939.8~~	~~1284.2~~	~~7948.7~~	~~17.54~~	~~-561.3~~	~~7.28~~
~~5~~	~~THETA-1~~	~~55.7~~	~~43.2~~	~~90.0~~	~~.58~~	~~-90.0~~	~~.58~~
~~6~~	~~THETA-2~~	~~26.1~~	~~18.2~~	~~59.9~~	~~.63~~	~~-90.0~~	~~.58~~
~~7~~	~~THETA-3~~	~~57.7~~	~~11.8~~	~~90.0~~	~~30.98~~	~~-90.0~~	~~27.68~~
~~8~~	~~THETA-1,2~~	~~24.1~~	~~11.3~~	~~90.0~~	~~.58~~	~~.0~~	~~27.68~~
~~9~~	~~THETA-1,3~~	~~48.4~~	~~37.4~~	~~68.2~~	~~24.58~~	~~.0~~	~~.58~~
~~10~~	~~THETA-2,3~~	~~16.8~~	~~12.4~~	~~21.9~~	~~10.63~~	~~.0~~	~~.59~~
~~11~~	~~F-TANGENT~~	~~1644.2~~	~~1072.1~~	~~6881.8~~	~~31.30~~	~~-1216.7~~	~~17.41~~
~~12~~	~~F-NORMAL~~	~~706.7~~	~~453.4~~	~~2349.7~~	~~31.30~~	~~-520.7~~	~~17.41~~

TEST NO. 10 SUMP CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3 (FACE BIT)

HEAD SPEED: 18 RPM BIT SPACING: 2 INCHES

LOCATION: 5- 93 BIT POSITION: 2

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
~~1~~	~~F-BIT 1~~	~~361.6~~	~~330.6~~	~~2800.8~~	~~7.20~~	~~156.6~~	~~3.36~~
2	F-BIT 2	1903.6	951.2	7003.2	7.20	340.3	3.36
3	F-BIT 3	812.4	-240.6	5188.2	10.15	-3532.1	7.15
~~4~~	~~F-RESULT~~	~~2203.2~~	~~1113.1~~	~~7926.5~~	~~7.20~~	~~662.6~~	~~3.36~~
~~5~~	~~THETA-1~~	~~41.5~~	~~24.5~~	~~80.9~~	~~19.41~~	~~68.1~~	~~9.41~~
~~6~~	~~THETA-2~~	~~18.8~~	~~10.7~~	~~66.7~~	~~19.41~~	~~21.5~~	~~4.01~~
~~7~~	~~THETA-3~~	~~42.8~~	~~-11.8~~	~~90.6~~	~~4.68~~	~~-90.0~~	~~7.37~~
~~8~~	~~THETA-1,2~~	~~14.2~~	~~6.7~~	~~64.8~~	~~19.41~~	~~.8~~	~~7.27~~
~~9~~	~~THETA-1,3~~	~~35.6~~	~~20.8~~	~~68.5~~	~~4.01~~	~~22.3~~	~~19.41~~
~~10~~	~~THETA-2,3~~	~~11.8~~	~~7.0~~	~~22.0~~	~~2.61~~	~~4.1~~	~~19.41~~
~~11~~	~~F-TANGENT~~	~~1884.3~~	~~941.6~~	~~6931.4~~	~~7.20~~	~~386.9~~	~~3.36~~
~~12~~	~~F-NORMAL~~	~~807.4~~	~~403.4~~	~~2971.1~~	~~7.20~~	~~161.0~~	~~3.36~~

TEST NO. 11 SHEAR CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3 (GAUGE BIT)

HEAD SPEED: 18 RPM BIT SPACING: 4 INCHES

LOCATION: 5-129 BIT POSITION: 1

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	F-BIT 1	556.7	287.2	2930.9	6.94	-237.3	6.81
~~2~~	~~F-BIT 2~~	~~3391.4~~	~~1635.2~~	~~13817.6~~	~~6.81~~	~~7.9~~	~~6.66~~
3	F-BIT 3	1355.3	653.5	5519.0	6.81	3.2	6.66
~~4~~	~~F-RESULT~~	~~3694.4~~	~~1794.6~~	~~15041.1~~	~~6.75~~	~~307.0~~	~~6.66~~
~~5~~	~~THETA-1~~	~~49.3~~	~~30.9~~	~~90.0~~	~~.00~~	~~-89.9~~	~~13.87~~
~~6~~	~~THETA-2~~	~~16.9~~	~~10.6~~	~~88.6~~	~~6.66~~	~~31.7~~	~~.10~~
~~7~~	~~THETA-3~~	~~44.0~~	~~28.0~~	~~89.5~~	~~6.66~~	~~68.2~~	~~.00~~
~~8~~	~~THETA-1,2~~	~~13.4~~	~~9.5~~	~~21.8~~	~~.00~~	~~.6~~	~~6.66~~
~~9~~	~~THETA-1,3~~	~~48.9~~	~~25.9~~	~~68.3~~	~~.10~~	~~1.4~~	~~6.66~~
~~10~~	~~THETA-2,3~~	~~9.9~~	~~5.3~~	~~88.5~~	~~6.66~~	~~.1~~	~~.00~~
~~11~~	~~F-TANGENT~~	~~2736.9~~	~~1359.2~~	~~11499.2~~	~~6.75~~	~~240.2~~	~~6.66~~
~~12~~	~~F-NORMAL~~	~~2079.1~~	~~953.0~~	~~9892.1~~	~~6.81~~	~~-229.0~~	~~6.66~~

TEST NO. 16 SHEAR CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3 (FACE BIT)

HEAD SPEED: 51 RPM BIT SPACING: 4 INCHES

LOCATION: 4-130 BIT POSITION: 2

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	F-BIT 1	628.4	-165.8	2674.7	24.37	-2174.4	24.27
~~2~~	~~F-BIT 2~~	~~2344.0~~	~~833.7~~	~~10182.8~~	~~20.75~~	~~-7629.0~~	~~18.32~~
3	F-BIT 3	935.9	333.4	4073.0	20.75	-3051.8	18.32
~~4~~	~~F-RESULT~~	~~2597.4~~	~~1668.1~~	~~11031.2~~	~~20.75~~	~~267.7~~	~~28.03~~
~~5~~	~~THETA-1~~	~~58.2~~	~~-9.0~~	~~89.9~~	~~20.56~~	~~-90.0~~	~~19.35~~
~~6~~	~~THETA-2~~	~~38.1~~	~~7.5~~	~~89.4~~	~~8.56~~	~~-89.8~~	~~8.57~~
~~7~~	~~THETA-3~~	~~59.3~~	~~21.2~~	~~90.0~~	~~8.57~~	~~-89.9~~	~~21.86~~
~~8~~	~~THETA-1,2~~	~~16.2~~	~~13.3~~	~~21.8~~	~~7.37~~	~~.0~~	~~8.57~~
~~9~~	~~THETA-1,3~~	~~48.7~~	~~39.5~~	~~68.3~~	~~6.11~~	~~.2~~	~~8.57~~
~~10~~	~~THETA-2,3~~	~~24.7~~	~~15.9~~	~~89.8~~	~~8.57~~	~~.1~~	~~19.35~~
~~11~~	~~F-TANGENT~~	~~1444.7~~	~~472.1~~	~~8037.9~~	~~20.75~~	~~-5048.7~~	~~6.20~~
~~12~~	~~F-NORMAL~~	~~1943.1~~	~~706.7~~	~~7629.8~~	~~9.70~~	~~-6756.6~~	~~18.32~~

TEST NO. 17 SHEAR CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3 (FACE BIT)

HEAD SPEED: 51 RPM

BIT SPACING: 4 INCHES

LOCATION: 4-130

BIT POSITION: 2

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	F-BIT 1	826.1	-233.9	2883.4	20.64	-2589.6	17.00
2	F-BIT 2	2111.3	-538.4	7369.9	20.64	-6619.0	17.00
3	F-BIT 3	1049.0	185.6	3329.6	19.35	-2963.0	14.67
4	F-RESULT	2498.1	1770.8	8302.5	20.64	381.9	3.54
5	THETA-1	59.2	-4.3	90.0	12.08	-89.9	12.10
6	THETA-2	33.4	-1.0	90.0	12.08	-89.8	12.10
7	THETA-3	53.9	9.4	89.9	25.63	-89.9	19.49
8	THETA-1,2	29.3	18.5	89.9	12.08	.1	19.49
9	THETA-1,3	45.5	35.2	68.6	19.49	.0	12.08
10	THETA-2,3	14.8	11.6	21.4	22.09	.0	12.08
11	F-TANGENT	2076.8	-588.4	7249.0	20.64	-6510.6	17.00
12	F-NORMAL	908.6	-257.7	3172.0	20.64	-2848.8	17.00

TEST NO. 18 SUMP CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3 (FACEBIT)

HEAD SPEED: 51 RPM BIT SPACING: 4 INCHES

LOCATION: 4-130 BIT POSITION: 2

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	F-BIT 1	730.6	-574.4	576.4	.21	-2296.3	.05
~~2~~	~~F-BIT 2~~	~~2929.1~~	~~1434.5~~	~~9600.4~~	~~18.06~~	~~-3948.4~~	~~.26~~
3	F-BIT 3	811.3	573.4	3799.6	18.06	-1579.7	.26
~~4~~	~~F-RESULT~~	~~2304.2~~	~~1747.4~~	~~10204.4~~	~~18.06~~	~~708.4~~	~~.19~~
~~5~~	~~THETA-1~~	~~62.6~~	~~-53.2~~	~~89.9~~	~~18.07~~	~~-90.0~~	~~18.07~~
~~6~~	~~THETA-2~~	~~30.4~~	~~26.3~~	~~65.3~~	~~.06~~	~~-31.1~~	~~.19~~
~~7~~	~~THETA-3~~	~~64.6~~	~~57.3~~	~~80.4~~	~~.05~~	~~-70.1~~	~~.19~~
~~8~~	~~THETA-1,2~~	~~18.1~~	~~16.5~~	~~21.8~~	~~18.07~~	~~9.6~~	~~.06~~
~~9~~	~~THETA-1,3~~	~~53.6~~	~~48.7~~	~~68.3~~	~~.08~~	~~34.7~~	~~.06~~
~~10~~	~~THETA-2,3~~	~~29.5~~	~~19.2~~	~~63.3~~	~~.05~~	~~.0~~	~~18.07~~
~~11~~	~~F-TANGENT~~	~~1089.2~~	~~608.1~~	~~6277.3~~	~~18.06~~	~~-2576.9~~	~~.26~~
~~12~~	~~F-NORMAL~~	~~1861.0~~	~~1420.3~~	~~7578.5~~	~~18.06~~	~~-3006.2~~	~~.26~~

TEST NO. 19 SUMP CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3 (FACE BIT)

HEAD SPEED: 51 RPM BIT SPACING: 4 INCHES

LOCATION: 4-130 BIT POSITION: 2

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	F-BIT 1	629.1	-429.1	279.4	.11	-2579.8	.06
~~2~~	~~F-BIT 2~~	~~1596.4~~	~~1066.4~~	~~9609.6~~	~~.06~~	~~-646.7~~	~~.11~~
3	F-BIT 3	638.1	426.1	3843.4	.06	-258.9	.11
~~4~~	~~F-RESULT~~	~~1930.7~~	~~1249.7~~	~~10483.6~~	~~.06~~	~~749.7~~	~~.11~~
~~5~~	~~THETA-1~~	~~56.1~~	~~-41.2~~	~~89.6~~	~~13.03~~	~~-89.6~~	~~1.21~~
~~6~~	~~THETA-2~~	~~25.9~~	~~20.4~~	~~56.3~~	~~9.48~~	~~-30.5~~	~~.11~~
~~7~~	~~THETA-3~~	~~56.8~~	~~45.8~~	~~77.2~~	~~9.48~~	~~-69.8~~	~~.11~~
~~8~~	~~THETA-1,2~~	~~16.1~~	~~13.9~~	~~21.8~~	~~1.21~~	~~12.8~~	~~9.48~~
~~9~~	~~THETA-1,3~~	~~47.9~~	~~38.6~~	~~68.3~~	~~13.03~~	~~33.7~~	~~9.48~~
~~10~~	~~THETA-2,3~~	~~19.5~~	~~14.1~~	~~53.3~~	~~9.48~~	~~.4~~	~~1.21~~
~~11~~	~~F-TANGENT~~	~~389.7~~	~~460.6~~	~~5861.3~~	~~.06~~	~~-348.4~~	~~.03~~
~~12~~	~~F-NORMAL~~	~~1522.6~~	~~1057.3~~	~~8331.7~~	~~.06~~	~~-654.8~~	~~.11~~

TEST NO. 19 SHEAR CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3 (FACE BIT)

HEAD SPEED: 51 RPM BIT SPACING: 4 INCHES

LOCATION: 4-130 BIT POSITION: 2

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	F-BIT 1	848.1	-163.6	1525.4	4.88	-2638.6	7.23
~~2~~	~~F-BIT 2~~	~~3276.6~~	~~1322.5~~	~~10887.3~~	~~6.01~~	~~-4971.9~~	~~3.69~~
3	F-BIT 3	1308.4	528.7	4354.5	6.01	-1989.5	3.69
~~4~~	~~F-RESULT~~	~~3624.2~~	~~2262.2~~	~~11873.9~~	~~4.82~~	~~277.8~~	~~10.79~~
~~5~~	~~THETA-1~~	~~58.6~~	~~-3.9~~	~~89.9~~	~~3.63~~	~~-89.8~~	~~2.48~~
~~6~~	~~THETA-2~~	~~38.7~~	~~-2.4~~	~~90.0~~	~~10.85~~	~~-88.5~~	~~12.31~~
~~7~~	~~THETA-3~~	~~66.1~~	~~4.0~~	~~89.7~~	~~10.78~~	~~-90.0~~	~~10.85~~
~~8~~	~~THETA-1,2~~	~~16.6~~	~~14.4~~	~~21.8~~	~~5.99~~	~~.0~~	~~10.85~~
~~9~~	~~THETA-1,3~~	~~49.5~~	~~42.5~~	~~68.3~~	~~2.48~~	~~.0~~	~~10.85~~
~~10~~	~~THETA-2,3~~	~~34.2~~	~~24.6~~	~~89.9~~	~~10.85~~	~~.1~~	~~3.63~~
~~11~~	~~F-TANGENT~~	~~1942.4~~	~~819.3~~	~~2744.7~~	~~5.99~~	~~-3264.8~~	~~3.69~~
~~12~~	~~F-NORMAL~~	~~2765.2~~	~~1050.7~~	~~9018.9~~	~~4.82~~	~~-3765.6~~	~~3.69~~

TEST NO. 22 SHEAR CYCLE

IN MINE TESTING OF HHMS 456, BLUE STAR NO.3 (FACE BIT)

HEAD SPEED: 51 RPM BIT SPACING: 8 INCHES

LOCATION: 4-130 BIT POSITION: 2

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	F-BIT 1	447.9	-219.6	687.4	28.81	-2460.9	12.67
2	F-BIT 2	2009.3	1599.3	6442.9	12.69	-2057.3	12.67
~~3~~	~~F-BIT 3~~	~~810.6~~	~~646.9~~	~~2578.0~~	~~12.69~~	~~-180.8~~	~~12.14~~
~~4~~	~~F-RESULT~~	~~2212.5~~	~~1789.9~~	~~6993.9~~	~~12.69~~	~~312.0~~	~~24.68~~
~~5~~	~~THETA-1~~	~~33.7~~	~~-20.5~~	~~90.0~~	~~13.58~~	~~-90.0~~	~~9.12~~
~~6~~	~~THETA-2~~	~~27.6~~	~~25.7~~	~~88.0~~	~~12.68~~	~~-87.9~~	~~12.17~~
~~7~~	~~THETA-3~~	~~68.8~~	~~67.8~~	~~88.9~~	~~37.82~~	~~-89.3~~	~~12.17~~
~~8~~	~~THETA-1,2~~	~~20.9~~	~~20.6~~	~~61.7~~	~~12.68~~	~~.7~~	~~12.17~~
~~9~~	~~THETA-1,3~~	~~63.5~~	~~62.6~~	~~68.3~~	~~28.83~~	~~2.0~~	~~12.68~~
~~10~~	~~THETA-2,3~~	~~17.3~~	~~12.6~~	~~87.8~~	~~12.17~~	~~.0~~	~~13.58~~
11	F-TANGENT	1265.1	975.5	4582.5	5.42	-3194.4	12.67
12	F-NORMAL	1623.7	1286.0	5170.1	12.69	-655.3	39.69

TEST NO. 23 SHEAR CYCLE

IN MINE TESTING OF HH 456, BLUE STAR NO.3 (FACE BIT)

HEAD SPEED: 51 RPM BIT SPACING: 4 INCHES

LOCATION: 4-130 BIT POSITION: 2

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	F-BIT 1	564.5	-349.5	494.1	7.23	-2688.5	6.09
2	F-BIT 2	4205.3	2656.9	11132.0	4.86	-2067.8	7.22
~~3~~	~~F-BIT 3~~	~~1681.1~~	~~1062.1~~	~~4449.9~~	~~4.86~~	~~-826.3~~	~~7.22~~
~~4~~	~~F-RESULT~~	~~4564.0~~	~~2896.7~~	~~12116.2~~	~~4.86~~	~~854.6~~	~~.42~~
~~5~~	~~THETA-1~~	~~61.7~~	~~-43.9~~	~~90.0~~	~~.32~~	~~-90.0~~	~~.30~~
~~6~~	~~THETA-2~~	~~18.4~~	~~13.9~~	~~42.5~~	~~8.47~~	~~-29.2~~	~~7.23~~
~~7~~	~~THETA-3~~	~~52.3~~	~~39.7~~	~~22.8~~	~~8.47~~	~~-69.6~~	~~7.23~~
~~8~~	~~THETA-1,2~~	~~16.3~~	~~12.4~~	~~21.9~~	~~2.74~~	~~17.2~~	~~8.47~~
~~9~~	~~THETA-1,3~~	~~50.2~~	~~38.2~~	~~68.3~~	~~2.74~~	~~47.5~~	~~8.47~~
~~10~~	~~THETA-2,3~~	~~8.2~~	~~5.3~~	~~27.4~~	~~8.47~~	~~.0~~	~~.32~~
11	F-TANGENT	2669.3	1631.3	7938.9	.32	-1243.0	7.22
12	F-NORMAL	3297.5	2125.5	9605.0	6.09	-1680.9	7.22

TEST NO. 26 SUMP CYCLE

IN MINE TESTING OG HH456, BLUE STAR NO.3 (FACE BIT)

HEAD SPEED: 18 RPM BIT SPACING: 4 INCHES

LOCATION: 5-129 BIT POSITION: 2

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	F-BIT 1	796.2	486.2	2704.5	.89	-.1	6.94
2	F-BIT 2	1990.1	1215.2	6762.6	.89	1.7	6.94
3	F-BIT 3	310.6	2.8	1478.5	.26	-2471.2	.98
4	F-RESULT	2165.9	1323.4	7305.7	.89	267.4	6.93
5	THETA-1	44.0	30.7	89.6	6.93	-90.0	6.94
6	THETA-2	16.2	10.6	89.7	6.94	21.8	7.37
7	THETA-3	55.8	6.3	90.0	.84	-90.0	7.01
8	THETA-1,2	7.3	3.2	89.7	6.94	.0	.04
9	THETA-1,3	44.6	29.8	68.2	7.37	.3	6.94
10	THETA-2,3	14.4	9.6	21.9	4.16	.0	6.94
11	F-TANGENT	1970.0	1202.9	6693.3	.89	1.2	6.94
12	F-NORMAL	844.1	515.4	2869.1	.89	1.3	6.94

TEST NO. 26 SHEAR CYCLE

IN MINE TESTING OG HH456, BLUE STAR NO.3 (FACE BIT)

HEAD SPEED: 18 RPM BIT SPACING: 4 INCHES

LOCATION: 5-129 BIT POSITION: 2

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	F-BIT 1	853.4	461.9	3423.2	17.01	-40.1	26.79
2	F-BIT 2	2133.0	1164.6	8559.2	17.01	-98.3	26.79
3	F-BIT 3	402.6	50.9	1739.9	10.07	-2538.5	33.64
4	F-RESULT	2332.4	1274.2	9228.9	17.01	269.4	13.16
5	THETA-1	45.8	26.6	89.8	26.80	-90.0	30.19
6	THETA-2	21.6	9.6	89.8	26.80	-89.3	26.78
7	THETA-3	51.7	17.3	90.0	16.68	-90.0	16.94
8	THETA-1,2	16.8	5.8	89.8	30.19	.0	16.68
9	THETA-1,3	41.5	26.1	68.2	.00	.2	26.80
10	THETA-2,3	13.4	8.5	21.9	9.90	.0	30.19
11	F-TANGENT	2111.3	1142.8	8471.6	17.01	-97.9	26.79
12	F-NORMAL	904.7	489.7	3631.1	17.01	-41.2	26.79

TEST NO. 27 SUMP CYCLE

IN MINE TESTING OF HH456, BLUE STAR NO.3 (FACE BIT)

HEAD SPEED: 18 RPM BIT SPACING: 4 INCHES

LOCATION: 5-129 BIT POSITION: 2

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	F-BIT 1	1174.4	733.2	3127.9	.95	380.1	8.31
~~2~~	~~F-BIT 2~~	~~2975.3~~	~~1832.4~~	~~7821.4~~	~~.95~~	~~942.6~~	~~8.31~~
3	F-BIT 3	452.7	-167.3	770.6	3.66	-2766.9	.96
~~4~~	~~F-RESULT~~	~~3193.6~~	~~1994.0~~	~~8298.3~~	~~.96~~	~~1016.3~~	~~8.31~~
~~5~~	~~THETA-1~~	~~49.6~~	~~35.9~~	~~71.5~~	~~3.60~~	~~68.0~~	~~8.31~~
~~6~~	~~THETA-2~~	~~17.1~~	~~12.3~~	~~37.8~~	~~3.60~~	~~21.8~~	~~4.76~~
~~7~~	~~THETA-3~~	~~60.5~~	~~-16.1~~	~~90.0~~	~~1.05~~	~~-90.0~~	~~.76~~
~~8~~	~~THETA-1,2~~	~~6.8~~	~~3.5~~	~~31.6~~	~~3.60~~	~~.0~~	~~1.05~~
~~9~~	~~THETA-1,3~~	~~48.2~~	~~34.9~~	~~68.2~~	~~4.76~~	~~52.2~~	~~3.60~~
~~10~~	~~THETA-2,3~~	~~15.6~~	~~11.3~~	~~22.0~~	~~8.31~~	~~18.5~~	~~3.60~~
~~11~~	~~F-TANGENT~~	~~2905.6~~	~~1813.9~~	~~7741.1~~	~~.95~~	~~935.1~~	~~8.31~~
~~12~~	~~F-NORMAL~~	~~1245.0~~	~~777.1~~	~~3318.3~~	~~.95~~	~~397.6~~	~~8.31~~

TEST NO. 27 SHEAR CYCLE

IN MINE TESTING OF HH456, BLUE STAR NO.3 (FACE BIT)

HEAD SPEED: 18 RPM BIT SPACING: 4 INCHES

LOCATION: 5-129 BIT POSITION: 2

CHAN	LABEL	RMS	AVG	MAX	TMAX	MIN	TMIN
1	F-BIT 1	1184.7	623.8	3190.6	7.46	199.5	10.42
~~2~~	~~F-BIT 2~~	~~2961.2~~	~~1559.0~~	~~7978.1~~	~~7.46~~	~~495.6~~	~~10.42~~
3	F-BIT 3	578.4	-73.6	4410.9	10.46	-2808.0	10.76
~~4~~	~~F-RESULT~~	~~3241.4~~	~~1705.5~~	~~9242.0~~	~~10.49~~	~~719.0~~	~~10.41~~
~~5~~	~~THETA-1~~	~~44.0~~	~~28.2~~	~~74.5~~	~~10.42~~	~~68.0~~	~~14.64~~
~~6~~	~~THETA-2~~	~~15.4~~	~~9.8~~	~~48.5~~	~~10.42~~	~~21.8~~	~~14.20~~
~~7~~	~~THETA-3~~	~~53.0~~	~~-9.7~~	~~90.0~~	~~14.59~~	~~-90.0~~	~~24.30~~
~~8~~	~~THETA-1,2~~	~~6.6~~	~~3.2~~	~~44.4~~	~~10.42~~	~~.0~~	~~24.30~~
~~9~~	~~THETA-1,3~~	~~42.5~~	~~27.3~~	~~68.2~~	~~14.20~~	~~41.5~~	~~10.42~~
~~10~~	~~THETA-2,3~~	~~13.8~~	~~6.8~~	~~22.0~~	~~14.64~~	~~15.5~~	~~10.42~~
~~11~~	~~F-TANGENT~~	~~2931.2~~	~~1543.2~~	~~7896.3~~	~~7.46~~	~~491.5~~	~~10.42~~
~~12~~	~~F-NORMAL~~	~~1254.0~~	~~661.2~~	~~3384.8~~	~~7.46~~	~~209.3~~	~~10.42~~

APPENDIX B. TEST PROTOCOLS

BIT RECORDER, OPERATING PROCEDURE

1. Set-Up Procedure

A. Remove cover plate from battery compartment.

B. Insert programming plug to set desired sampling rate, recording mode (single or multiple strain gages) and time delay "D".

C. Install fully charged battery pack

+ Lead	— Lead	Reading
V_1	C	< 5.2 volts
V_1	C	< 6.5 volts
V_3	C	<13.0 volts

D. Connect battery terminals *in this order*:

c, V_1, V_2, V_3

E. Check indicating light in battery compartment—if it is "ON", remove battery leads and reconnect as in 1-C, above.

F. Replace cover plate over battery compartment; check to ensure proper seal; and tighten all bolts.

2. Record Cycle

A. After cutting head makes eight complete revolutions within a 6-second period, recorder automatically turns on.

B. Following a delay of "d" seconds after the cutting bit strikes coal, the data recording cycle is automatically initiated and continues until the sold state memory is filled.

C. At the end of the record cycle (60 seconds for 1 msec rate) the circuit switches into a low power mode and holds the stored data for a time interval of up to four hours.

3. Data Retrieve Cycle

A. Set the "Bit Recorder Dump Switch" on the control console to the "OFF" position.

B. Remove the round, threaded protective cover (pipe plug) on bit recorder to expose the multi-pin output connector.

C. Connect the data transfer cable to the output connector.

D. Set console controls and make connections required for data transfer. See instruction manual.

E. Put "Bit Recorder Dump Switch" in the "DUMP" position to initiate transfer of data from bit recorder to the tape recorder.

F. At end of data retrieval, return switch to "OFF" position. (This will be a time period of two-minutes or less). An additional transfer of data from the bit recorder can be initiated, if desired, by again placing switch in the "DUMP" position.

4. Shut-Down Procedure

A. Remove output cable and replace and tighten protective plug over output connector.

B. Remove cover over battery compartment.

C. Remove battery.

D. Replace cover over battery compartment ensuring proper seal.

E. Recharge battery.

INSTRUMENTATION POWER UP PROCEDURE

1. Turn on power to Instrumentation Cart with main power ON-OFF switch. The cart blower will operate when the power is on.
2. Apply power to the tape recorder and chart recorder; also switch Control Console ON-OFF switch to ON.
3. Depress the STOP push-button on tape recorder to take up slack tape.
4. Switch on clock display to check time and battery. If display is dim or does not light up, change out the 12-volt battery. This battery powers both clock and communication system.
5. At the HH456 Miner, turn on power to the Model 4020 Signal Conditioning box and the main on power to the HH456 Miner.
6. At the Control Console, place the CAL toggle switch in the + position. Depress the Manual CAL push-button and use Selector switch with Channel Monitor (DPM) to check data channels 1 thru 13 for CAL level.
7. Turn on Communications and verify system is working.
8. Place the Digital Recorder Interface switch in the UP position with the red LED off and the Dump toggle switch in the OFF position.
9. On the tape recorder set tape speed to 15 IPS and place tape recorder in the record mode of operation. Verify that voice is being recorded by recording the following information: time and that this is a voice CAL check. Turn chart on recorder and select six data channels. Depress auto CAL button on Control Console, and monitor chart recorder to verify that a CAL pulse was recorded on tape. Repeat steps to check all 14 data channels for a CAL pulse.
10. Place Tape and Chart recorder in the stop mode.

TEST PROCEDURE—CART OPERATOR

This procedure should be used after the Power Up Procedure has been completed.

1. Write down tape footage.
2. Place HH456 Miner in the zero load position.
3. At the Control Console, check the offset on data channels 1 thru 13 with Selector switch and Channel Monitor (DPM). All data channels should read below 100 mV.
4. Place Tape Recorder in the record mode and turn on chart recorder. Record the following voice information: date, time, test number, and any other needed information about the test. Then depress Auto CAL push-button and verify CAL pulse was recorded with chart recorder. Place tape recorder and chart recorder in the STOP mode.
5. Move HH456 Miner into beginning test position.
6. Place tape recorder in the RECORD mode and turn on chart recorder. Use voice communication to tell the Miner operator to start test. Monitor chart recorder to verify data is being recorded.
7. At the end of the test, place the tape and chart recorder in the STOP mode. Write down the tape footage and write down test number on the chart paper.
8. Move HH456 Miner into position to dump Digital Recorders.
9. At the Control Console, switch Digital Recorder Switch so that red LED is on and Dump Switch is in the OFF position.
10. Connect umbilical cable to Digital Recorder.
11. At the Control Console, select channels 1, 2, and 3 for the chart recorder.
12. Write down tape footage and Digital Recorder number.
13. Place tape recorder in the RECORD mode and turn Chart on recorder. With voice, record the Digital Recorder number being dumped.
14. Switch on Dump switch and monitor chart recorder to know when the dump is finished. Place both tape and chart recorder in the STOP mode.
15. Repeat steps 9 thru 15 for each Digital Recorder to be dumped.
16. Switch Digital Recorder switch to the UP position so that the red LED is off, and place the Dump toggle switch in the OFF position.
17. After all testing is completed, the following is a turn-off check list.

    a. At the Control Console

        (1) Clock Display (OFF)
        (2) Communication (OFF)
        (3) Console Power (OFF)

    b. Main Power to the chart (OFF)

PRETEST PROCEDURE—MACHINE OBSERVER

1. Prior to going underground, inspect the machine log book and record any usage since the preceeding test shift. Note the number of shifts, tonnage per shift, bits replaced, and mechanical problems encountered. Verify that the machine is in the proper test configuration.
2. Discuss with the section crew the test objectives for the shift. Record the date, test number, test conditions, the shift, the crew designation, and the location where testing will commence.
3. Upon arriving at the section, inspect the machine. Record the hour meter reading. Check the RPM designation and bit lacings. Make sure that the bits are new and all blocks are secure. Record any changes that are necessary.

4. Inspect the test entry and record the general conditions—bottom, top, cutting direction, slope, etc. Install roof spad for reference. Note its designation on the log sheet.
5. Instruct the instrumentation cart operator to prepare for testing. Advise him of the test entry location and test number.
6. Instruct the machine operator to set the required sump and shear rates. Check values after oil temperatures have stabilized.
7. Instruct the machine operator to put the machine in position for pretest calibration. Verify that the bit recorders have been prepared and are ready.
8. After calibration is verified by the cart operator, instruct the machine operator to tram the machine to the test position.
9. Position the sump transducer anchor and advise the cart operator that the machine is ready for testing.

TEST PROCEDURE—MACHINE OBSERVER

1. The cart operator will give the command for test initiation by stating "go for test number _______ at time _______."
2. As machine advances, monitor machine travel; position the sump anchor as required.
3. Record the number of cars loaded by vocal response.
4. Record vocally any unusual events or circumstances during the test.
5. In the event machine downtime is encountered, note the cause and time. If failures are observed, ascertain the source and the corrective action required.