CLASSIFICATION AND ANALYSIS OF LONGWALL DELAYS

by

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ABSTRACT

Spectacular production rates have been achieved by certain U.S. longwalls, and yet a large number of longwall operations have failed to meet anticipated production targets. This study attempts to identify the primary factors which contribute to the production shortcomings of many marginal longwall operations. This study presents details of the classification and analysis of delay data for a group of thirty-nine longwall sections located in the eastern and mideastern United States. Downtime data corresponding to over fourteen-thousand shifts were collected and classified according to equipment type, delay type, and specific delay event. A dBase IV-based database was constructed to allow flexible interrogation of the data. The relative downtime contributions of the various equipment components and of the delay types have been determined. Machine availabilities and system availabilities are presented. Probability density functions have been fit to the time-to-failure and to the time-to-repair data sets, both for the principal equipment types and for the longwall system as a whole. Recommendations are made for increasing the availability of longwall systems.

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I. INTRODUCTION

The share of longwall mining in the underground coal production of the United States had risen from 5% in the late 1970's to more than 20% by 1986 (Merrit, 1984; Sprouls 1986). By the end of 1989, there were ninety-five longwall operations in the U.S., three more than existed the previous year (Sprouls, 1990). Despite the initial growth of the longwall industry, the number of U.S. longwalls has hovered around the 100 mark for the last nine years, whereas earlier predictions called for 200 by this time. Spectacular production rates have been achieved by certain U.S. longwall operations , and yet a large number of such operations have failed to meet anticipated production targets.

This research was begun as a result of the great disparity between highly productive U.S. longwalls and those which were only marginally productive. In many applications of longwall mining, the full production potential of highly mechanized longwall faces has not been achieved. The average productivity of U.S. longwall operations has been steadily rising, reaching 2,004 clean tons per shift in 1988 (Combs, 1990). The range of longwall productivity, however, is very large; the reported productivity low for 1988 was 640 clean tons per shift, while the reported high was 6,000 tons per shift (Combs, 1990). It is suspected that some production figures are far below the expectation of mine operators, and therefore can be considered as a contributing factor to the failure of some longwall operations. The uncertainty of production forecasts and the large capital cost of longwall mining are factors which have contributed to the slowness of the growth of the U.S. longwall industry.

Historical figures for longwall operational system availability range from roughly 50 to 70 percent. Figures for face availability range from 60 to 80 percent (Curry, 1976; Pimentel, 1981; Topuz, 1982; Lee, 1983). It is believed that low system availability contributes significantly to the marginal performance of many U.S. longwalls.

It was the objective of this study to identify the sources of delays contributing to the low availability of many longwalls. The term "delay" was used in this study to represent any occurrence which lead to the cessation of coal production at a longwall section. Each delay lead to a period during which the longwall face equipment was idled for the purpose of equipment repair or adjustment, or for the performance of some organizational action. This idled period is referred to as "downtime."

In this study, longwall delays have been systematically categorized. Delay sources with large contributions to downtime have been identified, and accurate calculations of system and face availability have been made through the analysis of a large body of field data. Recommendations have been made to increase the availability of longwall operations.

II. LONGWALL MINING

2.1 Description of the Longwall Method

The longwall method involves the removal of coal in thin strips or "shears" from a single, long working face called a longwall. Longwall faces are typically 500 to 1,000 feet wide and join two sets of parallel entries, the "head" entries and the "tail" entries.

U.S. longwall panels are usually mined on the retreat. Development of a retreat longwall panel begins with driving the parallel head and tail entries perpendicularly to a main or submain entry for a distance of 2,500 to 10,000 feet. These entries or gate roads are then joined by a single perpendicular entry. The longwall equipment is then set up along this connecting entry and the entire length of the entry becomes the longwall face. The longwall face is then retreated back towards the main or submain entry from which production began.

As the face is retreated, the roof is controlled in a zone extending the length of the face and out from the face for a distance of 20 to 25 feet. Immediately behind this moving zone the roof is allowed to cave. The roof is supported by self-advancing hydraulic supports which are generally of the shield-support design.

Coal is cut from the face by a shearer or plow which moves back and forth between the gate roads. As the coal is cut it falls onto an armored face conveyor which conveys the coal to one of the gate roads, commonly the head gate. At the head gate, the coal is transferred via a stageloader and crusher to a panel belt and hence to the main haulage system.

The longwall method has many advantages over the room-and-pillar method. First, recovery of the panel block is almost 95%, compared to room-and-pillar's 50% to 75%. The longwall method concentrates a large amount of mechanical power at a single work area, reducing labor costs and increasing productivity. The method also provides increased safety due to the strict control of the roof in the work area and to the small number of face workers needed.

2.2 Distribution of U.S. Longwalls

At the end of 1989 there were ninety-five longwalls in operation (Sprouls, 1990). These longwalls were divided among eleven states as follows: West Virginia (28), Pennsylvania (13), Virginia (12), Alabama (10), Illinois (9), Colorado (6), Kentucky (6), Utah (5), Ohio (4), Maryland (1) and Wyoming (1). Twenty-eight coal companies were operating these ninety-five longwalls. The following ten principle operators accounted for three quarters of all U.S. longwalls: Consolidation Coal (21), Jim Walter Resources (8), Island Creek (7), Cyprus Coal (6), Peabody Coal (6), U.S. Steel Mining (6), American Electric Power (5), BethEnergy Mines (5), Old Ben Coal (5) and Pittston Coal (3) (Sprouls, 1990). Figure 1 shows the variation in the number of U.S. longwalls during the period 1985 to 1989.

2.3 Longwall Productivity

Longwall unit shift productivity rose at an average annual rate of 28% between 1985 and 1988 (Combs, 1988; Combs, 1989). Figure 2 illustrates the rise in productivity which surged between 1986 and 1988. Increases in productivity were achieved primarily through the use of new and more powerful equipment, larger panels, and more flexible production scheduling. Nineteen-eighty-eight productivity figures show that faces installed after 1984 were 73% more productive than faces installed before that date (Combs, 1990).

It was during this period that equipment models were introduced, particularly shearers and face conveyors, with greater horsepower and improved reliability. All-electric

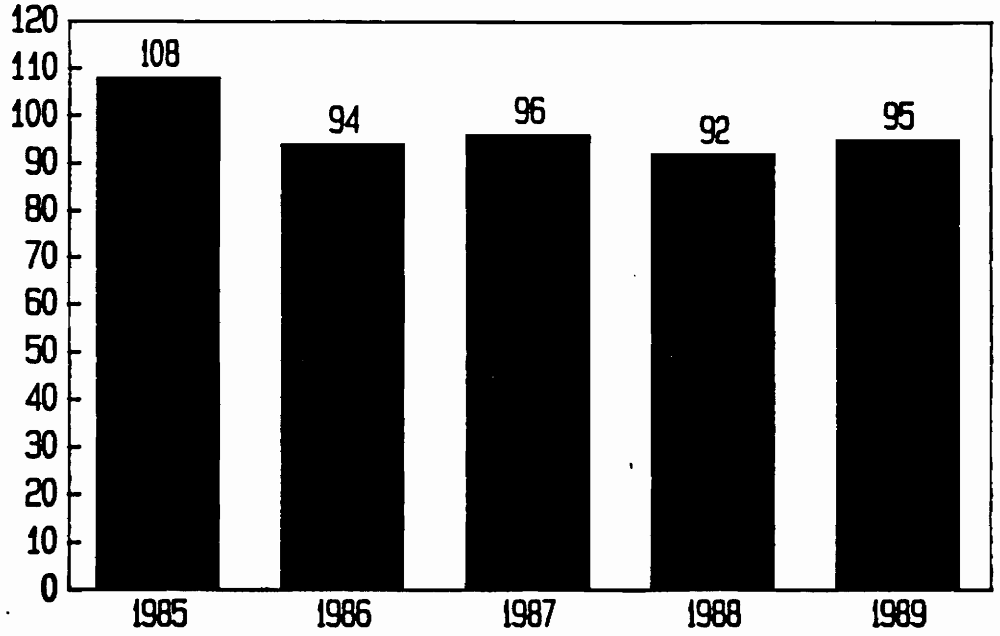

Figure 1. Number of U.S. longwalls: 1985 - 1989

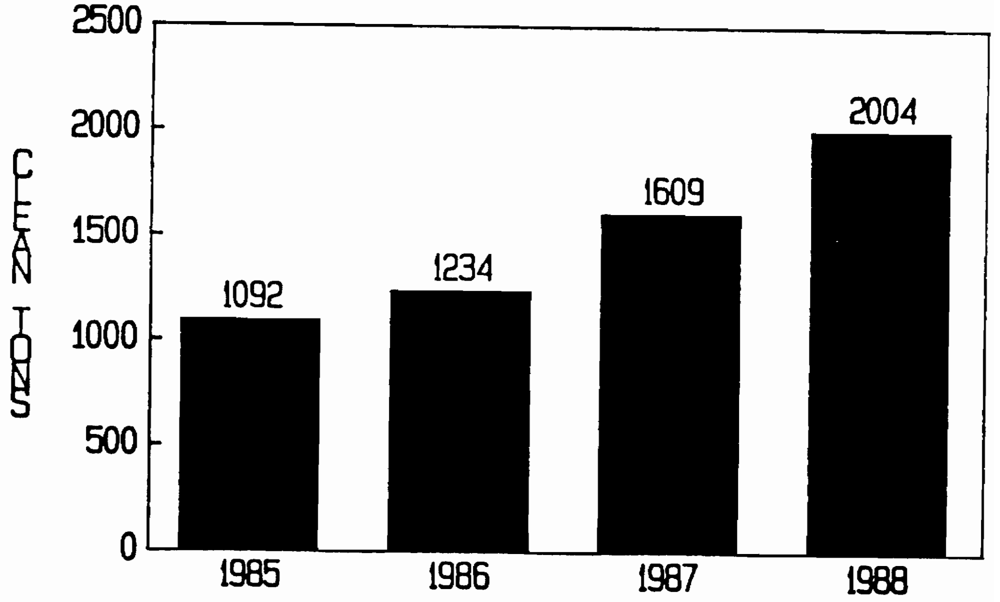

Figure 2. Longwall productivity: 1985 - 1988

shearer models, in particular, demonstrated far greater reliability and maintainability than the previous, hydraulically powered units; this was brought about, in part, by the elimination of frequent failure of hydraulic hoses and pumps. Modularization of equipment assemblies increased maintainability. Face conveyors with wider pans, larger chains, and increased horsepower were introduced, and low-maintenance, solid-cast conveyor pans also became more common. The new equipment included shield supports with electrohydraulic controls. Shortened cycle time for these supports lead to increased shearer tram rates.

Operating schedules were streamlined at many new faces; scheduled service time was reduced and travel and lunch times were eliminated at many mines. Also, weekend operations became more common. A 1990 survey showed that newer faces averaged 590 production shifts per year, while older faces averaged only 529 (Combs, 1990).

2.4 Panel Geometry and Equipment Statistics

Longwall panels grew in size by 80% between 1984 and 1988. During this time the average face width increased from 518 feet to 692 feet; average panel length increased from 3,786 feet to 5,118 feet (Peake, 1986; Combs, 1990).

By 1989, the average longwall panel contained about one million tons of coal (Combs, 1990).

Equipment power rose significantly between 1985 and 1988. Average shearer horsepower rose by 25% between 1985 and 1988, from 442 hp to 552 hp. During the same period, face conveyor horsepower rose by 25%, from 601 hp to 752 hp (Coal Age, August 1986; Combs, 1990). Face voltage at many faces was increased from 990 v to 2,300 or 4,160 v in order to accommodate more powerful equipment.

Automation of face equipment increased also, particularly the use of shield supports with electrohydraulic controls. In 1985, 16.7% of all faces had shield supports with electrohydraulic controls; by 1988, this figure had risen to 28.4% (Coal Age, August 1986; Combs, 1990). Electrohydraulic controls combined with increased hydraulic fluid-pumping capacity were responsible for reducing support-cycle times to below five seconds at some faces. With the reduced support-cycle time, shearer tram rates were increased to as high as 45 feet per minute.

III. LONGWALL DELAYS

3.1 Data Collection

The following sub-sections provide information about the longwall operations from which data were collected, formats and composition of the data, and inconsistencies observed in the data.

3.1.1 Distribution of Mines in Study

Production and delay data were collected from 39 longwalls operating in 36 mines. Data corresponding to over fourteen thousand shifts were compiled and entered into a computer database. A separate database was established for each longwall section. The mines were distributed among five states as follows: West Virginia - 21, Virginia - 12, Ohio - 3, Illinois - 2, and Pennsylvania - 1. The mines were located in fourteen coal seams, the largest concentration being in the Pittsburgh and Pocahontas #3 seams. Seam height ranged from 44 inches to 108 inches with an average of 70 inches. Seven of the sections consistently cut rock with an average thickness of 6 inches. Fourteen of the sections consistently left top or bottom coal with an average thickness of slightly more than 7 inches. Average panel width was 671 feet, and average depth of the coal seams was 913 feet. These figures conform closely to the national longwall averages of 73 inches for seam height (Combs, 1988) and 666 feet for panel width (Sprouls, 1989). The 39 longwalls in this study constitute approximately 41% of the U.S. longwalls presently in operation. See Appendix 1 for specific mine data.

3.1.2. Raw Data Formats

Raw data were collected from three sources: 1) section foremans' production reports, 2) maintenance foremans' reports, and 3) computer printouts from proprietary databases. The section foremans' reports were the most desirable because they usually recorded the exact time of occurrence for all longwall delays in addition to the duration of each delay. Foremans' reports frequently provided useful information about shift production, percent reject, rate of advance, work-force size, and scheduled delay time. Maintenance foremans' and computer generated reports rarely recorded the times of occurrence for delays. This information was needed for the calculation of time-to-failure (TTF) statistics. Computer printouts were the least desirable because they often grouped delays into summaries, obscuring the frequency and duration of individual delays. Figures 3, 4, and 5 provide examples of data from each of the three formats.

All data were acquired directly from mine management. Several companies maintained an industrial engineering department which archived delay data. In other cases, production and delay data were kept by a longwall coordinator. A number of companies had entered selected details from section foremans' reports into a computer database and subsequently disposed of the original data. These databases were only useful in establishing mean-time-to-failure (MTTF) and mean-time-to-repair (MTTR) for major equipment failures.

Whenever possible, the mine site was visited and an underground tour was made. Survey information concerning equipment, geological conditions and panel geometry was sought for each longwall section. Equipment-rebuild data was also obtained when possible.

3.1.3 Composition of Data

Delay data corresponding to an estimated 14,398 production shifts were collected from 39 longwall sections. The number of shifts represented has been estimated because of instances where the delay events were recorded without specific reference to the number of production shifts elapsed. With the exception of one mine, the data range in date of origin from March 1986 to

LONGWALL: 0237-3SW SHIFT: DAY FOREMAN: R. BLACK DATE: 4-28-88

LEFT SURFACE	800	TIME OFF CI	248	CLEAN TONS	
ARRIVED SECTION	845	LEFT SECTION		PLAN	ACTUAL
TIME IN COAL	905	ARRIVED SURFACE			

END OF SHIFT STATUS REPORT

SHEARER LOCATION	#46	RUNNING COAL BETWEEN SHIFTS?	Y N
TIME SERVICED	922	TAILPIECE STRAIGHT?	(Y) N
BITS SET? NO. USED 6 bits	(Y) N	AFC CHAIN OK?	(Y) N
SPRAYS OPERATIONAL?	(Y) N	SL CHAIN OK?	(Y) N
SPRAY ARM ON/WORKING	(Y) N	TIMBERS SET TO 500 NO. SET	
AIR SPLITTER ON/INTACT?	(Y) N	FULL GAS BOTTLES	O_2 2 ACC 2
FACE STRAIGHT?	(Y) N	EMPTY GAS BOTTLES	O_2 1 ACC
BELT LEFT IN STORAGE UNIT	60 FT.	EMULSION CAR STATUS	3/4
SUPPLIES NEEDED		AMT OF WENDON LEFT	7

TONNAGE CALCULATIONS

SHIELDS: FROM LAST SHIFT	0	
SHIELDS: ON-SHIFT	360	
TOTAL SHIELDS CALLED OUT	360	
MULTIPLIER		
TONNAGE CALLED OUT		
S.O.S. FACE STATION	H 454	T 466
E.O.S. FACE STATION	442	457
TOTAL FOOTAGE	12	9
AVG. FACE ADVANCE	10 1/2	
CREEP		
SECTION READY TO RUN	YES	(NO)

COMMENTS: 65 TO 80 - PAN GOING DOWN — HOSE BLOWED ON VALVE BANK T.E.
25 TO 50 - PAN LEANING TOWARDS FACE
25 TO 40 PAN NOT GOING OVER
[illegible] TAIL DRIVE NEEDS TO GO DOWN - AT CREST OF HILL

ASSET NO.	DOWNTIME CODE	FROM	TO	SECTION DELAY (MIN)	PLANNED DELAY (Y/N)	2:38 TO 3:15 - #40 HOSE ON SHEARER	
		715	800	45min		TRAVEL OUT	BETWEEN SHIFT DOWNTIME (8:15+
4125	302	243	248	5min		WELD COVER UP. TAIL END	
4125	303	248	315	27		REPAIR HOSE HYD ON VALVE BANK T.E.	
		800	845	45min		TRAVEL	
						FIREBOSS	
		845	855	10min.		SAFETY	
		855	905	10min		ALIGN T.P. - LINE - CREW UP	
	207	928	939	11min		BRK. ROCK	
4125	219	952	1135	103		PUT - SPRAY ARM - WELD SPRAYS	
	207	1151	1158	7min		BRK ROCK	
	207	1209	1214	5min		BRK. ROCK	
	207	1218	1228	10min		BRK ROCK	
	207	105	111	6min		BRK ROCK	
	138	111	115	4min		S/B BELT DOWN	
	207	123	210	47min		ROCK IN CRUSHER HUNG UP	
	207	214	224	10min		" " " "	
	207	230	237	7min		BRK. ROCK	18?

OTAL INUTES	DELAY	362	% UPTIME (UPTIME ÷ 480)	25 %	SHIELDS/UPTIME HR
	UPTIME	119	MAX CAPACITY (SHIELDS)		
UT TIME (# SHIELDS X .215)		77	PRODUCTIVITY (SHIELDS ÷ MAX CAP)	%	
FFICIENCY (CUT TIME ÷ UPTIME		50 %	FOREMAN'S SIGNATURE: Roger Black		BETWEEN SHIFT DOWNTIME 3:15 4:00

Figure 3. Raw data sample: production report

US CREWS

44 DATE 1-13-89

NAME	JOB PERFORMED THIS SHIFT	WORK AREA	COST CODE	HOURS	JO/SC SM	TOPIC
W BALL	L.W GENERAL	40LW		8		
H. McFARLENE	"	"		"		
M. CANTRELL	"	"		"		
R SHARP	"	"		"		
R. LESTER	"	"		"		
J. LESTER	"	"		"		
E MILLER	"	"		"		

WORK REPORT

(1) washed shear off
(2) washed headers off jacks 3-15
(3) Took remote and telephone slack out and took cable to end of track
(4) Drilled and installed 7 monorails
(5) supplied and rockdusted 400FT in track HD.
(6) Helped supply crew and delivered rockdust to HD bcks.
(7) cleaned porta-bus
(8) set 3 bcks. of timbers along rib in belt entry
(9) charged 41-603 scoop
(10) Repaired 1 hinge and lid on tool box
(11) trashed, rockdusted (5 pallets) and built 6 cribs in 4Hd.
(12) Drained all oils in air hoist and refilled
(13) Put cables and hoses on dollies and pulled them down with hoist

FOREMAN ____________ MINE FOREMAN [signature]

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Figure 4. Raw data sample: maintenance report

```
REPORT NO.        (MR-1)                                                    DEC/1987         PAGE NO.      7
                                                                                                 DATE  11/15/88
                                          DELAY TIME SHOWN IN HOURS AND TENTHS OF HOURS          TIME  11:23:21
   MAJOR CLASS -    FACE CONVEYORS/STAGE LOADERS

                    -------COMPONENT----------------------- TYPE    DELAY ----ACTION TAKEN-----
  UNIT      DATE    CODE LOC  DESCRIPTION                   MAINT   TIME  ACTION/TYPE EQUIPMENT    PART NO. / COMMENTS

*******MINOR CLASS -            FACE CONVEYOR

4          12/10/87 4301      CONVEYOR CHAIN                SCHED    0.00 REPL                  TOOK OUT 4 LINKS OF SLACK
           12/12/87 2303      CONVEYOR MOTOR (TAIL)         BREAK    2.16                       ELECTRICAL PROBLEM REPL DIODE AT
                                                                                                TO MOTOR
           12/20/87 4301      CONVEYOR CHAIN                SCHED    0.00 REPL                  TOOK OUT 2 LINKS OF SLACK
           12/20/87 4301      CONVEYOR CHAIN                SCHED    0.00 REPL                  TIGHTEN ALL CHAIN CONNECTORS
                                                TOTAL UNIT           2.16

                                          TOTAL MINOR CLASS          2.16

*******MINOR CLASS -             STAGE LOADER

2          12/02/87 4301      CONVEYOR CHAIN                SCHED    0.00                       ADJUST CONVEYOR CHAIN
           12/03/87 4301      CONVEYOR CHAIN                SCHED    0.00                       TOOK OUT 4 LINKS OF SLACK
           12/07/87 4301      CONVEYOR CHAIN                BREAK    2.16                       CONVEYOR HUNG UP
           12/12/87 4303      TAIL ROLLER/SPROCKET          SCHED    0.00 REPL                  CHANGE OUT TAIL SPROCKET ASSEMBLY
           12/20/87 4301      CONVEYOR CHAIN                SCHED    0.00                       TOOK OUT 2 LINKS OF SLACK
           12/21/87 5699      STRUCTURAL TROUBLESHOOTING    BREAK    5.00                       HAD TO WELD UP BROKEN SIGMA & ADJ
                                                                                                SEGMENT OF STAGE LOADER
                                                TOTAL UNIT           7.16

                                          TOTAL MINOR CLASS          7.16

                                          TOTAL MAJOR CLASS          9.32
```

Figure 5. Raw data sample: computer printout from proprietary database.

March 1989. Most of the data were recorded in 1987 and 1988. Specific delay incidents were recorded for 8,517 of these shifts. Aggregate delay times of grouped delay events were recorded for 5,881 shifts. Section foremans' production reports were available for fifteen longwall sections from thirteen mines. Five of these fifteen sections were further covered by maintenance foremans' reports. Twenty-four longwall sections from twenty-three mines were covered by computer-delay databases. Eighteen of these databases recorded individual delay occurrences. The remaining six recorded aggregate delay times for similar occurrences. Table 1 summarizes the composition of the data.

3.1.4 Inadequacies and Inconsistencies of Data

Certain inadequacies were apparent in much of the data. The failure to record a time of occurrence for each delay was an inadequacy of most computer printout and maintenance data, which precluded the calculation of TTF statistics for many longwall sections. Another deficiency was the failure to record delays of minor consequence. This problem was prevalent among all computer printout data and much of the section foremans' and maintenance foremans' data. Omission of short-duration delays, such as the breaking of rock or momentary conveyor overloads,

Table 1. Summary of raw data composition.

SECT.	SHIFTS	TIME INTERVAL	INDIVIDUAL INCIDENT	COMBINED INCIDENT	PROD. REPORT	MAINT. REPORT
LW 1	228	09/19/88-02/07/89	*		*	
LW 2	384	06/20/88-02/28/89	*		*	
LW 3	50	12/01/87-12/31/87	*			*
LW 4	50	12/01/87-12/31/87	*			*
LW 5	50	12/01/87-12/31/87	*			*
LW 6	50	12/01/87-12/31/87	*			*
LW 7	50	12/01/87-12/31/87	*			*
LW 8	50	12/01/87-12/31/87	*			*
LW 9	50	12/01/87-12/31/87	*			*
LW 10	50	12/01/87-12/31/87	*			*
LW 11	50	12/01/87-12/31/87	*			*
LW 12	50	12/01/87-12/31/87	*			*
LW 13	50	12/01/87-12/31/87	*			*
LW 14	50	12/01/87-12/31/87	*			*
LW 15	600	12/01/87-12/31/87	*			*
LW 16	50	12/02/87-12/31/87	*			*
LW 17	5136	1978 - 1988		*	*	
LW 18	175	03/01/86-06/31/86		*	*	
LW 19	241	12/01/88-03/31/89	*		*	*
LW 20	200	12/01/88-03/31/89	*		*	*
LW 21	114	12/01/88-03/31/89	*		*	*
LW 22	245	12/01/88-03/31/89	*		*	*
LW 23	238	12/01/88-03/31/89	*		*	*
LW 24	455	05/01/88-12/31/88	*		*	
LW 25	1431	12/12/85-07/15/88	*		*	
LW 26	701	10/01/87-12/31/88	*		*	
LW 27	691	01/05/88-02/28/89	*		*	
LW 28	630	09/01/87-10/04/88	*		*	*
LW 29	570	10/04/87-07/23/88	*		*	*
LW 30	229	01/03/89-03/31/89	*		*	
LW 31	171	01/03/89-03/31/89	*		*	
LW 32	174	01/03/89-03/31/89	*		*	
LW 33	195	01/03/89-03/31/89	*		*	
LW 34	185	01/03/89-03/31/89	*		*	
LW 35	185	01/03/89-03/31/89	*		*	
LW 36	104	01/02/87-03/31/87	*		*	
LW 37	72	01/02/87-03/31/87	*		*	
LW 38	129	01/02/87-03/31/87	*		*	
LW 39	265	01/02/87-03/31/87	*		*	

resulted in an inflation of availability figures. Scheduled delays and inherent delays such as travel time were also omitted in some databases. System availability figures could not be calculated for these mines. Other deficiencies included the occasional omission of delay durations and the failure to qualify delays with an equipment or delay type.

Inconsistencies in the data made it necessary to perform certain remedial operations upon the databases. One inconsistency was mixed or confused shift designations. A standard designation was chosen, and all shift designations were converted to this standard. Also, shift arrival and leave times sometimes overlapped. In such cases, arrival times were not altered; instead, leave times were adjusted to the arrival times of the ensuing shift. Repair operations which spanned a shift transition boundary were split between the consecutive shifts. Delays were sometimes assigned to the wrong shift, which was evident when repair intervals began after the recorded leave time for a particular shift. A program which compared repair intervals to a crew's work interval was used to correct improper shift designations. Where overlapping repair intervals were recorded in databases, a maintenance program was written which truncated secondary repairs, thereby eliminating overlapping delays.

3.2 Classification of Delays

In this study, longwall delays were classified according to equipment type, delay type and specific delay event. Delays were identified as either scheduled or unscheduled, and a short description of each delay was included in the downtime record. This hierarchical classification scheme permitted the identification of equipment types with a large downtime contribution, as well as of the predominant delay types and component failures which plagued the machine.

Equipment Types: Twenty-two Equipment Types were identified and are listed in Table 2. Eight of the twenty-two were considered primary: 1) shearer, 2) face conveyor, 3) shields, 4) stage loader, 5) crusher, 6) section belt, 7) haulage belt, and 8) bin. The availabilities of these primary equipment types were studied individually.

Delay Types: Nine Delay Types were identified and are listed in Table 3. In distinguishing between delay types, causal information about each delay was recorded. Failures of a geologic nature were filtered out of the TTF and TTR analysis of the eight primary Equipment Types. This eliminated much of the environmental bias experienced by individual mines and made equipment performance

Table 2. Equipment Types

NUMBER	CODE	QUALIFYING EQUIPMENT
1	BN	BIN, BIN FEEDER, BUNKER, SILO
2	CR	CRUSHER
3	CU	COMMUNICATION EQUIPMENT
4	FA	FACE PROBLEM, SUPPLY, CREW, LUNCH
5	FC	ARMORED FACE CONVEYOR
6	HB	BELT OTHER THAN SECTION BELT
7	HO	HOSE, PIPE
8	LI	LIGHTING EQUIPMENT
9	MM	METHANE MONITOR
10	MT	MANTRIP, TRACK, MONORAIL
11	PD	PORTAL DELAY
12	PM	PUMP
13	PW	POWER
14	RF	ROOF PROB.,JACKS,PROPS,CRIBS,TIMBERS
15	RX	DRAW ROCK INTERFERENCE
16	SA	SAFETY MEETINGS, INSPECTIONS, DRILLS
17	SB	SECTION BELT/TAILPIECE
18	SD	SHIELDS
19	SH	SHEARER
20	SL	STAGELOADER
21	VT	VENTILATION PROBLEM/WORK, DUST PROB.
22	UK	UNKNOWN/OTHER

Table 3. Delay Types

NUMBER	CODE	DELAY TYPE
1	C	UNDER CAPACITY
2	E	ELECTRICAL FAILURE
3	EH	ELECTROHYDRAULIC FAILURE
4	G	GEOLOGIC DISTURBANCE
5	H	HYDRAULIC FAILURE
6	M	MECHANICAL FAILURE
7	P	PREPARATORY ACTIVITY
8	SA	SAFETY REQUIREMENTS
9	V	VENTILATION REQUIREMENTS

comparisons more relevant.

Specific Delay Events: Specific Delay Event classifications describe a particular repair or service activity or the failure of a specific equipment component or assembly. One hundred and twelve Specific Delay Events were recognized. These events were divided among the nine Delay Types according to their causal nature. The identification of Specific Delay Events allows expected life analyses of equipment components to be performed. Such analyses can be used for rebuild and replacement scheduling and for identifying substandard parts. A complete list of Specific Delay Events is given in Table 4.

Table 4. Specific Delay Events

ELECTRICAL	MECHANICAL
001 HAUL DR	050 SPLICE/TRIM BELT
	051 GEARS, GEARBOX
002 CUTTER DRIVE	052 TENSION CHAIN
	053 BROKEN CHAIN, ROPE OFF TP TU
003 GROUND, FUSE, CIR WIRE, CONNECTION	054 CHAIN HUNG OR FOULED IN RACE
004 CABLES, SPLICES	055 BROKEN/HUNG FLIGHT
	056 COWL, COWL ARM/BLADE
005 BREAKERS	057 SHEARER DRUM
	058 SPILL TRAY, GUARD SCRAPER, WEAR STRIP, SPLITTER ARM
006 REMOTE CONTROL, HOST, SEQUENCE ROLL, PULL CORD, LOCK OUT	059 BRETBY, CABLE ANCHOR
007 THERMISTER	060 TRAPPING SHOE, SHEARER DERAILED
008 OVERLOADS	061 BUSHING, BEARING
	062 ALIGN TAILPIECE, PUSH STAGELOADER
009 COMMUNICATIONS, PRESTART	063 REMOVE BELT
	064 STRAIGHTEN PANLINE
010 LIGHTS	065 BIN, TIPPLE, SILO, SKIP, HOIST, OUTSIDE BELT
011 POWER CENTER, HIGH VOLTAGE	066 WELD BITS, SPOT BIT
	067 SERVICE AND BIT
	068 BASE LIFT JACK, CLEVIS RELAY BAR, BRIDGE PLATE
012 JUNCTION BOX, PANEL BOX, POWER SUPPLY	069 SET TIPS, ADJUST CANOPY GOB SHIELD, FORE POLE, PUSH RAM, LEG RAM
013 MANTRIP, ELEV	070 COVERS / HUB CAPS OFF
014 DRIVES (OTHER) [BOOSTER, STATIC-STARTER, QUAD, FRICTION, FC] BIN FEEDER	071 PINS, BOLTS, FITTINGS
	072 EICOTRACK, HAULAGE WHEEL SPROCKET, DYNACHAIN
	074 GOOSENECK, PANS, SANDWHICH PLATE, DOG BONE
016 PROBLEM, UNKNOWN INOPERABLE, TROUBLE SHOOT, MALFUNCTION	075 RANGING ARMS
	076 IMPACTOR
	077 LUMP BREAKER
	078 TORQUE SHAFT, QUILL SHAFT
	079 ROLLERS, BELT BRAKE
015 BATTERIES	080 TAILPIECE TAKE-UP
	081 PROBLEM, OFF, INOPERABLE DOWN
	082 FRICTION DRIVES, DRIVES (OTHER)
	083 DRIVE BELT OFF

Table 4. Specific Delay Events (continued)

HYDRAULIC		GEOLOGIC	
100	HYDRAULIC HOSE/PIPE FITTING LEAK	150	BREAK ROCK
101	WATER HOSE/PIPE FITTING LEAK	151	GOBBED OUT,HUNG
102	HYDRAULIC PUMP	153	SOFT BOTTOM SHIELDS PLOWING PAN LEANING PAN NOT PUSH TAILPIECE HUNG
103	WATER PUMP	154	SHIELDS WON'T SET OR REACH TOP
104	VALVES	155	CUT ROCK RECUT BOTTOM BINDER ROCK
105	RANGING ARM RAM, SHIELD PUSH RAM	156	CLEARANCE PROB
106	LEG RAM	157	BAD TOP/RIBS CRIB/TIMBER/PROP /BOLTING WORK
107	HYDRAULIC PROPS	159	CLEAN SHIELDS
109	TORQUE CONVERTER, COUPLER,SOFT PLUGS, SPEED REDUCER	160	FAULT
110	FILTERS	161	ROCK/ROOF FALL
111	GEAR/HYDRAULIC OIL, SERVICE, WATER IN OIL	162	FLOODED FACE OR TRACK
112	WATER SPRAYS,NOZZLE WATER MANIFOLD	163	GROUT FACE/TOP
113	TAILPIECE TAKE-UP ADVANCE RAM	164	SHOOT OR CUT KETTLEBOTTOM, OR ROOF ROLL
114	PROBLEM, DOWN, OFF TROUBLE SHOOT	166	DRAW ROCK CAUSE STOPPAGE OF SPECIFIC PIECE OF EQUIPMENT
115	HAULAGE DRIVE (SH)		
116	CUTTER DRIVE		
117	DRIVES (OTHER)		
118	COWL		

Table 4. Specific Delay Events (continued)

CAPACITY

200 WAIT ON SHIELDS

201 BIN, BIN FEEDER TIPPLE, SILO, SKIP, HOIST

202 SPILLAGE

203 OVERLOAD/UNLOAD FACE CONVEYOR, BELT, CRUSHER, STAGELOADER

PREPARATORY

250 POWER CENTER MOVE

251 DATA COLLECTOR, OIL SAMPLE

252 TRAINING

253 RUN SUPPLIES IN/OUT, REMOVE MONO-RAIL, MOVE EQUIP

254 REMOVE TIMBERS FROM GATEWAYS OR PAN

255 PRODUCTION MEETING RCP, LUNCH

256 MEASURE CENTERS OR FACE HEIGHT OR WEB, CALIBRATE METH MON

257 MANTRIP UNAVAILABLE, PORTAL DELAY, CREW SHORT OR LATE

258 OVER SUMP, XTRA CUT AT GATE END, CUT 1 WAY WHERE BIDI NORMAL

259 FLIT

260 TRAVEL IN/OUT

SAFETY

300 INJURY

301 INSPECTION, VIOLATION PERMISSIBILITY CHECK

302 TRAINING, DRILLS

303 SAFETY MEETING

VENTILATION

350 AIR QUANTITY LOW, FAN DOWN

351 ROCK DUST, DUST

352 METHANE WARNING, SMOKE

354 BUILD/KNOCK STOPPING ADJUST VENTILATION CURTAINS

NOT AVAILABLE

401 PROBLEM, UNKNOWN DOWN, OFF, TROUBLE SHOOT

IV DATABASE DEVELOPEMENT

4.1 Raw Database Types

dBase IV database software was used to record and organize the field data collected. Raw data were entered into one of two database formats: the Shift Database and the Downtime Database. One Shift Database and Downtime Database were created for each longwall section, except when prevented by a severe omission of data. Tables 5 and 6 list the field names, field types, and contents of the Shift Database and of the Downtime Database respectively.

4.1.1 Shift Database Format

The Shift Database format contains all information relevant to the shift as a whole. Each record in a particular Shift Database corresponds to a single shift at a single section. Fields one and two contain the date and shift during which the given data were collected. These two fields were used to correlate data between Shift Databases and Downtime Databases. Fields three through six list arrival and departure times and the mining interval. These times were recorded as minutes after midnight 01/01/85. This reference base was used to locate all timed events. Field seven, LEAV2_SECT, is an adjusted

Table 5. Shift Database format

Field	Field Name	Field Type	Content
1	DATE	D	DATE
2	SHIFT	C/1	SHIFT
3	ARR_SECT	N/7.0	ARRIVAL TIME ON SECTION
4	START_MINE	N/7.0	START TIME COAL LOADING
5	END_MINE	N/7.0	STOP TIME COAL LOADING
6	LEAVE_SECT	N/7.0	DEPARTURE TIME OFF SECTION
7	LEAV2_SECT	N/7.0	ADJUSTED DEPARTURE TIME
8	TIME_IN	N/2.0	TRAVEL TIME IN
9	TIME_OUT	N/2.0	TRAVEL TIME OUT
10	TIME_RCP	N/2.0	TIME FOR FACE INSPECTION
11	MDELAY	N/3.0	FACE DELAY TIME
12	TDELAY	N/3.0	TOTAL SHIFT DELAY TIME
13	TDEL_BEGIN	N/3.0	DELAY WITH BEGIN TIME
14	IDELAY	N/3.0	INHERENT DELAY
15	MAVAIL	N/5.2	FACE AVAILABILITY
16	TAVAIL	N/5.2	SYSTEM AVAILABILITY
17	TTFFACTOR	N/6.4	TTF ADJUSTMENT FACTOR
18	WORKERS	N/2.0	NUMBER OF WORKERS
19	PASSES	C/5	NUMBER OF SHEARER PASSES
20	FEET_HEAD	C/5	ADVANCE AT HEAD (FEET)
21	FEET_TAIL	C/5	ADVANCE AT TAIL (FEET)
22	FEET_ADVAN	C/5	AVERAGE ADVANCE HEAD/TAIL
23	RAW_TONS	C/4	RAW SHIFT TONNAGE
24	CLEAN_TONS	C/4	CLEAN SHIFT TONNAGE
25	COMMENTS	C/40	SPECIAL CONDITIONS

Table 6. Downtime Database format

Field	Field Name	Field Type	Content
1	DATE	D	DATE
2	SHIFT	C/1	SHIFT
3	EQUIP	C/6	EQUIPMENT TYPE/FAILURE CODE
4	TIME	N/7.0	TIME OF BREAKDOWN (MIN PAST BENCHMARK)
5	BEGIN	N/4.0	TIME OF BREAKDOWN (MIN PAST MIDNIGHT)
6	BEGIN2	N/4.0	ADJUSTED TIME OF BREAKDOWN
7	DURATION	N/4.0	TIME TO REPAIR
8	DURATION2	N/4.0	ADJUSTED DURATION
9	TYPE	C/4	FAILURE TYPE (M, E, H, G, ETC)
10	SCHEDULED	L	SCHEDULED DELAY YES/NO
11	COMM	C/35	DECSRIPTION OF BREAKDOWN

leave time which extends the listed departure time to encompass work between shifts. Fields eight and nine are incoming and outgoing travel times. Field ten, TIME_RCP, records the pre-mining interval used for face and safety checks. Field eleven, MDELAY, records the minutes of face delay time during the shift. Field twelve, TDELAY, contains the minutes of total delay time. TDEL_BEGIN records the minutes of delay time for all downtime events with a recorded time of occurrence. Field fourteen, IDELAY, records the inherent or organizational delay time. Inherent delays constitute such items as travel time, face checks, safety talks, lunch and production meetings. Field fifteen, MAVAIL, contains the face availability, and TAVAIL lists the total system availability. The difference between MAVAIL and TAVAIL is due to the effect of inherent delay time and the effect of delays during transit to and from the section. TTFFACTOR is an indicator of the percentage of delays which were recorded without a time of occurrence. The calculation of TTFFACTOR is described in Section 5.1.1. Such occurrences cannot be located in time and therefore are excluded from all TTF calculations. The effect of filtering out these incidents is to inflate the apparent active time between failures. Fields eighteen and nineteen list the number of face workers and the number of complete shears. Fields twenty through twenty-two record the feet of advance of the headgate, the tailgate, and an average advance for the entire face. The final three fields record raw tonnage and clean tonnage for the shift and a notation of any special face conditions.

4.1.2 Downtime Database Format

The Downtime Database format contains all information relevant to a singular downtime occurrence. The eleven fields of the Downtime Database are listed in Table 6. Each record in a Downtime Database corresponds to a singular delay occurrence on a particular longwall face. Fields one and two identify the date and shift during which the downtime event took place. Correlation of these fields with identical fields in the Shift Database makes it possible to calculate the shift statistics MDELAY, TDELAY, TDEL_BEGIN, IDELAY, MAVAIL and TAVAIL. Field three, EQUIP, contains two letters identifying the equipment type followed by three digits identifying the Specific Delay Event responsible for a period of delay. The fields TIME and BEGIN record the time of occurrence of the delay incident. Time is recorded in minutes past midnight 01/01/85. This permits the calculation of statistics such as TTF upon a timeline common to all database section records. BEGIN records the same time of occurrence in minutes after midnight on the day of occurrence, and is intended for ease of operator interpretation. Field five, BEGIN2, presents an adjusted time of occurrence in minutes after midnight which differs from BEGIN in cases where downtime incidents have overlapped. The treatment of overlapping downtime will be discussed in Section 4.2.7. Fields seven and eight list the duration and adjusted duration of the downtime occurrence, also called the time to repair (TTR). The adjusted duration results from an overlapping delay. The field TYPE indicates which of the nine delay types best characterizes the delay event. SCHEDULED is a logical field which indicates whether the event was scheduled (.T.) or unscheduled (.F.). The COMMENTS field contains a brief description of the specific delay occurrence, and is intended to supplement the EQUIP field by providing a description more detailed than that used to categorize each of the one-hundred-and-twelve Specific Delay Events. A complete listing of the nomenclature used in the COMMENTS field is given in Appendix II.

In some cases the information available concerning delay incidents from a particular section was either too sparse or otherwise given in a format which could not be translated into the previously described Shift and Downtime Database formats. In most cases, unacceptable formats were the result of some sort of aggregation or summarization of data. In such cases, information was usually not available concerning specific delay incidents or the delays specific to a single shift. Alternative formats were designed which were amenable to these data. In general these data were not deemed useful for the calculation of availability figures or for the generation of time-to-failure (TTF) and time-to-repair (TTR) statistics. As such these alternative formats will not be discussed.

4.2 Database Maintenance Programs

Seven database maintenance programs have been written for the purpose of simplifying data entry and to correct inconsistencies within the data. A controlling program, MAINTAIN, is used to run the seven maintenance programs in an automated sequence. In order to run the maintenance programs, and to run the data generation programs which follow, a Shift Database and a Downtime Database must be created in accordance with Sections 4.1.1 and 4.1.2. The names and field types of all database fields must be identical to those presented in Table 5 and Table 6. The Shift and Downtime Databases must be created using Ashton-Tate dBASE software version III-Plus, IV or a compatible version. Refer to a dBASE manual for an description of the field types. Data must be input using the following units: time (minutes), distance (feet) and tonnage (short ton).

To perform the database maintenance process, the following programs must first be copied to a hard-drive subdirectory: MAINTAIN, ADDTYPE, FILLSFT, CORRSFT, INTERSFT, ADDSFT, TRAVRCP and OVERLAP. If disk copies of these programs are not available, program files identical to those found in Appendix III may be created using the MODIFY COMMAND editor from dBASE. Next, the Shift and Downtime Databases which are to be maintained must be copied into the same subdirectory. dBASE III Plus or dBASE IV, or a compatible version from the same subdirectory, should then be booted up. User should then exit from the assist menu to the dot prompt, type MAINTAIN and enter the names of the Shift Database and Downtime Database to be maintained at the program query. When the maintenance sequence is completed, all database files will be closed and the cursor will return to the dot prompt. "Use <database name>" should be typed at this prompt, followed by "browse" in order to enable the newly maintained databases to be viewed.

At this time both dBASE III-Plus and dBASE IV have a number of "bugs." Therefore when preparing to run the data maintenance or data generation sequences the dBase command "RUN" may not be invoked . This command temporarily transfers control to DOS and may lead to problems with the RAM memory stack. Problems of this type typically are accompanied by messages such as "DISK FULL" or "DATA ERROR." If this occurs dBASE should be re-installed and all damaged program and database files should be recopied. Damaged files can be identified with a utility program such as the Norton Utilities Disk Doctor. The use of DOS 4.0 should be avoided, and memory resident programs such as "Fastopen," "Sidekick" or "Burnout" may not be installed while dBASE is in use . Because it was necessary to include the dBASE "RUN" command at the end of the MAINTAIN sequence and at the end of the DATAGEN sequence, it is recommended that dBASE be rebooted after each of these runs.

4.2.1 ADDTYPE Program

The seven maintenance programs are performed in a series, the first being the ADDTYPE program. ADDTYPE operates exclusively upon the Downtime Database. ADDTYPE's function is to simplify the data entry process by automating the assignment of a Delay Type code to the TYPE field of the Downtime Database. Specific failure event codes are grouped by delay type. For example, codes

001 to 049 represent electrical failures and codes 050 to 099 represent mechanical failures. Because of this grouping, a delay type can be positively identified on the basis of the last three characters of the EQUIP field. The TYPE field was created, despite this apparent redundancy, to facilitate the frequently performed operation of filtering out delays of a particular type. When entering raw data into a Downtime Database it is not necessary to enter a Delay Type into the TYPE field. Assignment of a Specific Delay Event code should be made in light of the particular equipment component which has failed and the causal nature of the delay.

4.2.2 FILLSFT Program

The second program of the maintenance series, FILLSFT, operates on both the Shift Database and the Downtime Database. This program performs the following three functions: 1) it fills in blank DATE and SHIFT fields of the Downtime Database; 2) it deletes empty records; and 3) it calculates and substitutes average shift advance to the FEET_ADVAN field.

A thorough foreman's report may list as many as fifteen work stoppages during a single shift. Such a report would yield fifteen records within a Downtime Database, each with an identical DATE and SHIFT field.

The first function of FILLSFT requires that the DATE and SHIFT fields be entered for the first delay of a particular shift only; the remaining delays during that shift need not contain a DATE or SHIFT field entry.

A common method for inputting data with the Ashton-Tate dBase is by use of the APPEND command. This command creates a blank record at the end of a database file. There are a number of ways in which a collection of these empty records can be accidentally gathered. Such records can thwart attempts to determine the range of the DATE field. The second function of the FILLSFT program is to delete any empty records.

Whenever possible, rate-of-advance data was entered as two figures, advance at the headgate and advance at the tailgate. This information makes it possible to study the effect of alignment problems upon the productivity of a face. For comparison of advance rates between sections, a single figure for the average advance of the entire face is calculated and entered into the FEET_ADVAN Field. It is the third function of FILLSFT which performs this operation.

4.2.3 CORRSFT Program

The first function of CORRSFT is to correct the SHIFT field designations within the Shift and Downtime

Databases. CORRSFT also converts all fields which locate an occurrence in time to minutes after midnight 01/01/85. BEGIN and BEGIN2 are exceptions which remain in minutes after midnight of the day of occurrence.

Two situations arise in which the SHIFT field needs to be redesignated. The first case arises when the shift designations found in the raw data differ from those used in the standardized Shift and Downtime Database formats. The standard used in this study is as follows: shift = "1" (midnight to 8 AM), shift = "2" (8 AM to 4 PM), shift = "3" (4 PM to midnight). The second type of correction occurs when a downtime incident is assigned to a shift from which it is temporally excluded. This is the case when the time of occurrence of a delay event is either before the shift crew's arrival at the face or after the crew's departure from the face.

4.2.4 INTERSFT Program

The fourth program of the maintenance series, INTERSFT, adjusts shift departure times whenever delays occur between shifts and splits delays which span two shifts.

When a delay occurs between shifts without extending beyond the arrival of the inbound crew, the departure time of the outbound crew is adjusted to equal the arrival time of the inbound crew. In such cases, it is assumed that a contingent of the retiring crew remained behind to operate or repair equipment until the arrival of the relief crew. Extending the departure time of the outbound crew extends the available face time and renders face availability calculations more accurate. Note that, if downtime is recorded during an interval when no crew is at the face, the calculated face availability would be less than zero.

Delays which span two shifts are split. The first portion of the delay goes to the retiring shift and ends upon arrival of the relief crew. The second portion of the delay goes to the relief shift and begins upon the arrival at the face of the relief crew. The departure time of the retiring crew is adjusted to the arrival time of the relief crew.

4.2.5 ADDSFT Program

The ADDSFT program creates surrogate records in both the Shift and Downtime Databases. Surrogate records are used to fill gaps in these databases.

In the case of the Shift Database, the gaps filled are missing Shift Database records for which a Downtime Database record exists. In the study data, such occurrences were the result of two shifts' downtime having been logged on a single production report (an event which occurred frequently when a single delay spanned two shifts) or typographical errors. In such cases, ADDSFT creates a surrogate Shift record with the following information:

1) DATE - Date of missing shift record.
2) SHIFT - Missing shift.
3) ARR_SECT - Average arrival time for this shift.
4) LEAVE_SECT - Average departure time for this shift.
5) LEAV2_SECT - Same as LEAVE_SECT.
6) TIME_IN - Average travel time, ingoing.
7) TIME_OUT - Average travel time, outgoing.
8) TIME_RCP - Average face check/preparation time.
9) COMMENTS - "SURROGATE SHIFT RECORD TYPE #2".

The remaining fields are left blank. These records make it possible to calculate availability figures for cases of missing Shift Database records.

ADDSFT fills gaps in Downtime Databases for which there are no Shift Database and no Downtime Database records. A surrogate Downtime Database record is created in cases which correspond to idle periods on the section or to production reports which were lost. The following information is contained in the surrogate Downtime Database record:

1) DATE - Date of missing downtime record.
2) SHIFT - Missing shift.
3) EQUIP - Day of week of DATE.
4) TIME - Minutes between midnight 01/01/85 and time of the start of the shift.
5) BEGIN - Start of shift, minutes after midnight (SHIFT - 1) * 480.
6) DURATION - 480.
7) TYPE - P.
8) SCHEDULED - (.T.)
9) COMM - "NO WORK OR MISSING SHIFT RECORD."

These surrogate records make the timeline continuous. All time between delays must be accounted for in order to calculate TTF statistics.

4.2.6 TRAVRCP Program

The TRAVRCP program creates Downtime Database records for the following scheduled delay events: travel in, travel out, and face check/preparation (RCP). This is the final phase of filling gaps within the timeline. All time which is not accounted for by listed delays, travel in/travel out delays, face check/preparation delays and idle shifts is assumed to be active production time.

4.2.7 OVERLAP Program

The OVERLAP program adjusts the Downtime Database fields BEGIN and DURATION in order to eliminate overlapping delay time. The adjusted field values are recorded in the fields BEGIN2 and DURATION2. Generally, when two delay events overlap one event remains unchanged while the other is shortened to remove the overlapping portion. The priority of a delay event determines which delay is truncated. The following is a list of delay categories in decreasing priority: 1) listed delay event (listed on production report), 2) travel delay, 3) RCP delay, and 4) idle shift delay. When a travel delay overlaps with any delay, the travel delay's DURATION field is set to 0. It is assumed that crews are changing out at the face if the delay (repair) is ongoing during crew travel. The OVERLAP program is the final program of the MAINTAIN series.

4.3 Data Generation Programs

After maintaining the Shift Database and the Downtime Database for a particular longwall section, the data generation programs can be run. The eleven data generation programs are: SFTDELAY, SFTAVAIL, TTFPRG, TTRPRG, AUTOTTF, AUTOTTR, EQUIP%, TYPE%, STATS, SECAVAIL, and MEANTIME. With the exception of TTFPRG and TTRPRG, these programs are run in an automated sequence controlled by the program DATAGEN. Data generation programs manipulate the raw data contained in the Shift Database and the Downtime Database in order to calculate various statistics which characterize the performance of a particular longwall section. The calculated statistics either fill empty fields of the Shift Database or fill fields in newly generated databases. The Shift Database fields which are filled with generated data are: MDELAY, TDELAY, TDEL, BEGIN, IDELAY, MAVAIL, TAVAIL, and TTFFACTOR. See Table 6 for a description of these fields. Three types of generated databases are created: 1) TTF Database, 2) TTR Database, and 3) Result Database.

A TTF Database or TTR Database can be created for any Equipment Type or Delay Type, or combination thereof. Tables 7, 8, and 9 list the field types and contents of the TTF, TTR, and Result Databases respectively.

The TTR database fields DATE, SHIFT, EQUIP, TIME and BEGIN are identical to the Downtime Database fields having the same names. These fields were included for correlation between the TTR database and the Downtime

Table 7. TTF Database format

Field	Field Name	Field Type	Content
1	DATE	D	DATE
2	SHIFT	C/1	SHIFT
3	EQUIP	C/6	EQUIPMENT TYPE/FAILURE CODE
4	TIME	N/7.0	TIME OF OCCURRENCE (MIN. PAST BM)
5	BEGIN	N/4.0	TIME OF OCCURRENCE (MIN. PAST 12 PM)
6	DURATION2	N/4.0	ADJUSTED DURATION
7	ACCUMDOWN	N/7.0	INTER-DELAY DOWNTIME
8	TIME_IDLE	N/7.0	INTER-DELAY IDLE TIME
9	TTFACT	N/7.0	ACTIVE TIME TO FAILURE
10	TTFTOT	N/7.0	TOTAL TIME TO FAILURE

Table 8. TTR Database format

Field	Field Name	Field Type	Content
1	DATE	D	DATE
2	SHIFT	C/1	SHIFT
3	EQUIP	C/6	EQUIPMENT TYPE/FAILURE CODE
4	TIME	N/7.0	TIME OF OCCURRENCE (MIN. PAST BM)
5	BEGIN	N/4.0	TIME OF OCCURRENCE (MIN. PAST 12 PM)
6	TTR	N/7.0	DURATION OF DELAY

Table 9. Result Database format

Field	Field Name	Field Type	Content
1	MINE	C/2	MINE ID. PREFIX
2	RAW_AVE	N/4.0	RAW SHORT TONS/SFT
3	CLEAN_AVE	N/4.0	CLEAN SHORT TONS/SFT
4	REJECT	N/5.2	REJECT (%)
5	PROD_RATE	N/5.2	TONS PER ACTIVE FACE MIN.
6	TON_MAN	N/4.0	TONS PER FACE MAN * SHIFT
7	PASS_SFT	N/4.1	SHEARS PER SHIFT
8	ADVAN_SFT	N/4.1	FACE ADVAN (FT./SFT)
9	DOWNPERTON	N/7.3	DOWNTIME (MIN./TON)
10	SFT_WEEK	N/4.1	PRODUCTION SHIFTS PER WEEK
11	TON_WEEK	N/6.0	RAW TONS/WEEK
12	WORKER_AVE	N/4.1	NUMBER OF SECTION WORKERS
13	SHMTTF	N/5.0	MTTF SHEARER
14	FCMTTF	N/5.0	MTTF FACE CONVEYOR
15	SDMTTF	N/5.0	MTTF SHIELDS
16	SLMTTF	N/5.0	MTTF STAGELOADER
17	CRMTTF	N/5.0	MTTF CRUSHER
18	SBMTTF	N/5.0	MTTF SECTION BELT
19	HBMTTF	N/5.0	MTTF HAULAGE BELT
20	BNMTTF	N/5.0	MTTF BIN/SKIP/TIPPLE
21	SYMTTF	N/5.0	MTTF SYSTEM
22	SHMTTR	N/5.0	MTTR SHEARER
23	FCMTTR	N/5.0	MTTR FACE CONVEYOR
24	SDMTTR	N/5.0	MTTR SHIELDS
25	SLMTTR	N/5.0	MTTR STAGELOADER
26	CRMTTR	N/5.0	MTTR CRUSHER
27	SBMTTR	N/5.0	MTTR SECTION BELT
28	HBMTTR	N/5.0	MTTR HAULAGE BELT
29	BNMTTR	N/5.0	MTTR BIN/SKIP/TIPPLE
30	SYMTTR	N/5.0	MTTR SYSTEM
31	SHAVAIL	N/7.3	SHEARER AVAILABILITY
32	FCAVAIL	N/7.3	FACE CONVEYOR AVAILABILITY
33	SDAVAIL	N/7.3	SHIELD AVAILABILITY
34	SLAVAIL	N/7.3	STAGELOADER AVAILABILITY
35	CRAVAIL	N/7.3	CRUSHER AVAILABILITY
36	SBAVAIL	N/7.3	SECTION BELT AVAILABILITY
37	HBAVAIL	N/7.3	HAULAGE BELT AVAILABILITY

Table 9. Result Database format (continued)

Field	Field Name	Field Type	Content
38	BNAVAIL	N/7.3	BIN AVAILABILITY
39	FACEAVAIL	N/7.3	FACE AVAILABILITY
40	SYSTAVAIL	N/7.3	SYSTEM AVAILABILITY
41	INHERDELAY	N/3.0	INHERENT DELAY
42	SH_UNS	N/7.3	SH % OF UNSCHEDULED DELAYS
43	FC_UNS	N/7.3	FC % OF UNSCHEDULED DELAYS
44	SD_UNS	N/7.3	SD % OF UNSCHEDULED DELAYS
45	SL_UNS	N/7.3	SL % OF UNSCHEDULED DELAYS
46	CR_UNS	N/7.3	CR % OF UNSCHEDULED DELAYS
47	SB_UNS	N/7.3	SB % OF UNSCHEDULED DELAYS
48	HB_UNS	N/7.3	HB % OF UNSCHEDULED DELAYS
49	BN_UNS	N/7.3	BN % OF UNSCHEDULED DELAYS
50	SH_ALL	N/7.3	SH % OF ALL DELAYS
51	FC_ALL	N/7.3	FC % OF ALL DELAYS
52	SD_ALL	N/7.3	SD % OF ALL DELAYS
53	SL_ALL	N/7.3	SL % OF ALL DELAYS
54	CR_ALL	N/7.3	CR % OF ALL DELAYS
55	SB_ALL	N/7.3	SB % OF ALL DELAYS
56	HB_ALL	N/7.3	HB % OF ALL DELAYS
57	BN_ALL	N/7.3	BN % OF ALL DELAYS
58	E_UNS	N/7.3	E % OF UNSCHEDULED DELAYS
59	M_UNS	N/7.3	M % OF UNSCHEDULED DELAYS
60	H_UNS	N/7.3	H % OF UNSCHEDULED DELAYS
61	EH_UNS	N/7.3	EH % OF UNSCHEDULED DELAYS
62	G_UNS	N/7.3	G % OF UNSCHEDULED DELAYS
63	C_UNS	N/7.3	C % OF UNSCHEDULED DELAYS
64	P_UNS	N/7.3	P % OF UNSCHEDULED DELAYS
65	SA_UNS	N/7.3	SA % OF UNSCHEDULED DELAYS
66	V_UNS	N/7.3	V % OF UNSCHEDULED DELAYS
67	E_ALL	N/7.3	E % OF ALL DELAYS
68	M_ALL	N/7.3	M % OF ALL DELAYS
69	H_ALL	N/7.3	H % OF ALL DELAYS
70	EH_ALL	N/7.3	EH % OF ALL DELAYS
71	G_ALL	N/7.3	G % OF ALL DELAYS
72	C_ALL	N/7.3	C % OF ALL DELAYS
73	P_ALL	N/7.3	P % OF ALL DELAYS
74	SA_ALL	N/7.3	SA % OF ALL DELAYS
75	V_ALL	N/7.3	V % OF ALL DELAYS
76	DATAQUAL	N/6.3	DATA QUALITY

Database. The field TTR is identical to the Downtime Database field DURATION. Note that the unadjusted delay time is used to represent repair time.

The TTF database fields DATE, SHIFT, EQUIP, TIME, BEGIN and DURATION2 are identical to the Downtime Database fields of the same name. The TTF database and the Downtime Database are correlated with these fields. The remaining four fields contain statistics which are calculated by TTFPRG and are discussed in Section 4.3.3.

The Result Database contains seventy-six fields. All fields of the Result Database are filled with data generated during the DATAGEN run. Field one, MINE, contains the two-character identification prefix which is entered in response to a DATAGEN screen query. Fields two through twelve contain statistics generated by the STATS program. Fields two and three contain raw and clean average shift production in short tons. Field four contains the average reject for the section. Field five, PROD_RATE, contains the average value of raw tons produced per operational minute. TON_MAN contains the average value of raw tons produced per face man per shift. Field seven, PASS_SFT, records the average number of complete shears made per shift. ADVAN_SFT contains the average feet of advance per shift of the face. DOWNPERTON records the average minutes of downtime per raw ton of coal produced.

Field ten, SFT_WEEK, contains the average weekly number of production shifts; TON_WEEK records the average weekly raw coal production. WORKER_AVE contains the average number of workers at the section including face workers, mechanics, helpers, and the section boss. Fields thirteen through thirty contain the MTTF and MTTR statistics for the eight primary Equipment Types, and for the system (SY) as a whole. Fields thirty-one through thirty-eight contain availability figures for the primary Equipment Types. Fields thirty-nine and forty contain the average face availability and the average system availability. These figures are the average values of the Shift Database fields MAVAIL and TAVAIL. Field forty-one contains the average value of the Shift Database field IDELAY, or inherent delay per production shift. Fields forty-two through forty-nine contain the relative contribution (in percent) of each of the eight primary Equipment Types toward the total unscheduled delay time. Fields fifty through fifty-seven contain similar figures calculated for all downtime, scheduled and unscheduled. Fields fifty-eight through sixty contain the relative contribution (in percent) of each of the nine Delay Types toward the total unscheduled delay time. Fields sixty-seven through seventy-five contain similar figures calculated for all downtime, scheduled and unscheduled.

Field seventy-six, DATAQUAL, contains an index which rates the quality of the Downtime Database. The calculation of DATAQUAL is described in Section 5.3.2.

To run the data-generation sequence, the eleven data-generation programs and the files TTF.DBF, TTR.DBF and RESULT.DBF must first be copied to the hard drive subdirectory containing the previously maintained Shift Database and Downtime Database. If disk copies of these programs are not available, the MODIFY COMMAND editor from dBase may be used to reproduce these files as they appear in Appendix III . Next, "DATAGEN" must be typed at the dot prompt from within dBase. DATAGEN will issue a screen prompt for the names of the Shift Database and the Downtime Database to be worked on. (The ".DBF" extension given to all dBASE files should not be included when file names are typed.) DATAGEN will then issue a prompt for a two-character prefix to be used for identifying the TTF,TTR, and Result Databases which will be generated during the run. This prefix is to be inside quotes, e.g., "20." It is recommended that all Downtime Databases be named with two digits followed by "D," and that all Shift Databases be named with two digits followed by "S."

The DATAGEN output is a series of TTF and TTR Databases and a single Result Database. The names of the output databases will be constructed as follows:

Characters one and two will be the identification prefix, and for TTF and TTR Databases this will be followed by two characters indicating the Equipment Type, followed by "TTF" or "TTR" while in the case of the Result Database the identification prefix will be followed by "RESULT." When DATAGEN has terminated, all database files will be closed and the cursor will be at the dot prompt. A check of the subdirectory will show that fifteen new files have been created. Of the fifteen, seven are TTR databases, seven are TTF databases, and one is a Result database. The generation of these databases will be discussed in Sections 4.3.3 - 4.3.9.

4.3.1 SFTDELAY Program

SFTDELAY is used to calculate four delay statistics: face delay, total delay (all records), total delay (records with time of occurrence only) and inherent delay. These statistics are calculated for each shift and are input to the shift fields MDELAY, TDELAY, TDEL_BEGIN and IDELAY.

Face delay includes all delays which affect the operation of face equipment during the scheduled production period; these delays include equipment other than that strictly at the face. The scheduled production period begins after the crew has arrived at the section, finished all production and safety talks, and the fireboss has checked the face. It ends when the crew leaves the face. In practice, face delay includes all delays, scheduled and unscheduled, occurring during production shifts with the exception of "PD," "MT" and "SA" equipment delays, and the Specific Delay Event "FA 255." Face delay is input to the shift database field MDELAY.

The second delay statistic calculated is TDELAY or total delay. TDELAY includes all delays occurring during a production shift. The third statistic, TDEL_BEGIN, is the sum of all delays occurring during a production shift for which a time of occurrence is recorded. Lastly, inherent delay or IDELAY is the difference TDELAY - MDELAY. This difference represents all equipment delays of the "PD," "MT" and "SA" type, and the Specific Delay Event "FA 255."

4.3.2 SFTAVAIL Program

SFTAVAIL is used to calculate face availability (MAVAIL), system availability (TAVAIL) and TTFFACTOR. Face availability and system availability are based upon MDELAY and TDELAY. TTFFACTOR is an index which measures the proportion of delays which do not have a recorded beginning time. It is useful for establishing a threshold below which TTF statistics will not be calculated due to the bias introduced through ignoring many unlocated delays. The computational formulae for these three statistics are given in Sections 5.1.1 and 5.1.4.

4.3.3 <u>TTFPRG Program</u>

TTFPRG is used to calculate TTF statistics; a TTF database is built and filled with these statistics. The program can calculate TTF statistics for any combination of Equipment Type(s) and Delay Type(s). As with all TTF and TTR generating programs in this study, only unscheduled delays are considered.

The TTF database has ten fields; its structure can be seen in Table 7. The first six fields are identical to their namesake fields in the Downtime Database. The remaining four fields are calculated by TTFPRG.

Field seven, ACCUMDOWN, records the accumulation of downtime between successive failures. This downtime is from all sources other than the particular Equipment Type(s) and/or Delay Type(s) under examination. Field eight, TIME_IDLE, registers the amount of idle time accumulated between delays. Idle time delays represent a subset of ACCUMDOWN identified by the notation "NO WORK OR MISSING SHIFT RECORD" in the Downtime Database.

TTFPRG calculates TTF statistics on two bases: an active TTF basis and a total TTF basis. The active TTF basis registers only productive time between delays. The total TTF basis registers all time between delays except for idle shift time. Field nine, TTFACT, contains the active TTF; field ten, TTFTOT, contains the total TTF.

TTFPRG is not part of the DATAGEN series. This program may be initiated by typing "DO TTFPRG" at the dot prompt. The program will issue a screen query for the following information: 1) Downtime Database name, 2) Shift Database name, 3) TTF Database name (to be created by program), 4) Equipment Type(s) to be examined , and 5) Delay Type(s) to be examined.

A TTF is not calculated for delays which have been truncated because of delay overlap. Overlapping delays would generate TTF statistics of zero. Overlapping delays were not viewed as spontaneous events (see Section 5.1.1).

4.3.4 AUTOTTF Program

AUTOTTF is a preprogramed series of TTFPRG runs. It is useful for ease of operator use granted that the selection of Equipment Type and Delay Type groupings are acceptable. AUTOTTF is used to calculate TTF statistics for Equipment Types SH, FC, SD, CR, SL, SB, HB, BN, for the Delay Type G, and for the system as a whole. The Equipment Type calculations are made exclusive of geologic delays. Geologic delays are filtered out to reveal equipment performance base solely on equipment design and condition. TTF calculations of Delay Type G (geologic) are made upon delays of all Equipment Types.

The output of AUTOTTF consists of the following ten TTF Databases: SHTTF, FCTTF, SDTTF, SLTTF, CRTTF, SBTTF, HBTTF, BNTTF, SYTTF and GTTF. The names of these TTF Databases are given the identification prefix entered in response to the third DATAGEN screen query. Each database contains TTF statistics of the Equipment Type or Delay Type identified in its name. SYTTF contains TTF figures for the system as a whole; GTTR contains TTR figures for all delays of Delay Type G.

4.3.5 TTRPRG Program

TTRPRG is used to calculate TTR statistics; a TTR database is constructed and filled with these statistics. The program can calculate TTR statistics for any combination of equipment types and delay types. The statistic TTR is equivalent to delay duration (repair time). The unadjusted repair time, represented by the Downtime Database field DURATION, is used for the TTR statistic. A TTR is not calculated for delays which are overlapped by a prior delay. Such occurrences were not viewed as being purely spontaneous equipment failures (see Section 5.1.1).

TTRPRG is not a part of the DATAGEN sequence and must be initiated by typing "DO TTRPRG" at the dBase dot prompt. The program will issue a screen query for the following information: 1) Downtime Database name, 2) TTR Database name, 3) Equipment Type(s) to be examined, and 4) Delay Type(s) to be examined.

Section 4.3 and Table 8 contain descriptions of the TTR Database fields which are generated by TTRPRG.

4.3.6 <u>AUTOTTR Program</u>

AUTOTTR is a preprogramed series of TTRPRG runs. It is a part of the DATAGEN series; it automatically calculates TTR statistics for equipment types SH, FC, SD, SL, CR, SB, HB, BN, and for delay type G. The output of AUTOTTR is ten TTR Databases: SHTTR, FCTTR, SDTTR, SLTTR, CRTTR, SBTTR, HBTTR, BNTTR, SYTTR and GTTR. These TTR Database names are given the identification prefix entered in response to a DATAGEN screen query for a TTR and Result Database name. Each database will contain TTR statistics of the Equipment Type or Delay Type identified in its name. SYTTR contains TTR figures for the entire system; GTTR contains TTR figures for all delays of the G (geologic) Delay Type.

4.3.7 EQUIP% Program

EQUIP% calculates the percentage of all downtime which is attributable to specific Equipment Types. Unlike AUTOTTF and AUTOTTR, this program does not isolate all delays of a geologic origin. EQUIP% is used to rank equipment types according to the size of their downtime contribution. Calculations are made for the following equipment types: SH, FC, SD, SL, CR, SB, HB and BN.

Two sets of calculations are performed. The first evaluates unscheduled delays only; the second evaluates all delays. The results of these calculations are written to the Result Database created by DATAGEN at the start of the data generation sequence (see Table 9 for the Result Database field structure and content). The calculations performed using unscheduled delays are written to the Result Database fields with the extension "UNS." The calculations based upon all delays are written to the fields with the extension "ALL." Equipment Types in each case are matched by the first two characters of the field names.

4.3.8 TYPE% Program

TYPE% calculates the percentage of the total downtime which is attributable to each Delay Type. Calculations are performed for all of the nine Delay Types: C, E, EH, G, H, M, P, SA and V (see Table 3 for a description of the Delay Types). Two sets of calculations are performed: the first evaluates unscheduled delays and the second evaluates all delays. The results are written to the Result Database field whose name begins with the given Delay Type. Unscheduled delay calculations go to fields with the "UNS" extension; calculations performed upon all delays go to the fields with the "ALL" extension.

4.3.9 STATS Program

STATS calculates average values of certain production and operational statistics for each section. The following average values are calculated and written to the Result Database (field names are given in parentheses: 1) raw tons per shift (RAW_AVE), 2) clean tons per shift (CLEAN_AVE), 3) percent reject (REJECT), 4) production rate in tons per minute (PROD_RATE), 5) tons per face man shift (TON_MAN), 6) shears per shift (PASS_SFT), 7) face advance per shift (ADVAN_SFT), 8) downtime minutes per ton (DOWNPERTON), 9) production shifts per week (SFT_WEEK), 10) raw tons per week (TON_WEEK), and 11) number of face workers (WORKER_AVE). Production rate and downtime per ton are given on a raw coal basis. If only clean coal figures are available, raw coal production is estimated using a value for reject of 33%.

4.3.10 <u>SECAVAIL Program</u>

SECAVAIL calculates average equipment availability figures for each section. Calculations are made for the following Equipment Types: SH, FC, SD, SL, CR, SB, and HB. Equipment Type availabilities are written to Result Database fields beginning with the same Equipment Type code and ending with "AVAIL." Average face availability, system availability and inherent delay are calculated and written to the Result Database fields FACEAVAIL, SYAVAIL and INHERDELAY.

4.3.11 <u>MEANTIME Program</u>.

MEANTIME calculates MTTF and MTTR statistics for the eight primary Equipment Types, the G Delay Type, and for the system as a whole. MTTF and MTTR figures are calculated from the TTF and TTR statistics generated by the programs AUTOTTF and AUTOTTR. MTTF and MTTR values are written to the Result Database fields beginning with the same Equipment Type code and ending with "MTTF" or "MTTR". Mean values for the system as a whole are written to SYMTTF and SYMTTR; mean values for geologic delays are written to GTTF and GTTR.

V. STATISTICAL ANALYSIS

The two main phases of the statistical analysis are the analysis of TTF and TTR data, and the comparison of availability figures. TTF statistics reflect the reliability of the longwall system components; TTR statistics reflect the maintainability of those components. Availability figures combine reliability and maintainability and provide one measure of system performance. System performance is further evaluated with the use of statistics which measure production, production rate, productivity, rate of advance and downtime per ton.

5.1 Statistics of Study Defined

5.1.1 Time To Failure (TTF)

In this study, any event which caused the cessation of normal longwall production was classified as a "failure." Such events are commonly referred to as "delays."

Times to failure (TTF's) were measured between the ending of one delay and the start of the following delay. Two types of TTF's were calculated: active TTF's and total TTF's. Active TTF's measured the time between the onset of successive delays minus all nonproductive time during this interval. Total TTF's measured all time between successive delays excluding idle shifts, when equipment was intentionally idled and no effort was made to initiate coal production. Idle shifts included maintenance shifts, holiday periods, longwall move periods, etc. Shifts for which production records were lost were treated as idle shifts. TTF statistics represent random inter-delay periods; therefore, only unscheduled delays were considered when calculating TTF's.

Occasionally, delays were recorded which began while another delay was in progress. Such occurrences were believed to result from errors in delay recording, or planned equipment maintenance. When overlapping delays occurred, the latter delay was generally truncated in such a way as to adjust its begin time to the ending time of the previous delay. This resulted in a TTF between the two delays equal to zero. It was reasoned that spontaneous failure of longwall components would only occur while equipment was in operation. Delays which were overlapped by prior occurrences were therefore classified as non-spontaneous or secondary delays. Secondary delays were viewed as actions purposely initiated by longwall operators in an attempt to complete adjustments or repairs concurrently with a spontaneous or primary delay. TTF statistics were not calculated for secondary delays because of their dependent nature.

Some TTF calculations were biased due to the presence of delay records with no reported time of occurrence. Such records were ignored in TTF calculations. This lead to the exaggeration of some TTF figures. The statistic TTFFACTOR, recorded in the Shift Database, was created to help assess this bias. TTFFACTOR is calculated as follows:

$$TTFFACTOR = \frac{LEAV2\_SECT - ARR\_SECT - TIME\_RCP - MDELAY}{LEAV2\_SECT + TDELAY - ARR\_SECT - TIME\_RCP - MDELAY - TDEL\_BEGIN}$$

All components of this equation are Shift Database fields. TTFFACTOR is the ratio of face availability with consideration of all face delays to face availability with consideration of only those delays with a time occurrence.

5.1.2 <u>Time To Repair (TTR)</u>

Whenever a longwall delay occurred, production was halted for some period of time. In this study it was assumed that during this period repairs were in effect upon the longwall component responsible for the cessation of production. Time to repair is defined as the delay duration. TTR statistics were not calculated for secondary delays (described in Section 5.1.1).

5.1.3 Delay Time

Delay time was tabulated on a per-shift basis for the purpose of calculating shift availabilities. Apart from the nine Delay Types described in Section 3.2, delays were tabulated in three fundamental groups: 1) total system delay, 2) face delay, and 3) inherent delay. All delays, both scheduled and unscheduled, were categorized as total system delay and written to the Shift Database field TDELAY. Delays, scheduled and unscheduled, which occurred during a planned production interval were categorized as face delays and recorded in the Shift Database field MDELAY. The term "planned production interval" or PPI refers to the period beginning upon completion of the fireboss's face check and ending with the crew's departure from the face. In terms of the fields recorded in the Shift Database, the PPI can be defined as the interval (ARR_SECT + TIME_RCP, LEAV2_SECT). Scheduled delays which occurred outside of the PPI were categorized as inherent delays and recorded in the Shift Database field IDELAY.

5.1.4 Availability

Two availability figures were calculated for each shift: face availability and system availability.

The calculation of face availability was based upon the concept of "intrinsic availability". Intrinsic availability has been defined as follows (Govil, 1983):

$$A_I = \frac{\text{Operation Time}}{\text{Operation time + Active Downtime}}$$

In terms of the units described thus far, this becomes:

$$A_I = \text{face availability} = \frac{\text{PPI - MDELAY}}{\text{PPI}}$$

System availability was calculated in accordance with the concept of "operational availability." Operational availability has been defined as follows (Govil, 1983):

$$A_O = \frac{\text{Operation Time}}{\text{Operation Time + Total Downtime}}$$

in terms of the units presented thus far, this becomes:

$$A_o = \text{System Availability} = \frac{PPI - MDELAY}{PPI + IDELAY}$$

5.1.5 Productivity

The following six measures of productivity were evaluated for each longwall section: 1) tons per shift, 2) tons per man shift, 3) tons per week, 4) production rate, 5) advance per shift, and 6) passes per shift. Tons-per-shift and tons-per-week statistics were calculated on a raw-coal basis using short tons. Tons-per-man shift figures were calculated on a raw-coal, short-ton basis with only face workers considered. Production rate figures were calculated as raw short tons per minute of operational time. Advance per shift calculations were made in feet. Passes per shift figures were determined as the number of complete shears per shift, irrespective of face width.

5.2 Probability Density Functions for TTF and TTR Statistics

TTF statistics were calculated for all Downtime

Databases which contained a sufficient proportion of delay records including a time of occurrence. A proportion of less than 75% was generally considered insufficient. Several databases had a large number of untimed records for the delay event "breaking rock." Because breaking rock is of short duration and does not specifically target one of the primary Equipment Types, it was assumed that these records did not unduly bias the TTF statistics. TTR statistics were calculated for all Downtime Databases which contained a delay duration for at least 75% of all records.

Probability density functions were fit to the TTF and TTR statistics because it was felt that the mean and variance alone did not sufficiently characterize the samples. A VAX-based statistical software package, UNIFIT, was used to perform the most likely estimator (MLE) of function parameters. The distribution types exponential, gamma, lognormal, and Weibull were investigated in the attempt to find distibutions which fit the samples adequately. The goodness-of-fit between probability models and sample sets were assessed with the chi-square, Kolmogorov-Smirnov, and Anderson-Darling goodness-of-fit tests. The chi-square test was given precedent in cases where the other tests gave conflicting results.

The exponential distribution characterizes times between independent component failures. Because successive failures are independent, the failure rate remains constant with the failure occurring according to the postulates of a Poisson process (Law, 1982). Such failures are seen to occur as the result of random shocks and do not occur as a result of wear or deterioration (Mann, 1974). Some longwall equipment components may experience a constant hazard rate due to the renewal effect of preventive maintenance. The exponential distribution represents a special case of the gamma and Weibull distributions.

The gamma distribution is an extension of the exponential distribution. It can be derived by considering the time to the K^{th} successive arrival in a Poisson process or the K^{th} fold convolution of an exponential distribution (Law, 1982). Failures which can be characterized by a gamma distribution are seen as responses to shocks generated according to a Poisson distribution. In the case of the gamma distribution, it is assumed that equipment will only fail after it has received K shocks. The gamma distribution is often used to represent the time to complete some task such as a machine repair or customer service (Mann, 1974).

The Weibull distribution has become widely used in reliability studies to describe lifetimes of devices (Mann, 1974). The Weibull distribution has also been used to represent the time necessary to complete some task (Law, 1982). The density takes on shapes similar to gamma densities. Whereas the exponential distribution always has a constant hazard rate, the Weibull distribution can be written to include an increasing or decreasing hazard rate. Since many failures encountered in practice, especially those pertaining to non-electronic components, are characterized by an increasing failure rate (due to deterioration or wear), the Weibull distribution is useful for describing failures of this type.

The lognormal distribution is used to represent quantities which are the products of a large number of other quantities, e.g., measurement errors. The lognormal distribution has been also been used to represent the time necessary to accomplish some task (Law, 1982). The density takes on shapes similar to the gamma (α, β) densities for $\alpha > 1$. The hazard rate of the lognormal distribution as a function of time is an increasing function followed by a decreasing function.

5.2.1 TTF Probability Density Functions

TTF statistics were calculated for the following twelve longwall sections: 20, 22, 24, 25, 26, 27, 30, 31, 32, 33, 34, and 35. Mean time to failure (MTTF) for each of the primary Equipment Types is presented in Table 10. This table includes data for the twelve sections mentioned above. Figure 6 shows the average values of MTTF for the primary Equipment Types at the twelve sections. Probability density functions were fit to the TTF statistics of the following six data sets, which contained sufficient data: 20, 22, 25, 26, 27 and 31. For the purpose of fitting probability density functions to TTF and TTR statistics, the following major Equipment Types and Delay Type were considered: 1) shearer (SH), 2) face conveyor (FC), 3) stageloader + crusher + section belt + mains belt (HAUL), 4) shields & hydraulic pumps (SD), 5) geologic delays (G), and 6) whole system (SY). This grouping of Equipment Types was chosen for its compatibility with previously developed simulation models and analytical models. Geologically induced delays were separated from all of the Equipment Types in order that the true character of purely equipment-related failures could be exposed. Geologic delays were effectively treated as a separate Equipment Type. The parameters of the best-fit probability density functions for the TTF statistics are presented in Appendix IV.

The probability density functions which provided the "best fit" to the data came from all of the four

Table 10. Mean time to failure (MTTF) of primary Equipment Types: values for 12 selected longwall sections.

SECT.	SH	FC	SD	SL	CR	SB	HB	BN	SYST.
20	213	833	1,917	2,304	--	3,387	1,334	663	84
22	919	2,855	1,418	4,391	--	37,602	1,475	36,128	555
24	1,068	24,633	7,505	4,252	7,705	1,043	176	15,192	99
25	1,311	1,311	3,749	3,644	3,950	752	652	6,245	148
26	164	271	251	2,459	12,968	553	307	9,115	38
27	127	524	349	1,949	6,300	434	316	10,398	30
30	1,415	19,501	3,399	491	2,119	2,738	1,247	293	159
31	767	1,825	2,107	3,440	--	881	1,287	15,947	150
32	3,615	1,592	3,824	9,932	--	3,711	3,976	1,409	311
33	1,598	4,830	4,416	2,976	5,827	2,144	3,816	906	242
34	1,494	2,287	--	3,538	--	3,211	3,568	845	219
35	895	1,652	19,177	13,534	10,482	3,268	1,592	--	282

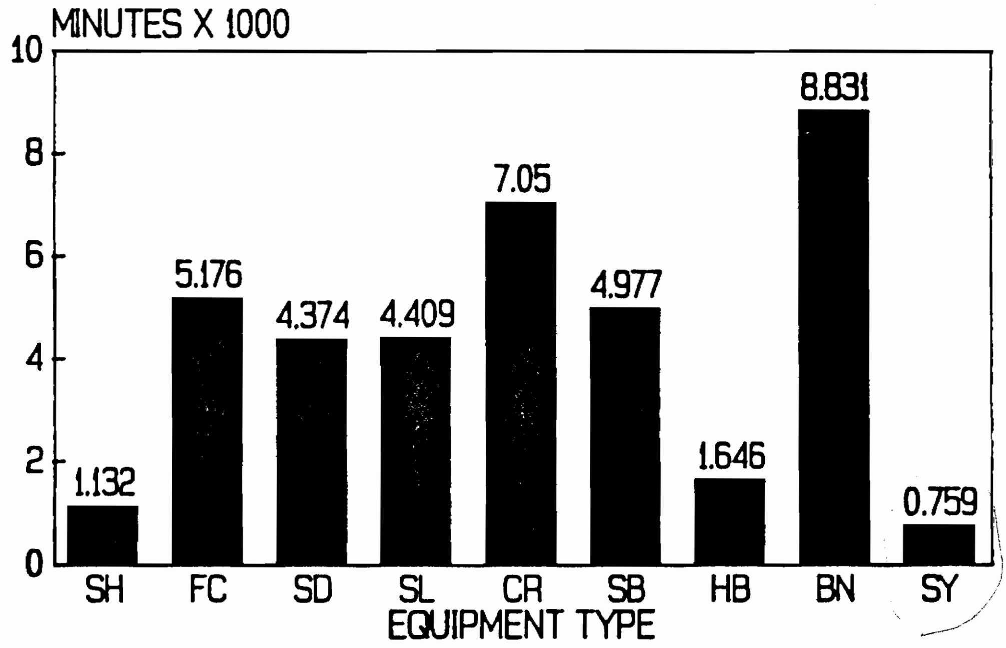

Figure 6. Mean time to failure (MTTF) of primary Equipment Types: average values for 12 selected longwall sections.

distribution families examined. The Weibull density function provided the most best-fits to the TTF data, with eighteen fits. Because the Weibull density is the most adequate for representing failure times influenced by wear and deterioration, this seemed reasonable. Lognormal density functions were the second most prevalent density type, with sixteen best-fits. Because longwall equipment failures result from the failure of any one of many assemblies, subassemblies and components, this also seemed reasonable. Eleven best-fit density functions were found of the gamma type, and three were found of the exponential type.

5.2.2 TTR Probability and Density Functions

TTR statistics were calculated for the primary Equipment Types at the twelve longwall sections used for TTF calculations. Mean time to repair (MTTR) of the eight primary Equipment Types are presented in Table 11. This table includes data for the twelve sections. Figure 7 shows the average values of MTTR for the primary Equipment Types at the twelve sections. Probability density functions were fit to the TTR statistics from the following six data sets: 20, 22, 25, 26, 27 and 31. The parameters of the best-fit probability density functions for the TTR statistics are presented in Appendix IV.

Table 11. Mean time to repair (MTTR) of primary Equipment Types: values for 12 selected longwall sections.

SECT.	SH	FC	SD	SL	CR	SB	HB	BN	SYSTEM
20	60	49	34	44	--	35	30	31	47
22	45	52	47	33	--	30	32	37	51
24	54	93	76	46	90	78	58	264	60
25	76	92	49	54	70	54	53	61	63
26	27	16	12	50	16	16	14	27	19
27	20	27	9	45	7	13	10	23	13
30	30	20	26	68	56	36	41	23	29
31	97	57	25	25	--	28	29	20	55
32	71	83	38	90	--	70	57	57	66
33	67	73	28	50	29	46	32	35	39
34	47	68	--	45	--	31	35	32	39
35	58	48	29	38	53	53	39	--	59

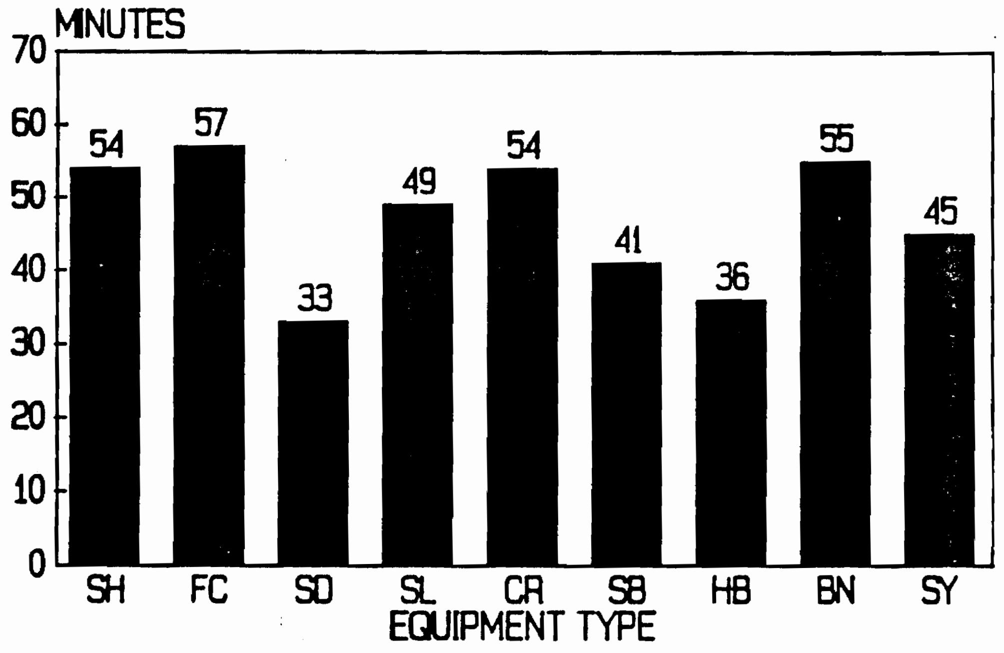

Figure 7. Mean time to repair (MTTR) of primary Equipment Types: average values for twelve selected longwall sections.

Forty-one of the best-fit density functions for TTR statistics were found to be of the lognormal family. This seemed reasonable because lognormal density functions are most commonly used to represent the time to perform some task, e.g., a machine repair. Only four gamma densities were found which provided the best fit to TTR data. No Weibull densities were found which provided the best fit to TTR statistics.

5.3 Availability

Two measures of availability were used: face availability (intrinsic availability) and system availability (operational availability). The method used for calculating these availabilities is described in Section 5.1.

Face availabilities were calculated so that deficiencies in the performance of face equipment and in face organization could be identified. Face availabilities were subdivided with the calculations of the intrinsic availability of the major Equipment Types SH, FC, SD, SL, CR, SB, HB and BN. The relative performance of these major Equipment Types were evaluated with the calculations of the share of overall downtime contributed by each Equipment Type. These calculations were made on an unscheduled-delays basis, and also on an all-delays basis.

System availabilities were calculated as a measure of comparison of the overall performance of the longwall sections. System availability reflects face-equipment performance, face-organizational efficiency, and overall operational efficiency. The differences between face availability and system availability were the result of inherent system delays. Inherent system delay time was tabulated for each longwall section. Inherent delays constitute such items as travel time, lunch time, face checks, and safety and production talks.

Availability calculations were made for the twelve longwall sections with adequate downtime records. Availabilities could only be calculated if all shift time was accounted for, including production time, production delay time, and inherent delay time.

5.3.1 System Availability

The system availabilities of the twelve sections analyzed ranged from a low of 47.7% at mine #20 to a high of 72.4% at mine #30. The average system availability of the twelve sections analyzed was 59.0%. Figure 8 displays the system availability of each of the twelve sections. Figure 9 presents all system delays ranked by Delay Type.

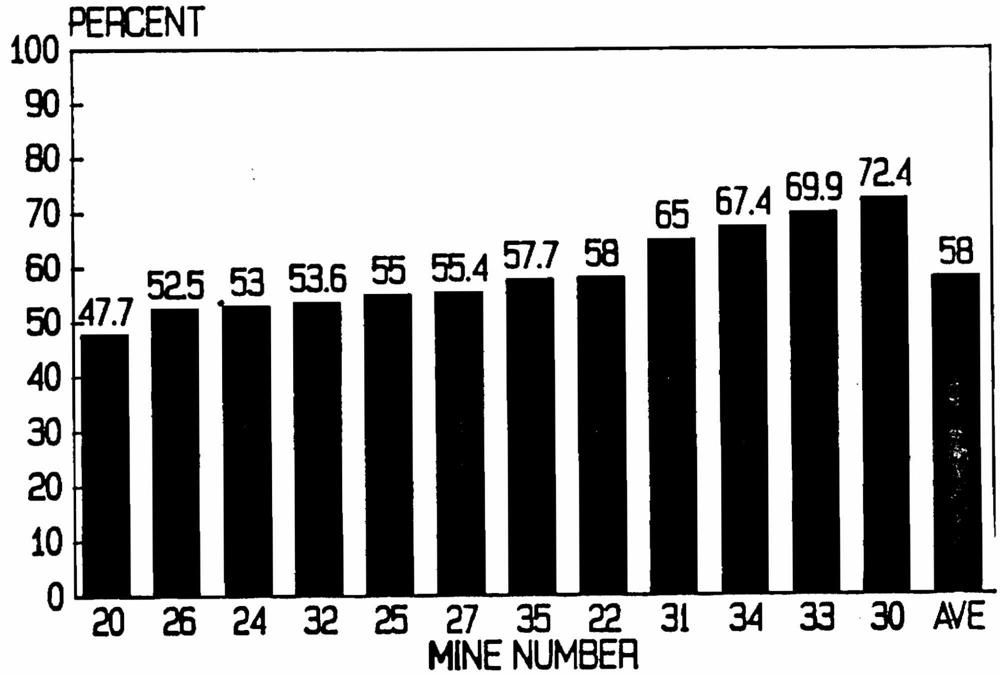

Figure 8. System availability of 12 selected longwall sections.

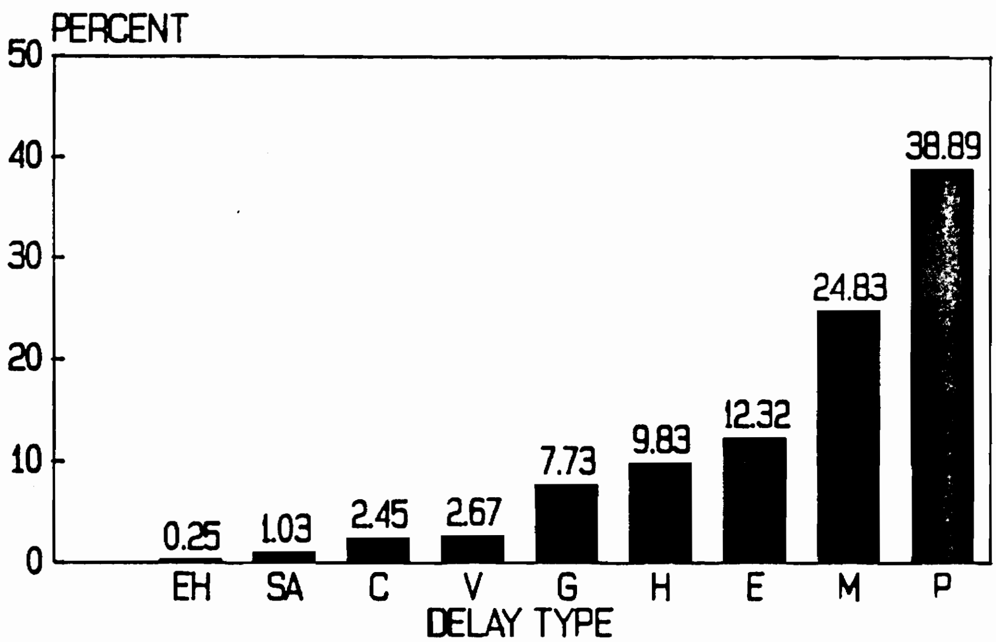

Figure 9. Downtime ranked by Delay Type: all delays averaged for 12 selected longwall sections.

5.3.2 Face Availability

Face availability ranged from a low of 51.8% at longwall section #20 to a high of 83.0% at section #30. The average face availability of the twelve sections analyzed was 67.5%. Figure 10. displays the face availabilities of each of the twelve sections. Unscheduled face delays were ranked by Delay Type and are presented in Figure 11.

The availabilities calculated in this study were roughly equivalent to many previously calculated availability figures (Curry, 1976; Pimentel, 1981; Topuz, 1982; Lee, 1983). This occurred despite the fact that longwall equipment has shown much improvement in reliability in recent years (Carr, 1988; Combs, 1988). It is believed that many previous availability figures were inflated. Availability figures are often calculated based solely upon MTTF and MTTR statistics. Often MTTF and MTTR statistics are available for major equipment failures only and are not available for the myriad minor production stoppages which are common on longwall faces. This bias leads to exaggerated availability figures. In other cases, availability calculations may be based upon an incomplete record of production delays. If the production delay record fails to note minor delays (e.g., breaking of draw rock) or fails to note unscheduled delays (e.g., checking

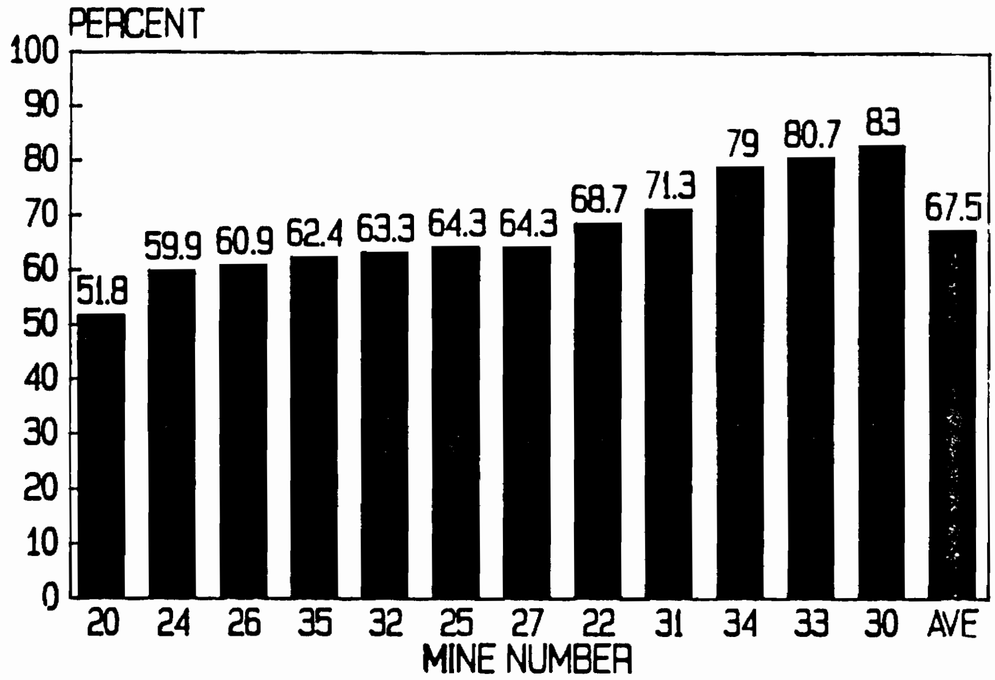

Figure 10. Face availability of 12 selected longwall sections.

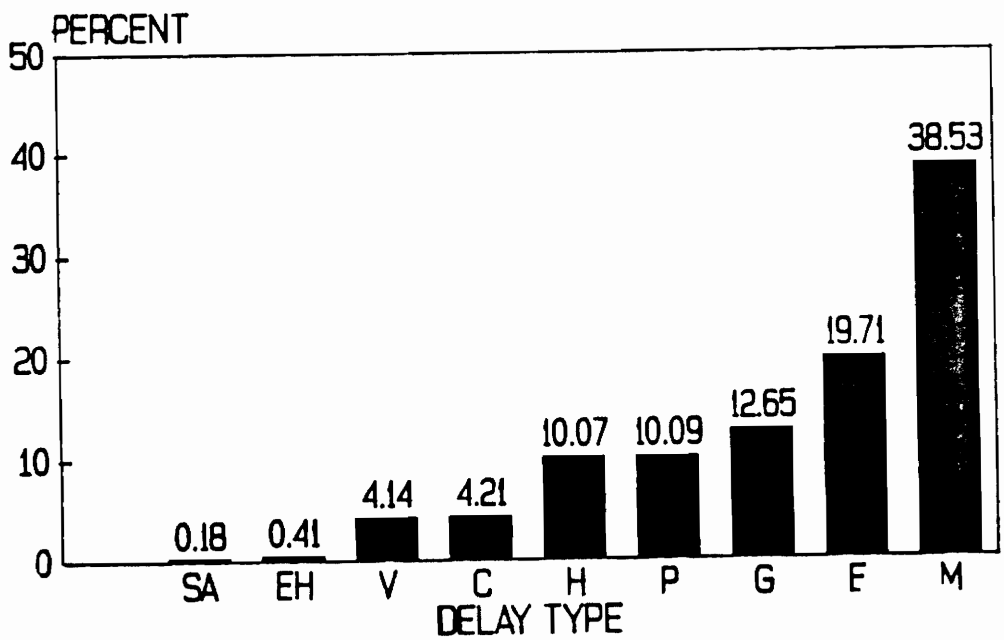

Figure 11. Downtime ranked by Delay Type: unscheduled delays averaged for 12 selected longwall sections.

shearer oil levels), availability figures will be exaggerated. Sometimes production delays will be faithfully reported, but the duration of delays are intermittently omitted. This would also lead to an exaggeration of availability figures.

Care was taken in this analysis to calculate availability figures for those sections that appeared to faithfully report production delays which were both scheduled and unscheduled, regardless of the magnitude of the delays. Despite this attention, the quality of the delay data was not uniform. A few sections were thorough to the extent of reporting numerous delays of less than five minutes in duration. A rating factor was established for comparing the quality and thoroughness of the delay reporting. Quality was based upon the fraction of delay incidents with recorded durations and the number of delays reported per shift. The quality of a database was rated between 0 and 100 and recorded in the Result Database field DATAQUAL. DATAQUAL was assessed in the following way:

DATAQUAL = 100 * ((Factor1 / 2 + Factor2 / 2))

where:

Factor1 = the fraction of delay records with a reported duration.

Factor2 = 0.25 when the average number of delays per shift < 2

= 0.50 when the average number of delays per shift < 3

= 0.75 when the average number of delays per shift < 4

= 1.00 when the average number of delays per shift >= 4

5.3.3 Inherent Delay

The discrepancy between face availability and system availability is due to inherent delays (also refered to as organizational delays.) Inherent delays included were such items as travel time, lunch time, and time spent on safety checks, production meetings and face checks. Inherent delay times ranged from a low of 36 minutes per production shift at mine #20 to a high of 68 minutes per shift at mine #22. The average inherent delay time among the twelve sections analyzed was 53.5 minutes per shift. Figure 12 displays the inherent delay time for the twelve sections.

The range of inherent delay time was due to the practice at certain mines of changing-out production crews

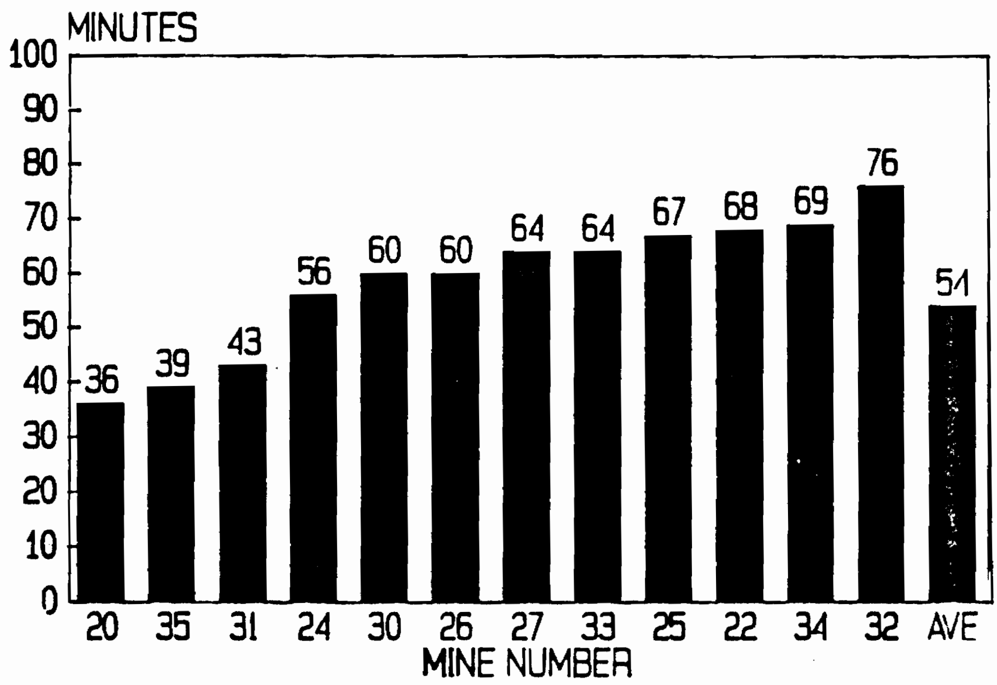

Figure 12. Inherent delay time of 12 selected longwall sections.

at the face. Such "hot change-outs" eliminated most, if not all, of the idle time between shifts as well as contributing to communication between shifts. Communication of equipment behavior and special face conditions can be a factor in reducing production-shift delays. The practice of staggering lunch breaks also reduced inherent delay time at certain mines.

Inherent delay time was a very significant factor in determining system availability. If all inherent delays were eliminated at an average section, system availability would rise from 59% to 70%. In this calculation, only inherent delay time associated directly with production shifts was considered; this ignores idle weekend shifts, a significant source of inherent delay time. None of the sections in this study had regularly scheduled Sunday shifts, and only ten sections had production shifts on Saturdays. Most of the sections with Saturday production shifts worked only sporadically. Regularly scheduled production shifts on Saturdays and Sundays would increase the amount of available time by 26% on average. Assuming the same average system availability on weekends as on weekdays, equipment utilization would increase by 15.5% on average. Table 12 shows the available time which is lost through travel time, lunch time, and idle weekend shifts at four selected longwall sections.

Table 12. Available time lost to inherent delay: values for four selected longwall sections.

SECT.	Crew Change Out	Lunch	Idle Saturdays	Total
19	14.6 %	2.8 %	14.3 %	31.7 %
20	6.0 %	0.0 %	14.3 %	20.3 %
31	8.1 %	0.0 %	10.5 %	18.6 %
32	14.8 %	0.0 %	14.3 %	29.1 %

5.3.4 <u>Equipment Availability</u>

Availability figures were calculated for the eight primary Equipment Types: SH, FC, SD, SL, CR, SB, HB and BN. Calculations were made for the same twelve longwall sections analyzed in the previous sections describing face availability and system availability.

The components of a longwall system are serially connected. A delay affecting one component in the system causes the entire system to come to a halt. It follows that the availability of a longwall system is equal to the product of the availabilities of its constituent components. The system availability of any longwall section in this study is the product of the availabilities of the twenty-two Equipment Types. Face availability is equal to the product of the availabilities of the nineteen Equipment Types which are directly related to production (Equipment Types PD, MT, SA, and Delay Event FA 225 are not directly involved in production). The eight Equipment Types for which availabilities were calculated represent the major equipment components of the production-equipment group.

Table 13 gives the availability figures for the eight primary Equipment Types for each of the twelve sections. Table 14 gives the low, high and average availability

Table 13. Availability of the primary Equipment Types: for 12 selected longwall sections.

SECT.	SH	FC	SD	SL	CR	SB	HB	BN
20	76.7%	94.8%	97.9%	98.6%	100%	99.2%	98.3%	97.1%
22	95.7%	98.6%	97.8%	99.7%	99.9%	96.9%	98.1%	97.5%
24	96.4%	99.5%	98.6%	99.3%	99.4%	95.2%	76.7%	99.0%
25	93.9%	94.6%	98.1%	98.9%	98.9%	94.4%	93.2%	99.3%
26	83.6%	95.3%	96.2%	98.1%	99.9%	97.9%	96.7%	99.8%
27	82.9%	95.8%	98.1%	97.5%	99.9%	97.6%	97.6%	99.9%
30	97.6%	99.9%	99.4%	99.9%	99.9%	98.7%	97.1%	93.0%
31	89.5%	98.3%	99.1%	99.6%	100%	97.8%	98.5%	99.9%
32	97.2%	94.0%	99.4%	99.3%	99.8%	97.2%	97.1%	92.2%
33	99.7%	98.8%	99.5%	99.1%	99.8%	96.8%	99.2%	96.0%
34	93.5%	97.8%	100%	99.3%	100%	98.5%	97.9%	96.6%
35	86.4%	96.6%	99.8%	99.7%	99.4%	98.2%	97.4%	100%

Table 14. Availability of the primary Equipment Types: low, high and average values for 12 selected longwall sections.

	SH	FC	SD	SL	CR	SB	HB	BN
LOW	76.7%	94.0%	96.2%	97.5%	98.9%	94.4%	76.7%	92.2%
HIGH	99.6%	99.9%	99.9%	98.8%	100%	99.2%	99.2%	100%
AVE.	91.1%	97.0%	98.7%	99.1%	99.7%	95.7%	95.7%	97.5%

values for each of the eight primary Equipment Types. The same information is shown in the form of a graph in Figure 13. Shearers had the lowest average availability while crushers had the highest. The share of total downtime contributed by each of the eight major Equipment Types is shown graphically in Figure 14. These are average figures for the twelve mines. This figure provides an indication of the relative importance of the primary Equipment Types, secondary Equipment Types (OTHER), and inherent delays as targets for increased availability. Figure 15 shows the share of unscheduled downtime provided by the major Equipment Types and the secondary Equipment Types (OTHER). This figure shows more clearly the relative availability of the primary Equipment Types without taking into account the effect of inherent delays.

The delays of the primary Equipment Types were ranked by Delay Type. Calculations performed on an all-delays basis are presented in Figures 16a through 23a. Calculations performed on an unscheduled delays basis are presented in Figures 16b through 23b. Figures represent average values for the twelve sections included in the availability analysis. Among all delays preparatory delays were the most common, followed by mechanical delays and then electrical delays. Among unscheduled delays, mechanical delays were most frequent, followed by

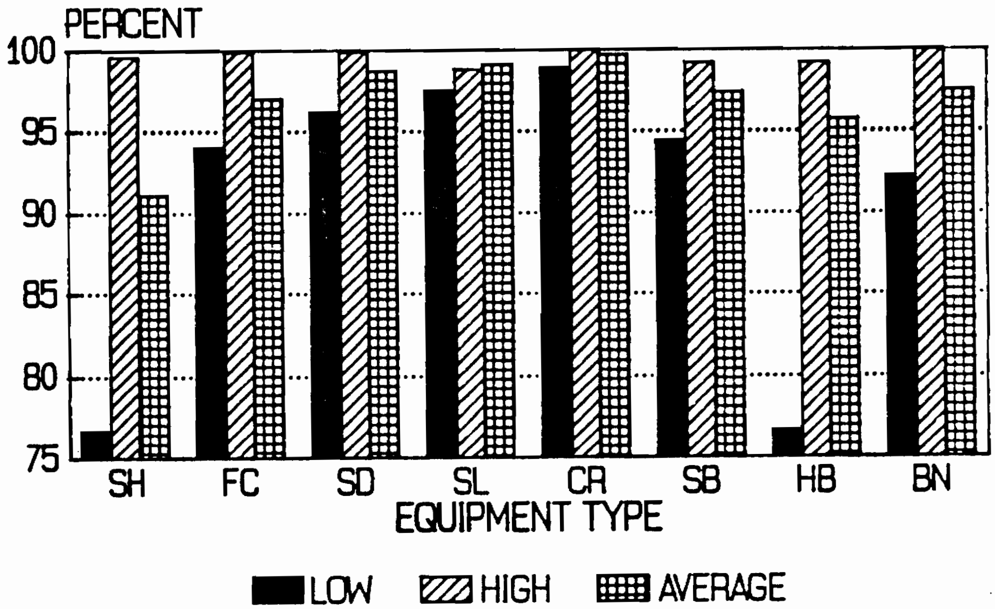

Figure 13. Availability of the primary Equipment Types: low, high, and average availability of 12 selected longwall sections.

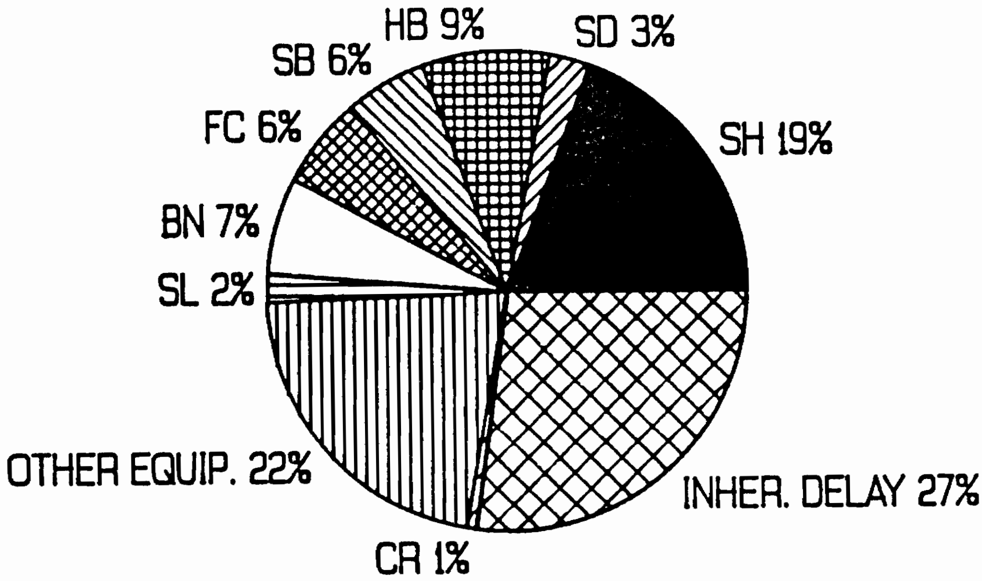

Figure 14. Downtime ranked by Equipment Type: scheduled and unscheduled delays averaged for 12 selected longwall sections.

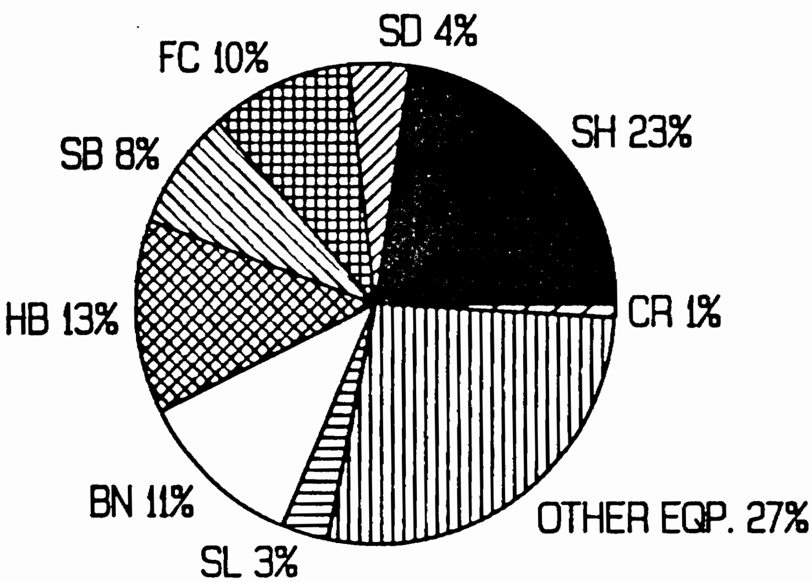

Figure 15. Downtime ranked by Equipment Type: unscheduled delays averaged for 12 selected longwall sections.

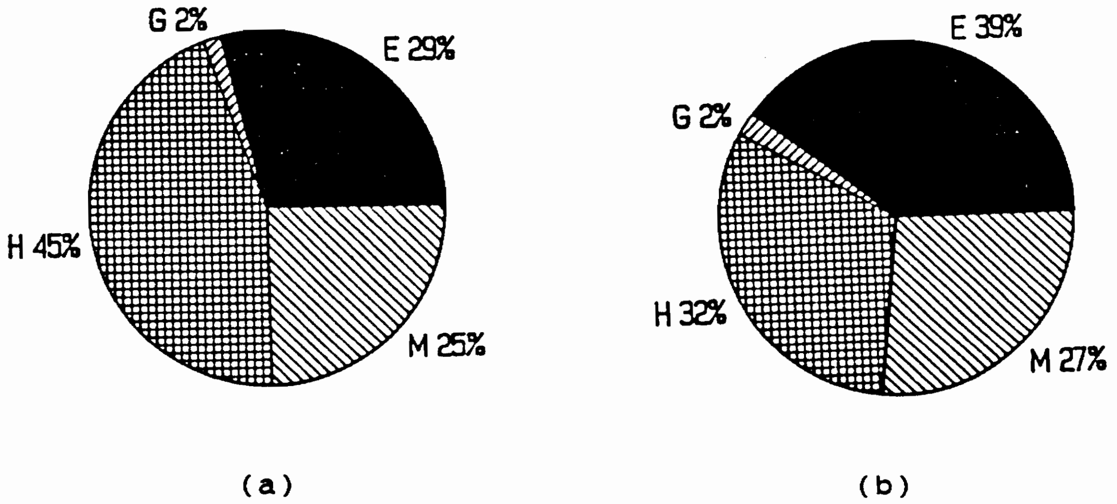

Figure 16. Shearer downtime ranked by Delay Type: average values for 12 selected longwall sections; a) all delays, b) unscheduled delays.

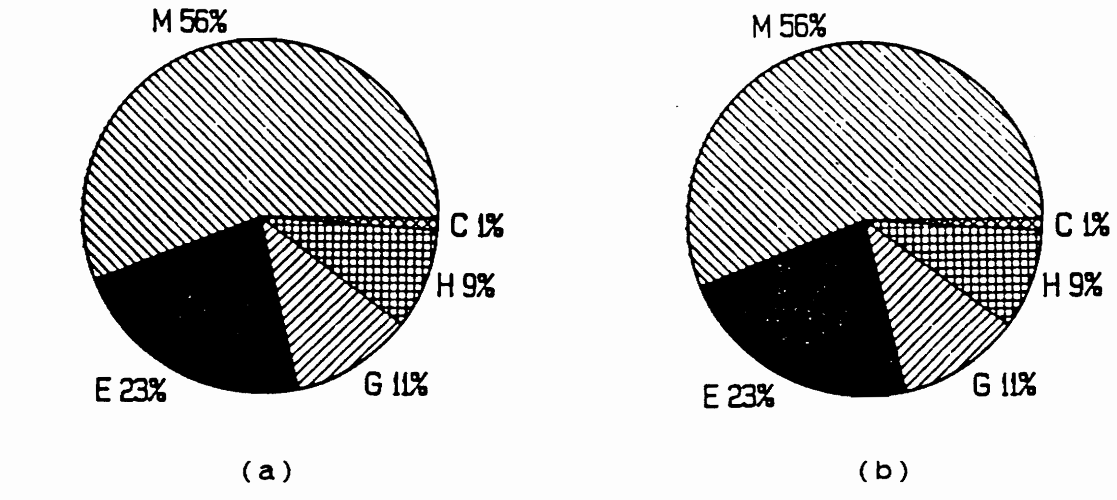

Figure 17. Face conveyor downtime ranked by Delay Type: average values for 12 selected longwall sections; a) all delays, b) unscheduled delays.

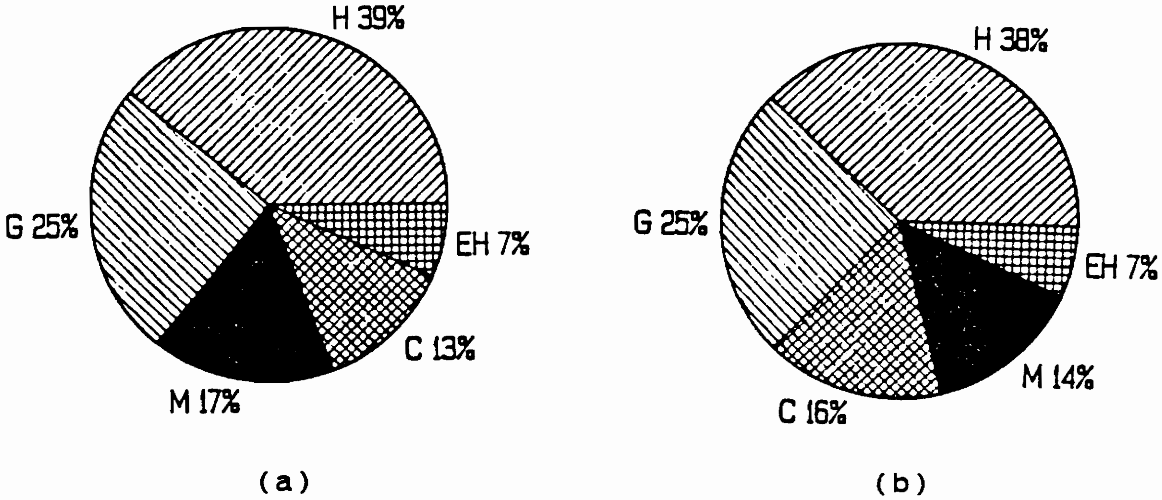

Figure 18. Shield downtime ranked by Delay Type: average values for 12 selected longwall sections; a) all delays, b) unscheduled delays.

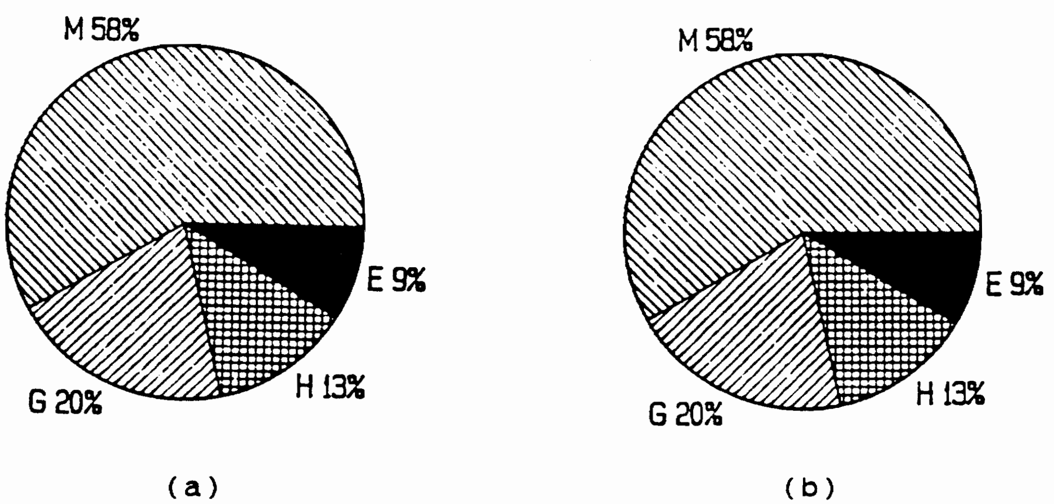

Figure 19. Stage loader downtime ranked by Delay Type: average values for 12 selected longwall sections; a) all delays, b) unscheduled delays.

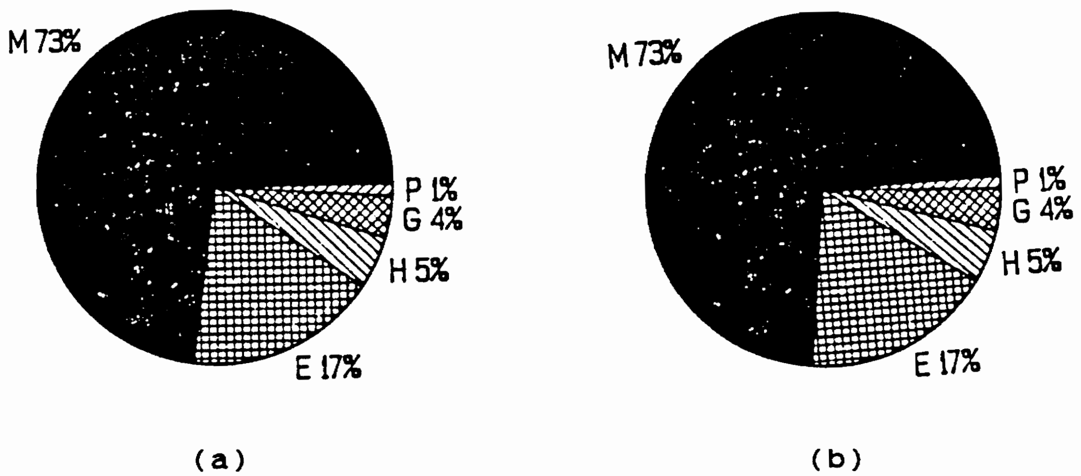

Figure 20. Crusher downtime ranked by Delay Type: average values for 12 selected longwall sections; a) all delays, b) unscheduled delays.

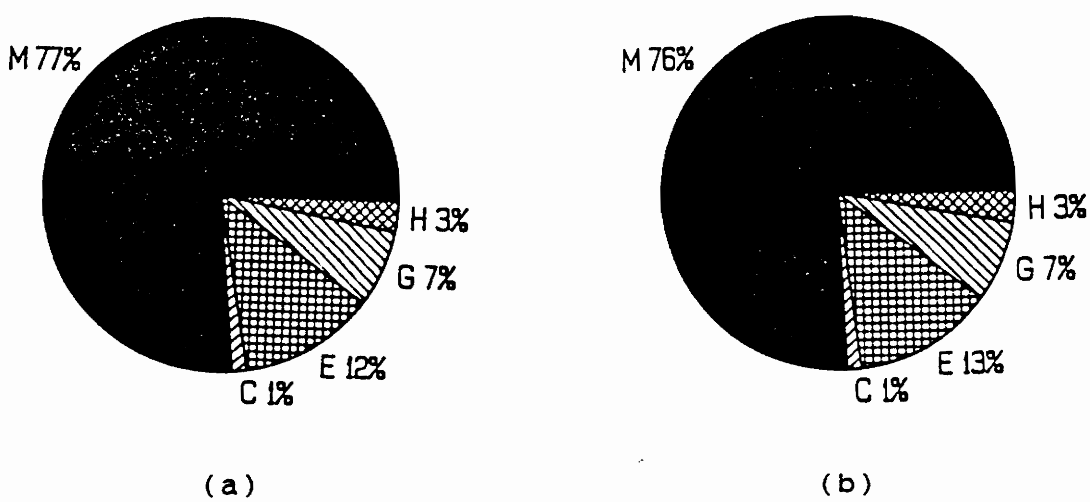

Figure 21. Section-belt downtime ranked by Delay Type: average values for 12 selected longwall sections; a) all delays, b) unscheduled delays.

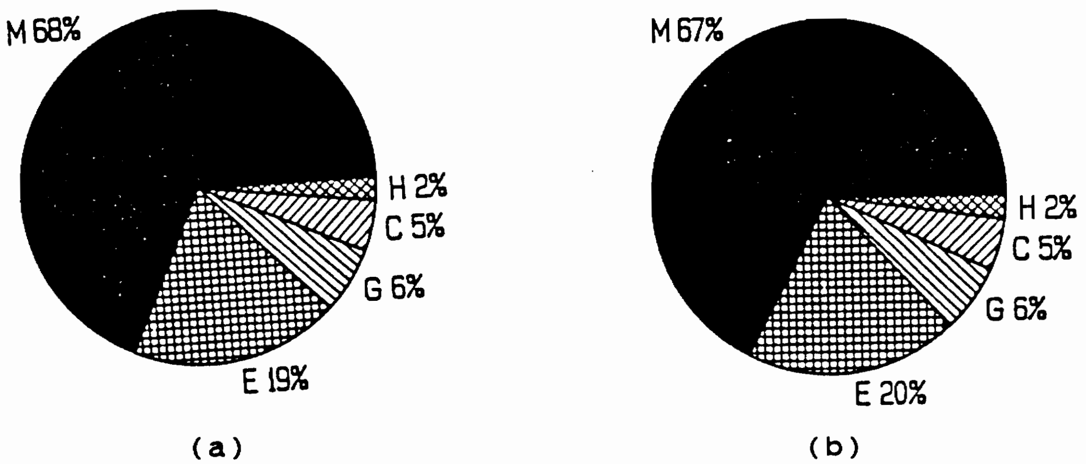

Figure 22. Haulage-belt downtime ranked by Delay Type: average values for 12 selected longwall sections; a) all delays, b) unscheduled delays.

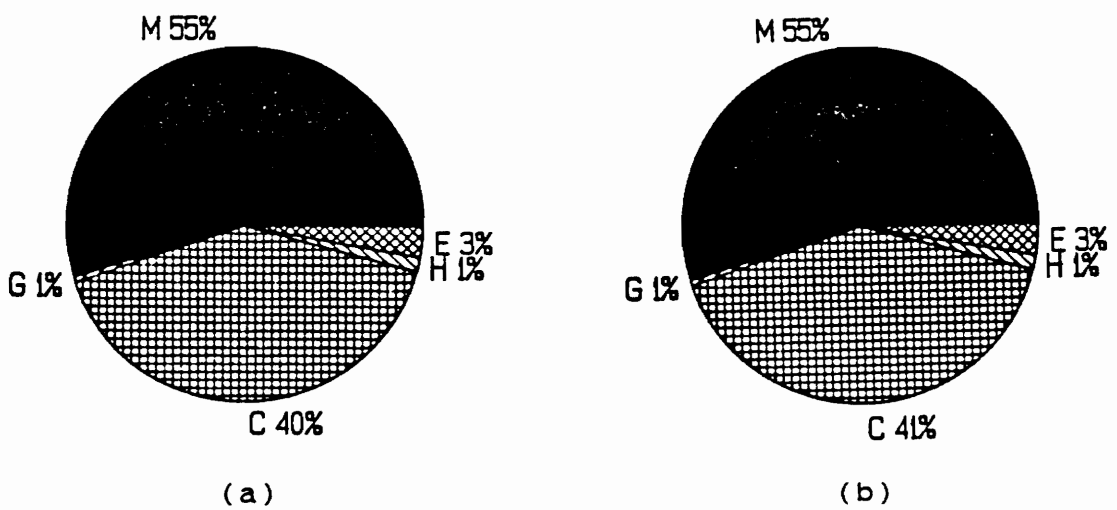

Figure 23. Bin downtime ranked by Delay Type: average values for 12 selected longwall sections; a) all delays, b) unscheduled delays.

electrical delays. In both cases ventilation, safety and electrohydraulic delays were generally the rarest. Ventilation and safety delays may have gone unreported because of their short durations. Electrohydraulic failures, particular those involving shield controls, may have gone unreported because they often do not entirely disable the equipment.

The five most time-consuming Delay Events were identified for each of the eight major Equipment Types; these are given in Tables 15 through 22.

5.4 Performance Indicators

The following performance indicators were calculated for the twelve sections included in the availability analysis: 1) tons per shift (raw; short tons), 2) tons per week, 3) production rate (raw; short tons/operative min.), 4) production per face man (raw; short tons), 5) shears per shift, 6) shifts per week, and 7) downtime per ton. Table 23 gives the values for the seven perfomance indicators at the twelve mines. Table 24 gives the low, high and average values of the seven performance indicators. A complete set of performance indicators was available for only ten out of the twelve sections due to an absence of production data for sections #32 and #34.

Table 15. Major sources of shearer downtime.

DELAY TYPE	DELAY CODE	DELAY DESCRIPTION	% OF TOTAL SH DOWNTIME
E	004	CABLE CONNECTIONS AND SPLICES	5.0 %
E	002	CUTTER DRIVE ELECTRICAL PROBLEM	4.2 %
E	003	WIRE, FUSE, OR CIRCUIT	3.6 %
H	111	ADD GEAR OIL OR HYD. FLUID	20.3 %
H	112	ADJUST WATER SPRAYS	3.7 %
H	100	REPLACE HYD. HOSE OR FITTING	3.3 %
H	101	REPLACE WATER HOSE OR FITTING	3.3 %
H	115	PROBLEM WITH HYD. HAULAGE DRIVE	3.1 %
M	066/067	CHANGE CUTTING BITS	5.1 %
M	059	BRETBY BROKE OR IN PANLINE	2.5 %
M	072	HAULAGE SPROCKET OR HAULAGE TRACK	2.4 %
M	056	COWL OR COWL ARM LOOSE	1.9 %
		TOTAL	58.4 %

Table 16. Major sources of face conveyor downtime.

DELAY TYPE	DELAY CODE	DELAY DESCRIPTION	% OF TOTAL FC DOWNTIME
E	003	GROUND FAULT, WIRE, FUSE, CIRCUIT	8.1 %
E	004	CABLE CONNECTION AND SPLICES	3.4 %
E	014	ELECTRICAL PROBLEM WITH DRIVE MOTOR	3.6 %
G	166	BREAK DRAW ROCK IN PAN	5.7 %
H	109	TORQUE CONVERTER SOFT PLUGS, SPEED RED.	7.9 %
M	053	BROKEN OR HUNG CHAIN	29.3 %
M	074	DOG BONE BROKE, WELD PAN	9.5 %
M	055	BROKEN OR HUNG FLIGHT	2.8 %
		TOTAL	70.3 %

Table 17. Major sources of shield downtime.

DELAY TYPE	DELAY CODE	DELAY DESCRIPTION	% OF TOTAL SD DOWNTIME
C	200	WAIT ON SHIELDS,CYCLE TIME SLOW	12.1 %
EH	450	EH SHIELD CONTROL OR COMPUTER PROBLEM	5.5 %
G	159	CLEAN DRAW ROCK OFF SHIELDS	19.6 %
G	153	SOFT BOTTOM, SHIELDS PLOWING	2.1 %
H	100	REPLACE HYDRAULIC HOSE	16.1 %
H	102	HYD. PRESSURE LOW	13.2 %
H	106	HYD. PROBLEM WITH LEG RAM	2.5 %
H	105	HYD. PROBLEM WITH PUSH RAM	2.0 %
M	069	MECH. PROB. WITH RAM, CANOPY, GOB SHIELD	9.6 %
M	068	CLEVIS, RELAY BAR, WELD BASE LIFT JACK	3.4 %
		TOTAL	86.1 %

Table 18. Major sources of stageloader downtime.

DELAY TYPE	DELAY CODE	DELAY DESCRIPTION	% OF TOTAL SL DOWNTIME
G	166	DRAW ROCK CAUGHT IN PAN	12.9 %
G	151	GOBBED OUT, HUNG WON'T PUSH	5.1 %
H	109	TORQUE CONVERTER SOFT PLUGS BLOWN	9.9 %
M	054	CHAIN HUNG	14.4 %
M	053	CHAIN BROKEN	9.1 %
M	055	REPLACE BROKEN FLIGHT	6.2 %
M	052	TENSION CHAIN	5.8 %
M	058	WELD SPILL TRAY, GUARD OR SCRAPER	5.7 %
M	061	REPLACE BEARINGS OR BUSHING	4.6 %
		TOTAL	73.7 %

Table 19. Major sources of crusher downtime.

DELAY TYPE	DELAY CODE	DELAY DESCRIPTION	% OF TOTAL CR DOWNTIME
E	014	PROBLEM WITH DRIVE MOTOR	4.5 %
E	005	REPLACE BREAKER	3.6 %
E	008	OVERLOAD, RESET BREAKER	3.0 %
M	076	REPLACE IMPACTOR	24.8 %
M	050	ADJUST OR REPLACE DRIVE BELT	12.4 %
M	061	REPLACE BEARINGS OR BUSHING	6.6 %
M	071	TIGHTEN OR REPLACE BOLTS	5.0 %
		TOTAL	59.9 %

Table 20. Major sources of section belt downtime.

DELAY TYPE	DELAY CODE	DELAY DESCRIPTION	% OF TOTAL SB DOWNTIME
C	202	SPILLAGE	1.1 %
E	014	PROB. WITH DRIVE MOTOR	2.8 %
E	003	GROUND FAULT, WIRE, FUSE, CIRCUIT	2.3 %
G	151	GOBBED OUT, HUNG WON'T PUSH	3.3 %
G	166	ROCK CAUGHT IN TAILPIECE	1.5 %
M	050	SPLICE BELT	21.7 %
M	080	MECH. PROB. WITH TAILPIECE	16.2 %
M	062	ALIGN TAILPIECE	6.3 %
M	063	REMOVE BELT AND BELT STRUCTURE	4.4 %
M	082	PROB. WITH FRICTION DRIVE	2.8 %
M	061	REPLACE BEARINGS OR BUSHING	1.9 %
M	058	WELD SPILL TRAY, GUARD, SCRAPER	1.6 %
M	079	REPLACE ROLLERS	1.4 %
		TOTAL	67.3 %

Table 21. Major sources of haulage belt downtime.

DELAY TYPE	DELAY CODE	DELAY DESCRIPTION	% OF TOTAL HB DOWNTIME
C	202	SPILLAGE	2.1 %
E	005	REPLACE BREAKER	3.4 %
E	014	PROB. WITH DRIVE MOTOR	1.4 %
E	003	GROUND FAULT, FUSE, WIRE, CIRCUIT	1.2 %
G	151	GOBBED OUT	2.3 %
M	050	SPLICE BELT	22.6 %
M	062	ALIGN TAILPIECE	2.2 %
M	079	REPLACE ROLLERS	2.0 %
M	061	REPLACE BEARING OR BUSHING	1.5 %
		TOTAL	38.7 %

Table 22. Major sources of bin downtime.

DELAY TYPE	DELAY CODE	DELAY DESCRIPTION	% OF TOTAL BN DOWNTIME
C	201	UNDERCAPACITY	39.4 %
E	014	ELECT. PROB. WITH BIN FEEDER	2.6 %
M	065	MECH. PROB. WITH BIN FEED,SKIP,TIPPLE	48.7 %
M	058	WELD SPILL TRAY, GUARD, SCRAPER	1.5 %
		TOTAL	92.2 %

Table 23. Performance Indicators: values for 12 selected longwall sections.

SECT.	TON/SFT (ST)	TON/WK (ST)	PROD RATE (ST/MIN.)	TON/MAN (ST)	PASS/SFT	SFT/WK	DELAY/TON (MIN./ST)
20	1,377	19,691	6.37	378	NA	14.3	0.481
22	2,393	34,452	8.58	328	NA	14.4	0.171
24	2,060	33,372	9.74	210	4.2	16.2	0.158
25	2,627	39,668	9.61	284	3.8	15.1	0.117
26	1,588	25,408	6.91	132	4.7	16.0	0.146
27	1,797	27,674	6.89	180	5.2	15.4	0.114
30	4,885	87,442	14.44	556	4.6	17.9	0.024
31	1,058	16,716	3.35	96	8.3	15.8	0.230
32	NA	NA	NA	NA	5.2	13.8	NA
33	2,337	35,522	7.31	194	7.1	15.2	0.046
34	NA	NA	NA	NA	8.1	14.9	NA
35	2,244	33,436	12.79	281	8.2	14.9	0.131

Table 24. Performance Indicators: low, high, and average values for 12 selected longwall sections.

	TON/SFT (ST)	TON/WK (ST)	PROD RATE (ST/MIN.)	TON/MAN (ST)	PASS/SFT	SFT/WK	DELAY/TON (MIN./ST)
LOW	1,058	16,716	3.35	96	3.8	13.8	0.024
HIGH	4,885	87,442	14.44	556	8.3	17.9	0.481
AVE.	2,237	35,338	8.90	264	5.9	15.3	0.162

A strong negative correlation was found between downtime per ton and tons per shift. A strong positive correlation was found between production rate and tons per shift. Figure 24 is a plot of downtime-per-ton rank (ranked from lowest to highest, 1-10) versus tons-per-shift rank (ranked from highest to lowest, 1-10). Figure 25 is a plot of production-rate rank (ranked highest to lowest, 1-10) versus tons-per-shift rank (ranked from highest to lowest, 1-10). Perfect correlation would occur if all points lay on a 45-degree line through the origin.

A previous study found production to be more sensitive to changes in downtime per ton than to changes in production rate (Pimentel, 1981). In this study the reverse was found to be true. Production was found to be three times as sensitive to production rate as it was to downtime per ton. Figure 26 is a plot of downtime-per-ton values versus tons-per-shift values. Figure 27 is a plot of production rate versus tons-per-shift values. From these plots it was determined that a decrease in the average downtime per ton of 50% would lead to an increase of 17.1% in production. Similarly, an increase in the average production rate of 50% would lead to a 52.1% increase in tons per shift. The fact that this value is greater than 50% points out that there are other dependent

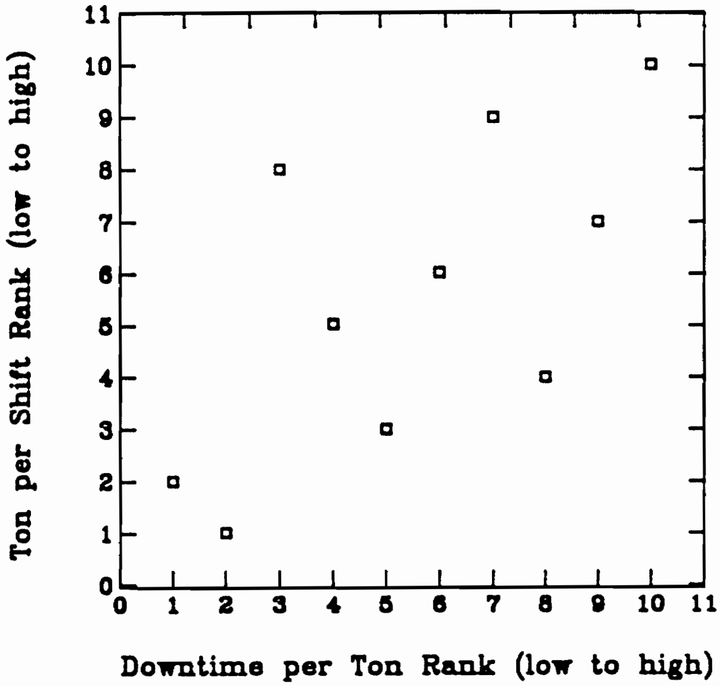

Figure 24. Scatter plot showing correlation between tons per shift and downtime per ton.

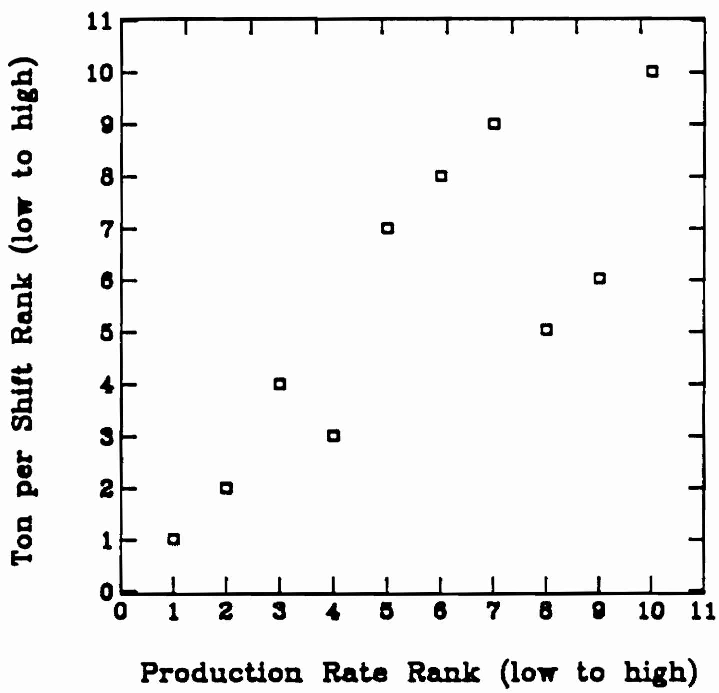

Figure 25. Scatter plot showing correlation between tons per shift and production rate.

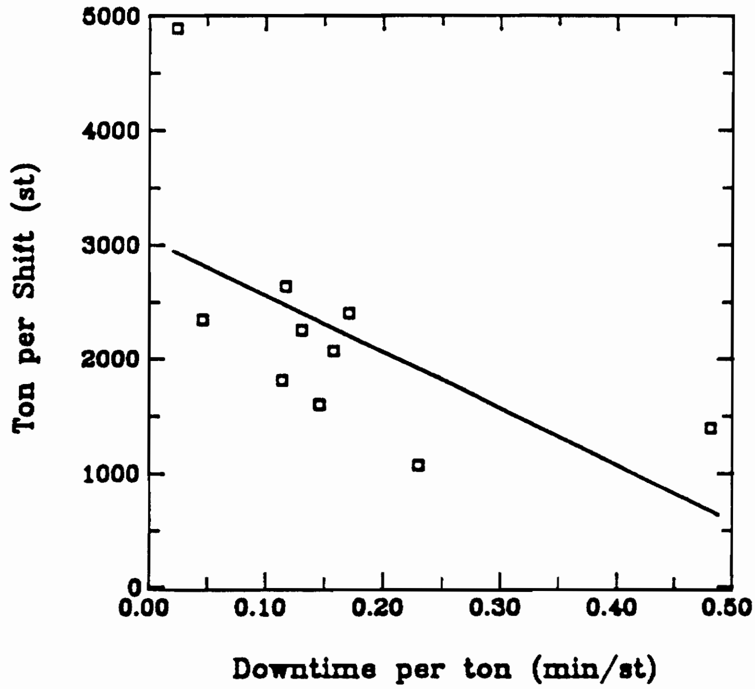

Figure 26. Linear trend of tons per shift vs. downtime per ton.

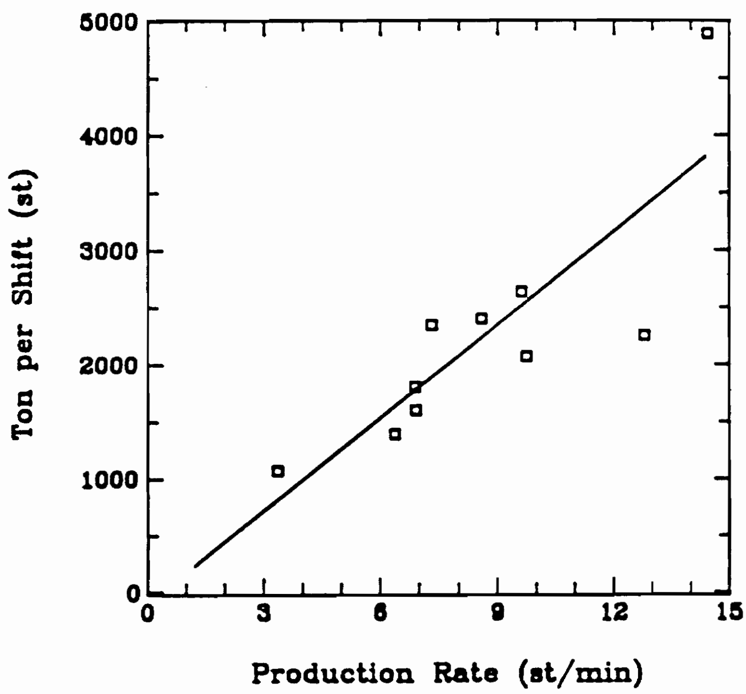

Figure 27. Linear trend of tons per shift vs. production rate.

factors. The sections which had high production rates tended also to have lower downtime.

VI. CONCLUSIONS AND RECOMMENDATIONS

A large factor in the marginal productivity of many U.S. longwalls is the under-utilization of equipment. This under-utilization results from three sources: 1) delay associated with equipment breakdowns and equipment servicing, 2) inherent delay associated with production shifts, and 3) inherent delay associated with idle shifts.

6.1 Reducing Delay Times Associated with Equipment Breakdowns and Equipment servicing

Face availability reflects the delay associated with equipment breakdowns and servicing. The average face availability of the twelve longwall sections analyzed in this study was 67.5%. The average available production time for these sections was 420 minutes (480 [total shift minutes] X 0.59 [system availability] / 0.675 [face availability]). It was observed that 32.5% of this time, or 136.5 minutes, was lost to equipment delays; 23% of this lost time was due to the shearer breakdowns and servicing, while 32% of the equipment delay time was due to the section belt + main haulage + bin + skip + tipple, which will collectively be called haulage. Reduction of equipment downtime should focus on these units.

Equipment downtime can be reduced in two general ways: 1) increase the mean time to failure (MTTF), and 2) decrease the mean time to repair (MTTR). The first approach involves increasing the reliability of the equipment; the second approach involves increasing the maintainability of the equipment.

6.1.1 Increasing Mean Time to Failure (MTTF)

This study recommends the following four actions for increasing MTTF:

(1) Design or select equipment for greater reliability.

(2) Perform expected life analyses of key components in order to determine rebuild or replacement schedules.

(3) Use flexible maintenance schedules.

(4) Replace common fault components.

Recent advances in equipment design have made the replacement of old equipment an attractive measure for decreasing MTTF and increasing production. The shearer was targeted in this study as a large source of downtime. New all-electric shearers have demonstrated much higher reliability levels than older, hydraulically powered units. Larger-capacity haulage belts and surge bins, combined with remote monitoring of the belts could reduce haulage delays, another area targeted. New face conveyors have cast pans, dual inby chains of up to 34mm in diameter, and power in excess of 1000 hp. Many of the sections in this study were already using new, high-reliability face conveyors. This may explain why face conveyors, which were formerly identified as a large source of delay time (Curry, 1976), were not identified as such by this study.

Expected life analyses can help to eliminate certain long-duration, unscheduled delays. Components such as haulage drives, cowl motors, and cutter motors which fail periodically and are time consuming to install should be changed-out on a scheduled basis. Statistical determination of the expected life of these components allows for scheduled replacement prior to most unscheduled failures. Monitoring of the expected life of a component also enables "out-of-control failures" to be recognized. A pattern of premature failures should lead to a check for disturbing influences or inferior materials.

Flexible maintenance policies can reduce the number of times that the system is idled for equipment servicing. Short-duration, regularly performed maintenance tasks, such as adding oil to the shearer or replacing cutting bits, can be performed while the system is already down. If a TTR analysis of belt repairs found that 80% of repairs were of 20 minutes in duration or more, and if servicing a shearer took this amount of time, a policy could be put into effect in which the shearer is serviced whenever a haulage belt goes down, where servicing of the shearer had not yet been performed.

Replacement of common fault components can reduce equipment breakdowns by eliminating chains of failure events. All machine parts which may be affected by a particular failure should be inspected and replaced when damaged. The repair procedure should include ancillary services, such as the flushing of a hydraulic circuit when changing that circuit's filter. Such policies stop the propagation of damage from one damaged part to adjacent parts.

6.1.2 Reducing Mean Time to Repair (MTTR)

This study recommends the following four actions for decreasing MTTR:

(1) Perform systematic fault diagnosis.

(2) Standardize repair training.

(3) Optimize parts and tools inventory.

(4) Select or design modularized equipment.

Because of the complexity of longwall equipment, a large percentage of repair time involves isolating a malfunctioning component. This was particularly evident in this study with delays involving electrical malfunctions of the shearer. Long delays for "electrical troubleshooting" would culminate with the location of a single bad connection or damaged relay. An "expert"-type fault-diagnosis system combined with formal training of personnel in fault diagnosis, could reduce the duration of such delays. A fuzzy logic-based fault-diagnosis system has been developed which establishes a probabilistic decision matrix relating common symptoms to failure causes (Kar, 1989). Experienced repair personnel would establish the correlation coefficients between symptoms and causes.

Unnecessarily long repair periods can result when parts or tools are not available at the face. A statistical study of parts utilization is necessary in order to determine the optimum inventory of parts to be maintained at a convenient location.

In addition to being more reliable, much of the new longwall equipment is more modularized than older equipment. Modularized equipment simplifies fault diagnosis and speeds component replacement. In many cases, faulty modules will be immediately replaced and then sent to the surface to be overhauled.

6.2 Reducing Inherent Delay Times Associated with Production Shifts

Inherent delay was responsible for an average of 53.5 minutes per shift, or 28% of the total production shift downtime. The main sources of inherent delay are travel time, lunch time, safety talks, and face inspection. Of these delays, only time for face inspection (about 10 minutes) cannot be eliminated. Travel and safety talks can be performed prior to relieving the face crew. In order to allow this, shifts should be expanded to nine hours. Idle time associated with meal breaks can be eliminated by staggering eating periods. Elimination of these three inherent delay sources would reduce production shift delay time by 43.5 minutes on average. This reduction would increase the average system availability of the twelve sections evaluated from 59% to 65%.

6.3 Reducing Inherent Delay Times Associated with Idle Shifts

None of the longwall sections in this study had production shifts on Sunday. Only ten of the sections had production shifts on Saturdays, all but one of which were sporadic. Flexible operating schedules have been cited as a source for increased production at newer installations (Combs, 1990). Three scheduled production shifts on Saturdays would increase the average available production time of the twelve sections evaluated by 12%. Assuming that all major maintenance tasks could be performed on Sundays, this would mean a 12% increase in weekly production.

6.4 Summary or Results

The average longwall section in this study had 283.3 minutes of production time per shift. In light of the large range of shearer availability demonstrated by the twelve sections analyzed (82.9% to 99.6%) and of haulage availability (72.08% to 95.85%), it is the opinion of this study that the recommendations given in Sections 6.1.1 and 6.1.2 could potentially eliminate 50% of shearer delay time and 25% of haulage-delay time. This would lead to an increase in production time of 26.6 minutes per shift, which corresponds to an increase in average face availability from 67.5% to 73.8%. Such an increase would lead to a 9.4% increase in production. The recommendations given in Section 6.2 could potentially eliminate 43.5 minutes of the inherent delay time associated with production shifts. Given an enhanced average face availability of 73.8%, this corresponds to an increase in production time of 32.1 minutes per shift. Scheduling three production shifts on Saturdays would increase the average production of the longwall sections evaluated by 12%. Sundays could be used to perform preventive maintenance and scheduled replacements.

The combined effect of decreased equipment downtime, decreased inherent delay time, and Saturday production shifts would be an average increase in weekly production of 35.2% for the twelve sections evaluated. Average available time would be 463.5 minutes per shift (420 + 43.5). Production time would be 342 minutes (0.738 X 463.5), an increase of 20.7% over the 283.3-minute average for the study group. Average shift production would be 120.7% of the original levels. Average weekly production would be 135.2% of original levels with the addition of Saturday production shifts (1.207 X 1.12).

6.5 Further Research

Further research should be undertaken to refine the availability figures provided in this study with the use of time study data. Computer simulation models and analytical models should be used to quantitatively evaluate the production gains achievable through other delay-reduction strategies.

In Section 5.3.2 it was stated that the availability figures in this study were believed to be more accurate than many previous figures. The improved accuracy was due to the use of high-quality foremans' reports (which detail individual downtime incidents), rather than MTTF and MTTR statistics as a basis for shift availability. Unfortunately, even the highest-quality foreman's report is not as accurate as a time-study report. In a time study report, every delay is accurately recorded regardless of apparent triviality. Time studies also document activities which would not necessarily be categorized as delays despite being non-productive (e.g., tramming of shearer). This cannot be expected from a section foreman whose primary job is to maintain production. The failure to report a delay occurrence will inflate availability calculations; for precise calculations of availability, there is no substitute for time-study reports. Unfortunately, compiling time studies over a lengthy period of time for a large number of mines is an exhausting task which may not be feasible.

Many other delay-reduction strategies are possible for increasing longwall availability and production. In the conclusions of this study the shearer and the haulage system were targeted as sources of excessive delay time. Computer simulation models and analytical models should be used to evaluate scenarios which involve reducing the delay time of other system components.

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APPENDICES

APPENDIX I

SPECIFIC MINE DATA

Note: The names of operators, mines and coal seams,as well as mine locations, have been ommitted to ensure the confidentiality of the data sources.

MINE No. 1

CODE_NAME	01
INIT_FACE	1980
PRES_FACE	1985
PERIOD	09/15/88 - 02/08/89
SHIFTS	228
INFO_SOURC	PRODUCTION REPORT
REP_FORMAT	SPECIFIC INCIDENTS
SEAM_HT	75
MINED_HT	75
PANEL_WIDE	915
PANEL_LEN	NA
DEPTH	600
ENTRIES	NA
FACE_VOLTS	2300
RAW_PROD	NA
CLEAN_PROD	NA
REJECT	NA
ROOF	NA
FLOOR	NA
PARTINGS	NA
COAL_HARD	NA
CONDITIONS	NA
SH	ANDERSON MAVOR ELECTRA 1000, 1200 HP, DERS, RACK EICKHOFF
FC	WESTFALIA LUNEN, 21B, 34MM, 3*450 HP
SL	WESTFALIA
CR	BRIDEN
SD	DOWTY, 2, 493 T, EH
OTHER_EQUP	SB = 48" CONTINENTAL DRIVE, 2*250 HP (*2 STAGES); REXNORD/NORDBERG PRODUCTION HOIST

MINE No. 2

CODE_NAME	02
INIT_FACE	1979
PRES_FACE	1985
PERIOD	06/20/88 - 02/28/89
SHIFTS	384
INFO_SOURC	PRODUCTION REPORT
REP_FORMAT	SPECIFIC INCIDENTS
SEAM_HT	96
MINED_HT	96
PANEL_WIDE	893
PANEL_LEN	NA
DEPTH	600
ENTRIES	NA
FACE_VOLTS	2300
RAW_PROD	NA
CLEAN_PROD	NA
REJECT	NA
ROOF	NA
FLOOR	NA
PARTINGS	NA
COAL_HARD	NA
CONDITIONS	NA
SH	ANDERSON MAVOR AM500, 1200 HP, DERS, RACK EICKHOFF
FC	WESTFALIA LUNEN, 21B, 34MM, 3*450 HP
SL	WESTFALIA
CR	WESTFALIA
SD	WESTFALIA LUNEN, 2, 450 T, EH
OTHER_EQUP	PM = HAUHINCO 3*150 HP;LW CONTROLLER = SERVICE MACHINE; SB = DOWTY-OWENS 48" 2*250 HP;REXNORD/NORDBERG PRODUCTION HOIST

MINE No. 3

CODE_NAME	03
INIT_FACE	1977
PRES_FACE	1986
PERIOD	12/01/87 - 12/30/87
SHIFTS	50
INFO_SOURC	MAINTENANCE REPORT
REP_FORMAT	SPECIFIC INCIDENTS
SEAM_HT	66
MINED_HT	73
PANEL_WIDE	600
PANEL_LEN	7200
DEPTH	600
ENTRIES	4
FACE_VOLTS	NA
RAW_PROD	NA
CLEAN_PROD	NA
REJECT	NA
ROOF	NA
FLOOR	NA
PARTINGS	NA
COAL_HARD	NA
CONDITIONS	NA
SH	JOY 4LS,470 HP DERS, RACK HALBACH & BRAUN, 30" CUT, INSTALL 01/01/87EICKOFF EDW 150-2L , INSTALL 08/01/87
FC	DOWTY, 840MM, 256 FPM, CROSS FRAME, 21B, 30MM, 1*350 1*300
SL	DOWTY, 1000MM, 276 FPM
CR	DOWTY - OWEN
SD	KLOECKNER-BECORIT, 2, 500 T, EH, INSTALL 01/01/87
OTHER_EQUP	

MINE No. 4

CODE_NAME	04
INIT_FACE	1975
PRES_FACE	1983
PERIOD	12/01/87 - 12/30/87
SHIFTS	50
INFO_SOURC	MAINTENANCE REPORT
REP_FORMAT	SPECIFIC INCIDENTS
SEAM_HT	70
MINED_HT	68
PANEL_WIDE	750
PANEL_LEN	7200
DEPTH	650
ENTRIES	4
FACE_VOLTS	NA
RAW_PROD	NA
CLEAN_PROD	NA
REJECT	NA
ROOF	NA
FLOOR	NA
PARTINGS	NA
COAL_HARD	NA
CONDITIONS	NA
SH	JOY 1LS-4E, 355 HP, DERS, RACK HALBACH & BRAUN
FC	HALBACH & BRAUN, 732MM, 256 FPM, 21B, 26MM, 2*300 HP, SIDE DISCHARGE
SL	HALBACH & BRAUN, 732MM, 310 FPM,
CR	KLOECKNER - BECORIT
SD	KLOECKNER-BECORIT, 2 LEG, 500 T, MANUAL, INSTALL 02/01/86
OTHER_EQUP	

MINE No. 5

CODE_NAME	05
INIT_FACE	1978
PRES_FACE	1988
PERIOD	12/01/87 - 12/30/87
SHIFTS	50
INFO_SOURC	MAINTENANCE REPORT
REP_FORMAT	SPECIFIC INCIDENTS
SEAM_HT	66
MINED_HT	72
PANEL_WIDE	600
PANEL_LEN	7200
DEPTH	600
ENTRIES	4
FACE_VOLTS	NA
RAW_PROD	NA
CLEAN_PROD	NA
REJECT	NA
ROOF	NA
FLOOR	NA
PARTINGS	NA
COAL_HARD	NA
CONDITIONS	NA
SH	EICKOFF-150-2L, 480 HP DERS, RACK HALBBACH & BRAUN REPLACED WITH JOY 4LS ON 01/01/88
FC	HALBACK & BRAUN, 21B, 30MM, 2*360 1*225 HP, 832MM, 256 FPM, CROSS FRAME DISCHARGE. REPLACED WITH AMERICAN LONGWALL ON 01/01/88
SL	HALBACH & BRAUN, 832MM, 320 FPM REPLACED WITH AMERICAN LONGWALL ON 01/01/88
CR	HALBACH & BRAUN
SD	KLOECKNER FERRO, MANUAL, INSTALL 09/17/79 REPLACED WITH GULLICK DOBSON, 2, 500T, 01/01/88
OTHER_EQUP	

MINE No. 6

CODE_NAME	06
INIT_FACE	1982
PRES_FACE	1982
PERIOD	12/01/87 - 12/30/87
SHIFTS	50
INFO_SOURC	MAINTENANCE REPORT
REP_FORMAT	SPECIFIC INCIDENTS
SEAM_HT	60
MINED_HT	60
PANEL_WIDE	600
PANEL_LEN	4500
DEPTH	575
ENTRIES	3
FACE_VOLTS	NA
RAW_PROD	NA
CLEAN_PROD	NA
REJECT	NA
ROOF	NA
FLOOR	NA
PARTINGS	NA
COAL_HARD	NA
CONDITIONS	NA
SH	JOY 4LS, 470 HP DERS, EICOTRACK, INSTALL 04/01/87
FC	HUWOOD - IRWIN, 21B, 26MM, 2*300 HP, 780MM, 285 FPM, SIDE DISCHARGE INSTALL 06/21/82
SL	HUWOOD - IRWIN, 330 FPM, INSTALL 06/21/82
CR	KLOECKNER - BECORIT
SD	KLOECKNER - BECORIT, 2 LEG, 400 T, MANUAL
OTHER_EQUP	

MINE No. 7

CODE_NAME	07
INIT_FACE	1982
PRES_FACE	1982
PERIOD	12/01/87 - 12/30/87
SHIFTS	50
INFO_SOURC	MAINTENANCE REPORT
REP_FORMAT	SPECIFIC INCIDENTS
SEAM_HT	63
MINED_HT	63
PANEL_WIDE	550
PANEL_LEN	6000
DEPTH	175
ENTRIES	3
FACE_VOLTS	NA
RAW_PROD	NA
CLEAN_PROD	NA
REJECT	NA
ROOF	NA
FLOOR	NA
PARTINGS	NA
COAL_HARD	NA
CONDITIONS	NA
SH	JOY 3LS-2E, 570 HP DERS, EICOTRACK
FC	HALBACH & BRAUN, 21B 26MM, 2*300 HP, 780MM, 284 FPM, SIDE DISCHARGE
SL	HUWOOD - IRWIN, 932MM, 317 FPM
CR	KLOECKNER - BECORIT
SD	DOWTY, 4 LEG, 610 T, MANUAL
OTHER_EQUP	

MINE No. 8

CODE_NAME	08
INIT_FACE	1983
PRES_FACE	1983
PERIOD	12/01/87 - 12/30/87
SHIFTS	50
INFO_SOURC	MAINTENANCE REPORT
REP_FORMAT	SPECIFIC INCIDENTS
SEAM_HT	90
MINED_HT	85
PANEL_WIDE	650
PANEL_LEN	6000
DEPTH	700
ENTRIES	4
FACE_VOLTS	NA
RAW_PROD	NA
CLEAN_PROD	NA
REJECT	NA
ROOF	NA
FLOOR	NA
PARTINGS	NA
COAL_HARD	NA
CONDITIONS	NA
SH	JOY 1LS-6, 370 HP, EICOTRAK, 30" CUT, INSTALL 02/01/88
FC	KLOECKNER - BECORIT, 21B, 26MM, 2*250 HP, 732MM, 238 FPM, CROSS FRAME DISHARGE, INSTALL 06/01/83
SL	KLOECKNER - BECORIT, 832MM, 305 FPM, INSTALL 06/01/83
CR	HALBACH & BRAUN
SD	JOY, 2 LEG, 400 T, MANUAL, INSTALL 06/01/83
OTHER_EQUP	

MINE No. 9

CODE_NAME	09
INIT_FACE	1981
PRES_FACE	1981
PERIOD	12/01/87 - 12/01/87
SHIFTS	50
INFO_SOURC	MAINTENANCE REPORT
REP_FORMAT	SPECIFIC INCIDENTS
SEAM_HT	84
MINED_HT	74
PANEL_WIDE	650
PANEL_LEN	4500
DEPTH	665
ENTRIES	4
FACE_VOLTS	NA
RAW_PROD	NA
CLEAN_PROD	NA
REJECT	NA
ROOF	NA
FLOOR	NA
PARTINGS	NA
COAL_HARD	NA
CONDITIONS	NA
SH	JOY 1LS-6, 370 HP DERS, EICOTRAK, 30" CUT, INSTALL 11/07/84
FC	HALBRACH & BRAUN EKF3, 21B, 26MM, 2*250 HP, 732MM, 238 FPM, CROSS FRAME DISCHARGE, INSTALL 10/19/81
SL	KLOECKER - BECORIT, 832MM, 305 FPM
CR	MCLANAHAN
SD	DOWTY, 4 LEG, 500 T, MANUAL
OTHER_EQUP	

MINE No. 10

CODE_NAME	10
INIT_FACE	1979
PRES_FACE	1986
PERIOD	12/01/87 - 12/30/87
SHIFTS	50
INFO_SOURC	MAINTENANCE REPORT
REP_FORMAT	SPECIFIC INCIDENTS
SEAM_HT	84
MINED_HT	84
PANEL_WIDE	750
PANEL_LEN	4000
DEPTH	650
ENTRIES	4
FACE_VOLTS	NA
RAW_PROD	NA
CLEAN_PROD	NA
REJECT	NA
ROOF	NA
FLOOR	NA
PARTINGS	NA
COAL_HARD	NA
CONDITIONS	NA
SH	JOY 1LS-6, 370 HP DERS, EICOTRAK, 30" CUT, INSTALL 05/01/87
FC	KLOECKNER - BECORIT, 21B, 26MM, 2*300 HP, 732MM, 238 FPM, CROSS FRAME DISCHARGE, INSTALL 09/01/83
SL	KLOECKNER - BECORIT, 832MM, 305 FPM, INSTALL 09/01/83
CR	MCCLANAHAN
SD	DOWTY, 2 LEG, 500 T, EH
OTHER_EQUP	

MINE No. 11

CODE_NAME	11
INIT_FACE	1979
PRES_FACE	1986
PERIOD	12/01/87 - 12/30/87
SHIFTS	50
INFO_SOURC	MAINTENANCE REPORT
REP_FORMAT	SPECIFIC INCIDENTS
SEAM_HT	92
MINED_HT	80
PANEL_WIDE	750
PANEL_LEN	4200
DEPTH	900
ENTRIES	4
FACE_VOLTS	NA
RAW_PROD	NA
CLEAN_PROD	NA
REJECT	NA
ROOF	NA
FLOOR	NA
PARTINGS	NA
COAL_HARD	NA
CONDITIONS	NA
SH	JOY 1LS-5, 370 HP DERS, EICOTRAK, 30" CUT, INSTALL 02/01/84
FC	KLOECKNER - BECORIT, 21B, 30MM, 2*300 HP, 732MM, 215 FPM, CROSS FRAME DISCHARGE
SL	EICKHOFF, 832MM, 287 FPM
CR	KLOECKNER - BECORIT
SD	DOWTY, 4 LEG, 500 T, MANUAL,HEMSCHEIDT, 2 LEG, 600 T, EH
OTHER_EQUP	

MINE No. 12

CODE_NAME	12
INIT_FACE	1981
PRES_FACE	1981
PERIOD	12/01/87 - 12/30/87
SHIFTS	50
INFO_SOURC	MAINTENANCE REPORT
REP_FORMAT	SPECIFIC INCIDENTS
SEAM_HT	72
MINED_HT	72
PANEL_WIDE	612
PANEL_LEN	6600
DEPTH	700
ENTRIES	4
FACE_VOLTS	NA
RAW_PROD	NA
CLEAN_PROD	NA
REJECT	NA
ROOF	NA
FLOOR	NA
PARTINGS	NA
COAL_HARD	NA
CONDITIONS	NA
SH	JOY 1LS-6, 370 HP DERS, EICOTRAK, 30" CUT
FC	HALBRACH & BRAUN EKF3, 21B, 26MM, 2*250, 732MM, 238 FPM, CROSS FRAME DISCHARGE, INSTALL 12/01/85
SL	KLOECKNER - BECORIT, 832MM, 305 FPM, INSTALL 11/23/81
CR	MCCLANAHAN
SD	DOWTY, 4 LEG, 500 T, MANUAL
OTHER_EQUP	

MINE No. 13

CODE_NAME	13
INIT_FACE	1978
PRES_FACE	1985
PERIOD	12/01/87 - 12/30/87
SHIFTS	50
INFO_SOURC	MAINTENANCE REPORT
REP_FORMAT	SPECIFIC INCIDENTS
SEAM_HT	94
MINED_HT	84
PANEL_WIDE	800
PANEL_LEN	6000
DEPTH	1250
ENTRIES	4
FACE_VOLTS	NA
RAW_PROD	NA
CLEAN_PROD	NA
REJECT	NA
ROOF	NA
FLOOR	NA
PARTINGS	NA
COAL_HARD	NA
CONDITIONS	NA
SH	JOY 3LS, 500 HP DERS, DYNATRAC, 36" CUT
FC	HALBRACH & BRAUN EKF4, 21B, 30MM, 2*360 1*225 HP, 832MM, 256 FPM, CROSS FRAME DISCHARGE, INSTALL 04/03/86
SL	HALBRACH & BRAUN, 832MM, 320 FPM, 03/01/87
CR	HALBRACH & BRAUN
SD	DOWTY, 2 LEG, 500 T, EH, INSTALL 04/01/85
OTHER_EQUP	

MINE NO. 14

CODE_NAME	14
INIT_FACE	1981
PRES_FACE	1981
PERIOD	12/01/87 - 12/30/87
SHIFTS	50
INFO_SOURC	MAINTENANCE REPORT
REP_FORMAT	SPECIFIC INCIDENTS
SEAM_HT	86
MINED_HT	70
PANEL_WIDE	600
PANEL_LEN	5800
DEPTH	750
ENTRIES	4
FACE_VOLTS	NA
RAW_PROD	NA
CLEAN_PROD	NA
REJECT	NA
ROOF	NA
FLOOR	NA
PARTINGS	NA
COAL_HARD	NA
CONDITIONS	NA
SH	JOY 3LS, 570 HP DERS, EICOTRAK, 30" CUT, INSTALL 06/01/87
FC	HALBRACH & BRAUN EKF4, 21B, 26MM, 2*300 HP, 732MM, 256 FPM, CROSS FRAME DISCHARGE, INSTALL 04/01/84
SL	HALBRACH & BRAUN, 732MM, 321 FPM
CR	HALBRACH & BRAUN
SD	GULLICK DOBSON, 2 LEG, 500 T, MANUAL BATCH, INSTALL 05/01/84
OTHER_EQUP	

MINE No. 15

CODE_NAME	15
INIT_FACE	1987
PRES_FACE	1987
PERIOD	02/87 - 09/88
SHIFTS	600
INFO_SOURC	MAITENANCE REPORT
REP_FORMAT	SPECIFIC INCIDENTS
SEAM_HT	60
MINED_HT	60
PANEL_WIDE	580
PANEL_LEN	4000
DEPTH	2000
ENTRIES	4
FACE_VOLTS	NA
RAW_PROD	NA
CLEAN_PROD	NA
REJECT	NA
ROOF	NA
FLOOR	NA
PARTINGS	NA
COAL_HARD	NA
CONDITIONS	NA
SH	JOY 4LS, 470 HP DERS, DYNATRACK, 30" CUT, INSTALL 06/01/87 AND 01/01/88
FC	HALBRACH & BRAUN EKF3, 21B, 30MM, 2*350 HP, 880MM, 263 FPM, CROSS FRAME DISCHARGE, INSTALL 06/01/87 THEN 06/01/88
SL	HALBACH & BRAUN, 1032MM, 312 FPM, INSTALL 06/01/87 THEN 06/01/88
CR	HALBACH & BRAUN
SD	DOWTY, 4 LEG, 808 T, EH, INSTALL 02/01/87 THEN 01/01/88
OTHER_EQUP	

MINE No. 16

CODE_NAME	16
INIT_FACE	1980
PRES_FACE	1980
PERIOD	12/01/87 - 12/30/87
SHIFTS	50
INFO_SOURC	MAINTENANCE REPORT
REP_FORMAT	SPECIFIC INCIDENT
SEAM_HT	84
MINED_HT	80
PANEL_WIDE	750
PANEL_LEN	4200
DEPTH	800 - 1150
ENTRIES	4
FACE_VOLTS	NA
RAW_PROD	NA
CLEAN_PROD	NA
REJECT	NA
ROOF	NA
FLOOR	NA
PARTINGS	NA
COAL_HARD	NA
CONDITIONS	NA
SH	JOY 1LS, 260 HP DERS, EICOTRAK, 30" CUT, INSTALLED 05/17/84
FC	HALBACH & BRAUN EKF3, 21B, 26MM, 1*350 HP 1*250 HP, 732 MM, 215 FPM, CROSS FRAME DISCHARGE. INSTALLED 10/15/83
SL	LONG AIRDOX INSTALLED 10/15/83
CR	KLOECKNER-BECORIT
SD	DOWTY, 4 LEG, 500 TON, MANUAL, INSTALLED 01/02/80 & 03/21/81
OTHER_EQUP	

MINE No. 17

CODE_NAME	17
INIT_FACE	1978
PRES_FACE	1986
PERIOD	1978 - 1988
SHIFTS	5136
INFO_SOURC	PRODUCTION REPORT
REP_FORMAT	GROUPED INCIDENTS
SEAM_HT	71
MINED_HT	71
PANEL_WIDE	700
PANEL_LEN	4300
DEPTH	590
ENTRIES	4
FACE_VOLTS	4160
RAW_PROD	NA
CLEAN_PROD	NA
REJECT	NA
ROOF	0" - 12" ROOF COAL LEFT ABOVE MUD/ROCK BAND (REMOVED);OCCASIONAL CLAY VEINS(SOMETIMES GASEOUS) AND SLIPS THROUGH-OUT FACE.
FLOOR	NA
PARTINGS	10" MUD/ROCK BAND ABOVE 60" BOTTOM COAL (REMOVED)
COAL_HARD	NA
CONDITIONS	100'*100' ABUTMENT PILLARS BETWEEN 10'*20' YIELD PILLARS. CONSIDERABLE SPALLING OF YIELD PILLARS LEADS TO EVENTUAL LOSS OF ON ENTRY.
SH	EICKHOFF-250-2L, 675 HP DERS, DYNATRAK 30" CUT, 1000 V
FC	HALBACH & BRAUN UK8V-1000, 2IB 26MM, 1000MM, 220 FPM, HB260/1040 CROSS FRAME, HB UH8V-1000 HB260 TAIL DRIVE, HB 1000 HB260C PANS
SL	AMERICAN LONGWALL MODEL 1064 26MM TI, 1064MM, 2 IB 26MM, 254 FPM 4160 V
CR	KLOECKNER - BECORIT MODEL SB63 UNVR
SD	142 * KLOECKNER - BECORIT, 2 LEG, 500 T, ELECTROHYDRAULIC
OTHER_EQUP	HAUHINCO PUMPS SINGLE CAR 32 GPM,DUAL CAR 64 GPM,TRIPLE CAR 156 GPM; SERVICE MACHINE POWER CENTER 7200/4160 V;ENSIGN 7200/950/600 PC

MINE No. 18

CODE_NAME	18
INIT_FACE	1980
PRES_FACE	1986
PERIOD	01/13/86 - 07/15/86
SHIFTS	175
INFO_SOURC	PRODUCTION REPORT
REP_FORMAT	GROUPED INCIDENTS
SEAM_HT	50
MINED_HT	46
PANEL_WIDE	460
PANEL_LEN	4950
DEPTH	875
ENTRIES	4
FACE_VOLTS	NA
RAW_PROD	1372
CLEAN_PROD	NA
REJECT	NA
ROOF	NA
FLOOR	NA
PARTINGS	NA
COAL_HARD	NA
CONDITIONS	NA
SH	WESTFALIA PLOW GLEITHOBEL, 2*125 HP, 4" CUT
FC	WESTFALIA, 21B, 26MM, 1*250 1*175 HP, 600MM, 267 FPM, END DISCHARGE
SL	LONG - AIRDOX, 30", 325 FPM
CR	INGERSOLL - RAND
SD	KLOECKNER - BECORIT, 2 LEG, 360 T, MANUAL BATCH
OTHER_EQUP	

MINE No. 19

CODE_NAME	19
INIT_FACE	1968
PRES_FACE	1978
PERIOD	12/01/88 - 03/31/89
SHIFTS	241
INFO_SOURC	SECTION BOSS REPORT
REP_FORMAT	SPECIFIC INCIDENTS
SEAM_HT	68
MINED_HT	68
PANEL_WIDE	730
PANEL_LEN	5225
DEPTH	1800
ENTRIES	4
FACE_VOLTS	NA
RAW_PROD	2917
CLEAN_PROD	1760
REJECT	39.7
ROOF	NA
FLOOR	NA
PARTINGS	NA
COAL_HARD	NA
CONDITIONS	NA
SH	JOY 1LS-6, 370 HP DERS, EICOTRAK, 30" CUT
FC	KLOECKNER - BECORIT AND AMERICAN LONGWALL, 21B, 30MM, 2*350 HP, 832/865 MM, 256 FPM, CROSS FRAME DISCHARGE
SL	AMERICAN LONGWALL, 1060MM, 330 FPM
CR	MCCLANAHAN
SD	WESTFALIA LUNEN, 4 LEG, 640 T, MANUAL
OTHER_EQUP	

MINE No. 20

CODE_NAME	20
INIT_FACE	1974
PRES_FACE	1988
PERIOD	12/01/88 - 03/31/89
SHIFTS	200
INFO_SOURC	SECTION BOSS REPORT
REP_FORMAT	SPECIFIC INCIDENTS
SEAM_HT	60
MINED_HT	60
PANEL_WIDE	600
PANEL_LEN	5560
DEPTH	2000
ENTRIES	4
FACE_VOLTS	950
RAW_PROD	NA
CLEAN_PROD	915
REJECT	30
ROOF	MASSIVE SHALEY SANDSTONE.
FLOOR	SANDY SHALE.
PARTINGS	SANDY SHALE 10" CUT.
COAL_HARD	95 GRIND
CONDITIONS	NO WATER, FACE SPALLS WELL
SH	ANDERSON MAVOR 500, 500 HP DERS, EICOTRAK, 2 REBUILDS, 5 YR OLD ANDERSON MAVOR 500, 500 HP DERS, EICOTRAK, NEW
FC	AMERICAN LONGWALL, 21B, 22MM, 3*175 HP, 732MM, 265 FPM, SIDE DISCHARGE, 5 YR OLD
SL	AMERICAN LONGWALL, NEW
CR	MCCLANAHAN, NEW
SD	WESTFALIA LUNEN, 4 LEG, 580 T, "PIANO KEY " MANUAL CONTROLS, 5 YR OLD; BATCH = 1
OTHER_EQUP	

MINE No. 21

CODE_NAME	21
INIT_FACE	1972
PRES_FACE	1977
PERIOD	12/01/88 - 03/31/89
SHIFTS	114
INFO_SOURC	SECTION BOSS REPORT
REP_FORMAT	SPECIFIC INCIDENTS
SEAM_HT	62
MINED_HT	62
PANEL_WIDE	600
PANEL_LEN	5560
DEPTH	2000
ENTRIES	4
FACE_VOLTS	950
RAW_PROD	NA
CLEAN_PROD	1343
REJECT	20
ROOF	MASSIVE SHALEY SANDSTONE.
FLOOR	SANDY SHALE.
PARTINGS	6" - 30" MIDDLE PARTING OF SANDY SHALE.
COAL_HARD	95 GRIND
CONDITIONS	NO WATER, FACE SPALLS WELL
SH	JOY 1LS-6, 370 HP DERS, EICOTRAK, 27" CUT
FC	AMERICAN LONGWALL, 21B, 30MM, 2*300 HP, NEW
SL	AMERICAN LONGWALL, NEW
CR	MCCLANAHAN, NEW
SD	HEMSCHEIDT, 4 LEG, 440 T, MANUAL, 11 YR OLD, BATCH = 1
OTHER_EQUP	

MINE No. 22

CODE_NAME	22
INIT_FACE	1980
PRES_FACE	1980
PERIOD	12/01/88 - 03/31/89
SHIFTS	245
INFO_SOURC	SECTION BOSS REPORT
REP_FORMAT	SPECIFIC INCIDENTS
SEAM_HT	72
MINED_HT	72
PANEL_WIDE	620
PANEL_LEN	5200
DEPTH	1500
ENTRIES	4
FACE_VOLTS	950
RAW_PROD	NA
CLEAN_PROD	1579
REJECT	NA
ROOF	SHALE WITH 0" - 3" DRAW SLATE (PROBLEMS)
FLOOR	FIRM SHALE.
PARTINGS	NA
COAL_HARD	SOFT
CONDITIONS	NO WATER, FACE SPALLS WELL "REALLY ROLLS OFF", HORIZONTAL CLEATS
SH	JOY 1LS-6, 370 HP DERS, EICOTRAK, 36" CUT, REBUILD EVERY PANEL
FC	AMERICAN LONGWALL, 21B, 30MM, 2*300 HP, 1986 NO REBUILD
SL	AMERICAN LONGWALL, 1060MM, 295 FPM
CR	MCCLANAHAN, NEW
SD	WESTFALIA LUNEN, 4 LEG, 580 T, PISTON AND BASE HEMSCHEIDT CANOPY, MANUAL BATCH = 1
OTHER_EQUP	

MINE No. 23

CODE_NAME	23
INIT_FACE	1982
PRES_FACE	1982
PERIOD	12/01/88 - 03/31/89
SHIFTS	238
INFO_SOURC	SECTION BOSS REPORT
REP_FORMAT	SPECIFIC INCIDENTS
SEAM_HT	72
MINED_HT	72
PANEL_WIDE	730
PANEL_LEN	6800
DEPTH	2050
ENTRIES	4
FACE_VOLTS	NA
RAW_PROD	1909
CLEAN_PROD	1397
REJECT	26.8
ROOF	NA
FLOOR	NA
PARTINGS	NA
COAL_HARD	NA
CONDITIONS	NA
SH	JOY 1LS-6, 370 HP DERS, EICOTRAK, 30" CUT
FC	KLOECKNER - BECORIT, 21B, 30MM, 2*350 HP, 832MM, 256 FPM, CROSS FRAME DISCHARGE
SL	HALBACH & BRAUN, 1032MM, 250 FPM
CR	HALBACH & BRAUN
SD	DOWTY, 4 LEG, 620 T, MANUAL
OTHER_EQUP	

MINE No. 24

CODE_NAME	24
INIT_FACE	1978
PRES_FACE	1984
PERIOD	05/01/88 - 12/01/88
SHIFTS	455
INFO_SOURC	SECTION BOSS REPORT
REP_FORMAT	SPECIFIC INCIDENTS
SEAM_HT	108
MINED_HT	108
PANEL_WIDE	550
PANEL_LEN	7040
DEPTH	400
ENTRIES	4
FACE_VOLTS	NA
RAW_PROD	2055
CLEAN_PROD	1299
REJECT	36.8
ROOF	NA
FLOOR	NA
PARTINGS	NA
COAL_HARD	NA
CONDITIONS	NA
SH	EICKHOFF-350 EDW, 402 HP DERS, EICOTRAK, 30" CUT
FC	KLOECKNER - BECORIT, 21B, 30MM, 2*350 HP, 867MM, 224 FPM, CROSS FRAME DISCHARGE
SL	KLOECKNER - BECORIT, 1066MM, 250 FPM
CR	KLOECKNER - BECORIT
SD	KLOECKNER - BECORIT, 2 LEG, 550 T, MANUAL : DOWTY, 4 LEG, 500T
OTHER_EQUP	

MINE No. 25

CODE_NAME	25
INIT_FACE	1981
PRES_FACE	1981
PERIOD	12/12/85 - 09/10/86
SHIFTS	1431
INFO_SOURC	SECTION BOSS REPORT
REP_FORMAT	SPECIFIC INCIDENTS
SEAM_HT	108
MINED_HT	108
PANEL_WIDE	750
PANEL_LEN	4350
DEPTH	375
ENTRIES	3
FACE_VOLTS	NA
RAW_PROD	2677
CLEAN_PROD	1407
REJECT	46.4
ROOF	NA
FLOOR	NA
PARTINGS	NA
COAL_HARD	NA
CONDITIONS	NA
SH	EICKHOFF 300-EDW, 402 HP DERS, EICOTRAK, 30" CUT
FC	KLOECKNER - BECORIT, 21B, 34MM, 3*350 HP, 867MM, 224 FPM, CROSS FRAME DISCHARGE
SL	KLOECKNER - BECORIT, 1066MM, 250 FPM
CR	KLOECKNER - BECORIT
SD	KB, 2 LEG, 550 T, MANUAL
OTHER_EQUP	

MINE No. 26

CODE_NAME	26
INIT_FACE	1978
PRES_FACE	1987
PERIOD	10/01/87 - 12/31/88
SHIFTS	701
INFO_SOURC	SECTION BOSS REPORT
REP_FORMAT	SPECIFIC INCIDENTS
SEAM_HT	65
MINED_HT	73
PANEL_WIDE	900
PANEL_LEN	10000
DEPTH	300
ENTRIES	5
FACE_VOLTS	1000
RAW_PROD	1588
CLEAN_PROD	NA
REJECT	NA
ROOF	NA
FLOOR	NA
PARTINGS	NA
COAL_HARD	NA
CONDITIONS	NA
SH	JOY 4LS, 590 HP DERS, EICOTRAK, 30" CUT, REMOTE CONTROL
FC	WESTFALIA LUNEN, 21B, 34MM, 3*400 HP, 855MM, 226 FPM, CROSS FRAME DISCHARGE
SL	WESTFALIA LUNEN, 1032MM, 305 FPM, 1*250 HP
CR	KB
SD	WESTFALIA LUNEN, (121) 2 LEG, 620 T,EH : WESTFALIA LUNEN, (62) 4 LEG640 T, EH
OTHER_EQUP	

MINE No. 27

CODE_NAME	27
INIT_FACE	1981
PRES_FACE	1987
PERIOD	01/05/88 - 02/28/89
SHIFTS	691
INFO_SOURC	SECTION BOSS REPORT
REP_FORMAT	SPECIFIC INCIDENTS
SEAM_HT	65
MINED_HT	73
PANEL_WIDE	900
PANEL_LEN	1000
DEPTH	300
ENTRIES	5
FACE_VOLTS	1000
RAW_PROD	1803
CLEAN_PROD	NA
REJECT	NA
ROOF	NA
FLOOR	NA
PARTINGS	NA
COAL_HARD	NA
CONDITIONS	NA
SH	JOY 4LS, 590 HP, DERS, 30" CUT, REMOTE CONTROL
FC	WESTFALIA LUNEN, 21B, 34MM, 3*400 HP, 852MM, 226 FPM, CROSS FRAME DISCHARGE
SL	WESTFALIA LUNEN, 1032MM, 1*250 HP
CR	KB
SD	WESTFALIA LUNEN, 4 LEG, 640 T, EH
OTHER_EQUP	

MINE No. 28

CODE_NAME	28
INIT_FACE	1984
PRES_FACE	1984
PERIOD	09/01/87 - 10/04/88
SHIFTS	630
INFO_SOURC	PRODUCTION & MAINT
REP_FORMAT	SPECIFIC INCIDENTS
SEAM_HT	50
MINED_HT	48
PANEL_WIDE	580
PANEL_LEN	2400
DEPTH	1150
ENTRIES	3
FACE_VOLTS	NA
RAW_PROD	NA
CLEAN_PROD	NA
REJECT	NA
ROOF	NA
FLOOR	NA
PARTINGS	NA
COAL_HARD	NA
CONDITIONS	NA
SH	(2) ANDERSON MAVOR AB16, 300 HP SDR, 36" CUT, REMOTE CONTROL
FC	AMERICAN LONGWALL, 21B, 26MM, 2*300 HP
SL	
CR	
SD	GULLICK DOBSON, 2 LEG, 580 T, EH
OTHER_EQUP	

MINE No. 29

CODE_NAME	29
INIT_FACE	1985
PRES_FACE	1985
PERIOD	10/04/87 - 07/23/88
SHIFTS	570
INFO_SOURC	PRODUCTION & MAINT
REP_FORMAT	SPECIFIC INCIDENTS
SEAM_HT	78
MINED_HT	78
PANEL_WIDE	685
PANEL_LEN	6200
DEPTH	1250
ENTRIES	3
FACE_VOLTS	NA
RAW_PROD	NA
CLEAN_PROD	NA
REJECT	NA
ROOF	NA
FLOOR	NA
PARTINGS	NA
COAL_HARD	NA
CONDITIONS	NA
SH	JOY 3LS, 500 HP DERS, DYNATRAC, 36" CUT, REMOTE CONTROL
FC	AMERICAN LONGWALL, 21B, 30MM, 2*300 HP
SL	AMERICAN LONGWALL
CR	
SD	DOWTY, 2 LEG, 500 T, EH
OTHER_EQUP	

MINE No. 30

CODE_NAME	30
INIT_FACE	1987
PRES_FACE	1987
PERIOD	01/03/89 - 03/31/89
SHIFTS	229
INFO_SOURC	SECTION BOSS REPORT
REP_FORMAT	SPECIFIC INCIDENTS
SEAM_HT	90
MINED_HT	78
PANEL_WIDE	770
PANEL_LEN	5500
DEPTH	750
ENTRIES	4
FACE_VOLTS	NA
RAW_PROD	NA
CLEAN_PROD	NA
REJECT	NA
ROOF	NA
FLOOR	NA
PARTINGS	NA
COAL_HARD	NA
CONDITIONS	NA
SH	EICKHOFF 300-L, 470 HP DERS, EICOTRAK, 30" CUT
FC	DOWTY, 21B, 30MM, 1*450 1*350 HP, 732MM, 212 FPM, SIDE DISCHARGE
SL	DOWTY, 1032MM, 256 FPM
CR	HALBACH & BRAUN
SD	KLOECKNER-BECORIT, 2 LEG, 550 T
OTHER_EQUP	

MINE No. 31

CODE_NAME	31
INIT_FACE	1966
PRES_FACE	1981
PERIOD	01/03/89 - 03/31/89
SHIFTS	171
INFO_SOURC	SECTION BOSS REPORT
REP_FORMAT	SPECIFIC INCIDENTS
SEAM_HT	54
MINED_HT	50
PANEL_WIDE	520
PANEL_LEN	5300
DEPTH	550
ENTRIES	3
FACE_VOLTS	NA
RAW_PROD	4856
CLEAN_PROD	NA
REJECT	NA
ROOF	NA
FLOOR	NA
PARTINGS	NA
COAL_HARD	NA
CONDITIONS	NA
SH	WESTFALIA LUNEN GLEITHOBEL PLOW, 2*200 HP, CHAIN HAUL, 3" CUT
FC	WESTFALIA LUNEN, 11B, 30MM, 3*125
SL	WESTFALIA, 920MM
CR	KLOECKNER-BECORIT
SD	WESTFALIA LUNEN, 2 LEG, 560 T, MANUAL
OTHER_EQUP	

MINE No. 32

CODE_NAME	32
INIT_FACE	1986
PRES_FACE	1986
PERIOD	01/03/89 - 03/31/89
SHIFTS	174
INFO_SOURC	SECTION BOSS REPORT
REP_FORMAT	SPECIFIC INCIDENTS
SEAM_HT	75
MINED_HT	75
PANEL_WIDE	700
PANEL_LEN	4600
DEPTH	NA
ENTRIES	3
FACE_VOLTS	NA
RAW_PROD	1053
CLEAN_PROD	NA
REJECT	NA
ROOF	NA
FLOOR	NA
PARTINGS	NA
COAL_HARD	NA
CONDITIONS	NA
SH	ANDERSON MAVOR 500, 500 HP DERS, EICOTRAK, 30" CUT
FC	HALBACH & BRAUN, 11B, 30MM, 2*250 HP, 555MM, 222 FPM, SIDE DISCHARGE
SL	HALBACH & BRAUN, 555MM, 256 FPM
CR	WESTFALIA
SD	DOWTY, 2 LEG, 760 T
OTHER_EQUP	

MINE No. 33

CODE_NAME	33
INIT_FACE	1968
PRES_FACE	1984
PERIOD	01/03/89 - 03/31/89
SHIFTS	195
INFO_SOURC	SECTION BOSS REPORT
REP_FORMAT	SPECIFIC INCIDENTS
SEAM_HT	66
MINED_HT	60
PANEL_WIDE	500
PANEL_LEN	5200
DEPTH	700
ENTRIES	4
FACE_VOLTS	NA
RAW_PROD	2336
CLEAN_PROD	NA
REJECT	NA
ROOF	NA
FLOOR	NA
PARTINGS	NA
COAL_HARD	NA
CONDITIONS	NA
SH	EICKHOFF 340-L, 400 HP DERS, EICOTRAK, 30" CUT
FC	HALBACK & BRAUN, 11B, 30MM, 2*250, 600MM, 217 FPM
SL	HALBACH & BRAUN, 620MM, 256 FPM
CR	WESTFALIA
SD	WESTFALIA LUNEN, 2 LEG, 500 T, MANUAL
OTHER_EQUP	

MINE No. 34

CODE_NAME	34
INIT_FACE	1970
PRES_FACE	1983
PERIOD	01/03/89 - 03/31/89
SHIFTS	185
INFO_SOURC	SECTION BOSS REPORT
REP_FORMAT	SPECIFIC INCIDENTS
SEAM_HT	60
MINED_HT	60
PANEL_WIDE	600
PANEL_LEN	3500
DEPTH	1250
ENTRIES	4
FACE_VOLTS	NA
RAW_PROD	NA
CLEAN_PROD	NA
REJECT	NA
ROOF	NA
FLOOR	NA
PARTINGS	NA
COAL_HARD	NA
CONDITIONS	NA
SH	EICKHOFF 170-L, 228 HP DERS, EICOTRACK, 30" CUT
FC	HALBACH & BRAUN, 11B, 30MM, 2*250, 600MM, 216 FPM, SIDE DISCHARGE
SL	HALBACH & BRAUN, 600MM, 254 FPM
CR	DOWTY
SD	WESTFALIA LUNEN, 4 LEG, 460 TON
OTHER_EQUP	

MINE No. 35

CODE_NAME	35
INIT_FACE	1974
PRES_FACE	1985
PERIOD	01/03/89 - 03/31/89
SHIFTS	185
INFO_SOURC	SECTION BOSS REPORT
REP_FORMAT	SPECIFIC INCIDENTS
SEAM_HT	60-100
MINED_HT	66
PANEL_WIDE	480
PANEL_LEN	NA
DEPTH	500 - 1000
ENTRIES	4
FACE_VOLTS	NA
RAW_PROD	NA
CLEAN_PROD	1496
REJECT	NA
ROOF	NA
FLOOR	NA
PARTINGS	NA
COAL_HARD	NA
CONDITIONS	NA
SH	JOY 4LS, DERS, EICOTRAC, 30" CUT
FC	HALBACH & BRAUN, 21B, 26MM, 30 IN., 2*300 HP, 256 FPM, SIDE DISCHARGE
SL	HALBACH & BRAUN, 40 IN., 312 FPM
CR	HALBACH & BRAUN
SD	DOWTY, 4 LEG, 760 TON, ELECTROHYDRAULIC CONTROL
OTHER_EQUP	

MINE No. 36

CODE_NAME	36
INIT_FACE	1986
PRES_FACE	1986
PERIOD	1/1/87 - 3/31/87
SHIFTS	104
INFO_SOURC	PRODUCTION REPORT
REP_FORMAT	GROUPED INCIDENTS
SEAM_HT	44
MINED_HT	44
PANEL_WIDE	600
PANEL_LEN	4000
DEPTH	800
ENTRIES	3
FACE_VOLTS	NA
RAW_PROD	NA
CLEAN_PROD	664
REJECT	NA
ROOF	SHALE W/ RIDER 1-3' ABOVE
FLOOR	DARK SHALE W/COAL DISCONTINUOUS COAL BANDS FOR 5-15" BELOW
PARTINGS	GENERALLY CLEAN
COAL_HARD	NA
CONDITIONS	NA
SH	WESTFALIA LUNEN GLEITHOBEL PLOW, MODEL 9-30V/4.5, 2*225 HP, CHAIN HAUL
FC	WESTFALIA LUNEN, PANZER PFII-30-S, 21B, 26MM, 25 IN, 2*200 HP, 150 FPM, SIDE DISCHARGE
SL	WESTFALIA LUNEN, MODEL PFII-30-K, 25 IN. SECTION BELT WALKING TAILPIECE BY AMERICAN LONGWALL
CR	BRIEDEN, MODEL K8.00
SD	WESTFALIA LUNEN, 2 LEG, 420 TON, HAUCHINO HT70 PUMPS
OTHER_EQUP	

MINE No. 37

CODE_NAME	37
INIT_FACE	1983
PRES_FACE	1983
PERIOD	01/01/87 - 03/31/87
SHIFTS	72
INFO_SOURC	PRODUCTION REPORT
REP_FORMAT	GROUPED INCIDENTS
SEAM_HT	60
MINED_HT	66
PANEL_WIDE	600
PANEL_LEN	3300
DEPTH	475 - 1175
ENTRIES	3
FACE_VOLTS	NA
RAW_PROD	932
CLEAN_PROD	NA
REJECT	NA
ROOF	SHALE OR SILTSTONE W/MANY FOSSIL FRAGS.PROBS WITH CHANNEL SCOUR SST ALSO THICH FOLLIS BANDED SH/SILT W/FRAC TRENDS PARALLEL TO DEV.
FLOOR	DARK SHALE W/ COAL SPARS AND LEADER COAL 0-20" THICK 1-3' BELOW. SST UNDERLIES LEADED.GOOD FLOOR EXCEPT WHEN LEADER WITHIN 2' OF FLOOR.
PARTINGS	BONE COAL A FEW INCHES THICK. FAULTS ARE PRESENT.
COAL_HARD	NA
CONDITIONS	NA
SH	EICHOFF EDW 260-230, 200 HP DERS, HB RACK (DYNATRAK), 30" CUT
FC	HALBACH & BRAUN, 21B, 26MM, 2*215 HP, 30 IN., 256 FPM,SIDE DISCHARGE
SL	HALBACH & BRAUN, 25 IN., 305 FPM
CR	HALBACH & BRAUN
SD	THYSSEN, 4 LEG, 700 TON, HAUHINCO EHP3K70 PUMPS
OTHER_EQUP	

MINE No. 38

CODE_NAME	38
INIT_FACE	1983
PRES_FACE	1983
PERIOD	01/01/87 - 03/31/87
SHIFTS	129
INFO_SOURC	PRODUCTION REPORT
REP_FORMAT	GROUPED INCIDENTS
SEAM_HT	52
MINED_HT	58
PANEL_WIDE	540
PANEL_LEN	3070
DEPTH	475 - 1175
ENTRIES	3
FACE_VOLTS	NA
RAW_PROD	503
CLEAN_PROD	NA
REJECT	NA
ROOF	SHALE OR SILTSTONE W/MANY FOSSIL FRAGS.PROBS WITH CHANNEL SCOUR SST ALSO THICH FOLLIS BANDED SH/SILT W/FRAC TRENDS PARALLEL TO DEV.
FLOOR	DARK SHALE W/ COAL SPARS AND LEADER COAL 0-20" THICK 1-3' BELOW. SSTUNDERLIES LEADER. GOOD FLOOR EXCEPT WHEN LEADER WITHIN 2' OF FLOOR
PARTINGS	BONE COAL A FEW INCHES THICK. FAULTS ARE PRESENT
COAL_HARD	NA
CONDITIONS	NA
SH	EICHOFF EDW 260-230, 200 HP DERS, HB RACK (DYNATRAK), 30" CUT
FC	HALBACH & BRAUN, 21B, 26MM, 2*215 HP, 30 IN., 256 FPM,SIDE DISCHARGE
SL	HALBACH & BRAUN, 25 IN., 305 FPM
CR	HALBACH & BRAUN
SD	THYSSEN, 4 LEG, 700 TON, HAUHINCO EHP3K70 PUMPS
OTHER_EQUP	

MINE No. 39

CODE_NAME	39
INIT_FACE	1983
PRES_FACE	1985
PERIOD	01/01/87 - 03/31/87
SHIFTS	265
INFO_SOURC	PRODUCTION REPORT
REP_FORMAT	GROUPED INCIDENTS
SEAM_HT	45
MINED_HT	45
PANEL_WIDE	400
PANEL_LEN	1350
DEPTH	500
ENTRIES	3
FACE_VOLTS	NA
RAW_PROD	923
CLEAN_PROD	NA
REJECT	NA
ROOF	SANDY SHALE OVERLAIN BY SANDSTONE LAYER OF UP TO 80'.
FLOOR	SANDY SHALE OR SHALE TO A LESSER DEGREE.
PARTINGS	OCCASIONALLY UP TO 3 PARTINGS. NO KNOWN FAULTS
COAL_HARD	NA
CONDITIONS	NA
SH	WESTFALIA LUNEN, GLEITHOBEL 9-30VE/2.4 PLOW, 2*200 HP, CHAIN HAUL, 4" CUT.
FC	WESTFALIA LUNEN, MODEL TF2-30.S, 21B, 26MM, 2*360 HP, 732MM, 226 FPMCROSS FRAME DISCHARGE.
SL	WESTFALIA LUNEN, MODEL PF2.30, 732MM, 307 FPM.
CR	HALBACH & BRAUN
SD	HEINTZMAN, 2 LEG, 350 TON, MANUAL, HAUCHINO PUMPS
OTHER_EQUP	

APPENDIX II

NOMENCLATURE USED TO DESCRIBE SPECIFIC DELAY EVENTS

1 1WAY = CUT ONE WAY (F / G,P,V)
2 A = ARMORED FACE CONVEYOR [ALSO AFC]
3 ADJ = ADJUST (ALL / M,H,EH,E,P)
4 AF = A FRAME [SPA AND SPRAY HELD] (SH / M)
5 AIR = NO AIR (V / V)
6 AL = ALIGN (OB,B,SH / M,G,H)
7 ATP = ALIGN TAILPIECE (OB,B / M,G)
8 B = BELT(S) OTHER THAN SECTION BELT [ALSO BELT] (B / ALL)
9 B OUT TU = TAKE BELT OUT OF STORAGE UNIT (OB / M)
10 BAT = BATTERY
11 BB = BAD BOTTOM (F,A,S / G)
12 BC = BEARING CAP (SH / M)
13 BEARING = BEARING [ALSO BEARING HOT] (SH,A,SL,OB,B / M)
14 BENT = BENT, WORK TO STRAIGHTEN (SH,A / M)
15 BF = BIN FEEDER (BIN / C,M,E)
16 BH = BELT HEAD (OB / M,C)
17 BIN = BIN, BUNKER, SILO [ALSO ROTARY BIN] (BIN / C,M,E)
18 BIND = BINDER (RX,F / G)
19 BIT = REPLACE BITS (SH / M)
20 BLJ = BASE LIFT JACK [ALSO BASE PLATE] (S / H,M)
21 BLO = BLOWN, BURST (H,P,S / H)
22 BO = BOLT (SH,A,SL,CR / M)
23 BOOST = BELT BOOSTER DRIVE (OB,B / M,E)
24 BOT = BOTTOM, FREQ USED WITH REC BOT (F / G,P)
25 BOT = CLEAN BOTTOM [ALSO REC BOT] (F / G,P)
26 BP = BRIDGE PLATE (S / M)
27 BRIT = BRITTANY CHAIN, CABLE HANDLER (SH / M,H)
28 BRIT OFF = BRETBY SEPARATED FROM SHEARER (SH / M)
29 BRIT PAN = BRETBY IN PAN , OUT OF TROUGH (SH / M)
30 BRK = BROKE (ALL / M,H,E)
31 BRK RX = BREAKING ROCK (RX,F / G)
32 BRKER = ELECTRICAL BREAKER (A,SH,SL,CR,OB / E)
33 BS = BAD SHIELD, PROBLEM WITH BATCH OPERATION (S / EH,H)
34 BT = BAD TOP (F / G)
35 BUSH = BUSHING (SH / M) RA
36 C = CABLE (A,SH,SL,CR,OB / E)
37 C ANCHOR = CABLE ANCHOR (A,SH,SL,CR,OB / E,M)
38 CA = COWL ARM (SH / M)
39 CAL = CALIBRATE METH MON (METH / E)
40 CAN = SHIELD CANOPY (S / M)
41 CANA = CANABOLIZE, USE PART OFF OTHER EQUIPMENT (ALL / M)
42 CAT = CATHEAD CABLE CONNECTOR (POW / E)
43 CB = COWL BLADE (SH / M)
44 CC = CONCURENT, OVERLAPPING DOWNTIME (ALL / ALL)
45 CH = CHAIN (A,SL / M)
46 CH WR = CHAIN WRECKED (A,SL / M)
47 CIR = CIRCUIT [SEE OCIR] (ALL / E)
48 CK = CHECK (ALL / ALL)
49 CK FIRE = TEST FIRE SUPPRESSION EQUIP (SA / SA)
50 CL = CLEAN,CLEAR [ALSO CL S, CS] (S,A,SH / G,M)

51 CL REL VAL = CROSSLINE RELIEF VALVE (S / H)
52 CLEAR = CLEARANCE (F,SH,SL / G,M,P)
53 CLEVIS = CLEVIS (S / M)
54 CNTL = CONTROL [ALSO CNTL SW] (SL,OB / E)
55 COMP = AIR COMPRESSOR [FREQ WITH SHOT] (RX,F / G,P)
56 COMPU = SHIELD CONTROL COMPUTER (S / EH)
57 CON = CONNECTOR FOR WIRE LEADS (A,SH,SL,OB / E) JB,PB
58 CON'T = DT RECORD CONTINUED [USE IDENTICAL WORDING] (ALL/ALL
59 COOL WA = COOLANT WATER SYSTEM (SH / H)
60 COP = COUPLER [FREQ FLUID COUPLER] (A,SL,OB,B,SH / H,M)
61 COV = COVER (SH,A,SL / M)
62 COWL = COWL [ALSO COWL DR] (SH / M,H)
63 CREW = LINE UP CREW [FREQ GOES ON SFT REP AS RCP] (F / P)
64 CRIB = CRIB(S) (ROOF,PROP,F / G,P)
65 CRX = CLEAR FALLEN ROCKS (RX,S,F / G)
66 CRX S = CLEAR RX OFF CANOPY [ALSO CL S] (ROOF / G)
67 CS = CLEAN SHIELDS (S,RX / G,P)
68 CST O/T = ? OVER TEMP (OB / E,C)
69 CT = CHAIN TENSIONER UNIT (A,SL / M)
70 CTRX = CUT ROCK WITH SHEARER (F / G)
71 CURT = VENT CURTAIN (V / V,P)
72 CUT = CUTTER DRUM [ALSO HUB] (SH / M)
73 CUT COV = DRUM HUBCAP [ALSO HC] (SH / M)
74 CUT DR = CUTTER MOTOR [HG OR TG] (SH / E,M)
75 DATA = DATA COLLECTOR (SH,S / EH)
76 DB = DOG BONE (A / M)
77 DC = DRY COMPARTMENT (SH / E)
78 DIG CIR = DIGITAL CIRCUIT (S / EH)
79 DN = DOWN [FREQ WITH BELT] (B,OB / ALL)
80 DR = DRIVE MOTOR (A,OB,B / E,M,H)
81 DRY BAG = SEAL FOR ELECT COMPARTMENT (SH / E)
82 DYN CH = DYNATRAC CHAIN (SH / M)
83 E = EVEN, ie. FT ADV HEAD = FT ADV TAIL (SFT REPORT)
84 EF = EMULSION FLUID (H,P,S / H,EH)
85 EH = ELECTROHYDRAULIC (S / EH)
86 EICO = EICOTRACK PIN OR (SEG)MENT REPL (SH / M)
87 EICO ROLL = HAUL SPROCKET [ALSO EICO ROLLER] (SH / M)
88 ELEV = ELEVATOR (PD / S)
89 EMER SW = EMERGENCY OFF SWITCH (A,SL,CR / E)
90 END # = END OF PANEL NUMBER #
91 END PANEL = END OF PANEL
92 EP = EMULSION PRESSURE (P,H,S / H)
93 ET = EMULSION TANK (P,H / H,M)
94 FA = FAULT (F,RX / G)
95 FALL = ROOF FALL, ROCK FALL (ROOF,RX / G)
96 FAN = VENTILATION FAN [ALSO FAN CK] (V,SA / V)
97 FILT = FILTER (SH,P,S / H)
98 FIT = FITTING (SH,S / M,H)
99 FL = CONVEYOR FLIGHT (A,SL / M)
100 FL SEP = FLIGHT BROKE OUT OF CHAIN (A,SL / M)

101 FLIT = IDLE TRAM WITH SHEARER (F / P)
102 FLOODED = FACE OR TRACK FLOODED (F,T / G)
103 FORE POLE = SHIELD CANOPY TIP (S / M,H,G)
104 FRIC DR = BELT FRICTION DRIVE (B,OB / E,M)
105 FULL = REACHED CAPACITY (BIN / C)
106 FUSE = FUSE (SH,A,SL,CR,OB / E)
107 FZ = FROZEN
108 GEAR BEARING = HAULAGE GEAR BEARING (SH / M)
109 GO = GEAR OIL ADDED,LEAKED,FLUSHED[ALSO GO CASE](A,SL,SH /H)
110 GOB = GOBBED OUT (A,SL,OB,B / G,C)
111 GOB S = SIDE SHIELD, GOB SHIELD (S / M)
112 GOOSE = GOOSENECK PAN SECTION (A / M)
113 GRD = GROUND ELECTRICAL WIRE, GROUND FAULT (A,SH,SL,CR,OB/E)
114 GRD MON = GROUND MONITOR [USUALLY ONLY GRD USED]
115 GT = GROUT (F,ROOF / G,P)
116 GU = GUARD (SL,CR / M)
117 H = HOSE (SH,S,OB / H) TP TU
118 HAUL DR = HAULAGE MOTOR, TRACTION DRIVE (SH / E,H)
119 HAUL ROLL = HAULAGE SPROCKET [ALSO EICO ROLLER] (SH / M)
120 HC = HUB CAP [ALSO CUT COV] (SH / M)
121 HD = HEADGATE DRIVE [ALSO HG DR] (A / H,E,M)
122 HG = HEAD GATE [FREQ USED TO SPECIFY SH OR A EQUIP]
123 HG DR = AFC HEADGATE DRIVE [ALSO HD] (A / E,H,M)
124 HO = HYDRAULIC OIL ADDED, LEAKED,FLUSHED (A,SL,SH / H)
125 HO HG RA = FLUSH AND CHG HEADGATE RANGING ARM FLUID (SH / H)
126 HO TG RA = FLUSH AND CHANGE OIL TG RANGING ARM (SH / H)
127 HOST = GOVENOR (SH / E)
128 HR = HAULAGE RACK [ALSO EICO] (SH / M)
129 HS C = HIGH SPEED CABLE (A,SH / E)
130 HT=# = COAL THICKNESS (SFT REPORT)
131 HUB = HUB OR DRUM [ALSO CUT] (SH / M)
132 HUNG = HUNG UP (A,SL,CR / G,M)
133 HV = HIGH VOLTAGE LINE (POW / E)
134 IMP = IMPACTOR OF CRUSHER (CR / M)
135 INOP = INOPERATIVE, NOT START (A,SL,SH,OB,B / E)
136 INS = INSERT [FREQ BIT INS] [ALSO W BIT] (SH / M)
137 INSP = INSPECT [ALSO CK] (ALL / ALL)
138 INSP = INSPECTOR (SA / SA)
139 INST = INSTALL (ALL / ALL)
140 IR = INCOMPLETE RECORD (ALL / ALL)
141 JB = JUNCTION BOX [ALSO PB] (POW,A,SL,OB,SH / E)
142 LD = LINEAR DRIVE (OB,B / E,M)
143 LEAK = LEAK OF FLUID [WA H,HYD FIT,EF P] (H,P / H)
144 LEG = HYDRAULIC LEG OF SHIELD (S / H,M)
145 LINKS = REMOVE CHAIN LINKS [SIMILAR TO SLACK] (A,SL / M)
146 LMST = LIMESTONE ROCK TYPE (RX, ROOF / G)
147 LO = ELECTRIC LOCK OUT OF CONVEYOR (A / E)
148 LO SW = LOCKOUT SWITCH FAILURE (A,SL / E)
149 LOOSE = LOOSE (ALL / E,M,H) WI,FIT,BO,H
150 LOW FREQ RET = LOW FREQUENCY RETURN

151 LS = LOW SHIELDS (F,ROOF,S / P,G)
152 LS C = LOW SPEED CABLE (A / E)
153 LUMP = LUMP BREAKER (SH / M)
154 M = MANTRIP (PD,T / E,M,P)
155 MANI = MANIFOLD [FREQ WATER MANIFOLD] (SH / H)
156 MEA = MEASURE [MEA WEB DEPTH] (F / M,P)
157 MEA HT = MEASURE FLOOR TO ROOF DIST (F / P)
158 MEET = MEETING [ALSO MEET OS] (SA, F / P,SA) ALSO PROD
159 MEET IN = MEETING UNDERGROUND (F / P)
160 MF = MID FACE (METH,A,SH / E,G,M)
161 MON = MONITOR [ALSO MON SIG] (METH / E,SA)
162 MON SIG = METHANE WARNING SIGNAL (METH / SA)
163 MONO = HUNG MONORAIL [GENERAL WORK SFT REPORT]
164 MSDT = MISSING SHIFT DOWNTIME [ALSO IR] [FREQ IN SFT REPORT
165 NIS = NOT IN STOCK,PART UNAVAILABLE (ALL / ALL)
166 NO POWER = POWER SUP INTERRUPTED [ALSO POW SUP] (ALL / ALL)
167 NOT PUSH = HD OR TD WONT ADVANCE (A / G,M) BB
168 NOZ = SPRAY NOZZEL (SH / H)
169 O = O-RING ,GASKET ,SEAL (P,SH,A,SL / H)
170 OCIR = OPEN CIRCUIT (A,SL,SH,OB,CR / E) JB, PB
171 OIL SAM = OIL SAMPLE TAKEN FOR DIAGNOSTICS (SH,A / H)
172 OL #1, #2 = OVERLOAD HD TC (A / H)
173 OL = OVERLOAD (A,SL,SH,OB,B / E,C)
174 OL BRKER = OVERLOAD BREAKER (SH,A,SL,CR,P / E)
175 OL HG = OVERLOAD HEADGATE DRIVE [OL #1,#2;OL HD] (A / H)
176 OL POW = OVERLOAD,LOST POWER (SH,S / E)
177 OSUMP = OVER SUMP,FACE SLOPED (F / P)
178 P = PUMP [FREQ EF P] (P,S / H)
179 PAN = PAN TIPPING,FELL,WON'T PUSH [ALSO BRIT PAN] (A / M,G)
180 PAT = PATCH [FREQ PAT C] (A,SH,SL,CR,OB / E)
181 PB = PANEL BOX [ALSO JB] (A,SL,CR,SH,POW / E) PERM
182 PC = POWER CENTER (POW / E)
183 PC OFF = SECTION POWER INTERRUPTED (POW / E)
184 PD = PORTAL DELAY (PD / P) TARDY, M NIS
185 PERM = ELECTRICAL PERMISSIBILITY PROB (SH,A,SL / E) JB,PB
186 PHONE = TELEPHONE (COMM / E)
187 PLUG = JAMMED [FREQ NOZ PLUG] (SH / H)
188 POW SUPP = POWER SUPPLY (POW / E) PC,BH
189 PR OS = PRODUCTION MEETING OUTSIDE (PD / P)
190 PRE START = PRE START SIGNAL FAILURE (A,SL / E)
191 PRESS = PRESSURE (P,H / H)
192 PRI = PRIME (P / H)
193 PROD = PRODUCTION [FREQ PROD MEET] (F / P)
194 PROP = HYDRAULIC LEG JACK, WOODEN PROP (PROP,F,ROOF / G)
195 PS = SHIELDS PLOWING (S / G,M) BB
196 PT = PIG TAIL [ALSO RC; RC C] (SH / E)
197 PUSH SN = PUSH AFC TO CREATE SNAKE IN PANLINE (A / M,P)
198 QD = QUAD DRIVE (OB,B / E)
199 QS = QUILL SHAFT ? (A / M)
200 RA = RANGING ARM [FREQ SPECIFIED WITH HG OR TG] (SH / M,H)

201 RA RAM = RANGING ARM LIFT JACK (SH / H,M)
202 RACE = AFC CHAIN RACE,CHAIN OUT OF RACE (A,SL / M)
203 RAM = PUSH RAM AT SHIELD BASE OR TP TU (S,OB / H,M)
204 RB = ROOF BOLT (F,ROOF / P,G)
205 RC = REMOTE CONTROL [ALSO RC C] (SH,SL,OB / E)
206 RCP = ROOF CONTROL CK & FACE INSP & SA MESSAGE (F / P)
207 RD = ROCK DUST (F / P)
208 REC = RECUT [FREQ REC BOT] (F / G)
209 REL = RELAY CIRCUIT (ALL / E) OR RELAY BAR (S / M)
210 REM = REMOVE (ALL / ALL)
211 REM TIM = REMOVE TIM (HG OR TG) (F / P)
212 REP = REPAIR (ALL / ALL)
213 REPL = REPLACE (ALL / ALL)
214 RES = RESET SWITCH [ALSO RES SW] (A,SL,SH / E)
215 RET = HYDRAULIC RETURN LINE (H,S / H)
216 REV SW = REVERSE SWITCH (A / E)
217 RIB = PILLAR RIB (F,SA / P)
218 RING MAIN = EMULSION FLUID RING MAIN (H,S / H)
219 ROLLERS = BELT ROLLERS (OB,B / M)
220 ROOF = ROOF SUPPORT (ROOF,PROP / G,P)
221 RUN = RUN SUPPLY IN/OUT ON BELT (F / P)
222 RX = ROCK [ALSO CTRX,RX FALL,BRK RX,CRX] (RX,ROOF / G)
223 RX TH = THICK ROCK PARTING OR BINDER (ROOF,RX / G)
224 S = SHIELD (S / H,EH,C,M)
225 SA IN = SAFETY MEETING UNDERGROUND (SA / SA)
226 SA OS = SAFETY MEETING OUTSIDE (SA / SA)
227 SAND = SANDWICH PLATES (A,SL / M)
228 SC = SHORT CREW (F,PD / P)
229 SCH = SCHEDULED DOWNTIME ? (T)RUE OR (F)ALSE (ALL / ALL)
230 SCR = BELT SCRAPER (B,OB / M)
231 SEG = SEGMENT [FREQ REPL EICO SEG] (SH / M)
232 SEQ = SEQUENCE CABLE [ALSO SR,SS]
233 SER = SERVICE SHEARER [FREQ BIT SER] (SH / M,H) HO,GO
234 SER EQUIP =SERVICE ANY/ALL FACE EQUIPMENT (A,SL,CR,SH / H,M)
235 SET TIPS = PROGRAM SHIELD TIP SETTING (S / EH)
236 SEV = SEVERAL TIMES [FREQ WITH AVE=IND DUR] (ALL / ALL)
237 SH = SHEARER (SH / ALL)
238 SH WR = SHEARER DERAILED (SH / M,T)
239 SHOT = DRILLED AND SHOT ROCK OR KETTLEBOTTOM (RX,F / G)
240 SILO = SILO BELT (B / ALL)
241 SL = STAGE LOADER (SL / ALL)
242 SLA = SLATE ROCK TYPE (RX / G)
243 SLA SH = SHEARER STOPPED BY SLATE IN PAN (RX / G)
244 SMOKE = SMOKE DETECTOR SIGNAL (SA / V)
245 SN = SNAKE PANLINE (A / M)
246 SP = SOFT PLUG TORQUE CONVERTER FUSE (A,SL / H)
247 SPA = SPLITTER ARM (SH / M)
248 SPEED = SPEED REDUCER (A,SL,OB / M,H)
249 SPILL = SPILL COAL (OB / C) SPT
250 SPL = SPLICE BELT [ALSO SPLICE] (OB,B / M)

251 SPL = SPLICE CABLE [ALSO SPLICE] (A,SH,SL,OB / E)
252 SPL = STRAIGHTEN PANLINE (A / M)
253 SPOT BIT = SPOT REPLACEMENT OF BITS (SH / M)
254 SPR = SPROCKET (A,SH / M)
255 SPRAY = WATER SPRAY ARM (SH / H,M)
256 SPRAY CUT = DRUM SRAYS (SH / H)
257 SPT = SPILL TRAY, BOARDS, PLATE, OR FLAP (A,SL,OB / M) TP
258 SR = SEQUENCE ROLLER [ALSO SS] (OB,B / E)
259 SS = SEQUENCE SWITCH [ALSO HAWK] (OB,B / E)
260 SST = SANDSTONE ROLL (RX,ROOF / G)
261 ST = SLOW TRAMMING OF SHEARER [FREQ ST LS] (F,SH / G,P)
262 ST PAN LEAN = SLOW TRAMMING PAN LEANING (F / M)
263 STALL VAL = STALL VALVE ? (S,SH / H)
264 START # = START OF PANEL NUMBER #
265 START PANEL = BEGIN NEW PANEL
266 STOP = VENTILATION STOPPING (V / V)
267 STR = BELT STRUCTURE (OB / M)
268 STS = STATIC STARTER (OB,B / E,M)
269 SUP = RUN SUPPLIES OUTBY OR ONTO FACE (F / P)
270 SW = SWITCH (ALL / E)
271 SWRT = SHIELDS WONT REACH TOP & ALL SETTING PROB (S,ROOF /G)
272 SYS = SYSTEM (ALL / ALL)
273 TARDY = LATE IN (PD / P)
274 TB = TIGHTEN BOLTS (ALL / ALL)
275 TC = TORQUE CONVERTER (A,SL / H)
276 TCP = TORQUE CONVERTER PLATE (A,SL / M)
277 TD = TAILGATE DRIVE [ALSO TG DR] (A / H,M,E)
278 TF = TIGHTEN FITTING (SH,S / M,H)
279 TG = TAILGATE [USED TO SPECIFY EQUIP OR POSITION] (SH / ALL)
280 TG DR = AFC TAILGATE DRIVE [ALSO TD] (A / H,M,E)
281 THERM = OL THERMISTER [ALSO OL BRKER HOT] (SH / E,C)
282 TI = TIGHTEN (ALL / ALL)
283 TIM = TIMBERS [FREQ IN SFT REPORT] (PROP,ROOF / G,P)
284 TIM PAN = REMOVE TIMBER FROM PAN (A,F / P)
285 TP = TAILPIECE OF BELT (OB,B / M)
286 TP SPILL = TAILPIECE COAL SPILL (OB,B / M,C) ATP,SPT
287 TQS = TORQUE SHAFT [FREQ HG TQS,TG TQS] (SH / M)
288 TRAIN = TRAINING (F / P) A,SH,S,SL,CR
289 TRANS = TRANSMISSION ?
290 TRANSF = TRANSFORMER (POW / E) PC
291 TRAVEL IN = TRAVEL TIME IN [SCHEDULED = .T.] (PD / P)
292 TRAVEL OUT = TRAVEL TIME OUT [SCHEDULED = .F.] (PD / P)
293 TRIM = TRIM SPLICE (OB,B / M)
294 TRS = TROUBLESHOOT,OR CK [ALSO TS] (SH,A,SL / E,H) JB,PB
295 TS = TRAPPING SHOE (SH / M)
296 TU = BELT TAKEUP (OB / M)
297 UK = UNKNOWN
298 V = ADJ VENTILATION [ALSO STOP,VT,VC] (V / V)
299 VAC BRKER = VACUME BREAKER (POW / E) PC
300 VAL = VALVE (S,SH / H)

301 VC = VENTILATION CURTAIN (V / V)
302 VIO = VIOLATION (SA / SA) INSP,PERM
303 VLP = VERY LITTLE PRODUCTION (SFT REPORT)
304 VSM = VEVY SLOW MINING (SFT REPORT)
305 VT = VENTILATION TUBING (V / V)
306 W = WEDGE CUT (SFT REPORT) [ALSO XCUT] (F / P)
307 W = WELD (SH,A,SL,S,CR / M) BIT,PAN,SPT,BLJ,BLP
308 W BIT = WELD BIT INSERTS [ALSO INS] (SH / M)
309 WA = WATER (H,P,SH / H) NO WA,WA PLUG
310 WA HO = WATER IN HYDRAULIC FLUID (SH,A,SL / H)
311 WA TE = WATER TANK EMPTY (H,P / H)
312 WAIT = WAIT ON SHIELDS (S,P / C,H) EF P,XCUT
313 WAP = WATER PLUG (SH / H)
314 WEAR STRIP = REAR STRIP (A,SL / M)
315 WI = WIRE,CONTACT,LEAD (ALL / E)
316 WK = WORK ON (ALL / ALL)
317 WR = WRECKED, FOULED (A,SL,SH / M) CH WR,FL WR,SH WR
318 XCUT = EXTRA CUT [ALSO WEDGE] (F / P)
319 [* / *] = [FT ADV HEAD / FT ADV TAIL] (SFT REPORT)
320 [TOT] = COMPOSITE TIME [ALSO SEV] (ALL / ALL)

APPENDIX III

DATA MAINTENANCE AND DATA GENERATION PROGRAMS

Note: The character ";" (semicolon) is the dBASE line continuation symbol. In order to ensure proper operation of the programs in this section, type a blank character before each semicolon (" ;").

MAINTAIN PROGRAM

```
TEXT

     THIS PROGRAM RUNS THE DATA MAINTENANCE PROGRAMS AS AN
     AUTOMATED SEQUENCE. THE SEVEN DATA MAINTENANCE PROGRAMS RUN BY
     THIS PROGRAM ARE: 1)ADDTYPE, 2)FILLSFT, 3)CORRSFT,
     4)INTERSFT, 5)ADDSFT, 6)TRAVRCP, 7)OVERLAP.

ENDTEXT


CLEAR ALL
SET EXACT ON
SET DATE TO YMD
CLEAR
DTDATA=SPACE(8)
@ 5,10 SAY "ENTER DOWNTIME DATABASE NAME" GET DTDATA
READ
SFTDATA=SPACE(8)
@ 6,10 SAY "ENTER SHIFT DATABASE NAME" GET SFTDATA
READ
SELE 1
USE &DTDATA
SELE 2
USE &SFTDATA
DO ADDTYPE
DO FILLSFT
DO CORRSFT
DO INTERSFT
DO ADDSFT
DO TRAVRCP
DO OVERLAP
RETURN
```

ADDTYPE PROGRAM

```
SET EXACT ON

SELE 1
GOTO TOP

TEXT

      THIS PROGRAM IS FOR CONVENIENCE ONLY. IT FILLS THE DOWNTIME
      DATABASE TYPE FIELD IN ACCORDANCE WITH THE LAST THREE CHARACTERS
      OF THE EQUIP FIELD.

ENDTEXT

REPLACE TYPE WITH "E" FOR VAL(RIGHT(EQUIP,3)) > 0 .AND.;
VAL(RIGHT(EQUIP,3)) < 50
REPLACE TYPE WITH "M" FOR VAL(RIGHT(EQUIP,3)) > 49.AND.;
VAL(RIGHT(EQUIP,3)) < 100
REPLACE TYPE WITH "H" FOR VAL(RIGHT(EQUIP,3)) > 99 .AND.;
VAL(RIGHT(EQUIP,3)) < 150 .AND..NOT. TYPE="EH"
REPLACE TYPE WITH "G" FOR VAL(RIGHT(EQUIP,3)) > 149.AND.;
VAL(RIGHT(EQUIP,3)) < 200
REPLACE TYPE WITH "C" FOR VAL(RIGHT(EQUIP,3)) > 199.AND.;
VAL(RIGHT(EQUIP,3)) < 250
REPLACE TYPE WITH "P" FOR VAL(RIGHT(EQUIP,3)) > 249.AND.;
VAL(RIGHT(EQUIP,3)) < 300
REPLACE TYPE WITH "SA" FOR VAL(RIGHT(EQUIP,3)) > 299 .AND.;
VAL(RIGHT(EQUIP,3)) < 350
REPLACE TYPE WITH "V" FOR VAL(RIGHT(EQUIP,3)) > 349 .AND.;
VAL(RIGHT(EQUIP,3)) < 400
REPLACE TYPE WITH "NA" FOR VAL(RIGHT(EQUIP,3)) > 399.AND.;
VAL(RIGHT(EQUIP,3)) < 450
REPLACE TYPE WITH "EH" FOR VAL(RIGHT(EQUIP,3)) > 449

RETURN
```

FILLSFT PROGRAM

```
SET EXACT ON

TEXT

     THIS PROGRAM DELETES EMPTY SHIFT AND DOWNTIME DATABASE
     RECORDS, AND FILLS DUPLICATE DATE AND SHIFT FIELDS OF THE
     DOWNTIME DATABASE. THIS PORTION OF CODE DELETES EMPTY SHIFT
     DATABASE RECORDS.

ENDTEXT

SELE 2
GOTO TOP
SET DATE TO YMD
DELETE FOR DATE = CTOD("  /  /  ")
PACK

TEXT

     THIS PORTION OF CODE REPLACES THE FEET_ADVAN FIELD WITH THE
     AVERAGE VALUE OF FIELDS FEET_HEAD AND FEET_TAIL.

ENDTEXT

GOTO TOP
REPLACE FEET_ADVAN WITH LTRIM(STR((VAL(FEET_HEAD) +;
VAL(FEET_TAIL))/2)) FOR .NOT. FEET_HEAD = "      " .AND.;
.NOT. FEET_TAIL = "      ".AND. FEET_ADVAN = "      "
REPLACE FEET_ADVAN WITH FEET_HEAD FOR FEET_TAIL = "      " ;
.AND. FEET_ADVAN = "      "
REPLACE FEET_ADVAN WITH FEET_TAIL FOR FEET_HEAD = "      " ;
.AND. FEET_ADVAN = "      "

TEXT

     THIS PORTION OF CODE FILLS IN BLANK DATE FIELDS OF THE
     DOWNTIME DATABASE.

ENDTEXT

SELE 1
GOTO TOP
MDATE = CTOD("80/01/01")
DO WHILE .NOT. EOF()
 IF DATE = CTOD("  /  /  ")
REPLACE DATE WITH MDATE
ELSE
```

```
MDATE = DATE
ENDIF
IF .NOT. EOF()
SKIP
ELSE
LOOP
ENDIF
ENDDO

TEXT

     THIS PORTION OF CODE FILLS IN BLANK SHIFT FIELDS OF THE
     DOWNTIME DATABASE.

ENDTEXT

GOTO TOP
STORE "0" TO MSHIFT
DO WHILE .NOT. EOF()
IF SHIFT = "0" .OR. SHIFT = " "
REPLACE SHIFT WITH MSHIFT
ELSE
MSHIFT = SHIFT
ENDIF
IF .NOT. EOF()
SKIP
ELSE
LOOP
ENDIF
ENDDO

TEXT

     THIS PORTION OF CODE DELETES EMPTY DOWNTIME DATABASE RECORDS.

ENDTEXT

GOTO TOP
DELETE FOR EQUIP = "       "
PACK

RETURN
```

CORRSFT PROGRAM

```
SET EXACT ON
CLEAR
SET DATE TO YMD
MBASE = CTOD("85/01/01")

TEXT

     THIS PROGRAM CONVERTS THE SHIFT FIELDS OF THE SHIFT DATABASE
     AND DOWNTIME DATABASE TO A STANDARD CONVENTION; FIELDS WHICH
     RECORD TIME ARE CONVERTED TO MINUTES AFTER MIDNIGHT 01/01/85.
     THE FIRST PORTION OF CODE CORRECTS THE SHIFT FIELD OF THE
     SHIFT DATABASE TO CONFORM TO THE STANDARD SHIFT CONVENTION.

ENDTEXT

SELE 2
REPLACE ALL ARR_SECT WITH MOD(ARR_SECT,1440)
REPLACE ALL START_MINE WITH MOD(START_MINE,1440)
REPLACE ALL END_MINE WITH MOD(END_MINE,1440)
REPLACE ALL LEAVE_SECT WITH MOD(LEAVE_SECT,1440)
GOTO TOP
REPLACE SHIFT WITH "1" FOR ARR_SECT >= 1310 .OR. ARR_SECT < 350
REPLACE SHIFT WITH "2" FOR ARR_SECT >= 350 .AND. ARR_SECT < 830
REPLACE SHIFT WITH "3" FOR ARR_SECT >= 830 .AND. ARR_SECT < 1310

TEXT

     THIS PORTION OF CODE CONVERTS THE SHIFT DATABASE FIELDS
     ARR_SECT,START_MINE,END_MINE, AND LEAVE_SECT TO MINUTES
     AFTER MIDNIGHT 01/01/85. MIDNIGHT 01/01/85 IS THE BENCHMARK
     FROM WHICH ALL TIME IS MEASURED FOR PROGRAM CALCULATIONS.

ENDTEXT

GOTO TOP
    REPLACE ARR_SECT WITH ((DATE - MBASE) * 1440) + ARR_SECT FOR .NOT.;
    SHIFT = "1"
    REPLACE ARR_SECT WITH (((DATE - 1) - MBASE) * 1440) + ARR_SECT FOR;
    SHIFT = "1" .AND. ARR_SECT >= 1310
    REPLACE ARR_SECT WITH ((DATE - MBASE) * 1440) + ARR_SECT FOR SHIFT;
    = "1" .AND. ARR_SECT < 1310
    REPLACE START_MINE WITH ((DATE - MBASE) * 1440) + START_MINE FOR;
    .NOT. SHIFT = "1"
    REPLACE START_MINE WITH (((DATE - 1) - MBASE) * 1440) + START_MINE;
    FOR SHIFT = "1" .AND. START_MINE >= 1360
    REPLACE START_MINE WITH ((DATE - MBASE) * 1440) + START_MINE FOR;
```

```
    SHIFT = "1" .AND. START_MINE < 1360
    REPLACE END_MINE WITH ((DATE - MBASE) * 1440) + END_MINE FOR .NOT.;
    SHIFT = "3"
    REPLACE END_MINE WITH (((DATE + 1) - MBASE) * 1440) + END_MINE FOR;
    SHIFT = "3" .AND. END_MINE <= 80
    REPLACE END_MINE WITH ((DATE - MBASE) * 1440) + END_MINE FOR SHIFT;
    = "3" .AND. END_MINE > 80
    REPLACE LEAVE_SECT WITH ((DATE - MBASE) * 1440) + LEAVE_SECT FOR,
    .NOT. SHIFT = "3"
    REPLACE LEAVE_SECT WITH (((DATE + 1) - MBASE) * 1440) + LEAVE_SECT,
    FOR SHIFT = "3" .AND. LEAVE_SECT <= 120
    REPLACE LEAVE_SECT WITH ((DATE - MBASE) * 1440) + LEAVE_SECT FOR;
    SHIFT = "3" .AND. LEAVE_SECT > 120

TEXT

     THIS PORTION OF CODE CORRECTS THE SHIFT FIELD OF THE
     DOWNTIME DATABASE TO CONFORM TO THE STANDARD SHIFT CONVENTION.

ENDTEXT

SELE 1
REPLACE ALL BEGIN WITH MOD(BEGIN,1440)
AVERAGE BEGIN TO MSFT1 FOR SHIFT = "1" .AND. BEGIN > 0
AVERAGE BEGIN TO MSFT2 FOR SHIFT = "2" .AND. BEGIN > 0
AVERAGE BEGIN TO MSFT3 FOR SHIFT = "3" .AND. BEGIN > 0
GOTO TOP
IF MSFT1 > 480 .AND. MSFT2 > 960 .AND. MSFT3 < 480
REPLACE SHIFT WITH "1" FOR SHIFT = "3"
REPLACE SHIFT WITH "2" FOR SHIFT = "1"
REPLACE SHIFT WITH "3" FOR SHIFT = "2"
ENDIF

TEXT

     THIS PORTION OF CODE AFFECTS DOWNTIME DATABASE RECORDS
     WITH NO RECORDED TIME OF OCCURRENCE. THESE RECORDS ARE
     DISTINGUISHED BY HAVING A BEGIN FIELD VALUE OF 0. AT
     THIS TIME THESE RECORDS ARE LABLED WITH THE NOTATION
     "*TIME" IN THE COMMENTS FIELD, AND THE TIME FIELD IS
     CONVERTED TO MINUTES AFTER MIDNIGHT 01/01/85.

ENDTEXT

SET FILTER TO BEGIN = 0
REPLACE COMM WITH SUBSTR(COMM,6) FOR "*TIME " $ COMM
REPLACE ALL TIME WITH ((DATE - MBASE) * 1440) + ((VAL(SHIFT) - 1);
* 480),COMM WITH "*TIME " + LTRIM(COMM)
SET FILTER TO
```

```
TEXT

     THIS PORTION OF CODE AFFECTS DOWNTIME DATABASE RECORDS WITH
     A RECORDED TIME OF OCCURRENCE; THE TIME FIELD OF THESE RECORDS
     IS CONVERTED TO MINUTES AFTER MIDNIGHT 01/01/85.

ENDTEXT

CLOSE INDEX
INDEX ON DTOC(DATE) + SHIFT TO DT01
SET FILTER TO BEGIN > 0
GOTO TOP
REPLACE TIME WITH (((DATE - 1) - MBASE) * 1440) + BEGIN FOR SHIFT =;
"1" .AND. BEGIN > 1360
REPLACE TIME WITH ((DATE - MBASE) * 1440) + BEGIN FOR SHIFT = "1";
.AND. BEGIN <= 1360
REPLACE TIME WITH ((DATE - MBASE) * 1440) + BEGIN FOR SHIFT = "2"
REPLACE TIME WITH (((DATE + 1) - MBASE) * 1440) + BEGIN FOR SHIFT;
= "3" .AND. BEGIN < 80
REPLACE TIME WITH ((DATE - MBASE) * 1440) + BEGIN FOR SHIFT = "3";
.AND. BEGIN >= 80

TEXT

     THIS PORTION OF CODE ADJUSTS THE SHIFT FIELD OF PORTAL DELAYS,
     MANTRIP DELAYS, AND SAFETY DELAYS. DELAYS WHICH OCCUR MORE
     THAN 80 MINUTES BEFORE OR AFTER THE NORMAL 480 MINUTE SHIFT
     SPAN ARE ADJUSTED.

ENDTEXT

GOTO TOP
SET FILTER TO "PD" $ EQUIP .OR. "MT" $ EQUIP .OR. "SA" $ EQUIP
REPLACE SHIFT WITH "1" FOR BEGIN > 80 .AND. BEGIN < 400
REPLACE SHIFT WITH "2" FOR BEGIN >560 .AND. BEGIN < 900
REPLACE SHIFT WITH "3" FOR BEGIN >1040 .AND. BEGIN < 1360

TEXT

     THIS PORTION OF CODE ADJUSTS THE SHIFT FIELD OF THE DOWNTIME
     DATABASE FOR DELAYS OTHER THAN PORTAL DELAYS, MANTRIP DELAYS,
     AND SAFETY DELAYS. DELAYS WHICH BEGIN BEFORE ARRIVAL AT THE
     FACE OR AFTER DEPARTURE FROM THE FACE ARE ADJUSTED.

ENDTEXT

SELE 2
CLOSE INDEX
INDEX ON DTOC(DATE) + SHIFT TO SFT01 UNIQUE
SELE 1
```

```
SET FILTER TO BEGIN > 0 .AND..NOT.("PD" $ EQUIP .OR. "MT" $ EQUIP ;
.OR. "SA" $ EQUIP)
GOTO BOTT
MEND = DATE
GOTO TOP
MDATE = DATE
SELE 2
GOTO TOP
DO WHILE DATE < MDATE
SKIP
ENDDO
DO WHILE MDATE <= MEND
SELE 2
MARR1 = 0
MARR2 = 0
*MARR3 = 0
DO WHILE DATE = MDATE
   DO CASE

   CASE SHIFT = "1"
     MARR1 = ARR_SECT

   CASE SHIFT = "2"
     MARR2 = ARR_SECT

   CASE SHIFT = "3"
     MARR3 = ARR_SECT

   ENDCASE
     SKIP
ENDDO
SELE 1
DO WHILE DATE = MDATE
   DO CASE

   CASE TIME < MARR2
     REPLACE SHIFT WITH "1"

   CASE MARR2 = 0 .AND. BEGIN <= 480
     REPLACE SHIFT WITH "1"

   CASE TIME >= MARR2 .AND. TIME < MARR3 .AND..NOT. MARR3 = 0
     REPLACE SHIFT WITH "2"

   CASE TIME >= MARR2 .AND. MARR3 = 0 .AND..NOT. MARR2 = 0 .AND.;
   BEGIN <= 960
     REPLACE SHIFT WITH "2"

   CASE MARR2 = 0 .AND. MARR3 = 0 .AND. BEGIN > 480 .AND. BEGIN <= 960
     REPLACE SHIFT WITH "2"
```

```
    CASE TIME >= MARR3 .AND..NOT. MARR3 = 0
      REPLACE SHIFT WITH "3"

    CASE MARR3 = 0 .AND. BEGIN > 960
    REPLACE SHIFT WITH "3"
    ENDCASE
    SKIP
ENDDO
MDATE = MDATE + 1
ENDDO
SELE 1
CLOSE INDEX
SET FILTER TO
SELE 2
CLOSE INDEX

RETURN
```

INTERSFT PROGRAM

```
SET EXACT ON
SET DATE TO YMD
MBASE = CTOD("85/01/01")

SELE 1
CLOSE INDEX
SET INDEX TO DT01
REINDEX
SET FILTER TO .NOT. "*TIME" $ COMM
GOTO TOP

TEXT

     THIS PROGRAM ADJUSTS DOWNTIME DATABASE RECORDS WHICH SPAN TWO
     SHIFTS.THE FIRST PORTION OF CODE CALCULATES AVERAGE VALUES OF
     STATISTICS NEEDED FOR THE CREATION OF SURROGATE SHIFT RECORDS.

ENDTEXT

SELE 2
CLOSE INDEX
SET INDEX TO SFT01
AVERAGE TIME_IN TO MTRAVIN
AVERAGE TIME_OUT TO MTRAVOUT
AVERAGE TIME_RCP TO MRCP
REPLACE LEAVE_SECT WITH ARR_SECT + (480 - MTRAVIN - MTRAVOUT) FOR;
LEAVE_SECT - ARR_SECT > 600
REPLACE ALL LEAV2_SECT WITH LEAVE_SECT

TEXT

     THIS PORTION OF CODE STORES THE TIMES CORRESPONDING TO THE
     BEGINING AND END OF THE SHIFT TO BE EXAMINED; THE BEGINNING
     TIME OF THE SUBSEQUENT SHIFT IS ALSO STORED. THESE TIMES ARE
     READ FROM THE SHIFT DATABASE.

ENDTEXT

GOTO TOP
DO WHILE .NOT. EOF()
MDATE = DATE
MSHIFT = SHIFT
MLEAVE = LEAV2_SECT
MARR = ARR_SECT
SKIP 1
NEXTARR = ARR_SECT
```

```
SKIP -1

TEXT

     THIS PORTION OF CODES LOCATES THE SHIFT UNDER EXAMINATION WITHIN
     THE DOWNTIME DATABASE; ALL DOWNTIME RECORDS FROM THIS SHIFT ARE
     THEN COMPARED THE CREWS' TIME ON THE SECTION. A DETERMINATION IS
     MADE WHETHER ALL, A PORTION OF, OR NONE OF THE REPAIR WAS
     PERFORMED BY THE CREW UNDER EXAMINATION. DELAYS (REPAIRS) WHICH
     SPANS TWO SHIFTS ARE SPLIT; THOSE WHICH FALL OUTSIDE THE CREWS'
     TIME ON SECTION ARE MOVED TO THE PROPER SHIFT. NOTE THAT IF NO
     SHIFT RECORD EXISTS FOR THE PERIOD WHEN THE DELAY OCCURS A
     SHIFT RECORD IS CREATED AND MARKED "SURROGATE SHIFT RECORD TYPE
     # 1".

ENDTEXT

SELE 1
LOOK = DTOC(MDATE) + MSHIFT
FIND &LOOK
 IF FOUND()

DO WHILE DATE = MDATE .AND. SHIFT = MSHIFT
DO CASE

  CASE TIME + DURATION <= MARR .AND..NOT. ("PD" $ EQUIP .OR. "MT" $;
  EQUIP .OR. "SA" $ EQUIP)
     NEWLEAVE = TIME + DURATION
     NEWSHIFT = LTRIM(STR(VAL(MSHIFT) - 1))
     NEWDATE = MDATE
      IF VAL (NEWSHIFT) < 1
     NEWSHIFT = "3"
     NEWDATE = MDATE - 1
     ENDIF
     REPLACE DATE WITH NEWDATE,SHIFT WITH NEWSHIFT
     SELE 2
     MREC = RECNO()
     SKIP -1
      IF DATE = NEWDATE .AND. SHIFT = NEWSHIFT
     REPLACE LEAVE_SECT WITH MAX(NEWLEAVE,LEAVE_SECT),LEAV2_SECT WITH;
     LEAVE_SECT
     ELSE
     APPEND BLANK
     REPLACE DATE WITH NEWDATE,SHIFT WITH NEWSHIFT,ARR_SECT WITH;
     (((NEWDATE - MBASE)*1440)+((VAL(NEWSHIFT)-1)*480) +;
     MTRAVIN),LEAVE_SECT WITH MAX(NEWLEAVE,ARR_SECT + 480 - MTRAVIN -;
     MTRAVOUT),LEAV2_SECT WITH LEAVE_SECT,TIME_IN WITH;
     MTRAVIN,TIME_OUT W ITH MTRAVOUT,TIME_RCP WITH MRCP,COMMENTS WITH;
     "SURROGATE SHIFT RECORD TYPE #1 "
     ENDIF
```

```
   GOTO MREC
   SELE 1

CASE TIME + DURATION > MARR .AND. TIME < MARR .AND..NOT. ("PD" $;
EQUIP .OR. "MT" $ EQUIP .OR. "SA" $ EQUIP)
   ADJDUR = (TIME + DURATION) - MARR
   NEWSHIFT = LTRIM(STR(VAL(MSHIFT) - 1))
   NEWDATE = MDATE
   IF VAL (NEWSHIFT) < 1
   NEWSHIFT = "3"
   NEWDATE = DATE - 1
   ENDIF
   MEQUIP = EQUIP
   MTIME = TIME
   NEWBEGIN = BEGIN
   NEWDUR = DURATION - ADJDUR
   MTYPE = TYPE
   MSCHEDULED = SCHEDULED
   MCOMM = COMM
   REPLACE TIME WITH MARR,BEGIN WITH MOD(MARR,1440),DURATION WITH;
   ADJDUR,COMM WITH " CON'T " + LTRIM(COMM)
   MREC = RECNO()
   APPEND BLANK
   REPLACE DATE WITH NEWDATE,SHIFT WITH NEWSHIFT,EQUIP WITH MEQUIP,;
   TIME WITH MTIME,BEGIN WITH NEWBEGIN,DURATION WITH NEWDUR,TYPE;
   WITH MTYPE,SCHEDULED WITH MSCHEDULED,COMM WITH MCOMM
   GOTO MREC
   SELE 2
   MREC = RECNO()
   SKIP -1
   IF DATE = NEWDATE .AND. SHIFT = NEWSHIFT
   REPLACE LEAVE_SECT WITH MARR,LEAV2_SECT WITH MARR
   ELSE
   APPEND BLANK
   REPLACE DATE WITH NEWDATE,SHIFT WITH NEWSHIFT,ARR_SECT WITH;
   (((NEWDATE - MBASE)*1440)+((VAL(NEWSHIFT)-1);
   *480)+MTRAVIN),LEAVE_SECT WITH MARR,LEAV2_SECT WITH MARR,TIME_IN;
   WITH MTRAVIN,TIME_OUT WITH MTRAVOUT,TIME_RCP WITH MRCP,COMMENTS;
   WITH "SURROGATE SHIFT RECORD TYPE #1 "
   ENDIF
   GOTO MREC
   SELE 1

CASE TIME + DURATION > MLEAVE .AND. TIME + DURATION < NEXTARR .AND.;
.NOT.("PD" $ EQUIP .OR. "MT" $ EQUIP)
   IF NEXTARR - MLEAVE < 420
   ADJLEAVE = TIME + DURATION
   SELE 2
   REPLACE LEAVE_SECT WITH ADJLEAVE,LEAV2_SECT WITH ADJLEAVE
   SELE 1
```

```
ELSE
MGAP = NEXTARR - MLEAVE
 IF MLEAVE > TIME
ADJDUR = MLEAVE - TIME
REMDUR = DURATION - ADJDUR
REPLACE DURATION WITH ADJDUR
XNEWDUR = MIN(REMDUR,MGAP)
NEWDUR = MIN(XNEWDUR,600)
NEWSHIFT = LTRIM(STR(VAL(MSHIFT) + 1))
NEWDATE = MDATE
 IF VAL(NEWSHIFT) > 3
NEWSHIFT = "1"
NEWDATE = MDATE + 1
ENDIF
MEQUIP = EQUIP
MTYPE = TYPE
MSCHEDULED = SCHEDULED
MCOMM = "CON'T " + LTRIM(COMM)
MREC = RECNO()
APPEND BLANK
REPLACE DATE WITH NEWDATE,SHIFT WITH NEWSHIFT,EQUIP WITH MEQUIP,;
TIME WITH MLEAVE,BEGIN WITH MOD(TIME,1440),DURATION WITH;
NEWDUR,TYPE WITH MTYPE,SCHEDULED WITH MSCHEDULED,COMM WITH MCOMM
GOTO MREC
SELE 2
MREC = RECNO()
APPEND BLANK
REPLACE DATE WITH NEWDATE,SHIFT WITH NEWSHIFT,ARR_SECT WITH;
MLEAVE,LEAVE_SECT WITH MAX(ARR_SECT + 480 - MTRAVOUT,NEWDUR);
,LEAV2_SECT WITH LEAVE_SECT,TIME_IN WITH MTRAVIN,TIME_OUT WITH;
MTRAVOUT,TIME_RCP WITH 0,COMMENTS WITH " SURROGATE SHIFT RECORD;
TYPE #1"
ELSE
NEWSHIFT = LTRIM(STR(VAL(MSHIFT)+1))
NEWDATE = MDATE
MTIME = TIME
 IF VAL(NEWSHIFT) > 3
NEWSHIFT = "1"
NEWDATE = MDATE + 1
ENDIF
REPLACE DATE WITH NEWDATE,SHIFT WITH NEWSHIFT
SELE 2
MREC = RECNO()
APPEND BLANK
REPLACE DATE WITH NEWDATE,SHIFT WITH NEWSHIFT,ARR_SECT WITH;
MIN(MTIME,MLEAVE + MTRAVIN),LEAVE_SECT WITH;
MIN(NEXTARR,ARR_SECT+480-MTRAVIN-MTRAVOUT),LEAV2_SECT WITH;
LEAVE_SECT,TIME_IN WITH MTRAVIN,TIME_OUT WITH MTRAVOUT,TIME_RCP;
WITH MRCP,COMMENTS WITH " SURROGATE SHIFT RECORD TYPE #1"
GOTO MREC
```

```
SELE 1
ENDIF
ENDIF

CASE TIME + DURATION > NEXTARR .AND. TIME < NEXTARR
ADJDUR = NEXTARR - TIME
NEWSHIFT = LTRIM(STR(VAL(MSHIFT) + 1))
NEWDATE = MDATE
 IF VAL(NEWSHIFT) > 3
NEWSHIFT = "1"
NEWDATE = MDATE + 1
ENDIF
MEQUIP = EQUIP
MTIME = NEXTARR
NEWBEGIN = MOD(NEXTARR,1440)
NEWDUR = DURATION - ADJDUR
MTYPE = TYPE
MSCHEDULED = SCHEDULED
MCOMM = " CON'T " + LTRIM(COMM)
REPLACE DURATION WITH ADJDUR
MREC = RECNO()
APPEND BLANK
REPLACE DATE WITH NEWDATE,SHIFT WITH NEWSHIFT,EQUIP WITH MEQUIP,;
TIME WITH MTIME,BEGIN WITH NEWBEGIN,DURATION WITH NEWDUR,TYPE;
WITH MTYPE,SCHEDULED WITH MSCHEDULED,COMM WITH MCOMM
GOTO MREC
SELE 2
REPLACE LEAVE_SECT WITH NEXTARR,LEAV2_SECT WITH NEXTARR
SELE 1
CASE TIME > NEXTARR .AND. NEXTARR > 0
NEWSHIFT = LTRIM(STR(VAL(MSHIFT) + 1))
NEWDATE = MDATE
 IF VAL(NEWSHIFT) > 3
NEWSHIFT = "1"
NEWDATE = MDATE + 1
ENDIF
REPLACE DATE WITH NEWDATE,SHIFT WITH NEWSHIFT
ENDCASE
SKIP
ENDDO
ENDIF
SELE 2
SKIP
ENDDO
SELE 1
SET FILTER TO
RETURN
```

ADDSFT PROGRAM

```
SET EXACT ON
SET DATE TO YMD
MBASE = CTOD("85/01/01")

TEXT

     THIS PROGRAM CREATES A SURROGATE SHIFT DATABASE RECORD WHENEVER
     A SHIFT IS REPRESENTED IN THE DOWNTIME DATABASE AND ABSENT
     FROM THE SHIFT DATABASE; THESE RECORDS ARE IDENTIFIED BY THE
     NOTATION "SURROGATE SHIFT RECORD TYPE # 2" IN THE COMMENTS FIELD.
     THE PROGRAM ALSO CREATES A SURROGATE DOWNTIME RECORD FOR IDLE
     SHIFTS; THESE RECORDS ARE IDENTIFIED BY THE NOTATION "NO WORK OR
     MISSING SHIFT RECORD" IN THE COMM FIELD. THE FIRST PORTION OF
     CODE SKIPS PAST ANY SURROGATE DOWNTIME DATABASE RECORDS.

ENDTEXT

SELE 1
CLOSE INDEX
DELETE FOR "MISSING SHIFT RECORD" $ COMM .OR. "NO PRODUCTION RECORD" $;
COMM
PACK
SET INDEX TO DT01
REINDEX
GOTO TOP
MDATE = DATE
MSHIFT = SHIFT

TEXT

     THIS PORTION OF CODE DELETES ANY PREVIOUSLY CREATED TYPE # 2
     SURROGATE SHIFT DATABASE RECORDS; AVERAGE VALUES NECESSARY FOR
     THE CREATION OF NEW SURROGATE SHIFT RECORDS ARE ALSO CALCULATED.

ENDTEXT

SELE 2
DELETE FOR "SURROGATE SHIFT RECORD TYPE #2" $ COMMENTS
PACK
CLOSE INDEX
SET INDEX TO SFT01
REINDEX
AVERAGE TIME_IN TO MTRAVIN FOR TIME_IN > 0
AVERAGE TIME_OUT TO MTRAVOUT FOR TIME_OUT > 0
AVERAGE TIME_RCP TO MRCP
```

```
TEXT

     THIS PORTION OF CODE CREATES TYPE # 2 SURROGATE SHIFT RECORDS.

ENDTEXT

GOTO TOP
DO WHILE .NOT. EOF()
LOOK = DTOC(MDATE) + MSHIFT
FIND  &LOOK
IF .NOT. FOUND()
APPEND BLANK
REPLACE DATE WITH MDATE,SHIFT WITH MSHIFT,ARR_SECT WITH (((MDATE- ;
MBASE)*1440)+((VAL(MSHIFT)-1)*480)+MTRAVIN),TIME_IN WITH MTRAVIN, ;
TIME_OUT WITH MTRAVOUT,TIME_RCP WITH MRCP,COMMENTS WITH " SURROGATE;
SHIFT RECORD TYPE #2 ",LEAVE_SECT WITH (ARR_SECT +;
(480-MTRAVIN-MTRAVOUT)),LEAV2_SECT WITH LEAVE_SECT
GOTO TOP
ENDIF

SELE 1
DO WHILE (DATE = MDATE .AND. SHIFT = MSHIFT) .AND..NOT. EOF()
SKIP
ENDDO

IF .NOT. EOF()
MDATE = DATE
MSHIFT = SHIFT
ELSE
LOOP
ENDIF

SELE 2
ENDDO

TEXT

     THIS PORTION OF CODE DELETES DUPLICATE SHIFT RECORDS

ENDTEXT

SELE 2
CLOSE INDEX
DELETE ALL
SET INDEX TO SFT01
REINDEX
RECALL ALL
PACK
CLOSE INDEX
```

```
TEXT

     THIS PORTION OF CODE SORTS THE SHIFT DATABASE BY DATE, SHIFT.

ENDTEXT

SFTDATA = RIGHT(DBF(),LEN(DBF())-2)
USE
RENAME &SFTDATA TO ZZ.DBF
USE ZZ
SORT ON DATE,SHIFT TO &SFTDATA
USE &SFTDATA

TEXT

     THIS PORTION OF CODE INITIALIZES THE PROCESS OF CREATING
     DOWNTIME RECORDS WHICH IDENTIFY IDLE SHIFTS.

ENDTEXT

SELE 1
GOTO TOP
MDATE = DATE
MSHIFT = SHIFT
GOTO BOTT
MEND = DTOC(DATE) + SHIFT
SELE 2
CLOSE INDEX
SET INDEX TO SFT01
REINDEX
GOTO TOP
DO WHILE DTOC(MDATE) + MSHIFT < MEND

TEXT

     THIS PORTION OF CODE IDENTIFIES IDLE SHIFTS AND CREATES
     SURROGATE DOWNTIME DATABASE RECORDS WITH THE NOTATION "NO
     WORK OR MISSING SHIFT RECORD" IN THE COMM FIELD TO IDENTIFY
     IDLE SHIFTS.

ENDTEXT

LOOK = DTOC(MDATE) + MSHIFT
FIND &LOOK
IF .NOT. FOUND()
SELE 1
ENDIF
FIND &LOOK
IF .NOT. FOUND()
APPEND BLANK
```

```
REPLACE DATE WITH MDATE,SHIFT WITH MSHIFT,EQUIP WITH CDOW(MDATE),TIME;
WITH (((MDATE - MBASE)*1440) + ((VAL(MSHIFT) - 1)*480)),BEGIN WITH;
MOD(TIME,1440),DURATION WITH 480,TYPE WITH "NA",SCHEDULED WITH .T.,;
COMM WITH " NO WORK OR MISSING SHIFT RECORD "
 IF BEGIN = 0
REPLACE BEGIN WITH 1
ENDIF
ENDIF
MSHIFT =LTRIM(STR(VAL(MSHIFT) + 1))
 IF VAL(MSHIFT) > 3
MSHIFT ="1"
MDATE = MDATE + 1
ENDIF

SELE 2
ENDDO

RETURN
```

TRAVRCP PROGRAM

```
SET EXACT ON
CLEAR

TEXT

     THIS PROGRAM CREATES DOWNTIME DATABASE RECORDS FOR ALL TRAVEL
     DELAYS AND FACE CHECK DELAYS (RCP DELAYS). THE FIRST PORTION
     OF CODE DELETES ANY PREVIOUSLY CREATED RECORDS OF THIS TYPE.
     AVERAGE TRAVEL TIME VALUES ARE USED WHEN TRAVEL TIME DATA IS
     OMITTED.

ENDTEXT

SELE 1
DELETE FOR "TRAVEL IN" $ COMM .OR. "TRAVEL OUT" $ COMM .OR. "RCP " $;
COMM
PACK
SELE 2
AVERAGE TIME_IN TO MTRAVIN FOR TIME_IN > 0
AVERAGE TIME_OUT TO MTRAVOUT FOR TIME_OUT > 0

TEXT

     THIS PORTION OF CODE STORES TRAVEL DELAY VALUES AND FACE CHECK
     DELAY VALUES (RCP).

ENDTEXT

GOTO TOP
DO WHILE .NOT. EOF()
MDATE = DATE
MSHIFT = SHIFT
MIN = TIME_IN
MOUT = TIME_OUT
MRCP = TIME_RCP
MARR = ARR_SECT
MLEAVE = LEAV2_SECT

TEXT

     THIS PORTION OF CODE CREATES A DOWNTIME DATABASE RECORD
     OF TRAVEL IN TIME FOR EACH SHIFT.

ENDTEXT

SELE 1
```

```
APPEND BLANK
REPLACE DATE WITH MDATE, SHIFT WITH MSHIFT,TIME WITH (MARR -;
MIN),BEGIN WITH MOD(TIME,1440), EQUIP WITH "PD 260", DURATION WITH;
MIN,TYPE WITH "P" , SCHEDULED WITH .T., COMM WITH " TRAVEL IN "
 IF DURATION = 0
REPLACE DURATION WITH MTRAVIN
ENDIF
 IF BEGIN = 0
REPLACE BEGIN WITH 1
ENDIF

TEXT

     THIS PORTION OF CODE CREATES A DOWNTIME DATABASE RECORD
     OF TRAVEL OUT TIME FOR EACH SHIFT.

ENDTEXT

APPEND BLANK
REPLACE DATE WITH MDATE, SHIFT WITH MSHIFT,TIME WITH MLEAVE,BEGIN WITH;
MOD(MLEAVE,1440),EQUIP WITH "PD 260", DURATION WITH MOUT, TYPE WITH;
"P", SCHEDULED WITH .T., COMM WITH " TRAVEL OUT "
 IF DURATION = 0
REPLACE DURATION WITH MTRAVOUT
ENDIF
 IF BEGIN = 0
REPLACE BEGIN WITH 1
ENDIF

TEXT

     THIS PORTION OF CODE CREATES A DOWNTIME DATABASE RECORD
     OF FACE CHECK TIME FOR EACH SHIFT.

ENDTEXT

 IF .NOT. MRCP = 0
APPEND BLANK
REPLACE DATE WITH MDATE, SHIFT WITH MSHIFT,TIME WITH MARR, BEGIN WITH;
MOD(MARR,1440),EQUIP WITH "FA 255", DURATION WITH MRCP, TYPE WITH "P";
, SCHEDULED WITH .T., COMM WITH " RCP "
 IF BEGIN = 0
REPLACE BEGIN WITH 1
ENDIF
ENDIF
SELE 2
SKIP
ENDDO

RETURN
```

OVERLAP PROGRAM

```
TEXT

    THIS PROGRAM TRUNCATES OVERLAPPING PORTIONS OF DELAY INCIDENTS.
    THE FIRST PORTION OF CODE SORTS THE DOWNTIME DATABASE BY TIME AND
    SHIFT.

ENDTEXT

SET EXACT ON
SET DATE TO YMD
MBASE = CTOD("85/01/01")

SELE 1
CLOSE INDEX
DTDATA = RIGHT(DBF(),LEN(DBF())-2)
USE
RENAME &DTDATA TO ZZZ.DBF
USE ZZZ.DBF
SORT ON TIME,SHIFT TO &DTDATA
USE &DTDATA

REPLACE ALL BEGIN2 WITH BEGIN,DURATION2 WITH DURATION
REPLACE COMM WITH SUBSTR(COMM,5) FOR "*FOO " $ COMM

SET FILTER TO .NOT. (DURATION2 = 0 .OR. "*TIME " $ COMM )
MHOLD = .F.

TEXT

     THIS PORTION OF CODE LOCATES OVERLAPPING DELAYS AND TRUNCATES
     THE OVERLAPPING PORTION. THE NEW BEGIN TIME FOR THE TRUNCATED
     RECORD IS RECORDED IN THE BEGIN2 FIELD, THE NEW DURATION IS
     RECORDED IN THE DURATION2 FIELD.

ENDTEXT

GOTO TOP
DO WHILE .NOT. EOF()

 IF .NOT. MHOLD
MTRAV = .F.
MPORT = .F.
MRCP  = .F.
NOWORK = .F.

  MTIME = TIME
```

```
  MEND = MTIME + DURATION2

DO CASE

  CASE " TRAVEL " $ COMM
  MTRAV = .T.

  CASE " RCP " $ COMM
  MRCP = .T.

  CASE .NOT. " TRAVEL " $ COMM .AND. ("PD" $ EQUIP .OR. "MT" $ EQUIP)
  MPORT = .T.

  CASE "MISSING SHIFT RECORD" $ COMM
  NOWORK = .T.

ENDCASE
SKIP
IF EOF()
  LOOP
ENDIF
ENDIF

MHOLD = .F.

DO CASE

CASE MEND < TIME .OR. MEND = TIME
  LOOP

CASE MEND > TIME .AND. (MEND - TIME) < DURATION2

  DO CASE

  CASE "MISSING SHIFT RECORD" $ COMM
  REPLACE DURATION2 WITH DURATION - (MEND-TIME),BEGIN2 WITH;
  MOD(MEND,1440),TIME WITH MEND

  CASE NOWORK = .T.
  OVERLAP = MEND - TIME
  SKIP -1
  REPLACE DURATION2 WITH DURATION - OVERLAP
  SKIP

  CASE " TRAVEL " $ COMM .AND. MTRAV
  REPLACE COMM WITH "*FOO "+LTRIM(COMM),DURATION2 WITH 0
  SKIP -1
  REPLACE COMM WITH "*FOO "+LTRIM(COMM),DURATION2 WITH 0
  SKIP
```

```
   CASE " TRAVEL " $ COMM .AND. MPORT
   REPLACE DURATION2 WITH DURATION - (MEND - TIME),BEGIN2 WITH;
   MOD(MEND,1440),TIME WITH MEND

   CASE " TRAVEL " $ COMM .AND..NOT.(MTRAV .OR. MPORT)
   REPLACE COMM WITH "*FOO " + LTRIM(COMM),DURATION2 WITH 0
   MHOLD = .T.
   SKIP -1
   SKIP

   CASE .NOT. " TRAVEL " $ COMM .AND..NOT. (MTRAV .OR. MRCP)
   REPLACE DURATION2 WITH DURATION - (MEND - TIME),BEGIN2 WITH;
   MOD(MEND,1440),TIME WITH MEND

   CASE .NOT. " TRAVEL " $ COMM .AND. ("PD" $ EQUIP .OR. "MT" $ EQUIP);
   .AND. MTRAV
   MOVERLAP = MEND - TIME
   SKIP -1
   REPLACE DURATION2 WITH DURATION - MOVERLAP
   SKIP

   CASE .NOT. " TRAVEL " $ COMM .AND..NOT.;
   ("PD" $ EQUIP .OR. "MT" $ EQUIP) .AND. MTRAV
   SKIP -1
   REPLACE COMM WITH "*FOO " + LTRIM(COMM),DURATION2 WITH 0
   SKIP

   CASE .NOT. " TRAVEL " $ COMM .AND. MRCP
   MOVERLAP = MEND - TIME
   SKIP -1
   REPLACE DURATION2 WITH DURATION - MOVERLAP
   SKIP

   ENDCASE

CASE MEND > TIME .AND. (MEND - TIME) >= DURATION2

   DO CASE

   CASE "MISSING SHIFT" $ COMM
   REPLACE DURATION2 WITH 0
   MHOLD = .T.
   SKIP -1
   SKIP

   CASE NOWORK = .T.
   OVERLAP = MEND - TIME
   SKIP -1
   REPLACE DURATION2 WITH DURATION - OVERLAP
   SKIP
```

```
    CASE " TRAVEL " $ COMM .AND. MTRAV
    REPLACE COMM WITH "*FOO " + LTRIM(COMM),DURATION2 WITH 0
    SKIP -1
    REPLACE COMM WITH "*FOO " + LTRIM(COMM),DURATION2 WITH 0
    SKIP

    CASE " TRAVEL " $ COMM .AND. MPORT
    MOVERLAP = MEND - TIME
    SKIP -1
    REPLACE DURATION2 WITH DURATION - MOVERLAP
    SKIP

    CASE " TRAVEL " $ COMM .AND..NOT. (MTRAV .OR. MPORT)
    REPLACE COMM WITH "*FOO " + LTRIM(COMM),DURATION2 WITH 0
    MHOLD = .T.
    SKIP -1
    SKIP

    CASE .NOT. " TRAVEL " $ COMM .AND..NOT. MTRAV .AND..NOT. MRCP
    REPLACE DURATION2 WITH 0
    MHOLD = .T.
    SKIP -1
    SKIP

    CASE .NOT. " TRAVEL " $ COMM .AND. ("PD" $ EQUIP .OR. "MT" $ EQUIP);
    .AND. MTRAV
    MMOVE = MEND - (TIME + DURATION)
    REPLACE TIME WITH TIME + MMOVE,BEGIN2 WITH BEGIN + MMOVE
    MDUR = DURATION
    SKIP -1
    REPLACE DURATION2 WITH DURATION - MDUR
    SKIP

    CASE .NOT. " TRAVEL " $ COMM .AND..NOT. ("PD" $ EQUIP .OR. "MT" $;
    EQUIP) .AND. MTRAV
    SKIP -1
    REPLACE COMM WITH "*FOO " + LTRIM(COMM),DURATION2 WITH 0
    SKIP

    CASE .NOT. " TRAVEL " $ COMM .AND. MRCP
    MOVERLAP = MEND - TIME
    SKIP -1
    REPLACE DURATION2 WITH DURATION - MOVERLAP
    SKIP

    ENDCASE
    ENDCASE

ENDDO
```

```
SET FILTER TO

TEXT

     THIS PORTION OF CODE LOCATES SHIFT CHANGES WHERE THE RELIEF
     CREW TRAVELS TO THE FACE PRIOR TO THE DEPARTURE OF THE RETIRING
     CREW. IN SUCH CASES THE TWO TRAVEL TIMES ARE SET TO ZERO (IE.
     FACE CHANGE-OUT). THE NEW DURATION ZERO IS RECORDED IN THE
     DURATION2 FIELD, AND THE CHARACTERS "*FCO" ARE ADDED TO THE
     COMM FIELD TO INDICATE THAT A FACE CHANGE-OUT HAS OCCURED.

ENDTEXT

GOTO TOP
DO WHILE .NOT. EOF()

DO WHILE .NOT. " TRAVEL IN " $ COMM .AND..NOT. EOF()
SKIP
ENDDO

MSHIFT = SHIFT
MDATE = DATE

IF .NOT. EOF()
SKIP
ELSE
LOOP
ENDIF

DO WHILE .NOT. " TRAVEL " $ COMM .AND..NOT. EOF()
SKIP
ENDDO

IF " TRAVEL IN " $ COMM
IF .NOT. "*FCO " $ COMM
REPLACE COMM WITH "*FCO " + LTRIM(COMM),DURATION2 WITH 0
ENDIF
IF .NOT. EOF()
SKIP
ENDIF
DO WHILE .NOT. " TRAVEL " $ COMM .AND..NOT. EOF()
SKIP
ENDDO
IF " TRAVEL OUT " $ COMM .AND. SHIFT = MSHIFT .AND. DATE = MDATE;
.AND..NOT. "*FCO" $ COMM
REPLACE COMM WITH "*FCO " + LTRIM(COMM),DURATION2 WITH 0
ENDIF
ENDIF
```

```
ENDDO

CLEAR ALL
RUN ERASE *.NDX
RUN ERASE ZZ.DBF
RUN ERASE ZZZ.DBF
RETURN
```

DATAGEN PROGRAM

```
TEXT

     THIS PROGRAM RUNS AND CONTROLS THE DATA GENERATION PROGRAMS
     AS A SEQUENCE. THE DATA GENERATION SEQUENCE INCLUDES THE
     FOLLOWING PROGRAMS: SFTDELAY, SFTAVAIL, AUTOTTF, AUTOTTR,
     EQUIP%, TYPE%, STATS, SECAVAIL, AND MEANTIME.

ENDTEXT

SET EXACT ON
SET DATE TO YMD
CLEAR
DTDATA=SPACE(8)
@ 5,10 SAY "ENTER DOWNTIME DATABASE NAME" GET DTDATA
READ
SFTDATA=SPACE(8)
@ 7,10 SAY "ENTER SHIFT DATABASE NAME" GET SFTDATA
READ
PREFIX=SPACE(4)
@ 9,10 SAY "ENTER TWO DIGIT PREFIX FOR IDENTIFYING"
@ 10,10 SAY "THE TTF,TTR, AND RESULT DATABASES TO BE"
@ 11,10 SAY "GENERATED DURING THIS RUN, USE QUOTATION"
@ 12,10 SAY "MARKS" GET PREFIX
READ
MRESULT = &PREFIX + "RESULT"
SELE 1
USE &DTDATA
SELE 2
USE &SFTDATA
SELE 4
USE RESULT
COPY STRU TO &MRESULT
USE &MRESULT
APPEND BLANK
REPLACE MINE WITH &PREFIX
DO SFTDELAY
DO SFTAVAIL
DO AUTOTTF
DO AUTOTTR
DO EQUIP%
DO TYPE%
DO STATS
DO SECAVAIL
DO MEANTIME

RETURN
```

SFTDELAY PROGRAM

```
TEXT

     THIS PROGRAM CALCULATES FOUR DELAY FIGURES: 1) FACE DELAY,
     2) TOTAL SYSTEM DELAY, 3) SYSTEM DELAY (DELAYS WITH TIME OF
     OCCURRENCE ONLY), 4) INHERENT DELAYS. THESE FOUR DELAY
     FIGURES ARE TRANSFERED TO THE SHIFT DATABASE FIELDS MDELAY,
     TDELAY,TDEL_BEGIN, AND IDELAY. THE FIRST PORTION OF CODE
     INDEXES THE SHIFT AND DOWNTIME DATABASES, AND ESTABLISHES
     THE RANGE OF DATES OVER WHICH TO MAKE DELAY CALCULATIONS.

ENDTEXT

SET EXACT ON
SET DATE TO YMD
SELE 2
CLOSE INDEX
 INDEX ON DTOC(DATE) + SHIFT TO SFT11 UNIQUE
SELE 1
CLOSE INDEX
 INDEX ON DTOC(DATE) + SHIFT TO DT11
SET FILTER TO .NOT. "MISSING SHIFT RECORD" $ COMM
GOTO TOP
MDATE = DATE
MSHIFT = SHIFT
TOTDELAY = 0
MSTART = DTOC(DATE) + SHIFT
GOTO BOTT
MEND = DTOC(DATE) + SHIFT
GOTO TOP

TEXT

     THIS PORTION OF CODE CALCULATES THE MINUTES OF FACE DELAY
     TIME (MDELAY) FOR EACH SHIFT, AND WRITES THE FIGURE TO THE
     MDELAY FIELD OF THE SHIFT DATABASE.

ENDTEXT

DO WHILE .NOT. EOF()
DO CASE

  CASE .NOT.("MT" $ EQUIP .OR. "PD" $ EQUIP .OR. EQUIP = "FA 255" .OR.;
  ("SA"$ EQUIP.AND.SCHEDULED )).AND. DATE = MDATE .AND. SHIFT = MSHIFT
       TOTDELAY = TOTDELAY + DURATION2

  CASE .NOT.("MT" $ EQUIP .OR. "PD" $ EQUIP .OR. EQUIP = "FA 255" .OR.;
```

```
  ("SA"$ EQUIP .AND.  SCHEDULED)).AND.(.NOT.DATE = MDATE .OR..NOT.;
  SHIFT = MSHIFT)
        SELE 2
        LOOK = DTOC(MDATE) + MSHIFT
        FIND &LOOK
        IF FOUND()
        REPLACE MDELAY WITH TOTDELAY
        ENDIF
        SELE 1
        MDATE = DATE
        MSHIFT = SHIFT
        TOTDELAY = DURATION2

  CASE ("MT" $ EQUIP .OR. "PD" $ EQUIP .OR. EQUIP = "FA 255" .OR.;
  ("SA"$EQUIP.AND.SCHEDULED)) .AND. DATE = MDATE .AND. SHIFT = MSHIFT

  CASE ("MT" $ EQUIP .OR. "PD" $ EQUIP .OR. EQUIP = "FA 255" .OR.;
  ("SA"$EQUIP.AND.SCHEDULED)) .AND. (.NOT. DATE = MDATE .OR..NOT.;
  SHIFT = MSHIFT)
        SELE 2
        LOOK = DTOC(MDATE) + MSHIFT
        FIND &LOOK
        IF FOUND()
        REPLACE MDELAY WITH TOTDELAY
        ENDIF
        SELE 1
        MDATE = DATE
        MSHIFT = SHIFT
        TOTDELAY = 0

ENDCASE

SKIP
ENDDO

SELE 2
LOOK = DTOC(MDATE) + MSHIFT
FIND &LOOK
IF FOUND()
REPLACE MDELAY WITH TOTDELAY
ENDIF

GOTO TOP
REPLACE MDELAY WITH 0 FOR MDELAY = 0 .AND. DTOC(DATE)+SHIFT >= MSTART;
.AND. DTOC(DATE)+SHIFT <= MEND

TEXT

     THIS PORTION OF CODE CALCULATES THE MINUTES OF TOTAL SYSTEM
     DELAY TIME (TDELAY) FOR EACH SHIFT, AND WRITES THE FIGURE TO
```

```
     THE TDELAY FIELD OF THE SHIFT DATABASE.

ENDTEXT

SELE 1
GOTO TOP
MDATE = DATE
MSHIFT = SHIFT
TOTDELAY = 0
DO WHILE .NOT. EOF()
DO CASE

  CASE DATE = MDATE .AND. SHIFT = MSHIFT
       TOTDELAY = TOTDELAY + DURATION2

  CASE(.NOT.DATE=MDATE.OR..NOT.SHIFT=MSHIFT)
       SELE 2
       LOOK = DTOC(MDATE) + MSHIFT
       FIND &LOOK
       IF FOUND()
       REPLACE TDELAY WITH TOTDELAY
       ENDIF
       SELE 1
       MDATE = DATE
       MSHIFT = SHIFT
       TOTDELAY = DURATION2

ENDCASE

SKIP
ENDDO

SELE 2
LOOK = DTOC(MDATE) + MSHIFT
FIND &LOOK
IF FOUND()
REPLACE TDELAY WITH TOTDELAY
ENDIF

GOTO TOP
REPLACE TDELAY WITH 0 FOR TDELAY = 0 .AND. DTOC(DATE)+SHIFT >= MSTART ;
.AND. DTOC(DATE)+SHIFT <= MEND

TEXT

     THIS PORTION OF CODE CALCULATES THE MINUTES OF SYSTEM DELAY TIME
     FOR DELAYS WITH A TIME OF OCCURRENCE RECORDED. THIS CALCULATION IS
     PERFORMED FOR EACH SHIFT AND THE RESULTS ARE WRITTEN TO THE
     TDEL_BEGIN FIELD OF THE SHIFT DATABASE.
```

```
ENDTEXT

SELE 1
SET FILTER TO .NOT. ("MISSING SHIFT RECORD" $ COMM .OR. "*TIME" $ COMM)
GOTO TOP
MDATE = DATE
MSHIFT = SHIFT
TOTDELAY = 0

DO WHILE .NOT. EOF()
DO CASE

  CASE DATE = MDATE .AND. SHIFT = MSHIFT
       TOTDELAY = TOTDELAY + DURATION2

  CASE(.NOT.DATE=MDATE.OR..NOT.SHIFT=MSHIFT)
       SELE 2
       LOOK = DTOC(MDATE) + MSHIFT
       FIND &LOOK
        IF FOUND()
       REPLACE TDEL_BEGIN WITH TOTDELAY
       ENDIF
       SELE 1
       MDATE = DATE
       MSHIFT = SHIFT
       TOTDELAY = DURATION2

ENDCASE

SKIP
ENDDO

SET FILTER TO

SELE 2
LOOK = DTOC(MDATE) + MSHIFT
FIND &LOOK
 IF FOUND()
REPLACE TDEL_BEGIN WITH TOTDELAY
ENDIF

GOTO TOP
REPLACE TDEL_BEGIN WITH 0 FOR TDEL_BEGIN = 0 .AND. DTOC(DATE)+SHIFT;
>= MSTART .AND. DTOC(DATE)+SHIFT <= MEND

TEXT

     THIS PORTION OF CODE CALCULATES THE MINUTES OF INHERENT DELAY TIME
     FOR EACH SHIFT AND WRITES THE RESULT TO THE SHIFT FIELD IDELAY.
```

```
ENDTEXT

GOTO TOP
REPLACE ALL IDELAY WITH TDELAY - MDELAY

SELE 1
SET INDEX TO
SET FILTER TO
SELE 2
SET INDEX TO
SET FILTER TO
RETURN
```

SFTAVAIL PROGRAM

```
TEXT

     THIS PROGRAM CALCULATES FACE AVAILABILITY (MAVAIL), TOTAL
     SYSTEM AVAILABILITY (TAVAIL), AND TTFFACTOR. THE FIRST
     PORTION OF CODE CALCULATES A FACE AVAILABILITY FOR EACH
     SHIFT AND WRITES THE FIGURE TO THE MAVAIL FIELD OF THE
     SHIFT DATABASE.

ENDTEXT

SET EXACT ON
SELE 2
GOTO TOP
REPLACE ALL MAVAIL WITH ((LEAV2_SECT - (ARR_SECT + TIME_RCP) - MDELAY);
/(LEAV2_SECT - (ARR_SECT + TIME_RCP))) * 100
REPLACE MAVAIL WITH 0 FOR MAVAIL < 0

TEXT

     THIS PORTION OF CODE CALCULATES THE TOTAL SYSTEM AVAILABILITY
     FOR EACH SHIFT AND WRITES THE FIGURE TO THE TAVAIL FIELD OF
     THE SHIFT DATABASE.

ENDTEXT

GOTO TOP
REPLACE ALL TAVAIL WITH ((LEAV2_SECT - (ARR_SECT + TIME_RCP) - MDELAY);
/(LEAV2_SECT - (ARR_SECT + TIME_RCP) + IDELAY)) * 100
REPLACE TAVAIL WITH 0 FOR TAVAIL < 0

TEXT

     THIS PORTION OF CODE CALCULATES A VALUE FOR TTFFACTOR FOR
     EACH SHIFT AND WRITES THE FIGURE TO THE TTFFACTOR FIELD OF
     THE SHIFT DATABASE.

ENDTEXT

GOTO TOP
REPLACE ALL TTFFACTOR WITH (LEAV2_SECT - (ARR_SECT + TIME_RCP) -;
MDELAY)/(LEAV2_SECT - (ARR_SECT + TIME_RCP) - MDELAY + (TDELAY -;
TDEL_BEGIN))
REPLACE TTFFACTOR WITH 0 FOR TTFFACTOR < 0
REPLACE TTFFACTOR WITH 1 FOR .NOT. TTFFACTOR >= 0

RETURN
```

TTFPRG PROGRAM

```
TEXT

     THIS PROGRAM CALCULATES TTF STATISTICS FOR ANY COMBINATION
     OF EQUIPMENT TYPES OR DELAY TYPES. THE FIRST PORTION OF CODE
     QUERIES THE OPERATOR FOR THE FOLLOWING INFORMATION: DOWNTIME
     DATABASE NAME, SHIFT DATABASE NAME, TTF DATABASE NAME,
     EQUIPMENT TYPES, DELAY TYPES.

ENDTEXT

CLEAR
CLEAR ALL
SET EXACT ON
SET DATE TO YMD
DTDATA=SPACE(8)
@ 3,4 SAY "ENTER DT DATABASE NAME" GET DTDATA
READ
SFTDATA=SPACE(8)
@ 4,4 SAY "ENTER SFT DATABASE NAME" GET SFTDATA
READ
TTFDBF=SPACE(8)
@ 5,4 SAY "ENTER TTF DATABASE NAME" GET TTFDBF
READ
USE TTF
COPY STRU TO &TTFDBF
USE
MEQUIP1=SPACE(8)
@ 6,4 SAY "ENTER EQUIP TYPE #1,USE QUOTATION MARKS,ONE BLANK FOR ALL;
EQUIP" GET MEQUIP1
READ
MEQUIP2=SPACE(8)
@ 7,4 SAY "ENTER EQUIP TYPE #2,USE QUOTATION MARKS,SIX BLANKS FOR;
NONE" GET MEQUIP2
READ
MEQUIP3=SPACE(8)
@ 8,4 SAY "ENTER EQUIP TYPE #3,USE QUOTATION MARKS,SIX BLANKS FOR;
NONE" GET MEQUIP3
READ
MEQUIP4=SPACE(8)
@ 9,4 SAY "ENTER EQUIP TYPE #4,USE QUOTATION MARKS,SIX BLANKS FOR;
NONE" GET MEQUIP4
READ
MTYPE1=SPACE(4)
@ 10,4 SAY "ENTER DELAY TYPE #1,USE QUOTATION MARKS,ONE BLANK FOR ALL";
GET MTYPE1
READ
```

```
IF MTYPE1 = " "
MTYPE2=" "
MTYPE3=" "
MTYPE4=" "
MTYPE5=" "
MTYPE6=" "
MTYPE7=" "
MTYPE8=" "
ELSE
MTYPE2=SPACE(4)
@ 11,4 SAY "ENTER DELAY TYPE #2,USE QUOTATION MARKS,XX FOR NONE" GET;
MTYPE2
READ
MTYPE3=SPACE(4)
@ 12,4 SAY "ENTER DELAY TYPE #3,USE QUOTATION MARKS,XX FOR NONE" GET;
MTYPE3
READ
MTYPE4=SPACE(4)
@ 13,4 SAY "ENTER DELAY TYPE #4,USE QUOTATION MARKS,XX FOR NONE" GET;
MTYPE4
READ
MTYPE5=SPACE(4)
@ 14,4 SAY "ENTER DELAY TYPE #5,USE QUOTATION MARKS,XX FOR NONE" GET;
MTYPE5
READ
MTYPE6=SPACE(4)
@ 15,4 SAY "ENTER DELAY TYPE #6,USE QUOTATION MARKS,XX FOR NONE" GET;
MTYPE6
READ
MTYPE7=SPACE(4)
@ 16,4 SAY "ENTER DELAY TYPE #7,USE QUOTATION MARKS,XX FOR NONE" GET;
MTYPE7
READ
MTYPE8=SPACE(4)
@ 17,4 SAY "ENTER DELAY TYPE #8,USE QUOTATION MARKS,XX FOR NONE" GET;
MTYPE8
READ
SELE 2
CLOSE INDEX
INDEX ON DTOC(DATE) + SHIFT TO SFT11
SELE 3
USE &TTFDBF
SELE 1
CLOSE INDEX

TEXT

     THIS FILTER EXCLUDES RECORDS WITHOUT A TIME OF OCCURRENCE,
     AND THOSE WHICH ARE COMPLETELY OVERLAPPED BY ANOTHER DELAY,
     FROM TTF CALCULATIONS.
```

```
ENDTEXT

SET FILTER TO .NOT.("*TIME" $ COMM .OR. DURATION2 = 0 )
GOTO TOP

TEXT

     THIS PORTION OF CODE INITIALIZES THE PROCESS OF CALCULATING
     THE TTF STATISTICS BY LOCATING THE FIRST UNSCHEDULED DELAY
     EVENT OF THE SPECIFIED EQUIPMENT TYPE AND DELAY TYPE.

ENDTEXT

LOCATE FOR (&MEQUIP1 $ EQUIP .OR. &MEQUIP2 $ EQUIP .OR. &MEQUIP3 $;
EQUIP .OR. &MEQUIP4 $ EQUIP) .AND. (MTYPE1 = " " .OR. TYPE=&MTYPE1;
.OR. TYPE=&MTYPE2 .OR. TYPE=&MTYPE3 .OR. TYPE=&MTYPE4 .OR.;
TYPE=&MTYPE5 .OR. TYPE=&MTYPE6 .OR. TYPE=&MTYPE7 .OR. TYPE;
=&MTYPE8) .AND..NOT. SCHEDULED
IF .NOT. EOF()
MTIME = TIME
TOTDELAY = DURATION2
MIDLE = 0
MEQUIP = '"' + EQUIP + '"'
SKIP
ENDIF

TEXT

     IN THIS PORTION OF CODE A CHECK IS MADE WHETHER THE
     CURRENT RECORD REPRESENTS A CONTINUATION OF THE PREVIOUS
     DELAY. DELAY RECORDS WHICH ARE PARTIALLY OVERLAPPED BY
     ANOTHER DELAY ARE EXCLUDED FROM TTF CALCULATIONS HERE.

ENDTEXT

DO WHILE .NOT. EOF()
DO WHILE (SCHEDULED .OR..NOT. DURATION = DURATION2 .OR. (EQUIP =;
&MEQUIP .AND. "CON'T" $ COMM)).AND..NOT. EOF()
TOTDELAY = TOTDELAY + DURATION2
IF "NO WORK OR MISSING SHIFT RECORD" $ COMM
MIDLE = MIDLE + DURATION2
ENDIF
SKIP
ENDDO

IF EOF()
LOOP
ENDIF
```

```
TEXT

      IN THIS PORTION OF CODE DELAYS OF THE SPECIFIED EQUIPMENT
      TYPE(S) AND DELAY TYPE(S) ARE DISTINGUISHED FROM THOSE
      WHICH ARE NOT. IF A DELAY IS OF THE TYPE SPECIFIED AN ACTIVE
      TTF AND A TOTAL TTF ARE CALCULATED AND WRITTEN TO THE TTF
      DATABASE FIELDS TTFACT AND TTFTOT RESPECTIVELY. IF A DELAY
      IS NOT OF THE TYPE SPECIFIED ITS DURATION IS ADDED TO
      TOTDELAY.

ENDTEXT

IF (&MEQUIP1 $ EQUIP .OR. &MEQUIP2 $ EQUIP .OR. &MEQUIP3 $ EQUIP .OR.;
&MEQUIP4 $ EQUIP) .AND. (MTYPE1 = " " .OR. TYPE=&MTYPE1 .OR.;
TYPE=&MTYPE2 .OR. TYPE=&MTYPE3 .OR. TYPE=&MTYPE4 .OR. TYPE=&MTYPE5;
.OR. TYPE=&MTYPE6 .OR. TYPE=&MTYPE7 .OR. TYPE=&MTYPE8)
TIMEPAST = TIME - MTIME
MTTF = TIMEPAST - TOTDELAY
MTIME = TIME
MDATE = DATE
MSHIFT = SHIFT
MBEGIN = BEGIN2
MDUR = DURATION2
MEQUIP = '"' + EQUIP + '"'
MMEQUIP = EQUIP
SELE 3
APPE BLANK
REPLACE DATE WITH MDATE,SHIFT WITH MSHIFT,EQUIP WITH MMEQUIP,TIME WITH;
MTIME,BEGIN WITH MBEGIN,DURATION WITH MDUR,TTFACT WITH MTTF,ACCUMDOWN;
WITH TOTDELAY - MIDLE,TIME_IDLE WITH MIDLE,TTFTOT WITH TIMEPAST - MIDLE
SELE 1
TOTDELAY = DURATION2
MIDLE = 0
ELSE
TOTDELAY = TOTDELAY + DURATION2
MEQUIP = '"' + EQUIP + '"'
ENDIF

SKIP
ENDDO

SET FILTER TO

TEXT

      IN THIS PORTION OF CODE ALL TTF VALUES ARE AUGMENTED BY
      ONE. THIS ELIMINATES ANY TTF VALUES OF 0 THEREBY
      FACILITATING THE FITTING OF PROBABILITY DENSITY FUNCTIONS
      TO THESE STATISTICS.
```

```
ENDTEXT

SELE 3
REPLACE ALL TTFACT WITH TTFACT + 1,TTFTOT WITH TTFTOT + 1

RETURN
```

AUTOTTF PROGRAM

```
TEXT

     THIS PROGRAM CALCULATES TTF STATISTICS FOR THE EQUIPMENT
     TYPES SH, FC, SD, SL, CR, SB, HB, AND BN. THESE CALCULATIONS
     ARE MADE EXCLUSIVE OF GEOLOGIC DELAYS. TTF STATISTICS ARE
     ALSO CALCULATED FOR DELAYS OF THE DELAY TYPE "G", AND FOR ALL
     SYSTEM DELAYS. THE FIRST PORTION OF CODE CALCULATES TTF
     STATISTICS FOR THE SHEARER (SH).

ENDTEXT

SET EXACT ON
SET DATE TO YMD
TTFNAME = &PREFIX + "SHTTF"
SELE 3
USE TTF
COPY STRU TO &TTFNAME
USE &TTFNAME
SELE 1
CLOSE INDEX
SET FILTER TO .NOT.("*TIME" $ COMM .OR. DURATION2 = 0 )
GOTO TOP
LOCATE FOR "SH" $ EQUIP .AND..NOT. (SCHEDULED .OR. TYPE = "G")
IF .NOT. EOF()
MTIME = TIME
TOTDELAY = DURATION2
MIDLE = 0
MEQUIP = '"' + EQUIP + '"'
SKIP
ENDIF
DO WHILE .NOT. EOF()
DO WHILE (SCHEDULED .OR. TYPE = "G" .OR..NOT. DURATION = DURATION2;
.OR. (EQUIP = &MEQUIP .AND. "CON'T" $ COMM)).AND..NOT. EOF()
TOTDELAY = TOTDELAY + DURATION2
IF "NO WORK OR MISSING SHIFT RECORD" $ COMM
MIDLE = MIDLE + DURATION2
ENDIF
SKIP
ENDDO
IF EOF()
LOOP
ENDIF
IF "SH" $ EQUIP
TIMEPAST = TIME - MTIME
MTTF = TIMEPAST - TOTDELAY
MTIME = TIME
```

```
MDATE = DATE
MSHIFT = SHIFT
MBEGIN = BEGIN2
MDUR = DURATION2
MEQUIP = '"' + EQUIP + '"'
MMEQUIP = EQUIP
SELE 3
APPE BLANK
REPLACE DATE WITH MDATE,SHIFT WITH MSHIFT,EQUIP WITH MMEQUIP,TIME;
WITH MTIME,BEGIN WITH MBEGIN,DURATION WITH MDUR,TTFACT WITH MTTF,;
ACCUMDOWN WITH TOTDELAY - MIDLE,TIME_IDLE WITH MIDLE,TTFTOT WITH ;
TIMEPAST - MIDLE
SELE 1
TOTDELAY = DURATION2
MIDLE = 0
ELSE
TOTDELAY = TOTDELAY + DURATION2
MEQUIP = '"' + EQUIP + '"'
ENDIF
SKIP
ENDDO
SELE 3
REPLACE ALL TTFACT WITH TTFACT + 1,TTFTOT WITH TTFTOT + 1

TEXT

     THIS PORTION OF CODE CALCULATES TTF STATISTICS FOR THE FACE
     CONVEYOR (FC).

ENDTEXT

TTFNAME = &PREFIX + "FCTTF"
SELE 3
USE TTF
COPY STRU TO &TTFNAME
USE &TTFNAME
SELE 1
GOTO TOP
LOCATE FOR "FC" $ EQUIP .AND..NOT. (SCHEDULED .OR. TYPE = "G")
IF .NOT. EOF()
MTIME = TIME
TOTDELAY = DURATION2
MIDLE = 0
MEQUIP = '"' + EQUIP + '"'
SKIP
ENDIF
DO WHILE .NOT. EOF()
DO WHILE (SCHEDULED .OR. TYPE = "G" .OR..NOT. DURATION = DURATION2;
.OR. (EQUIP = &MEQUIP .AND. "CON'T" $ COMM)).AND..NOT. EOF()
TOTDELAY = TOTDELAY + DURATION2
```

```
IF "NO WORK OR MISSING SHIFT RECORD" $ COMM
MIDLE = MIDLE + DURATION2
ENDIF
SKIP
ENDDO
IF EOF()
LOOP
ENDIF
IF "FC" $ EQUIP
TIMEPAST = TIME - MTIME
MTTF = TIMEPAST - TOTDELAY
MTIME = TIME
MDATE = DATE
MSHIFT = SHIFT
MBEGIN = BEGIN2
MDUR = DURATION2
MEQUIP = '"' + EQUIP + '"'
MMEQUIP = EQUIP
SELE 3
APPE BLANK
REPLACE DATE WITH MDATE,SHIFT WITH MSHIFT,EQUIP WITH MMEQUIP,TIME;
WITH MTIME,BEGIN WITH MBEGIN,DURATION WITH MDUR,TTFACT WITH MTTF,;
ACCUMDOWN WITH TOTDELAY - MIDLE,TIME_IDLE WITH MIDLE,TTFTOT WITH ;
TIMEPAST - MIDLE
SELE 1
TOTDELAY = DURATION2
MIDLE = 0
ELSE
TOTDELAY = TOTDELAY + DURATION2
MEQUIP = '"' + EQUIP + '"'
ENDIF
SKIP
ENDDO
SELE 3
REPLACE ALL TTFACT WITH TTFACT + 1,TTFTOT WITH TTFTOT + 1

TEXT

     THIS PORTION OF CODE CALCULATES TTF STATISTICS FOR THE SHIELDS
     (SD).

ENDTEXT

TTFNAME = &PREFIX + "SDTTF"
SELE 3
USE TTF
COPY STRU TO &TTFNAME
USE &TTFNAME
SELE 1
GOTO TOP
```

```
LOCATE FOR ("SD" $ EQUIP .OR. "HO 100" $ EQUIP .OR. "PM 102" $ EQUIP);
.AND..NOT. (SCHEDULED .OR. TYPE = "G")
 IF .NOT. EOF()
MTIME = TIME
TOTDELAY = DURATION2
MIDLE = 0
MEQUIP = '"' + EQUIP + '"'
SKIP
ENDIF
DO WHILE .NOT. EOF()
DO WHILE (SCHEDULED .OR. TYPE = "G" .OR..NOT. DURATION = DURATION2;
.OR. (EQUIP = &MEQUIP .AND. "CON'T" $ COMM)).AND..NOT. EOF()
TOTDELAY = TOTDELAY + DURATION2
 IF "NO WORK OR MISSING SHIFT RECORD" $ COMM
MIDLE = MIDLE + DURATION2
ENDIF
SKIP
ENDDO
 IF EOF()
LOOP
ENDIF
 IF ("SD" $ EQUIP .OR. "HO 100" $ EQUIP .OR. "PM 102" $ EQUIP)
TIMEPAST = TIME - MTIME
MTTF = TIMEPAST - TOTDELAY
MTIME = TIME
MDATE = DATE
MSHIFT = SHIFT
MBEGIN = BEGIN2
MDUR = DURATION2
MEQUIP = '"' + EQUIP + '"'
MMEQUIP = EQUIP
SELE 3
APPE BLANK
REPLACE DATE WITH MDATE,SHIFT WITH MSHIFT,EQUIP WITH MMEQUIP,TIME WITH;
MTIME,BEGIN WITH MBEGIN,DURATION WITH MDUR,TTFACT WITH MTTF,ACCUMDOWN;
WITH TOTDELAY - MIDLE,TIME_IDLE WITH MIDLE,TTFTOT WITH TIMEPAST - MIDLE
SELE 1
TOTDELAY = DURATION2
MIDLE = 0
ELSE
TOTDELAY = TOTDELAY + DURATION2
MEQUIP = '"' + EQUIP + '"'
ENDIF
SKIP
ENDDO
SELE 3
REPLACE ALL TTFACT WITH TTFACT + 1,TTFTOT WITH TTFTOT + 1

TEXT
```

THIS PORTION OF CODE CALCULATES TTF STATISTICS FOR THE
STAGELOADER (SL)

```
ENDTEXT

TTFNAME = &PREFIX + "SLTTF"
SELE 3
USE TTF
COPY STRU TO &TTFNAME
USE &TTFNAME
SELE 1
GOTO TOP
LOCATE FOR "SL" $ EQUIP .AND..NOT. (SCHEDULED .OR. TYPE = "G")
 IF .NOT. EOF()
MTIME = TIME
TOTDELAY = DURATION2
MIDLE = 0
MEQUIP = '"' + EQUIP + '"'
SKIP
ENDIF
DO WHILE .NOT. EOF()
DO WHILE (SCHEDULED .OR. TYPE = "G" .OR..NOT. DURATION = DURATION2;
.OR. (EQUIP = &MEQUIP .AND. "CON'T" $ COMM)).AND..NOT. EOF()
TOTDELAY = TOTDELAY + DURATION2
 IF "NO WORK OR MISSING SHIFT RECORD" $ COMM
MIDLE = MIDLE + DURATION2
ENDIF
SKIP
ENDDO
 IF EOF()
LOOP
ENDIF
 IF "SL" $ EQUIP
TIMEPAST = TIME - MTIME
MTTF = TIMEPAST - TOTDELAY
MTIME = TIME
MDATE = DATE
MSHIFT = SHIFT
MBEGIN = BEGIN2
MDUR = DURATION2
MEQUIP = '"' + EQUIP + '"'
MMEQUIP = EQUIP
SELE 3
APPE BLANK
REPLACE DATE WITH MDATE,SHIFT WITH MSHIFT,EQUIP WITH MMEQUIP,TIME;
WITH MTIME,BEGIN WITH MBEGIN,DURATION WITH MDUR,TTFACT WITH MTTF,;
ACCUMDOWN WITH TOTDELAY - MIDLE,TIME_IDLE WITH MIDLE,TTFTOT WITH;
TIMEPAST - MIDLE
SELE 1
TOTDELAY = DURATION2
```

```
MIDLE = 0
ELSE
TOTDELAY = TOTDELAY + DURATION2
MEQUIP = '"' + EQUIP + '"'
ENDIF
SKIP
ENDDO
SELE 3
REPLACE ALL TTFACT WITH TTFACT + 1,TTFTOT WITH TTFTOT + 1

TEXT

     THIS PORTIOPN OF CODE CALCULATES TTF STATISTICS FOR THE
     CRUSHER (CR).

ENDTEXT

TTFNAME = &PREFIX + "CRTTF"
SELE 3
USE TTF
COPY STRU TO &TTFNAME
USE &TTFNAME
SELE 1
GOTO TOP
LOCATE FOR "CR" $ EQUIP .AND..NOT. (SCHEDULED .OR. TYPE = "G")
IF .NOT. EOF()
MTIME = TIME
TOTDELAY = DURATION2
MIDLE = 0
MEQUIP = '"' + EQUIP + '"'
SKIP
ENDIF
DO WHILE .NOT. EOF()
DO WHILE (SCHEDULED .OR. TYPE = "G" .OR..NOT. DURATION = DURATION2;
.OR. (EQUIP = &MEQUIP .AND. "CON'T" $ COMM)).AND..NOT. EOF()
TOTDELAY = TOTDELAY + DURATION2
IF "NO WORK OR MISSING SHIFT RECORD" $ COMM
MIDLE = MIDLE + DURATION2
ENDIF
SKIP
ENDDO
IF EOF()
LOOP
ENDIF
IF "CR" $ EQUIP
TIMEPAST = TIME - MTIME
MTTF = TIMEPAST - TOTDELAY
MTIME = TIME
MDATE = DATE
MSHIFT = SHIFT
```

```
MBEGIN = BEGIN2
MDUR = DURATION2
MEQUIP = '"' + EQUIP + '"'
MMEQUIP = EQUIP
SELE 3
APPE BLANK
REPLACE DATE WITH MDATE,SHIFT WITH MSHIFT,EQUIP WITH MMEQUIP,TIME WITH;
MTIME,BEGIN WITH MBEGIN,DURATION WITH MDUR,TTFACT WITH MTTF,ACCUMDOWN;
WITH TOTDELAY - MIDLE,TIME_IDLE WITH MIDLE,TTFTOT WITH TIMEPAST - MIDLE
SELE 1
TOTDELAY = DURATION2
MIDLE = 0
ELSE
TOTDELAY = TOTDELAY + DURATION2
MEQUIP = '"' + EQUIP + '"'
ENDIF
SKIP
ENDDO
SELE 3
REPLACE TTFACT WITH TTFACT + 1,TTFTOT WITH TTFTOT + 1

TEXT

     THIS PORTION OF CODE CALCULATES TTF STATISTICS FOR THE SECTION
     BELT (SB).

ENDTEXT

TTFNAME = &PREFIX + "SBTTF"
SELE 3
USE TTF
COPY STRU TO &TTFNAME
USE &TTFNAME
SELE 1
GOTO TOP
LOCATE FOR "SB" $ EQUIP .AND..NOT. (SCHEDULED .OR. TYPE = "G")
IF .NOT. EOF()
MTIME = TIME
TOTDELAY = DURATION2
MIDLE = 0
MEQUIP = '"' + EQUIP + '"'
SKIP
ENDIF
DO WHILE .NOT. EOF()
DO WHILE (SCHEDULED .OR. TYPE = "G" .OR..NOT. DURATION = DURATION2;
.OR. (EQUIP = &MEQUIP .AND. "CON'T" $ COMM)).AND..NOT. EOF()
TOTDELAY = TOTDELAY + DURATION2
IF "NO WORK OR MISSING SHIFT RECORD" $ COMM
MIDLE = MIDLE + DURATION2
ENDIF
```

```
SKIP
ENDDO
 IF EOF()
LOOP
ENDIF
 IF "SB" $ EQUIP
TIMEPAST = TIME - MTIME
MTTF = TIMEPAST - TOTDELAY
MTIME = TIME
MDATE = DATE
MSHIFT = SHIFT
MBEGIN = BEGIN2
MDUR = DURATION2
MEQUIP = '"' + EQUIP + '"'
MMEQUIP = EQUIP
SELE 3
APPE BLANK
REPLACE DATE WITH MDATE,SHIFT WITH MSHIFT,EQUIP WITH MMEQUIP,TIME;
WITH MTIME,BEGIN WITH MBEGIN,DURATION WITH MDUR,TTFACT WITH MTTF,;
ACCUMDOWN WITH TOTDELAY - MIDLE,TIME_IDLE WITH MIDLE,TTFTOT WITH;
TIMEPAST - MIDLE
SELE 1
TOTDELAY = DURATION2
MIDLE = 0
ELSE
TOTDELAY = TOTDELAY + DURATION2
MEQUIP = '"' + EQUIP + '"'
ENDIF
SKIP
ENDDO
SELE 3
REPLACE ALL TTFACT WITH TTFACT + 1,TTFTOT WITH TTFTOT + 1

TEXT

     THIS PORTION OF CODE CALCULATES TTF STATISTICS FOR THE
     MAIN HAULAGE BELT(S) (HB).

ENDTEXT

TTFNAME = &PREFIX + "HBTTF"
SELE 3
USE TTF
COPY STRU TO &TTFNAME
USE &TTFNAME
SELE 1
GOTO TOP
LOCATE FOR "HB" $ EQUIP .AND..NOT. (SCHEDULED .OR. TYPE = "G")
 IF .NOT. EOF()
MTIME = TIME
```

```
TOTDELAY = DURATION2
MIDLE = 0
MEQUIP = '"' + EQUIP + '"'
SKIP
ENDIF
DO WHILE .NOT. EOF()
DO WHILE (SCHEDULED .OR. TYPE = "G" .OR..NOT. DURATION = DURATION2;
.OR. (EQUIP = &MEQUIP .AND. "CON'T" $ COMM)).AND..NOT. EOF()
TOTDELAY = TOTDELAY + DURATION2
IF "NO WORK OR MISSING SHIFT RECORD" $ COMM
MIDLE = MIDLE + DURATION2
ENDIF
SKIP
ENDDO
IF EOF()
LOOP
ENDIF
IF "HB" $ EQUIP
TIMEPAST = TIME - MTIME
MTTF = TIMEPAST - TOTDELAY
MTIME = TIME
MDATE = DATE
MSHIFT = SHIFT
MBEGIN = BEGIN2
MDUR = DURATION2
MEQUIP = '"' + EQUIP + '"'
MMEQUIP = EQUIP
SELE 3
APPE BLANK
REPLACE DATE WITH MDATE,SHIFT WITH MSHIFT,EQUIP WITH MMEQUIP,TIME;
WITH MTIME,BEGIN WITH MBEGIN,DURATION WITH MDUR,TTFACT WITH MTTF,;
ACCUMDOWN WITH TOTDELAY - MIDLE,TIME_IDLE WITH MIDLE,TTFTOT WITH;
TIMEPAST - MIDLE
SELE 1
TOTDELAY = DURATION2
MIDLE = 0
ELSE
TOTDELAY = TOTDELAY + DURATION2
MEQUIP = '"' + EQUIP + '"'
ENDIF
SKIP
ENDDO
SELE 3
REPLACE ALL TTFACT WITH TTFACT + 1,TTFTOT WITH TTFTOT + 1

TEXT

     THIS PORTION OF CODE CALCULATES TTF STATISTICS FOR THE
     BIN/SKIP/TIPPLE (BN).
```

```
ENDTEXT

TTFNAME = &PREFIX + "BNTTF"
SELE 3
USE TTF
COPY STRU TO &TTFNAME
USE &TTFNAME
SELE 1
GOTO TOP
LOCATE FOR "BN" $ EQUIP .AND..NOT. SCHEDULED
 IF .NOT. EOF()
MTIME = TIME
TOTDELAY = DURATION2
MIDLE = 0
MEQUIP = '"' + EQUIP + '"'
SKIP
ENDIF
DO WHILE .NOT. EOF()
DO WHILE (SCHEDULED .OR. TYPE = "G" .OR..NOT. DURATION=DURATION2 .OR.;
(EQUIP = &MEQUIP .AND. "CON'T" $ COMM)).AND..NOT. EOF()
TOTDELAY = TOTDELAY + DURATION2
 IF "NO WORK OR MISSING SHIFT RECORD" $ COMM
MIDLE = MIDLE + DURATION2
ENDIF
SKIP
ENDDO
 IF EOF()
LOOP
ENDIF
 IF "BN" $ EQUIP
TIMEPAST = TIME - MTIME
MTTF = TIMEPAST - TOTDELAY
MTIME = TIME
MDATE = DATE
MSHIFT = SHIFT
MBEGIN = BEGIN2
MDUR = DURATION2
MEQUIP = '"' + EQUIP + '"'
MMEQUIP = EQUIP
SELE 3
APPE BLANK
REPLACE DATE WITH MDATE,SHIFT WITH MSHIFT,EQUIP WITH MMEQUIP,TIME WITH;
MTIME,BEGIN WITH MBEGIN,DURATION WITH MDUR,TTFACT WITH MTTF,ACCUMDOWN;
WITH TOTDELAY - MIDLE,TIME_IDLE WITH MIDLE,TTFTOT WITH TIMEPAST - MIDLE
SELE 1
TOTDELAY = DURATION2
MIDLE = 0
ELSE
TOTDELAY = TOTDELAY + DURATION2
MEQUIP = '"' + EQUIP + '"'
```

```
ENDIF
SKIP
ENDDO
SELE 3
REPLACE ALL TTFACT WITH TTFACT + 1,TTFTOT WITH TTFTOT + 1

TEXT

     THIS PORTION OF CODE CALCULATES TTF STATISTICS FOR THE
     SYSTEM AS A WHOLE (SY).

ENDTEXT

TTFNAME = &PREFIX + "SYTTF"
SELE 3
USE TTF
COPY STRU TO &TTFNAME
USE &TTFNAME
SELE 1
GOTO TOP
LOCATE FOR .NOT. SCHEDULED
IF .NOT. EOF()
MTIME = TIME
TOTDELAY = DURATION2
MIDLE = 0
MEQUIP = '"' + EQUIP + '"'
SKIP
ENDIF
DO WHILE .NOT. EOF()
DO WHILE (SCHEDULED .OR..NOT. DURATION = DURATION2 .OR. (EQUIP =;
&MEQUIP .AND. "CON'T" $ COMM)).AND..NOT. EOF()
TOTDELAY = TOTDELAY + DURATION2
IF "NO WORK OR MISSING SHIFT RECORD" $ COMM
MIDLE = MIDLE + DURATION2
ENDIF
SKIP
ENDDO
IF EOF()
LOOP
ENDIF
TIMEPAST = TIME - MTIME
MTTF = TIMEPAST - TOTDELAY
MTIME = TIME
MDATE = DATE
MSHIFT = SHIFT
MBEGIN = BEGIN2
MDUR = DURATION2
MEQUIP = '"' + EQUIP + '"'
MMEQUIP = EQUIP
SELE 3
```

```
APPE BLANK
REPLACE DATE WITH MDATE,SHIFT WITH MSHIFT,EQUIP WITH MMEQUIP,TIME;
WITH MTIME,BEGIN WITH MBEGIN,DURATION WITH MDUR,TTFACT WITH MTTF,;
ACCUMDOWN WITH TOTDELAY - MIDLE,TIME_IDLE WITH MIDLE,TTFTOT WITH;
TIMEPAST - MIDLE
SELE 1
TOTDELAY = DURATION2
MIDLE = 0
SKIP
ENDDO
SELE 3
REPLACE ALL TTFACT WITH TTFACT + 1,TTFTOT WITH TTFTOT + 1

TEXT

     THIS PORTION OF CODE CALCULATES TTF STATISTICS FOR ALL
     GEOLOGIC DELAYS (G).

ENDTEXT

TTFNAME = &PREFIX + "GTTF"
SELE 3
USE TTF
COPY STRU TO &TTFNAME
USE &TTFNAME
SELE 1
GOTO TOP
LOCATE FOR TYPE = "G" .AND..NOT. SCHEDULED
IF .NOT. EOF()
MTIME = TIME
TOTDELAY = DURATION2
MIDLE = 0
MEQUIP = '"' + EQUIP + '"'
SKIP
ENDIF
DO WHILE .NOT. EOF()
DO WHILE (SCHEDULED .OR..NOT. DURATION = DURATION2 .OR. (EQUIP =;
&MEQUIP .AND. "CON'T" $ COMM)).AND..NOT. EOF()
TOTDELAY = TOTDELAY + DURATION2
IF "NO WORK OR MISSING SHIFT RECORD" $ COMM
MIDLE = MIDLE + DURATION2
ENDIF
SKIP
ENDDO
IF EOF()
LOOP
ENDIF
IF TYPE = "G"
TIMEPAST = TIME - MTIME
MTTF = TIMEPAST - TOTDELAY
```

```
MTIME = TIME
MDATE = DATE
MSHIFT = SHIFT
MBEGIN = BEGIN2
MDUR = DURATION2
MEQUIP = '"' + EQUIP + '"'
MMEQUIP = EQUIP
SELE 3
APPE BLANK
REPLACE DATE WITH MDATE,SHIFT WITH MSHIFT,EQUIP WITH MMEQUIP,TIME;
WITH MTIME,BEGIN WITH MBEGIN,DURATION WITH MDUR,TTFACT WITH MTTF,;
ACCUMDOWN WITH TOTDELAY - MIDLE,TIME_IDLE WITH MIDLE,TTFTOT WITH;
TIMEPAST - MIDLE
SELE 1
TOTDELAY = DURATION2
MIDLE = 0
ELSE
TOTDELAY = TOTDELAY + DURATION2
MEQUIP = '"' + EQUIP + '"'
ENDIF
SKIP
ENDDO

TEXT

     THIS PORTION OF CODE INCREASES ALL TTF STATISTICS BY ONE. THIS
     ELIMINATES TTF STATISTICS EQUAL TO ZERO MAKING DISTRIBUTION
     FITTING EASIER WHILE NEGLIGABLE ALTERING THE AVERAGE MAGNITUDE
     OF THE STATISTICS.

ENDTEXT

SELE 3
REPLACE ALL TTFACT WITH TTFACT + 1,TTFTOT WITH TTFTOT + 1
RETURN
```

TTRPRG PROGRAM

```
TEXT

     THIS PROGRAM CALCULATES TTR STATISTICS FOR ANY COMBINATION
     OF EQUIPMENT TYPES OR DELAY TYPES. THE FIRST PORTION OF CODE
     QUERIES THE OPERATOR FOR THE FOLLOWING INFORMATION: DOWNTIME
     DATABASE NAME, SHIFT DATABASE NAME, TTR DATABASE NAME,
     EQUIPMENT TYPES, DELAY TYPES.

ENDTEXT

CLEAR
CLEAR ALL
SET EXACT ON
SET DATE TO YMD
DTDATA=SPACE(8)
@ 3,4 SAY "ENTER DT DATABASE NAME" GET DTDATA
READ
SFTDATA=SPACE(8)
@ 4,4 SAY "ENTER SFT DATABASE NAME" GET SFTDATA
READ
TTRDBF=SPACE(8)
@ 5,4 SAY "ENTER TTR DATABASE NAME" GET TTRDBF
READ
USE TTR
COPY STRU TO &TTRDBF
USE
MEQUIP1=SPACE(8)
@ 6,4 SAY "ENTER EQUIP TYPE #1,USE QUOTATION MARKS,ONE BLANK FOR ALL;
EQUIP" GET MEQUIP1
READ
MEQUIP2=SPACE(8)
@ 7,4 SAY "ENTER EQUIP TYPE #2,USE QUOTATION MARKS,SIX BLANKS FOR;
NONE" GET MEQUIP2
READ
MEQUIP3=SPACE(8)
@ 8,4 SAY "ENTER EQUIP TYPE #3,USE QUOTATION MARKS,SIX BLANKS FOR;
NONE" GET MEQUIP3
READ
MEQUIP4=SPACE(8)
@ 9,4 SAY "ENTER EQUIP TYPE #4,USE QUOTATION MARKS,SIX BLANKS FOR;
NONE" GET MEQUIP4
READ
MTYPE1=SPACE(4)
@ 10,4 SAY "ENTER DELAY TYPE #1,USE QUOTATION MARKS,ONE BLANK FOR;
ALL" GET MTYPE1
READ
```

```
IF MTYPE1 = " "
MTYPE2=" "
MTYPE3=" "
MTYPE4=" "
MTYPE5=" "
MTYPE6=" "
MTYPE7=" "
MTYPE8=" "
ELSE
MTYPE2=SPACE(4)
@ 11,4 SAY "ENTER DELAY TYPE #2,USE QUOTATION MARKS,XX FOR NONE";
GET MTYPE2
READ
MTYPE3=SPACE(4)
@ 12,4 SAY "ENTER DELAY TYPE #3,USE QUOTATION MARKS,XX FOR NONE";
GET MTYPE3
READ
MTYPE4=SPACE(4)
@ 13,4 SAY "ENTER DELAY TYPE #4,USE QUOTATION MARKS,XX FOR NONE";
GET MTYPE4
READ
MTYPE5=SPACE(4)
@ 14,4 SAY "ENTER DELAY TYPE #5,USE QUOTATION MARKS,XX FOR NONE";
GET MTYPE5
READ
MTYPE6=SPACE(4)
@ 15,4 SAY "ENTER DELAY TYPE #6,USE QUOTATION MARKS,XX FOR NONE";
GET MTYPE6
READ
MTYPE7=SPACE(4)
@ 16,4 SAY "ENTER DELAY TYPE #7,USE QUOTATION MARKS,XX FOR NONE";
GET MTYPE7
READ
MTYPE8=SPACE(4)
@ 17,4 SAY "ENTER DELAY TYPE #8,USE QUOTATION MARKS,XX FOR NONE";
GET MTYPE8
READ
SELE 3
USE &TTRDBF
SELE 1
SET FILTER TO .NOT. (SCHEDULED .OR. DURATION = 0) .AND. (&MEQUIP1;
$ EQUIP .OR. &MEQUIP2 $ EQUIP .OR. &MEQUIP3 $ EQUIP .OR. &MEQUIP4;
$ EQUIP .OR. &MEQUIP5 $ EQUIP) .AND. (MTYPE1=" " .OR. TYPE=&MTYPE1;
.OR. TYPE=&MTYPE2 .OR. TYPE=&MTYPE3 .OR TYPE=&MTYPE 4 .OR.;
TYPE=&MTYPE5 .OR. TYPE=&MTYPE6 .OR. TYPE=&MTYPE7 .OR. ;
TYPE=&MTYPE8) .AND. DURATION = DURATION2
GOTO TOP

TEXT
```

```
     THIS PORTION OF CODE ESTABLISHES THE TTR OF EACH DELAY
     AS THE DURATION OF THE DELAY PLUS THE DURATION OF ANY
     CONTINUATIONS OF THAT DELAY. THE TTR IS THEN WRITTEN TO
     THE TTR FIELD OF THE TTR DATABASE.

ENDTEXT

DO WHILE .NOT. EOF()
MTTR = DURATION
MEQUIP = '"' + EQUIP + '"'
MMEQUIP = EQUIP
MTIME = TIME
MDATE = DATE
MSHIFT = SHIFT
MBEGIN = BEGIN
SKIP
DO WHILE "CON'T" $ COMM .AND. EQUIP = &MEQUIP
MTTR = MTTR + DURATION
SKIP
ENDDO
SELE 3
APPE BLANK
REPLACE TTR WITH MTTR,EQUIP WITH MMEQUIP,TIME WITH MTIME,SHIFT WITH;
MSHIFT,DATE WITH MDATE,BEGIN WITH MBEGIN
SELE 1
ENDDO
SET FILTER TO
RETURN
```

AUTOTTR PROGRAM

```
TEXT

     THIS PROGRAM CALCULATES TTR STATISTICS FOR THE EQUIPMENT
     TYPES SH, FC, SD, SL, CR, SB, HB, AND BN. THESE CALCULATIONS
     ARE MADE EXCLUSIVE OF GEOLOGIC DELAYS (G). TTF CALCULATIONS
     ARE ALSO MADE FOR ALL DELAYS OF GEOLOGIC DELAY TYPE (G), AND
     FOR THE SYSTEM AS A WHOLE (SY). THE FIRST PORTION OF CODE
     CALCULATES TTR STATISTICS FOR THE SHEARER.

ENDTEXT

SET EXACT ON
TTRNAME = &PREFIX + "SHTTR"
SELE 3
USE TTR
COPY STRU TO &TTRNAME
USE &TTRNAME
SELE 1
SET FILTER TO .NOT. (SCHEDULED .OR. TYPE = "G") .AND. DURATION > 0;
.AND. "SH" $ EQUIP .AND. DURATION = DURATION2
GOTO TOP
DO WHILE .NOT. EOF()
MTTR = DURATION
MEQUIP = '"' + EQUIP + '"'
MMEQUIP = EQUIP
MTIME = TIME
MDATE = DATE
MSHIFT = SHIFT
MBEGIN = BEGIN
SKIP
DO WHILE "CON'T" $ COMM .AND. EQUIP = &MEQUIP
MTTR = MTTR + DURATION
SKIP
ENDDO
SELE 3
APPE BLANK
REPLACE TTR WITH MTTR,EQUIP WITH MMEQUIP,TIME WITH MTIME,SHIFT WITH;
MSHIFT,DATE WITH MDATE,BEGIN WITH MBEGIN
SELE 1
ENDDO

TEXT

     THIS PORTION OF CODE CALCULATES TTR STATISTICS FOR THE
     FACE CONVEYOR (FC).
```

```
ENDTEXT

TTRNAME = &PREFIX + "FCTTR"
SELE 3
USE TTR
COPY STRU TO &TTRNAME
USE &TTRNAME
SELE 1
SET FILTER TO .NOT. (SCHEDULED .OR. TYPE = "G") .AND. DURATION > 0;
.AND. "FC" $ EQUIP .AND. DURATION = DURATION2
GOTO TOP
DO WHILE .NOT. EOF()
MTTR = DURATION
MEQUIP = '"' + EQUIP + '"'
MMEQUIP = EQUIP
MTIME = TIME
MDATE = DATE
MSHIFT = SHIFT
MBEGIN = BEGIN
SKIP
DO WHILE "CON'T" $ COMM .AND. EQUIP = &MEQUIP
MTTR = MTTR + DURATION
SKIP
ENDDO
SELE 3
APPE BLANK
REPLACE TTR WITH MTTR,EQUIP WITH MMEQUIP,TIME WITH MTIME,SHIFT WITH;
MSHIFT,DATE WITH MDATE,BEGIN WITH MBEGIN
SELE 1
ENDDO

TEXT

     THIS PORTION OF CODE CALCULATES TTR STATISTICS FOR THE
     SHIELDS (SD).

ENDTEXT

TTRNAME = &PREFIX + "SDTTR"
SELE 3
USE TTR
COPY STRU TO &TTRNAME
USE &TTRNAME
SELE 1
SET FILTER TO .NOT. (SCHEDULED .OR. TYPE = "G") .AND. DURATION > 0;
.AND. ("SD" $ EQUIP .OR. "HO 100" $ EQUIP .OR. "PM 102" $ EQUIP).AND.;
DURATION = DURATION2
GOTO TOP
DO WHILE .NOT. EOF()
MTTR = DURATION
```

```
MEQUIP = '"' + EQUIP + '"'
MMEQUIP = EQUIP
MTIME = TIME
MDATE = DATE
MSHIFT = SHIFT
MBEGIN = BEGIN
SKIP
DO WHILE "CON'T" $ COMM .AND. EQUIP = &MEQUIP
MTTR = MTTR + DURATION
SKIP
ENDDO
SELE 3
APPE BLANK
REPLACE TTR WITH MTTR,EQUIP WITH MMEQUIP,TIME WITH MTIME,SHIFT WITH;
MSHIFT,DATE WITH MDATE,BEGIN WITH MBEGIN
SELE 1
ENDDO

TEXT

     THIS PORTION OF CODE CALCULATES TTR STATISTICS FOR THE
     STAGELOADER (SL).

ENDTEXT

TTRNAME = &PREFIX + "SLTTR"
SELE 3
USE TTR
COPY STRU TO &TTRNAME
USE &TTRNAME
SELE 1
SET FILTER TO .NOT. (SCHEDULED .OR. TYPE = "G") .AND. DURATION > 0;
.AND. "SL" $ EQUIP .AND. DURATION = DURATION2
GOTO TOP
DO WHILE .NOT. EOF()
MTTR = DURATION
MEQUIP = '"' + EQUIP + '"'
MMEQUIP = EQUIP
MTIME = TIME
MDATE = DATE
MSHIFT = SHIFT
MBEGIN = BEGIN
SKIP
DO WHILE "CON'T" $ COMM .AND. EQUIP = &MEQUIP
MTTR = MTTR + DURATION
SKIP
ENDDO
SELE 3
APPE BLANK
REPLACE TTR WITH MTTR,EQUIP WITH MMEQUIP,TIME WITH MTIME,SHIFT WITH;
```

```
MSHIFT,DATE WITH MDATE,BEGIN WITH MBEGIN
SELE 1
ENDDO

TEXT

     THIS PORTION OF CODE CALCULATES TTR STATISTICS FOR THE
     CRUSHER (CR).

ENDTEXT

TTRNAME = &PREFIX + "CRTTR"
SELE 3
USE TTR
COPY STRU TO &TTRNAME
USE &TTRNAME
SELE 1
SET FILTER TO .NOT. (SCHEDULED .OR. TYPE = "G") .AND. DURATION > 0;
.AND. "CR" $ EQUIP .AND. DURATION = DURATION2
GOTO TOP
DO WHILE .NOT. EOF()
MTTR = DURATION
MEQUIP = '"' + EQUIP + '"'
MMEQUIP = EQUIP
MTIME = TIME
MDATE = DATE
MSHIFT = SHIFT
MBEGIN = BEGIN
SKIP
DO WHILE "CON'T" $ COMM .AND. EQUIP = &MEQUIP
MTTR = MTTR + DURATION
SKIP
ENDDO
SELE 3
APPE BLANK
REPLACE TTR WITH MTTR,EQUIP WITH MMEQUIP,TIME WITH MTIME,SHIFT WITH;
MSHIFT,DATE WITH MDATE,BEGIN WITH MBEGIN
SELE 1
ENDDO

TEXT

     THIS PORTION OF CODE CALCULATES TTR STATISTICS FOR THE
     SECTION BELT (SB).

ENDTEXT

TTRNAME = &PREFIX + "SBTTR"
SELE 3
USE TTR
```

```
COPY STRU TO &TTRNAME
USE &TTRNAME
SELE 1
SET FILTER TO .NOT. (SCHEDULED .OR. TYPE = "G") .AND. DURATION > 0;
.AND. "SB" $ EQUIP .AND. DURATION = DURATION2
GOTO TOP
DO WHILE .NOT. EOF()
MTTR = DURATION
MEQUIP = '"' + EQUIP + '"'
MMEQUIP = EQUIP
MTIME = TIME
MDATE = DATE
MSHIFT = SHIFT
MBEGIN = BEGIN
SKIP
DO WHILE "CON'T" $ COMM .AND. EQUIP = &MEQUIP
MTTR = MTTR + DURATION
SKIP
ENDDO
SELE 3
APPE BLANK
REPLACE TTR WITH MTTR,EQUIP WITH MMEQUIP,TIME WITH MTIME,SHIFT WITH;
MSHIFT,DATE WITH MDATE,BEGIN WITH MBEGIN
SELE 1
ENDDO

TEXT

     THIS PORTION OF CODE CALCULATES TTR STATISTICS FOR THE
     MAIN HAULAGE BELT(S).

ENDTEXT

TTRNAME = &PREFIX + "HBTTR"
SELE 3
USE TTR
COPY STRU TO &TTRNAME
USE &TTRNAME
SELE 1
SET FILTER TO .NOT. (SCHEDULED .OR. TYPE = "G") .AND. DURATION > 0;
.AND. "HB" $ EQUIP .AND. DURATION = DURATION2
GOTO TOP
DO WHILE .NOT. EOF()
MTTR = DURATION
MEQUIP = '"' + EQUIP + '"'
MMEQUIP = EQUIP
MTIME = TIME
MDATE = DATE
MSHIFT = SHIFT
MBEGIN = BEGIN
```

```
SKIP
DO WHILE "CON'T" $ COMM .AND. EQUIP = &MEQUIP
MTTR = MTTR + DURATION
SKIP
ENDDO
SELE 3
APPE BLANK
REPLACE TTR WITH MTTR,EQUIP WITH MMEQUIP,TIME WITH MTIME,SHIFT WITH;
MSHIFT,DATE WITH MDATE,BEGIN WITH MBEGIN
SELE 1
ENDDO

TEXT

     THIS PORTION OF CODE CALCULATES TTR STATISTICS FOR THE
     BIN/SKIP/TIPPLE (BN).

ENDTEXT

TTRNAME = &PREFIX + "BNTTR"
SELE 3
USE TTR
COPY STRU TO &TTRNAME
USE &TTRNAME
SELE 1
SET FILTER TO .NOT. (SCHEDULED .OR. TYPE = "G") .AND. DURATION > 0;
.AND. "BN" $ EQUIP .AND. DURATION = DURATION2
GOTO TOP
DO WHILE .NOT. EOF()
MTTR = DURATION
MEQUIP = '"' + EQUIP + '"'
MMEQUIP = EQUIP
MTIME = TIME
MDATE = DATE
MSHIFT = SHIFT
MBEGIN = BEGIN
SKIP
DO WHILE "CON'T" $ COMM .AND. EQUIP = &MEQUIP
MTTR = MTTR + DURATION
SKIP
ENDDO
SELE 3
APPE BLANK
REPLACE TTR WITH MTTR,EQUIP WITH MMEQUIP,TIME WITH MTIME,SHIFT WITH;
MSHIFT,DATE WITH MDATE,BEGIN WITH MBEGIN
SELE 1
ENDDO

TEXT
```

```
     THIS PORTION OF CODE CALCULATES TTR STATISTICS FOR THE
     SYSTEM AS A WHOLE (SY).

ENDTEXT

TTRNAME = &PREFIX + "SYTTR"
SELE 3
USE TTR
COPY STRU TO &TTRNAME
USE &TTRNAME
SELE 1
SET FILTER TO .NOT. SCHEDULED .AND. DURATION > 0 .AND. DURATION =;
DURATION2
GOTO TOP
DO WHILE .NOT. EOF()
MTTR = DURATION
MEQUIP = '"' + EQUIP + '"'
MMEQUIP = EQUIP
MTIME = TIME
MDATE = DATE
MSHIFT = SHIFT
MBEGIN = BEGIN
SKIP
DO WHILE "CON'T" $ COMM .AND. EQUIP = &MEQUIP
MTTR = MTTR + DURATION
SKIP
ENDDO
SELE 3
APPE BLANK
REPLACE TTR WITH MTTR,EQUIP WITH MMEQUIP,TIME WITH MTIME,SHIFT WITH;
MSHIFT,DATE WITH MDATE,BEGIN WITH MBEGIN
SELE 1
ENDDO

TEXT

     THIS PORTION OF CODE CALCULATES TTR STATISTICS FOR ALL DELAYS
     OF GEOLOGIC DELAY TYPE (G).

ENDTEXT

TTRNAME = &PREFIX + "GTTR"
SELE 3
USE TTR
COPY STRU TO &TTRNAME
USE &TTRNAME
SELE 1
SET FILTER TO .NOT. SCHEDULED .AND. DURATION > 0 .AND. TYPE = "G";
.AND. DURATION = DURATION2
GOTO TOP
```

```
DO WHILE .NOT. EOF()
MTTR = DURATION
MEQUIP = '"' + EQUIP + '"'
MMEQUIP = EQUIP
MTIME = TIME
MDATE = DATE
MSHIFT = SHIFT
MBEGIN = BEGIN
SKIP
DO WHILE "CON'T" $ COMM .AND. EQUIP = &MEQUIP
MTTR = MTTR + DURATION
SKIP
ENDDO
SELE 3
APPE BLANK
REPLACE TTR WITH MTTR,EQUIP WITH MMEQUIP,TIME WITH MTIME,SHIFT WITH;
MSHIFT,DATE WITH MDATE,BEGIN WITH MBEGIN
SELE 1
ENDDO
SET FILTER TO

RETURN
```

EQUIP% PROGRAM

```
TEXT

     THIS PROGRAM CALCULATES THE RELATIVE PERCENTAGE OF DOWNTIME
     CONTRIBUTED BY EACH OF THE PRIMARY EQUIPMENT TYPES. CALCULATIONS
     ARE MADE FIRST ON AN UNSCHEDULED DELAYS BASIS, AND THEN ON AN
     ALL DELAYS BASIS. THE FIRST PORTION OF CODE CALCULATES THE
     CONTRIBUTION OF THE SHEARER (SH) TOWARDS UNSCHEDULED DOWNTIME.

ENDTEXT

SET EXACT ON

OTDELAY = 0
MDELAY = 0
SELE 1
SET FILTER TO .NOT. ("MISSING SHIFT" $ COMM .OR. SCHEDULED .OR. "NA";
$ EQUIP)
GOTO TOP
DO WHILE .NOT. EOF()
 IF "SH" $ EQUIP
MDELAY = MDELAY + DURATION2
ELSE
OTDELAY = OTDELAY + DURATION2
ENDIF
 IF .NOT. EOF()
SKIP
ENDIF
ENDDO
SELE 4
REPLACE SH_UNS WITH 100*(MDELAY/(OTDELAY+MDELAY))

TEXT

     THIS PORTION OF CODE CALCULATES THE CONTRIBUTION OF THE
     FACE CONVEYOR (FC) TOWARDS UNSCHEDULED DOWNTIME.

ENDTEXT

OTDELAY = 0
MDELAY = 0
SELE 1
GOTO TOP
DO WHILE .NOT. EOF()
 IF "FC" $ EQUIP
MDELAY = MDELAY + DURATION2
ELSE
```

```
OTDELAY = OTDELAY + DURATION2
ENDIF
 IF .NOT. EOF()
SKIP
ENDIF
ENDDO
SELE 4
REPLACE FC_UNS WITH 100*(MDELAY/(OTDELAY+MDELAY))

TEXT

     THIS PORTION OF CODE CALCULATES THE CONTRIBUTION OF THE
     SHIELDS (SD) TOWARDS UNSCHEDULED DOWNTIME.

ENDTEXT

OTDELAY = 0
MDELAY = 0
SELE 1
GOTO TOP
DO WHILE .NOT. EOF()
 IF ("SD" $ EQUIP .OR. "HO 100" $ EQUIP .OR. "PM 102" $ EQUIP)
MDELAY = MDELAY + DURATION2
ELSE
OTDELAY = OTDELAY + DURATION2
ENDIF
 IF .NOT. EOF()
SKIP
ENDIF
ENDDO
SELE 4
REPLACE SD_UNS WITH 100*(MDELAY/(OTDELAY+MDELAY))

TEXT

     THIS PORTION OF CODE CALCULATES THE CONTRIBUTION OF THE
     STAGELOADER (SL) TOWARDS UNSCHEDULED DOWNTIME.

ENDTEXT

OTDELAY = 0
MDELAY = 0
SELE 1
GOTO TOP
DO WHILE .NOT. EOF()
 IF "SL" $ EQUIP
MDELAY = MDELAY + DURATION2
ELSE
OTDELAY = OTDELAY + DURATION2
ENDIF
```

```
IF .NOT. EOF()
SKIP
ENDIF
ENDDO
SELE 4
REPLACE SL_UNS WITH 100*(MDELAY/(OTDELAY+MDELAY))

TEXT

     THIS PORTION OF CODE CALCULATES THE CONTRIBUTION OF THE
     CRUSHER (CR) TOWARDS UNSCHEDULED DOWNTIME.

ENDTEXT

OTDELAY = 0
MDELAY = 0
SELE 1
GOTO TOP
DO WHILE .NOT. EOF()
IF "CR" $ EQUIP
MDELAY = MDELAY + DURATION2
ELSE
OTDELAY = OTDELAY + DURATION2
ENDIF
IF .NOT. EOF()
SKIP
ENDIF
ENDDO
SELE 4
REPLACE CR_UNS WITH 100*(MDELAY/(OTDELAY+MDELAY))

TEXT

     THIS PORTION OF CODE CALCULATES THE CONTRIBUTION OF THE
     SECTION BELT (SB) TOWARDS UNSCHEDULED DOWNTIME.

ENDTEXT

OTDELAY = 0
MDELAY = 0
SELE 1
GOTO TOP
DO WHILE .NOT. EOF()
IF "SB" $ EQUIP
MDELAY = MDELAY + DURATION2
ELSE
OTDELAY = OTDELAY + DURATION2
ENDIF
IF .NOT. EOF()
SKIP
```

```
ENDIF
ENDDO
SELE 4
REPLACE SB_UNS WITH 100*(MDELAY/(OTDELAY+MDELAY))

TEXT

     THIS PORTION OF CODE CALCULATES THE CONTRIBUTION OF THE
     MAIN HAULAGE BELT (HB) TOWARDS UNSCHEDULED DOWNTIME.

ENDTEXT

OTDELAY = 0
MDELAY = 0
SELE 1
GOTO TOP
DO WHILE .NOT. EOF()
 IF "HB" $ EQUIP
MDELAY = MDELAY + DURATION2
ELSE
OTDELAY = OTDELAY + DURATION2
ENDIF
 IF .NOT. EOF()
SKIP
ENDIF
ENDDO
SELE 4
REPLACE HB_UNS WITH 100*(MDELAY/(OTDELAY+MDELAY))

TEXT

     THIS PORTION OF CODE CALCULATES THE CONTRIBUTION OF THE
     BIN/SKIP/TIPPLE (BN) TOWARDS UNSCHEDULED DOWNTIME.

ENDTEXT

OTDELAY = 0
MDELAY = 0
SELE 1
GOTO TOP
DO WHILE .NOT. EOF()
 IF "BN" $ EQUIP
MDELAY = MDELAY + DURATION2
ELSE
OTDELAY = OTDELAY + DURATION2
ENDIF
 IF .NOT. EOF()
SKIP
ENDIF
ENDDO
```

```
SELE 4
REPLACE BN_UNS WITH 100*(MDELAY/(OTDELAY+MDELAY))

TEXT

     THIS PORTION OF CODE CALCULATES THE CONTRIBUTION OF THE
     SHEARER (SH) TOWARDS SCHEDULED AND UNSCHEDULED DOWNTIME
     (TOTAL DOWNTIME).

ENDTEXT

OTDELAY = 0
MDELAY = 0
SELE 1
SET FILTER TO .NOT. ("MISSING SHIFT" $ COMM .OR. "NA" $ EQUIP)
GOTO TOP
DO WHILE .NOT. EOF()
IF "SH" $ EQUIP
MDELAY = MDELAY + DURATION2
ELSE
OTDELAY = OTDELAY + DURATION2
ENDIF
IF .NOT. EOF()
SKIP
ENDIF
ENDDO
SELE 4
REPLACE SH_ALL WITH 100*(MDELAY/(OTDELAY+MDELAY))

TEXT

     THIS PORTION OF CODE CALCULATES THE CONTRIBUTION OF THE
     FACE CONVEYOR (FC) TOWARDS TOTAL DOWNTIME.

ENDTEXT

OTDELAY = 0
MDELAY = 0
SELE 1
GOTO TOP
DO WHILE .NOT. EOF()
IF "FC" $ EQUIP
MDELAY = MDELAY + DURATION2
ELSE
OTDELAY = OTDELAY + DURATION2
ENDIF
IF .NOT. EOF()
SKIP
ENDIF
ENDDO
```

```
SELE 4
REPLACE FC_ALL WITH 100*(MDELAY/(OTDELAY+MDELAY))

TEXT

     THIS PORTION OF CODE CALCULATES THE CONTRIBUTION OF THE SHIELDS
     (SD) TOWARDS TOTAL DOWNTIME.

ENDTEXT

OTDELAY = 0
MDELAY = 0
SELE 1
GOTO TOP
DO WHILE .NOT. EOF()
 IF ("SD" $ EQUIP .OR. "HO 100" $ EQUIP .OR. "PM 102" $ EQUIP)
MDELAY = MDELAY + DURATION2
ELSE
OTDELAY = OTDELAY + DURATION2
ENDIF
 IF .NOT. EOF()
SKIP
ENDIF
ENDDO
SELE 4
REPLACE SD_ALL WITH 100*(MDELAY/(OTDELAY+MDELAY))

TEXT

     THIS PORTION OF CODE CALCULATES THE CONTRIBUTION OF THE
     STAGELOADER (SL) TOWARDS TOTAL DOWNTIME.

ENDTEXT

OTDELAY = 0
MDELAY = 0
SELE 1
GOTO TOP
DO WHILE .NOT. EOF()
 IF "SL" $ EQUIP
MDELAY = MDELAY + DURATION2
ELSE
OTDELAY = OTDELAY + DURATION2
ENDIF
 IF .NOT. EOF()
SKIP
ENDIF
ENDDO
SELE 4
REPLACE SL_ALL WITH 100*(MDELAY/(OTDELAY+MDELAY))
```

```
TEXT

     THIS PORTION OF CODE CALCULATES THE CONTRIBUTION OF THE
     CRUSHER (CR) TOWARDS THE TOTAL DOWNTIME.

ENDTEXT

OTDELAY = 0
MDELAY = 0
SELE 1
GOTO TOP
DO WHILE .NOT. EOF()
 IF "CR" $ EQUIP
MDELAY = MDELAY + DURATION2
ELSE
OTDELAY = OTDELAY + DURATION2
ENDIF
 IF .NOT. EOF()
SKIP
ENDIF
ENDDO
SELE 4
REPLACE CR_ALL WITH 100*(MDELAY/(OTDELAY+MDELAY))

TEXT

     THIS PORTION OF CODE CALCULATES THE CONTRIBUTION OF THE
     SECTION BELT (SB) TOWARDS TOTAL DOWNTIME.

ENDTEXT

OTDELAY = 0
MDELAY = 0
SELE 1
GOTO TOP
DO WHILE .NOT. EOF()
 IF "SB" $ EQUIP
MDELAY = MDELAY + DURATION2
ELSE
OTDELAY = OTDELAY + DURATION2
ENDIF
 IF .NOT. EOF()
SKIP
ENDIF
ENDDO
SELE 4
REPLACE SB_ALL WITH 100*(MDELAY/(OTDELAY+MDELAY))

TEXT
```

```
     THIS PORTION OF CODE CALCULATES THE CONTRIBUTION OF THE
     MAIN HAULAGE BELT(S) (HB) TO TOTAL DOWNTIME.

ENDTEXT

OTDELAY = 0
MDELAY = 0
SELE 1
GOTO TOP
DO WHILE .NOT. EOF()
 IF "HB" $ EQUIP
MDELAY = MDELAY + DURATION2
ELSE
OTDELAY = OTDELAY + DURATION2
ENDIF
 IF .NOT. EOF()
SKIP
ENDIF
ENDDO
SELE 4
REPLACE HB_ALL WITH 100*(MDELAY/(OTDELAY+MDELAY))

TEXT

     THIS PORTION OF CODE CALCULATES THE CONTRIBUTION OF THE
     BIN/SKIP/TIPPLE (BN) TO TOTAL DOWNTIME.

ENDTEXT

OTDELAY = 0
MDELAY = 0
SELE 1
GOTO TOP
DO WHILE .NOT. EOF()
 IF "BN" $ EQUIP
MDELAY = MDELAY + DURATION2
ELSE
OTDELAY = OTDELAY + DURATION2
ENDIF
 IF .NOT. EOF()
SKIP
ENDIF
ENDDO
SELE 4
REPLACE BN_ALL WITH 100*(MDELAY/(OTDELAY+MDELAY))

SELE 1
SET FILTER TO
RETURN
```

TYPE% PROGRAM

```
TEXT

     THIS PROGRAM CALCULATES THE SHARE OF DOWNTIME ATTRIBUTABLE
     TO EACH OF THE NINE DELAT TYPES. CALCULATIONS ARE PERFORMED
     FIRST ON AN UNSCHEDULED DELAYS BASIS, AND THEN ON AN ALL
     DELAYS BASIS.

ENDTEXT

SET EXACT ON
SET DATE TO YMD

OTDELAY = 0
MDELAY = 0
SELE 1
SET FILTER TO .NOT. ("MISSING SHIFT" $ COMM .OR. SCHEDULED .OR.;
TYPE = "NA")
GOTO TOP
DO WHILE .NOT. EOF()
 IF TYPE = "E"
MDELAY = MDELAY + DURATION2
ELSE
OTDELAY = OTDELAY + DURATION2
ENDIF
 IF .NOT. EOF()
SKIP
ENDIF
ENDDO
SELE 4
REPLACE E_UNS WITH 100*(MDELAY/(OTDELAY+MDELAY))


OTDELAY = 0
MDELAY = 0
SELE 1
GOTO TOP
DO WHILE .NOT. EOF()
 IF TYPE = "M"
MDELAY = MDELAY + DURATION2
ELSE
OTDELAY = OTDELAY + DURATION2
ENDIF
 IF .NOT. EOF()
SKIP
ENDIF
ENDDO
```

```
SELE 4
REPLACE M_UNS WITH 100*(MDELAY/(OTDELAY+MDELAY))


OTDELAY = 0
MDELAY = 0
SELE 1
GOTO TOP
DO WHILE .NOT. EOF()
IF TYPE = "H"
MDELAY = MDELAY + DURATION2
ELSE
OTDELAY = OTDELAY + DURATION2
ENDIF
IF .NOT. EOF()
SKIP
ENDIF
ENDDO
SELE 4
REPLACE H_UNS WITH 100*(MDELAY/(OTDELAY+MDELAY))


OTDELAY = 0
MDELAY = 0
SELE 1
GOTO TOP
DO WHILE .NOT. EOF()
IF TYPE = "EH"
MDELAY = MDELAY + DURATION2
ELSE
OTDELAY = OTDELAY + DURATION2
ENDIF
IF .NOT. EOF()
SKIP
ENDIF
ENDDO
SELE 4
REPLACE EH_UNS WITH 100*(MDELAY/(OTDELAY+MDELAY))


OTDELAY = 0
MDELAY = 0
SELE 1
GOTO TOP
DO WHILE .NOT. EOF()
IF TYPE = "G"
MDELAY = MDELAY + DURATION2
ELSE
OTDELAY = OTDELAY + DURATION2
ENDIF
```

```
IF .NOT. EOF()
SKIP
ENDIF
ENDDO
SELE 4
REPLACE G_UNS WITH 100*(MDELAY/(OTDELAY+MDELAY))

OTDELAY = 0
MDELAY = 0
SELE 1
GOTO TOP
DO WHILE .NOT. EOF()
IF TYPE = "C"
MDELAY = MDELAY + DURATION2
ELSE
OTDELAY = OTDELAY + DURATION2
ENDIF
IF .NOT. EOF()
SKIP
ENDIF
ENDDO
SELE 4
REPLACE C_UNS WITH 100*(MDELAY/(OTDELAY+MDELAY))

OTDELAY = 0
MDELAY = 0
SELE 1
GOTO TOP
DO WHILE .NOT. EOF()
IF TYPE = "P"
MDELAY = MDELAY + DURATION2
ELSE
OTDELAY = OTDELAY + DURATION2
ENDIF
IF .NOT. EOF()
SKIP
ENDIF
ENDDO
SELE 4
REPLACE P_UNS WITH 100*(MDELAY/(OTDELAY+MDELAY))

OTDELAY = 0
MDELAY = 0
SELE 1
GOTO TOP
DO WHILE .NOT. EOF()
IF TYPE = "SA"
```

```
MDELAY = MDELAY + DURATION2
ELSE
OTDELAY = OTDELAY + DURATION2
ENDIF
 IF .NOT. EOF()
SKIP
ENDIF
ENDDO
SELE 4
REPLACE SA_UNS WITH 100*(MDELAY/(OTDELAY+MDELAY))


OTDELAY = 0
MDELAY = 0
SELE 1
GOTO TOP
DO WHILE .NOT. EOF()
 IF TYPE = "V"
MDELAY = MDELAY + DURATION2
ELSE
OTDELAY = OTDELAY + DURATION2
ENDIF
 IF .NOT. EOF()
SKIP
ENDIF
ENDDO
SELE 4
REPLACE V_UNS WITH 100*(MDELAY/(OTDELAY+MDELAY))


OTDELAY = 0
MDELAY = 0
SELE 1
SET FILTER TO .NOT. ("MISSING SHIFT" $ COMM .OR. TYPE = "NA")
GOTO TOP
DO WHILE .NOT. EOF()
 IF TYPE = "E"
MDELAY = MDELAY + DURATION2
ELSE
OTDELAY = OTDELAY + DURATION2
ENDIF
 IF .NOT. EOF()
SKIP
ENDIF
ENDDO
SELE 4
REPLACE E_ALL WITH 100*(MDELAY/(OTDELAY+MDELAY))


OTDELAY = 0
```

```
MDELAY = 0
SELE 1
GOTO TOP
DO WHILE .NOT. EOF()
 IF TYPE = "M"
MDELAY = MDELAY + DURATION2
ELSE
OTDELAY = OTDELAY + DURATION2
ENDIF
 IF .NOT. EOF()
SKIP
ENDIF
ENDDO
SELE 4
REPLACE M_ALL WITH 100*(MDELAY/(OTDELAY+MDELAY))


OTDELAY = 0
MDELAY = 0
SELE 1
GOTO TOP
DO WHILE .NOT. EOF()
 IF TYPE = "H"
MDELAY = MDELAY + DURATION2
ELSE
OTDELAY = OTDELAY + DURATION2
ENDIF
 IF .NOT. EOF()
SKIP
ENDIF
ENDDO
SELE 4
REPLACE H_ALL WITH 100*(MDELAY/(OTDELAY+MDELAY))


OTDELAY = 0
MDELAY = 0
SELE 1
GOTO TOP
DO WHILE .NOT. EOF()
 IF TYPE = "EH"
MDELAY = MDELAY + DURATION2
ELSE
OTDELAY = OTDELAY + DURATION2
ENDIF
 IF .NOT. EOF()
SKIP
ENDIF
ENDDO
SELE 4
```

```
REPLACE EH_ALL WITH 100*(MDELAY/(OTDELAY+MDELAY))


OTDELAY = 0
MDELAY = 0
SELE 1
GOTO TOP
DO WHILE .NOT. EOF()
 IF TYPE = "G"
MDELAY = MDELAY + DURATION2
ELSE
OTDELAY = OTDELAY + DURATION2
ENDIF
 IF .NOT. EOF()
SKIP
ENDIF
ENDDO
SELE 4
REPLACE G_ALL WITH 100*(MDELAY/(OTDELAY+MDELAY))


OTDELAY = 0
MDELAY = 0
SELE 1
GOTO TOP
DO WHILE .NOT. EOF()
 IF TYPE = "C"
MDELAY = MDELAY + DURATION2
ELSE
OTDELAY = OTDELAY + DURATION2
ENDIF
 IF .NOT. EOF()
SKIP
ENDIF
ENDDO
SELE 4
REPLACE C_ALL WITH 100*(MDELAY/(OTDELAY+MDELAY))


OTDELAY = 0
MDELAY = 0
SELE 1
GOTO TOP
DO WHILE .NOT. EOF()
 IF TYPE = "P"
MDELAY = MDELAY + DURATION2
ELSE
OTDELAY = OTDELAY + DURATION2
ENDIF
 IF .NOT. EOF()
```

```
SKIP
ENDIF
ENDDO
SELE 4
REPLACE P_ALL WITH 100*(MDELAY/(OTDELAY+MDELAY))


OTDELAY = 0
MDELAY = 0
SELE 1
GOTO TOP
DO WHILE .NOT. EOF()
 IF TYPE = "SA"
MDELAY = MDELAY + DURATION2
ELSE
OTDELAY = OTDELAY + DURATION2
ENDIF
 IF .NOT. EOF()
SKIP
ENDIF
ENDDO
SELE 4
REPLACE SA_ALL WITH 100*(MDELAY/(OTDELAY+MDELAY))


OTDELAY = 0
MDELAY = 0
SELE 1
GOTO TOP
DO WHILE .NOT. EOF()
 IF TYPE = "V"
MDELAY = MDELAY + DURATION2
ELSE
OTDELAY = OTDELAY + DURATION2
ENDIF
 IF .NOT. EOF()
SKIP
ENDIF
ENDDO
SELE 4
REPLACE V_ALL WITH 100*(MDELAY/(OTDELAY+MDELAY))

SELE 1
SET FILTER TO
RETURN
```

STATS PROGRAM

```
TEXT

     THIS PROGRAM CALCULATES OPERATIONAL STATISTICS INCLUDING
     THE SEVEN PERFORMANCE INDICATORS MENTIONED IN THE TEXT.
     THESE OPERATIONAL STATISTICS ARE RECORDED IN FIELDS (2)
     THROUGH (12) OF THE RESULT DATABASE AND FIELD (76).

ENDTEXT

SET EXACT ON

TEXT

     THIS PORTION OF CODE CALCULATES DATAQUAL.

ENDTEXT

SELE 1
COUNT FOR "*TIME" $ COMM .AND..NOT. SCHEDULED TO NUMTIME
COUNT FOR .NOT. SCHEDULED TO NUMTOT
FACTOR1 = (NUMTOT-NUMTIME)/NUMTOT
SELE 2
COUNT TO NUMSFTS
SELE 1
COUNT FOR .NOT. SCHEDULED TO NUMDELAYS
DELPERSFT = NUMDELAYS/NUMSFTS
DO CASE
   CASE DELPERSFT >= 4
   FACTOR2 = 1.00
   CASE DELPERSFT >= 3
   FACTOR2 = 0.75
   CASE DELPERSFT >= 2
   FACTOR2 = 0.50
   CASE DELPERSFT < 2
   FACTOR2 = 0.25
ENDCASE
MQUAL = ((0.5*FACTOR1)+(0.5*FACTOR2))*100

TEXT

     THIS PORTION OF CODE CALCULATES SFT_WEEK.

ENDTEXT

SELE 2
INDEX ON DATE TO SFT12 UNIQUE
```

```
SET FILTER TO .NOT. (CDOW(DATE)="Saturday" .OR. CDOW(DATE)="Sunday")
COUNT TO WKDAYS
SET INDEX TO
COUNT TO WKSFTS
SET FILTER TO CDOW(DATE)="Saturday" .OR. CDOW(DATE)="Sunday"
COUNT TO ENDSFTS
SFTPERWK = 5*((WKSFTS+ENDSFTS)/WKDAYS)
SET FILTER TO

TEXT

     THIS PORTION OF CODE CALCULATES WORKER_AVE, RAW_AVE,
     CLEAN_AVE, PASS_SFT, AND ADVAN_SFT.

ENDTEXT

GOTO TOP
AVERAGE WORKERS TO MWORK FOR WORKERS > 0
AVERAGE VAL(RAW_TONS) TO MRAW FOR VAL(RAW_TONS) > 0
AVERAGE VAL(CLEAN_TONS) TO MCLEAN FOR VAL(CLEAN_TONS) > 0
AVERAGE VAL(PASSES) TO MPASS FOR VAL(PASSES) > 0
AVERAGE VAL(FEET_ADVAN) TO MADVAN FOR VAL(FEET_ADVAN) > 0

TEXT

     THIS PORTION OF CODE CALCULATES PROD_RATE AND DOWNPERTON.

ENDTEXT

COUNT FOR VAL(RAW_TONS) > 0 .OR. VAL(CLEAN_TONS) > 0 TO MNUM
IF MNUM > 5
GOTO TOP
MCOUNT = 0
SUMRATE = 0
SUMDOWN = 0
DO WHILE .NOT. EOF()
IF VAL(RAW_TONS) > 0 .AND. MAVAIL > 0
SUMRATE = SUMRATE + (((1/(MAVAIL/100)) * VAL(RAW_TONS))/(LEAV2_SECT -;
ARR_SECT - TIME_RCP))
SUMDOWN = SUMDOWN + (MDELAY/VAL(RAW_TONS))
MCOUNT = MCOUNT + 1
ELSE
IF VAL(CLEAN_TONS) > 0 .AND. MAVAIL > 0
SUMRATE = SUMRATE + ((((1/(MAVAIL/100)) * VAL(CLEAN_TONS))/(LEAV2_SECT;
- ARR_SECT - TIME_RCP)) * 1.5)
SUMDOWN = SUMDOWN + ((MDELAY/VAL(CLEAN_TONS)) * 1.5)
MCOUNT = MCOUNT + 1
ENDIF
ENDIF
SKIP
```

```
ENDDO
AVERATE = SUMRATE/MCOUNT
AVEDOWN = SUMDOWN/MCOUNT
ELSE
AVERATE = 0
AVEDOWN = 0
ENDIF

TEXT

     THIS PORTION OF CODE CALCULATES REJECT.

ENDTEXT


COUNT FOR VAL(RAW_TONS) > 0 .AND. VAL(CLEAN_TONS) > 0 TO MNUM
IF MNUM > 5
GOTO TOP
MCOUNT = 0
SUMREJ = 0
DO WHILE .NOT. EOF()
IF VAL(RAW_TONS) > 0 .AND. VAL(CLEAN_TONS) > 0
SUMREJ = SUMREJ + ((VAL(RAW_TONS) - VAL(CLEAN_TONS))/VAL(RAW_TONS))
MCOUNT = MCOUNT + 1
ENDIF
SKIP
ENDDO
AVEREJ = (SUMREJ/MCOUNT) * 100
ELSE
AVEREJ = 0
ENDIF

TEXT

     THIS PORTION OF CODE CALCULATES TON_MAN.

ENDTEXT

IF MRAW > 0
TONMAN = MRAW/MWORK
ELSE
IF MCLEAN > 0
TONMAN = (MCLEAN*1.5)/MWORK
ELSE
TONMAN = 0
ENDIF
ENDIF

SELE 4
REPLACE WORKER_AVE WITH MWORK,RAW_AVE WITH MRAW,CLEAN_AVE WITH MCLEAN,;
```

```
TON_MAN WITH TONMAN,PASS_SFT WITH MPASS,ADVAN_SFT WITH MADVAN,SFT_WEEK;
WITH SFTPERWK,PROD_RATE WITH AVERATE,DOWNPERTON WITH AVEDOWN,REJECT;
WITH AVEREJ,DATAQUAL WITH MQUAL

TEXT

     THIS PORTION OF CODE CALCULATES TON_WEEK.

ENDTEXT

IF RAW_AVE > 0
TONPERWEEK = RAW_AVE * SFT_WEEK
ELSE
IF CLEAN_AVE > 0
TONPERWEEK = CLEAN_AVE * SFT_WEEK * 1.5
ELSE
TONPERWEEK = 0
ENDIF
ENDIF
REPLACE TON_WEEK WITH TONPERWEEK
RETURN
```

SECAVAIL PROGRAM

```
TEXT

     THIS PROGRAM CALCULATES THE AVERAGE SYSTEM, FACE, AND
     EQUIPMENT AVAILABILITIES FOR EACH LONGWALL SECTION.
     EQUIPMENT AVAILABILITIES ARE CALCULATED FOR THE EIGHT
     PRIMARY EQUIPMENT COMPONENTS. THE FIRST PORTION OF TEXT
     CALCULATES AVERAGE SYSTEM AVAILABILITY, FACE AVAILABILITY,
     AND INHERENT DELAY TIME.

ENDTEXT

SET EXACT ON
SET DATE TO YMD

SELE 2
CLOSE INDEX
AVERAGE MAVAIL TO MACHAVE
AVERAGE TAVAIL TO SYSTAVE
AVERAGE IDELAY TO INHAVE
SET INDEX TO SFT11

TEXT

     THIS PORTION OF CODE CALCULATES EQUIPMENT AVAILABILITIES.

ENDTEXT

SELE 1
CLOSE INDEX
SET INDEX TO DT11
SET FILTER TO .NOT. "MISSING SHIFT" $ COMM
GOTO TOP
MDATE = DATE
MSHIFT = SHIFT
SHDELAY = 0
FCDELAY = 0
SDDELAY = 0
SLDELAY = 0
CRDELAY = 0
SBDELAY = 0
HBDELAY = 0
BNDELAY = 0
SHSUM = 0
FCSUM = 0
SDSUM = 0
SLSUM = 0
```

```
CRSUM = 0
SBSUM = 0
HBSUM = 0
BNSUM = 0
MCOUNT = 0

DO WHILE .NOT. EOF()
DO CASE

CASE DATE = DATE .AND. SHIFT = MSHIFT

   DO CASE

   CASE "SH" $ EQUIP
   SHDELAY = SHDELAY + DURATION2

   CASE "FC" $ EQUIP
   FCDELAY = FCDELAY + DURATION2

   CASE ("SD" $ EQUIP .OR. "HO 100" $ EQUIP .OR. "PM 102" $ EQUIP)
   SDDELAY = SDDELAY + DURATION2

   CASE "SL" $ EQUIP
   SLDELAY = SLDELAY + DURATION2

   CASE "CR" $ EQUIP
   CRDELAY = CRDELAY + DURATION2

   CASE "SB" $ EQUIP
   SBDELAY = SBDELAY + DURATION2

   CASE "HB" $ EQUIP
   HBDELAY = HBDELAY + DURATION2

   CASE "BN" $ EQUIP
   BNDELAY = BNDELAY + DURATION2

   ENDCASE

CASE .NOT. (DATE = MDATE .AND. SHIFT = MSHIFT)

    MDATE = DATE
    MSHIFT = SHIFT

    SELE 2
    DO WHILE DTOC(DATE) + SHIFT < DTOC(MDATE) + MSHIFT
    SKIP
    ENDDO

    MCOUNT = MCOUNT + 1
```

```
    SHAVAL = ((LEAV2_SECT - (ARR_SECT + TIME_RCP) - SHDELAY)/;
    (LEAV2_SECT - (ARR_SECT + TIME_RCP))) * 100
    FCAVAL = ((LEAV2_SECT - (ARR_SECT + TIME_RCP) - FCDELAY)/;
    (LEAV2_SECT - (ARR_SECT + TIME_RCP))) * 100
    SDAVAL = ((LEAV2_SECT - (ARR_SECT + TIME_RCP) - SDDELAY)/;
    (LEAV2_SECT - (ARR_SECT + TIME_RCP))) * 100
    SLAVAL = ((LEAV2_SECT - (ARR_SECT + TIME_RCP) - SLDELAY)/;
    (LEAV2_SECT - (ARR_SECT + TIME_RCP))) * 100
    CRAVAL = ((LEAV2_SECT - (ARR_SECT + TIME_RCP) - CRDELAY)/;
    (LEAV2_SECT - (ARR_SECT + TIME_RCP))) * 100
    SBAVAL = ((LEAV2_SECT - (ARR_SECT + TIME_RCP) - SBDELAY)/;
    (LEAV2_SECT - (ARR_SECT + TIME_RCP))) * 100
    HBAVAL = ((LEAV2_SECT - (ARR_SECT + TIME_RCP) - HBDELAY)/;
    (LEAV2_SECT - (ARR_SECT + TIME_RCP))) * 100
    BNAVAL = ((LEAV2_SECT - (ARR_SECT + TIME_RCP) - BNDELAY)/;
    (LEAV2_SECT - (ARR_SECT + TIME_RCP))) * 100

    SHSUM = SHSUM + SHAVAL
    FCSUM = FCSUM + FCAVAL
    SDSUM = SDSUM + SDAVAL
    SLSUM = SLSUM + SLAVAL
    CRSUM = CRSUM + CRAVAL
    SBSUM = SBSUM + SBAVAL
    HBSUM = HBSUM + HBAVAL
    BNSUM = BNSUM + BNAVAL

    SELE 1
    SHDELAY = 0
    FCDELAY = 0
    SDDELAY = 0
    SLDELAY = 0
    CRDELAY = 0
    SBDELAY = 0
    HBDELAY = 0
    BNDELAY = 0

ENDCASE
SKIP
ENDDO

SHAVE = SHSUM/MCOUNT
FCAVE = FCSUM/MCOUNT
SDAVE = SDSUM/MCOUNT
SLAVE = SLSUM/MCOUNT
CRAVE = CRSUM/MCOUNT
SBAVE = SBSUM/MCOUNT
HBAVE = HBSUM/MCOUNT
BNAVE = BNSUM/MCOUNT

SELE 4
```

```
REPLACE SHAVAIL WITH SHAVE,FCAVAIL WITH FCAVE,SDAVAIL WITH SDAVE,;
SLAVAIL WITH SLAVE,CRAVAIL WITH CRAVE,SBAVAIL WITH SBAVE,HBAVAIL WITH;
HBAVE,BNAVAIL WITH BNAVE,FACEAVAIL WITH MACHAVE,SYSTAVAIL WITH SYSTAVE;
,INHERDELAY WITH INHAVE
SELE 1
SET INDEX TO
SET FILTER TO
SELE 2
SET INDEX TO
SET FILTER TO

RETURN
```

MEANTIME PROGRAM

```
TEXT

    THIS PROGRAM CALCULATES THE AVERAGE VALUE OF TTF AND TTR
    OF THE EIGHT PRIMARY EQUIPMENT TYPES. THESE AVERAGES ARE
    CALCULATED FROM THE TTF AND TTR STATISTICS GENERATED BY
    AUTOTTF PROGRAM AND AUTOTTR PROGRAM.

ENDTEXT


SET EXACT ON

SELE 3
TTRNAME = &PREFIX + "SHTTR"
USE &TTRNAME
AVERAGE TTR TO RSHAVE FOR TTR > 0
TTRNAME = &PREFIX + "FCTTR"
USE &TTRNAME
AVERAGE TTR TO RFCAVE FOR TTR > 0
TTRNAME = &PREFIX + "SDTTR"
USE &TTRNAME
AVERAGE TTR TO RSDAVE FOR TTR > 0
TTRNAME = &PREFIX + "SLTTR"
USE &TTRNAME
AVERAGE TTR TO RSLAVE FOR TTR > 0
TTRNAME = &PREFIX + "CRTTR"
USE &TTRNAME
AVERAGE TTR TO RCRAVE FOR TTR > 0
TTRNAME = &PREFIX + "SBTTR"
USE &TTRNAME
AVERAGE TTR TO RSBAVE FOR TTR > 0
TTRNAME = &PREFIX + "HBTTR"
USE &TTRNAME
AVERAGE TTR TO RHBAVE FOR TTR > 0
TTRNAME = &PREFIX + "BNTTR"
USE &TTRNAME
AVERAGE TTR TO RBNAVE FOR TTR > 0
TTRNAME = &PREFIX + "SYTTR"
USE &TTRNAME
AVERAGE TTR TO RSYAVE FOR TTR > 0
TTFNAME = &PREFIX + "SHTTF"
USE &TTFNAME
AVERAGE TTFACT TO FSHAVE FOR TTFACT > 0
TTFNAME = &PREFIX + "FCTTF"
USE &TTFNAME
```

```
AVERAGE TTFACT TO FFCAVE FOR TTFACT > 0
TTFNAME = &PREFIX + "SDTTF"
USE &TTFNAME
AVERAGE TTFACT TO FSDAVE FOR TTFACT > 0
TTFNAME = &PREFIX + "SLTTF"
USE &TTFNAME
AVERAGE TTFACT TO FSLAVE FOR TTFACT > 0
TTFNAME = &PREFIX + "CRTTF"
USE &TTFNAME
AVERAGE TTFACT TO FCRAVE FOR TTFACT > 0
TTFNAME = &PREFIX + "SBTTF"
USE &TTFNAME
AVERAGE TTFACT TO FSBAVE FOR TTFACT > 0
TTFNAME = &PREFIX + "HBTTF"
USE &TTFNAME
AVERAGE TTFACT TO FHBAVE FOR TTFACT > 0
TTFNAME = &PREFIX + "BNTTF"
USE &TTFNAME
AVERAGE TTFACT TO FBNAVE FOR TTFACT > 0
TTFNAME = &PREFIX + "SYTTF"
USE &TTFNAME
AVERAGE TTFACT TO FSYAVE FOR TTFACT > 0

SELE 4
REPLACE SHMTTR WITH RSHAVE,FCMTTR WITH RFCAVE,SDMTTR WITH RSDAVE,;
SLMTTR WITH RSLAVE,CRMTTR WITH RCRAVE,SBMTTR WITH RSBAVE,HBMTTR WITH;
RHBAVE,BNMTTR WITH RBNAVE,SYMTTR WITH RSYAVE,SHMTTF WITH FSHAVE,;
FCMTTF WITH FFCAVE,SDMTTF WITH FSDAVE,SLMTTF WITH FSLAVE,CRMTTF WITH;
FCRAVE,SBMTTF WITH FSBAVE,HBMTTF WITH FHBAVE,BNMTTF WITH FBNAVE,SYMTTF;
WITH FSYAVE
CLEAR ALL
RUN ERASE *.NDX
RUN ERASE *.DBO
RETURN
```

APPENDIX IV

TTF AND TTR PROBABILITY DENSITY FUNCTIONS

Mine 20

Category	type	Distribution	Scale	Shape
FC	TTF	Weibull	659.800	.728
	TTR	Lognormal	3.405	.981
HAUL*	TTF	Gamma	859.934	.744
	TTR	Lognormal	3.144	.814
SD	TTF	Gamma	2615.200	.743
	TTR	Lognormal	3.139	.850
SH	TTF	Gamma	206.862	1.035
	TTR	Lognormal	3.609	.888
G	TTF	Gamma	612.046	.797
	TTR	Gamma	17.389	2.540
SY	TTF	Gamma	80.187	1.122
	TTR	Lognormal	3.418	.869

* The category "HAUL" is composed of the primary Equipment Types SL, CR, SB, HB.

Mine 22

Category	type	Distribution	Scale	Shape
FC	TTF	Lognormal	6.451	2.251
	TTR	Lognormal	3.283	1.170
HAUL	TTF	Weibull	569.936	.826
	TTR	Lognormal	3.025	.777
SD	TTF	Lognormal	6.613	1.123
	TTR	Lognormal	3.494	.839
SH	TTF	Lognormal	5.936	1.535
	TTR	Lognormal	3.396	.859
G	TTF	Gamma	3629.180	.553
	TTR	Gamma	18.952	1.677
SY	TTF	Weibull	155.825	.835
	TTR	Lognormal	3.439	.963

Mine 25

Category	type	Distribution	Scale	Shape
FC	TTF	Weibull	1174.620	.787
	TTR	Lognormal	4.072	.936
HAUL	TTF	Gamma	340.816	.897
	TTR	Lognormal	3.600	.837
SD	TTF	Gamma	4622.860	.768
	TTR	Exponential	49.374	
SH	TTF	Weibull	1219.780	.862
	TTR	Lognormal	3.917	.861
G	TTF	Gamma	2438.880	.557
	TTR	Gamma	3.860	.940
SY	TTF	Exponential	162.108	
	TTR	Lognormal	3.698	.886

Mine 26

Category	type	Distribution	Scale	Shape
FC	TTF	Lognormal	4.472	1.637
	TTR	Lognormal	1.910	1.127
HAUL	TTF	Weibull	162.328	.740
	TTR	Lognormal	2.149	1.067
SD	TTF	Lognormal	4.612	1.484
	TTR	Lognormal	2.169	.766
SH	TTF	Lognormal	4.366	1.327
	TTR	Lognormal	2.550	1.125
G	TTF	Lognormal	4.165	1.465
	TTR	Lognormal	2.309	.912
SY	TTF	Lognormal	3.052	1.096
	TTR	Lognormal	2.286	1.036

Mine 27

Category	type	Distribution	Scale	Shape
FC	TTF	Lognormal	4.832	1.942
	TTR	Lognormal	2.080	1.348
HAUL	TTF	Weibull	142.964	.572
	TTR	Lognormal	1.849	1.087
SD	TTF	Weibull	317.948	.572
	TTR	Lognormal	1.905	.715
SH	TTF	Weibull	109.116	.778
	TTR	Lognormal	2.050	1.188
G	TTF	Lognormal	3.590	1.417
	TTR	Gamma	3.601	1.674
SY	TTF	Lognormal	2.899	1.042
	TTR	Lognormal	1.814	.991

Mine 31

Category	type	Distribution	Scale	Shape
FC	TTF	Gamma	2997.47	.609
	TTR	Lognormal	3.587	.969
HAUL	TTF	Weibull	429.399	.794
	TTR	Lognormal	3.021	.726
SD	TTF	Weibull	2045.278	.879
	TTR	Gamma	6.875	3.569
SH	TTF	Weibull	654.421	.765
	TTR	Exponential	96.797	-
G	TTF	-	-	-
	TTR	-	-	-
SY	TTF	Weibull	161.675	1.034
	TTR	Lognormal	3.516	.954

VITA

James Dunlap was born in 1963 in Washington, D.C. He was educated in Arlington, Virginia, and abroad in Ecuador, Chile, and Pakistan. He received the Bachelor of Science degree in Mining and Minerals Engineering at V.P.I. & S.U, Blacksburg, Virginia in 1987 and undertook graduate studies leading to the Master of Science degree in Mining and Minerals Engineering at that University in 1990.

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