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MOBIL RESEARCH AND DEVELOPMENT CORPORATION

RESEARCH DEPARTMENT

TECHNICAL MEMORANDUM NO. 67-26

TIME STUDIES OF MINING OPERATIONS

ANVIL POINTS OIL SHALE RESEARCH CENTER

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The primary object of the Anvil Points Oil Shale Research Center TECHNICAL MEMORANDUM is to advise authorized personnel employed by the Participating Parties (1) that various activities are in progress or that certain significant data have been obtained within the Research Center.

These TECHNICAL MEMORANDA have been prepared to provide rapid, on-the-spot reporting of research currently in progress at Anvil Points. The conclusions drawn by project personnel are tentative and may be subject to change as work progresses. The TECHNICAL MEMORANDA have not been edited in detail.

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TIME STUDIES OF MINING OPERATIONS

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TIME STUDIES OF MINING OPERATIONS

I. INTRODUCTION

During the course of the mining program at Anvil Points, most of the mining procedures were time studied to permit a better estimation of the mining costs in any future commercial oil shale mining enterprise. The actual mining procedures studied were: (1) drilling the headings and benches, (2) loading powder into the heading rounds, (3) loading the shot rock from heading rounds, and (4) rockbolting the roof above the mining headings. The only major mining procedures not studied were the scaling of the faces and ribs in the mining rooms and the benching operation. The scaling has been done manually and it is recognized that in a commercial venture most of the scaling would be done mechanically.

This report contains all the time studies in condensed form and the actual recorded times are given in the Appendix.

II. SUMMARY

Most of the mining procedures on the mining headings were time studied. The main conclusions are as follows:

A. Heading Drilling

Under the test conditions at Anvil Points the time required to drill off a standard heading round incorporating twenty-eight 4-inch diameter holes 29 feet long was approximately 6 1/2 hours.

B. Bench Drilling

Under the test conditions at Anvil Points the time required to drill off 25 feet of the bench with 4-inch diameter holes 35 feet deep was approximately 3 hours for a 12 by 12 foot spacing (12 holes) and 2 hours for a 15 by 15 foot (8 holes, approximately) spacing. This time does not include any bit changes.

C. Bit Sharpening

Using the equipment at Anvil Points the time taken to sharpen a 4-inch diameter, 4-blade rotary drag bit was approximately 13 minutes.

D. Powdering Heading Rounds

Under the test conditions at Anvil Points the time taken to load a standard heading round with explosives was 3 1/2 hours.

E. Loading Shot Rock From Heading Rounds

Under the test conditions at Anvil Points an average heading round (4000 T) would be mucked out in 12 hours using either the Koehring Skooper with 6 1/2 or 3 1/2 yard bucket, or the Caterpillar Front End Loader with a 3 yard bucket working at a rate of 350 tons per hour.

F. Rockbolting

Under the test conditions at Anvil Points the time required to bolt the roof above a heading round with 6 foot bolts in 6 foot spacings (40 bolts total), was 4 1/2 hours.

III. DISCUSSION

A. Time Studies of Drilling Heading Rounds

1. Description of the Elements

a. Moving Jumbo In

The drilling was performed by the heading jumbo Serial No. JED-1 manufactured by Gardner-Denver incorporating one rotary drill with a 29 foot feed. The thrust and rotation of the drill steel were supplied by hydraulic motors which were powered by an electric motor. Drill cuttings were removed from the hole by an air/water mist. The jumbo was mounted on a diesel truck bed and, at the commencement of drilling, the jumbo was driven into place opposite one side of the round to be drilled off. The electric cable, air hoses and water hoses were then connected to the jumbo. The water tanks were filled while the jumbo stabilizers were being set against the floor and adjusted so as to level the truck bed. The jumbo mast was then raised into position and locked. The tasks described above are grouped in the element - Moving Jumbo In and were normally performed by two men, the driller and his assistant.

b. Moving Jumbo Across Face

When the first half of the round was drilled off, the mast on the jumbo was lowered and the stabilizing jacks retracted. The jumbo was then repositioned at the other side of the round to be drilled off. While the mast was being raised and the jacks were being reset, the water tank was filled. The water tank capacity was 220 gallons.

c. Positioning

This element is the time taken to move the drill from one hole to another. Normal procedure, after having set up the jumbo and put on a new bit, was to travel to the topmost ribhole, drill that, then move sideways, drilling off all the holes in the one side of the top row before dropping down to the next row. This procedure was followed until the last hole had been drilled in the bottom row. Moving from the top of the face to the bottom of the face ensured that the drilling water did not enter holes lower down.

d. Stinging

When the drill feed had been correctly aligned, it was then advanced until the prong at the end of the feed came into contact with the rock face. The time taken to locate the prong securely in this manner was the stinging element. Protracted stinging elements were caused by smooth sloping surfaces which the prong or stinger could not grip. The purpose of stinging the face is to hold the drill feed in a steady position while drilling.

e. Collaring

Having stung the face, the air and water to the drill were then switched on and the drill was fed slowly into the rock face. The first foot of hole was drilled gently so as to ensure that the drill steel did not bow or the bit wander and produce a crooked hole with possible misalignment. The collaring element ceased when full feed pressure was applied to the drill.

f. Drilling - This was the time taken to drill the hole.

Hole depth in a standard heading round was 29 feet. Several studies were made of crosscut rounds where hole depths were 23 feet. Penetration rates were quite variable depending mainly on the conditions of the bit and the oil content of the rock being drilled. Drilling elements have been separated according to the position of the hole relative to the strata. Thus, Row A was the bottom row in the softest oil shale. Row B was 8 feet up from the floor in soft oil shale. Row C was 2 feet above the Mahogany Marker in very lean hard shale. Row D was 12 feet from the roof in a rich soft band and Row E was 2 feet from the roof in a moderately soft band of shale.

g. Retracting

When the hole was drilled, the water was shut off and the drill steel retracted from the hole. The element ceased when the drill motor reached the end of its travel and the air was shut off.

h. Changing Bits

This element covers the lowering of the drill bit to ground level and the removal of the drill bit

using pipe wrenches. The new bit was then put on and the drill returned to the next hole.

i. Filling Water Tanks

Generally the water tanks were filled while the jumbo was being moved over, but with the amount of water required, it was often necessary to interrupt the drilling to fill the water tanks.

2. Elemental Times

With the exception of the actual drilling times and retracting times, all elements were independent of the type of bit used and the depth of holes drilled. Therefore, the following table shows elemental times calculated from all of the time study drilling data.

<u>Element</u>	<u>Mean Elemental Time</u>	<u>Number of Observations</u>
Positioning	1.311	103
Stinging	0.796	109
Collaring	0.787	120
Retracting (hole depth 29 ft.)	0.793	116
Changing Bits	7.357	16
Filling Water Tanks	5.	0
Repairs	30.	0
Moving Jumbo Across Face	28.	3
Moving Jumbo In	45.	0

Filling Water Tanks, Repairs and Moving Jumbo In are elements which were not studied thoroughly and are therefore estimated.

Actual drilling times are expressed below in terms of a calculated penetration rate.

4-Inch Diameter Hole

	<u>Penetration Rate ft/min</u>	<u>Variance (min²)</u>	<u>Number of Observations</u>
E row	4.942	3.3305	25
D row	5.328	4.2447	31
C row	3.562	5.2526	20
B row	8.106	4.2612	10
A row	7.780	2.0417	11

4 3/4-Inch Diameter Hole

	<u>Penetration Rate ft/min</u>	<u>Number of Observations</u>
Top row	2.18	2
Upper middle row	1.80	1
Lower middle row	5.35	5
Bottom row	5.80	5

Note: The rows of 4 3/4-inch holes are at different horizons from the 4-inch holes.

3. Total Time Required to Drill the Various Rounds

a. Standard Heading Round using 28 holes, 4-inch diameter, 29 feet long. Face dimension - 60 feet wide by 40 feet high.

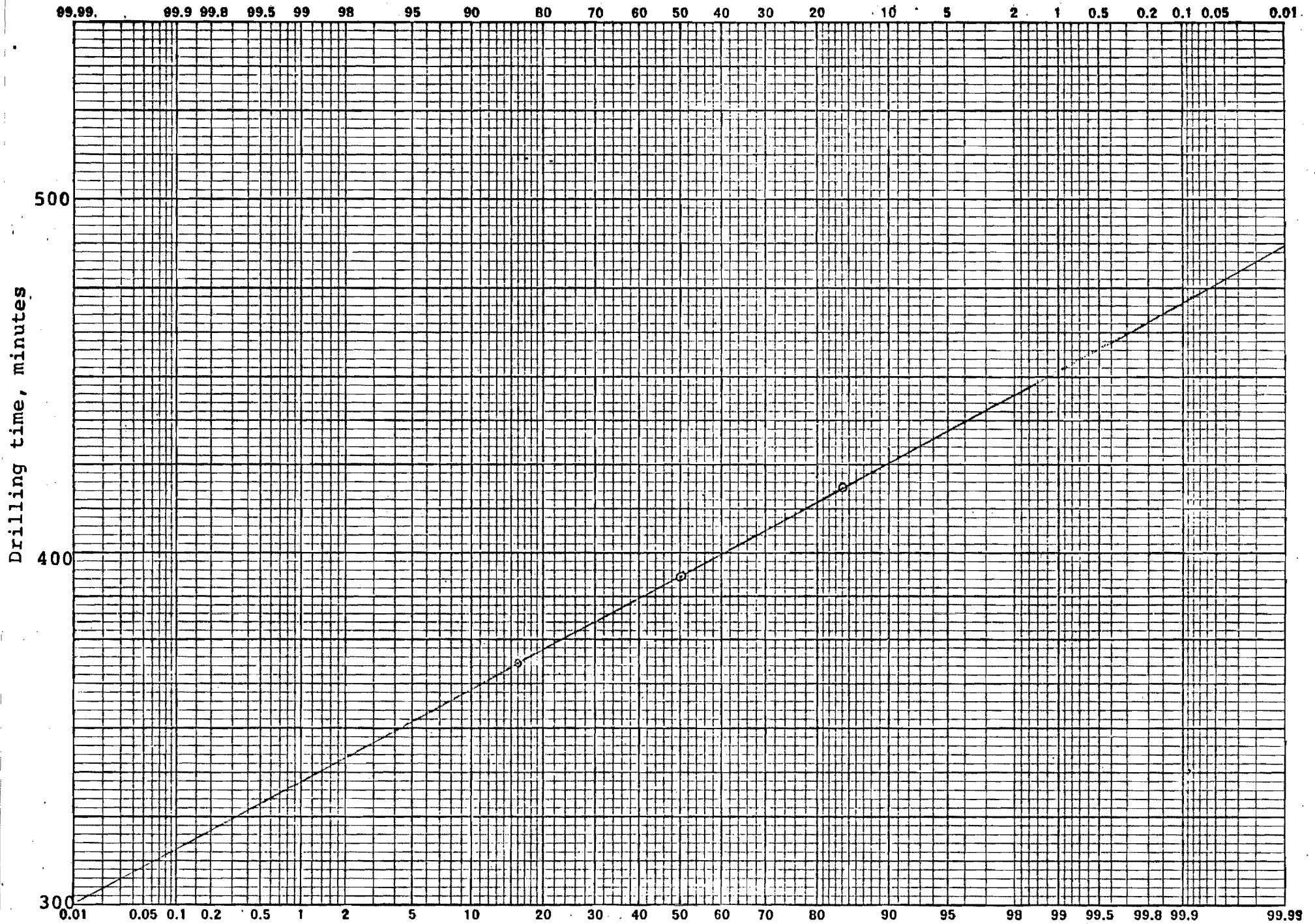
<u>Element</u>	<u>Mean Elemental Time (mins)</u>	<u>Variance of Sample</u>	<u>Occurrence</u>	<u>Total Time (mins)</u>	<u>Total Variance of Sample</u>
Positioning	1.31	0.7842	28	36.71	21.96
Stinging	0.80	0.8130	28	22.23	22.76
Collaring	0.79	1.2398	28	22.04	34.71
Drilling					
E row	5.67	3.8188	5	28.35	19.09
D row	5.26	4.1864	6	31.56	25.12
C row	7.86	11.5924	6	47.16	69.55
B row	3.45	1.8158	6	20.70	10.89
A row	3.60	1.0819	5	18.00	5.41
Retracting	0.79	3.3709	28	22.20	94.39
Changing Bits	7.36	6.3604	5	36.79	31.80
Filling Water Tanks	5.	1.	1	5.	1.00
Repairs	30.	100.	1	30.	100.00
Moving Jumbo Across Face	27.97	73.2	1	27.97	73.20
Moving Jumbo In	45.	100.	1	45.	100.00
			<u>Grand Totals</u>	<u>393.71</u>	<u>609.88</u>

Total time to drill off the above round was six hours 33.71 minutes with a standard deviation of ± 24.7 minutes. This is shown graphically in Figure 1.

Note: The drilling times include many observations taken from tests where conditions of thrust, rotation and bit design were far from the optimum. Thus the penetration rates as shown here are not as fast as they could be. As shown in F. W. Brackebusch's Technical

FIGURE 1

PREDICTED TIME DISTRIBUTION FOR DRILLING A STANDARD HEADING ROUND
OF 28 FOUR-INCH DIAMETER HOLES



Memorandum No. 67-19, the optimum penetration rates attainable with the present drill are as follows:

	<u>Penetration Rate, ft/min</u>
E row	4.7
D row	7
C row	4.5
B row	10
A row	9

If instead of using observed penetration rates, the optimum penetration rates are used, then the Drilling times would be as follows:

<u>Drilling</u>	<u>Elemental Time, minutes</u>	<u>Occurrence</u>	<u>Total Time, minutes</u>
E row	5.96	5	29.80
D row	4.00	6	24.00
C row	6.23	6	37.38
B row	2.80	6	16.80
A row	3.11	5	15.55
Total Drilling Time			123.53

The time taken to drill off a standard heading round would be 371.47 minutes, or 6 hours 11.47 minutes.

In this time study as in all the others the variance of the sample of elemental times has been shown. In the case of estimated mean elemental times, a standard deviation of 10 minutes has been assumed.

b. Heading Round using 19 holes, 4 3/4-inch diameter, 29 feet long.

<u>Element</u>	<u>Mean Elemental Time, (mins)</u>	<u>Occurrence</u>	<u>Total Time, (mins)</u>
Positioning	1.31	19	24.89
Stinging	0.80	19	15.20
Collaring	0.79	19	15.01
Drilling			
Top row	13.32	4	53.28
Upper Middle row	15.56	5	77.80

<u>Element</u>	<u>Mean Elemental Time, (mins)</u>	<u>Occurrence</u>	<u>Total Time, (mins)</u>
Lower Middle row	5.23	5	26.15
Bottom row	4.83	5	24.15
Retracting	0.79	19	15.01
Changing Bits	7.36	3	22.08
Filling Water Tanks	5.	1	5.00
Repairs	30.	1	30.00
Moving Jumbo Across Face	27.97	1	27.97
Moving Jumbo In	45.	1	45.00
Total Drilling Time			381.54

Time to drill off this heading round was 6 hours 21.54 minutes.

c. Crosscut Round using 24 holes, 4-inch diameter holes, average depth, 23 1/2 feet.

<u>Element</u>	<u>Mean Elemental Time, (mins)</u>	<u>Occurrence</u>	<u>Total Time, (mins)</u>
Positioning	1.31	24	31.44
Stinging	0.80	24	19.20
Collaring	0.79	24	18.96
Drilling			
E row	4.55	5	22.75
D row	4.22	5	21.10
C row	6.32	5	31.60
B row	2.78	5	13.90
A row	2.89	4	11.56
Retracting (23 1/2 feet)	0.62	24	14.88
Changing Bits	7.36	3	22.08
Repairs	30.	1	30.00
Moving Jumbo Across Face	27.97	1	27.97
Moving Jumbo In	45.	1	45.00
Total Drilling Time			310.44

Time required to drill a crosscut round was 5 hours 10.44 minutes.

4. Remarks on Heading Drilling Time Studies

Positioning elements could be speeded up by employing a greater number of drills on the jumbo each with less flexibility of movement than the one used in the tests.

Stinging was usually a simple matter, but occasionally sloping faces were encountered on which the stinger could not seat rigidly. This was particularly true of the ribholes and less often the cutholes. Stinging times would probably be reduced by having a greater number of drills, each with less flexibility and a more rigid support, in which case stinging would not be quite so time consuming.

Collaring the hole was not usually a problem if the feed was rigid. Drilling times shown in the time studies are not necessarily the optimum. In several of the studies drilling tests were being carried out at less than optimum conditions. Note that in calculating the time to drill a hole from the penetration rate, allowance has been made for the collaring of the hole by subtracting one foot off the length of the hole to be drilled.

Filling the water tanks could be arranged not to interfere with the drilling if the tank were made sufficiently large to hold either 350 gallons (enough for half a round i.e. fourteen 4-inch diameter holes 29 feet deep) or 700 gallons (enough for the entire round). The jumbo moving time would be reduced if a water hose was not required. A further moving time reduction could be gained by having an air compressor on the jumbo, thereby dispensing with the time required to drag air hoses to the jumbo.

B. Time Studies of Drilling Bench Rounds

For a complete description of the drill rig see F. W. Brackebusch's Technical Memorandum No. 67-22.

1. Description of the Elements

a. Drilling

This covers the actual drilling time which was in two parts, owing to the use of a telescoping drill pipe or kelly. The first drilling element covers the top 24 feet of the bench while the second refers to the bottom 11 feet of the bench.

b. Extending the Kelly

When the first 24 feet had been drilled, the kelly bar was telescoped out of the drill rod.

c. Reducing the Kelly

When the hole was completely drilled (35 feet), the drill steel was raised until it could be clamped to the drill jumbo. The kelly was then disengaged from the drill steel and telescoped back into the steel and re-engaged when fully inserted.

d. Retracting

After reducing the kelly the drill steel was completely withdrawn from the hole.

e. Moving

Moving covers the moving of the jumbo from one completed hole to the site of the next hole to be drilled.

2. Elemental Times

Drilling the bench holes was a non-cyclic operation in that there was no limitation to the amount of holes that could be drilled. However, since in the long run the benching could not proceed faster than the headings, for scheduling purposes it is advantageous to consider a benching round advancing as much as a heading round, namely 25 feet. The number of holes required to obtain this advance will depend on the hole spacing and burden. The time to drill one down-hole is as follows:

<u>Element</u>	<u>Mean Elemental Time (mins)</u>	<u>Occurrence</u>	<u>Total Time, (mins)</u>
Moving	4.57	1	4.57
Drilling Top 24 feet	3.40	1	3.40
Extending Kelly	2.08	1	2.08
Drilling Bottom 11 feet	2.40	1	2.40
Reducing Kelly	1.91	1	1.91
Retracting	0.88	1	0.88
		Total Drilling Time	15.24

These studies were incomplete. No times are available on changing drill bits, filling the water tank or on setting up the downhole drilling machine with hoses and electric cables when moving to a new area to drill. For a 12-foot hole spacing the time required to drill 25 feet of bench would be $\frac{60 \times 25}{12 \times 12} \times 15.24$ minutes = 159 minutes and for a 15 foot spacing the time required was 102 minutes. There was insufficient data for the calculation of variances.

C. Time Studies of Bit Sharpening

1. Description of the Elements

a. Installing Bit Into Holder

The grinding machine had a holder for one bit only. The bit was screwed into the holder and the holder was positioned ready to start grinding.

b. Sharpening One Blade

This was the time taken to sharpen one edge of one blade; done by repeated traversing of the blade against the grinding wheel.

c. Changing Blades

The rotary drag bits generally incorporated a 4-blade construction. This element is the time taken to loosen the holder and rotate the bit to the next blade.

d. Changing From Inside to Outside

Each blade of the rotary drag bits had a V-shaped cutting edge. First, all the outside edges of the V were sharpened on each blade; then, the holder was repositioned so as to enable the inside edges of the V to be sharpened. This element is the time taken to reposition the holder.

e. Removing Bit

After all the edges had been sharpened, the bit was removed from the holder.

f. Honing Edges

The sharp edges of the freshly sharpened bit blades were lightly honed on a fine grinding wheel. This was done to prevent premature chipping and dulling of the bit.

g. Dressing Steel Body

In normal usage the bit bodies might become gouged due to inserts chipping or to wrench marks. The final operation in bit sharpening was to remove these defects and also to maintain adequate clearance behind the blade inserts and the reaming inserts.

2. Elemental Times

Gault - 4-inch diameter - 4-blade drag bits.

<u>Element</u>	<u>Mean Elemental Time (mins)</u>	<u>Variance of Sample Occurrence</u>	<u>Total Time (mins)</u>	<u>Total Variance (min)²</u>
Installing Bit in Holder	1.98	0.5949	1	0.5949
Sharpening One Blade	0.66	0.0588	8	0.4704
Changing Blades	0.21	0.0081	6	0.0486
Changing From Outside to Inside	1.80	0.1386	1	0.1386
Removing Bit	0.94	0.2078	1	0.2078
Honing Edges	0.76	0.0235	1	0.0235
Dressing Steel Body	0.72	0.0136	1	0.0136
			<u>12.74</u>	<u>1.4974</u>

Total time to sharpen one bit = 12.74 minutes ± 1.22 minutes. This is shown graphically in Figure 2.

D. Time Studies of Loading Powder into Heading Rounds

1. Description of the Elements

a. Setting up the Loading Equipment

Assuming that the powder had been brought from the magazines by servicemen, then the first job was to position the ANFO loading machine and the aerial platform close to the drilled-off face.

b. Pushing Primer into Hole with Tube

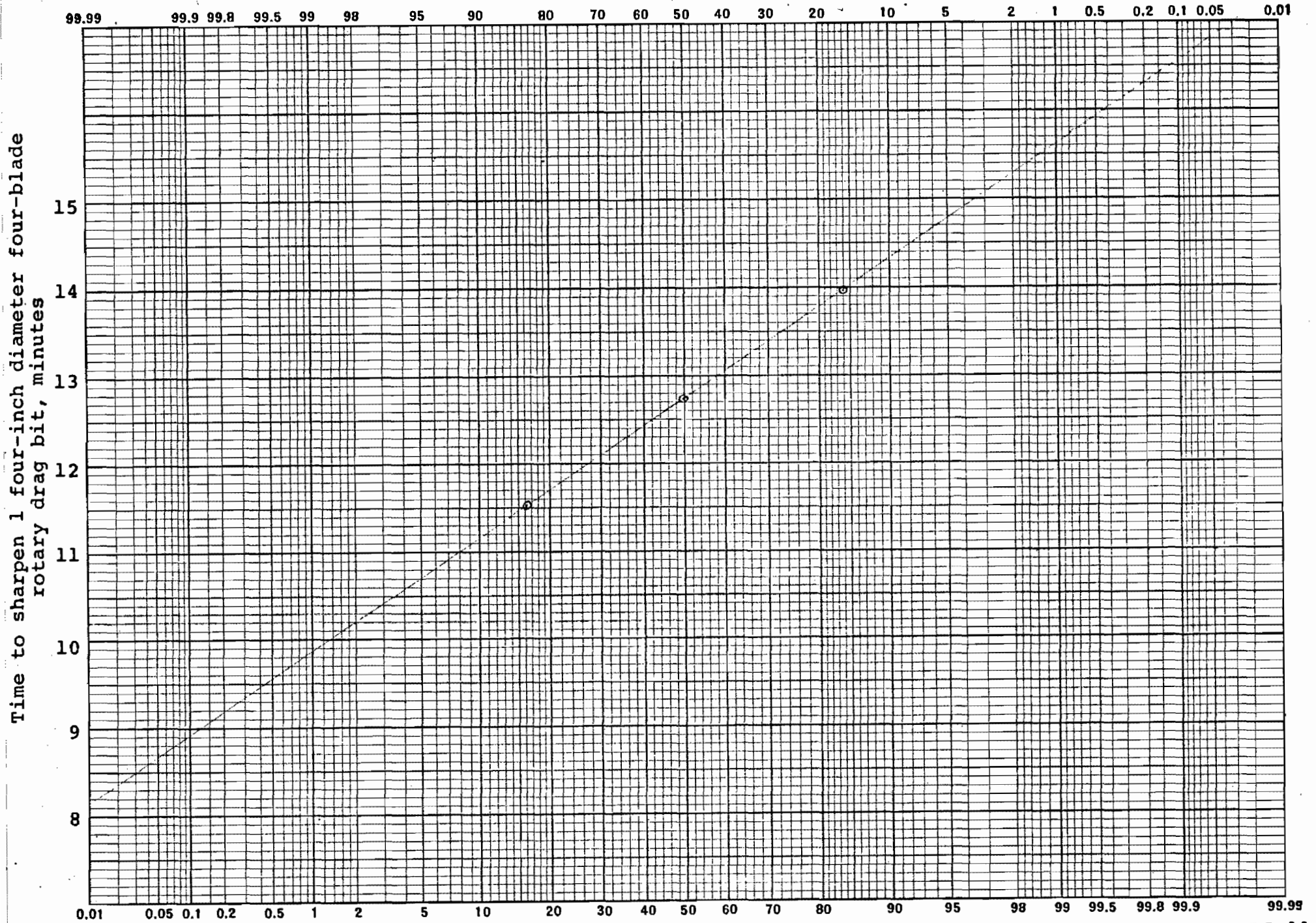
In the heading rounds holes were toe primed. The complete primer was pushed to the back of the hole using the ANFO loading tube.

c. Loading Prill into Hole

Prill ANFO was fed pneumatically from a 500 pound capacity, pressurized container through the loading tube into the blasthole. Flow control was maintained by a valve on the end of the tube operated close to the mouth of the hole being loaded. As ANFO filled the hole the loading tube was slowly withdrawn until the hole was loaded to the correct depth. The valve was then switched off.

FIGURE 2

PREDICTED TIME DISTRIBUTION FOR SHARPENING 1 FOUR-INCH DIAMETER DRAG BIT



d. Retracting the Tube

Since the holes were not loaded to the collar, time was required to pull the remainder of the loading tube from the hole after the cessation of loading.

e. Moving from Hole to Hole

Holes were loaded from the aerial platform. While one man moved the platform from hole to hole, another man on the platform began preparing the next primer.

f. Preparing Primer

A detonator was inserted into a stick of explosive the lead wires were stretched out and tied around the primer.

g. Filling Tank with Prill

The ANFO loading machine held 500 pounds and required filling 4 to 5 times per round. This was done by depressurizing the tank and pouring ANFO from 50-pound bags into the top.

h. Tieing in the Lead Wires or Primer Cord

When all the holes were loaded the detonator lead wires protruding from the holes were connected together in series.

i. Connecting Blasting Wires

When the lead wires were tied together, blasting wires were strung from the face to the end of the main blasting line. Circuits were checked electrically during this procedure and the loading equipment was removed from the area.

2. Elemental Times

Elemental times for a standard-28 hole heading round. Prill loading pressure 40 psi and a powder factor of 0.50 pound ANFO/ton shale.

<u>Element</u>	<u>Mean Elemental Time, (mins)</u>	<u>Variance of Sample</u>	<u>Occurrence</u>	<u>Total Time, (mins)</u>	<u>Total Variance (mins)</u>
Setting Up	45.	100.	1	45.00	100.000
Pushing Primer into Hole	0.78	0.0769	28	21.84	2.153
Loading Hole with Prill	0.60	0.0212	28	16.80	0.594
Retracting Tube	0.34	0.0568	28	9.52	1.590
Moving from Hole to Hole	0.75	0.1142	28	21.00	3.198
Preparing Primer	0.66	0.0275	28	18.48	0.770
Filling Tank with Prill	4.51	0.1682	5	22.55	0.841
Tieing in Lead Wires	18.00	100.	1	18.00	100.000
Connecting Blasting Wires	30.	100.	1	30.00	100.000
				<u>203.19</u>	<u>309.146</u>

Then total time to load ANFO into a standard heading round, and connect up blasting lines was 3 hours 23.19 minutes, with a standard deviation of 17.6 minutes. This is shown graphically in Figure 3.

E. Time Studies of Truck Loading Shot Rock From Heading Rounds

1. Description of the Elements

a. Dump

This was the operation of tipping the loader bucket to discharge rock into the truck.

b. Swing

In the case of the Skooper, this was simply a rotation of the turntable from truck to muckpile or vice-versa. For the front-end loader the swing involved a movement of the whole machine from truck to muckpile or back again.

c. Dig

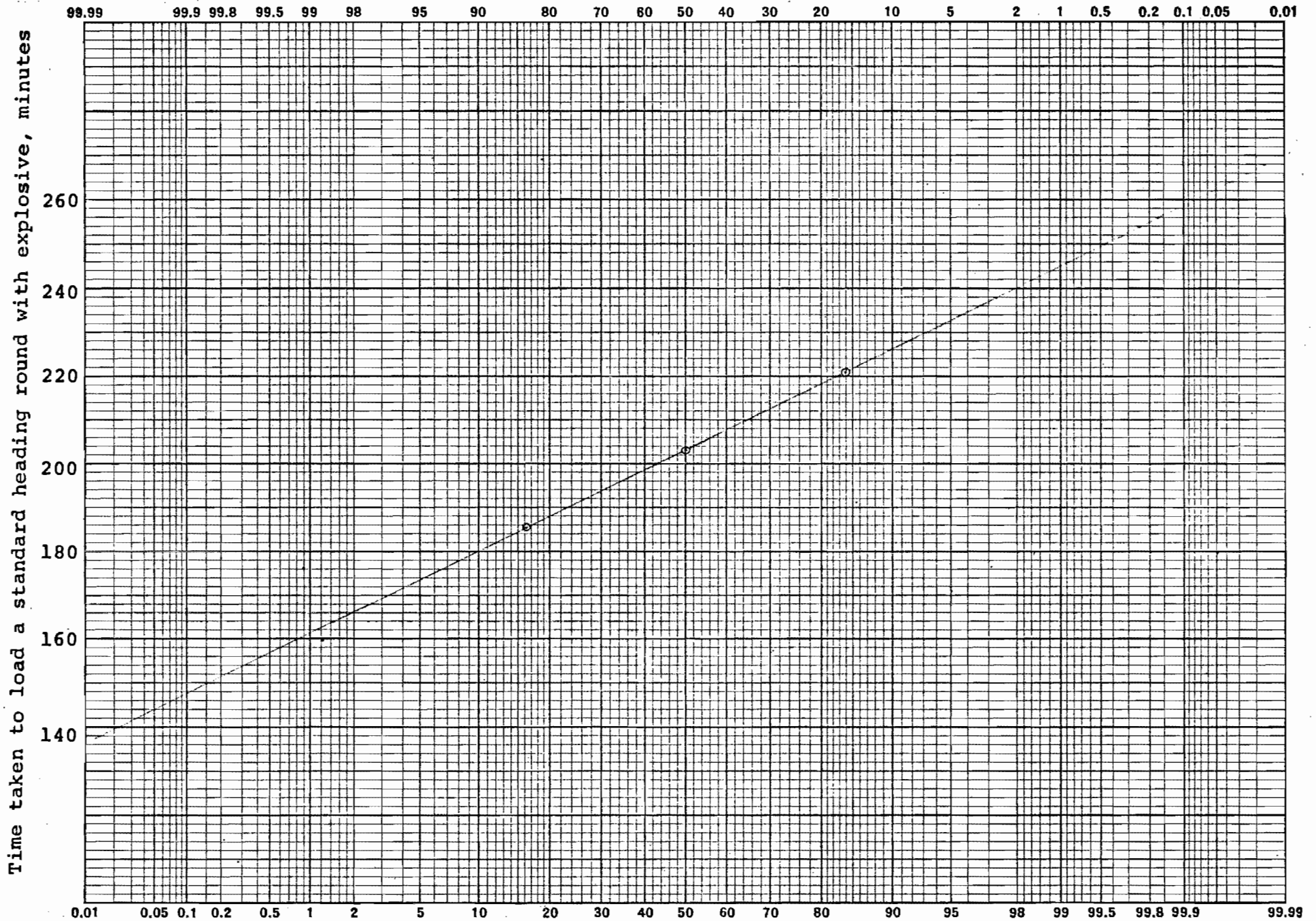
This was the act of filling the bucket by crowding it into the muckpile.

d. Truck Change

This element started when, with a blast on the horn, the loader operator signified that the truck was full. The element finished with another blast on the horn which signified that the next truck, which was empty, was under the loading point. In between, the full truck was busy moving out as

FIGURE 3

PREDICTED TIME DISTRIBUTION FOR POWDERING A STANDARD HEADING ROUND



the empty truck moved in. The loader itself was either engaged in clean-up work at the muckpile or in waiting for the truck to reach the loading point. The act of digging up the first bucket load in readiness for dumping into the empty truck was timed separately. It was extracted from the time between horn blasts to give the truck change element.

2. Elemental Times

a. Skooper With 6.67 Cubic Yard Bucket

- (1) Date - 5/3/67; the muckpile was 60 feet wide and 20 to 25 feet high; fragmentation was average and the truck fill factor was 95% (20-ton Darts).

<u>Element</u>	<u>Mean Elemental Time, (mins)</u>	<u>Variance of Sample</u>	<u>Occurrence</u>	<u>Total Time, (mins)</u>	<u>Total Variance (min)</u>
Dump	0.078	.0020	4.14	0.323	.0083
Swing	0.117	.0038	4.14	0.484	.0157
Dig	0.368	.0245	4.14	1.524	.1014
Swing	0.093	.0009	4.14	0.385	.0037
Truck Change	0.618	.6210	1.00	<u>0.618</u>	<u>.6210</u>
				3.334	.7501

Loading Rate = $\frac{60 \text{ min/hour}}{3.334 \text{ min/truck}} \times 0.95 \text{ Fill Factor} \times 20 \text{ tons/truck} = 342 \text{ tons per hour.}$

To calculate the total time required to load out a standard heading round of 4000 tons, the following formula is used: $T = \frac{4000}{L} \times M$

where, T is the total time
 L is the tons per truck load
 M is the mean loading time per truck

To calculate the variance of T, the variance of L is assumed to be $V_L = 0.25$ tons per truck load.

$$V_T = \left(\frac{4000}{L^2} M \right) V_L + \left(\frac{4000}{L} \right) V_M$$

In the present case, L = 19
 M = 3.334
 V_M = 0.7501

Then, $V_T = 185.6$ minutes
 standard deviation = 13.6 minutes
 $T = 701.89$ minutes

The predicted time distribution is shown in Figure 4.

- (2) Date - 4/13/67; the muckpile was 60 feet wide and 20 to 30 feet high, fragmentation was larger than average, there were some large boulders and the muckpile was tight and hard to dig into. Truck Fill Factor was 90% (20-ton Dart and 40-ton Mack).

<u>Element</u>	<u>Mean Elemental Time, minutes</u>	<u>Occurrence (20-ton Dart)</u>	<u>Total Time, minutes</u>
Dump	0.075	4.21	0.316
Swing	0.141	4.21	0.594
Dig	0.419	4.21	1.764
Swing	0.105	4.21	0.442
Truck Change	0.650	1.00	<u>0.650</u>
			3.766 Minutes

Loading Rate = $\frac{60 \text{ min/hour}}{3.766 \text{ min/truck}} \times 0.90 \text{ Fill Factor} \times 20 \text{ tons/truck} = 287 \text{ tons per hour.}$

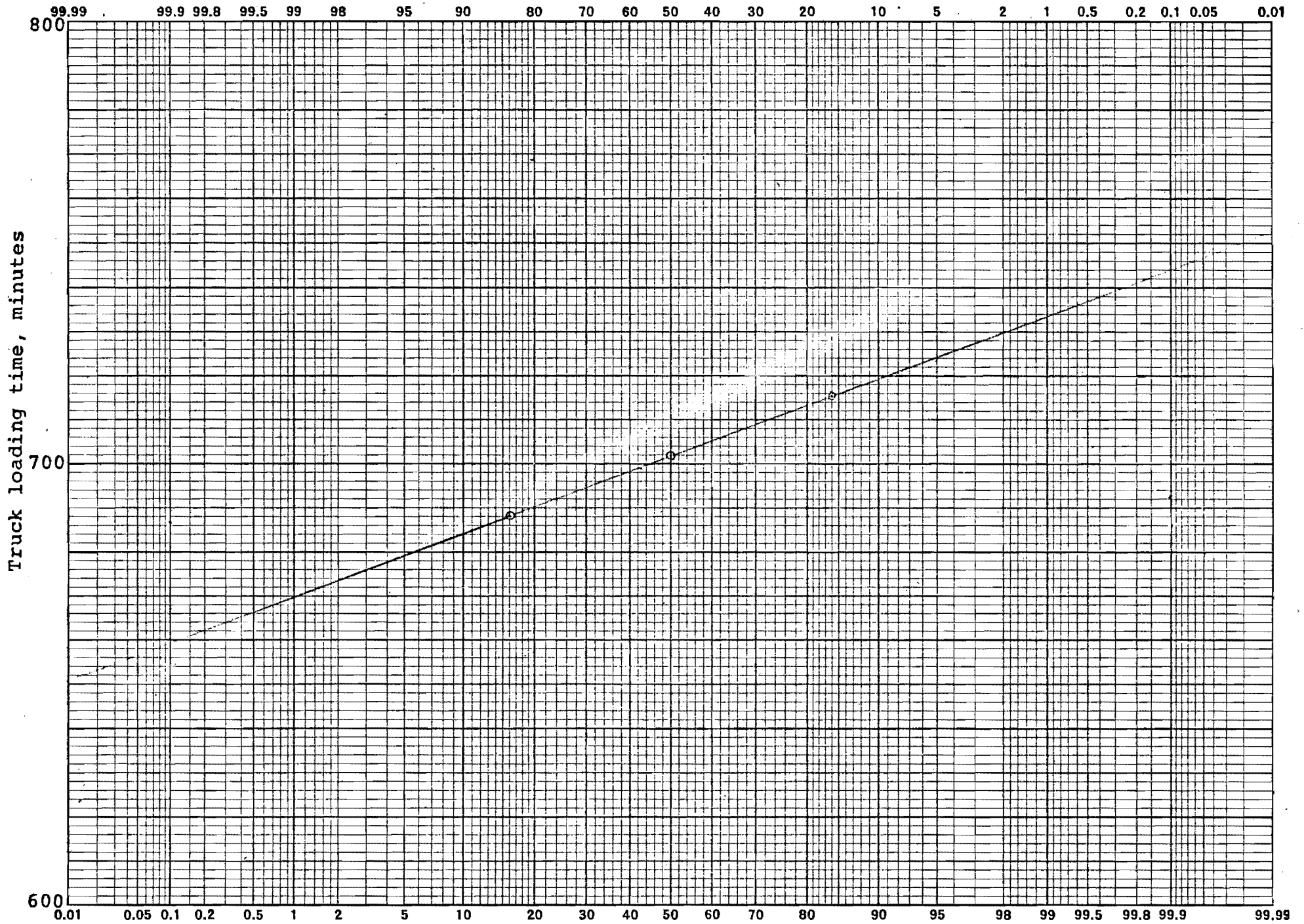
<u>Element</u>	<u>Mean Elemental Time, minutes</u>	<u>Occurrence (40-ton Mack)</u>	<u>Total Time, minutes</u>
Dump	0.075	7.875	0.591
Swing	0.141	7.875	1.110
Dig	0.419	7.875	3.300
Swing	0.105	7.875	0.826
Truck Change	0.650	1.000	<u>0.650</u>
			6.477 Minutes

Loading Rate = $\frac{60 \text{ min/hour}}{6.477 \text{ min/truck}} \times 0.90 \text{ Fill Factor} \times 40 \text{ tons/truck} = 333 \text{ tons per hour.}$

- (3) Date - 6/7/67; muckpile was 60 feet wide and 20 feet high; fragmentation was much finer than average; Truck Fill Factor was 90% (20-ton Darts).

FIG RE 4

PREDICTED TIME DISTRIBUTION FOR LOADING OUT A STANDARD HEADING ROUND OF 4000 TONS



<u>Element</u>	<u>Mean Elemental Time, minutes</u>	<u>Occurrence</u>	<u>Total Time, minutes</u>
Dump	0.06	4	0.24
Swing	0.11	4	0.44
Dig	0.20	4	0.80
Swing	0.10	4	0.40
Truck Change	0.70	1	0.70
Total			2.58 Minutes

Loading Rate = $\frac{60 \text{ min/hour}}{2.58 \text{ min/truck}} \times 0.90 \text{ Fill Factor} \times 20 \text{ tons/truck} = 416 \text{ tons per hour.}$

b. Skooper With 3.65 Cubic Yard Bucket

- (1) Date - 7/18/67; muckpile was 6 to 8 feet high; fragmentation was average; Truck Fill Factor was 90% (20-ton Darts).

<u>Element</u>	<u>Mean Elemental Time, minutes</u>	<u>Occurrence</u>	<u>Total Time, minutes</u>
Dump	0.058	5.87	0.340
Swing	0.079	5.87	0.464
Dig	0.202	5.87	1.186
Swing	0.088	5.87	0.517
Truck Change	0.730	1.00	0.730
Total			3.237 Minutes

Loading Rate = $\frac{60 \text{ min/hour}}{3.237 \text{ min/truck}} \times 0.90 \text{ Fill Factor} \times 20 \text{ tons/truck} = 350 \text{ tons per hour.}$

- (2) Date 8/16/67; muckpile was 10 to 15 feet high and 60 feet wide; fragmentation was slightly finer than average; Truck Fill Factor was 95% (20-ton Dart).

<u>Element</u>	<u>Mean Elemental Time, minutes</u>	<u>Occurrence</u>	<u>Total Time, minutes</u>
Dump	0.053	5.00	0.265
Swing	0.090	5.00	0.450
Dig	0.194	5.00	0.970
Swing	0.097	5.00	0.485
Truck Change	0.949	1.00	0.949
Total			3.119 Minutes

Loading Rate = $\frac{60 \text{ min/hour}}{3.119 \text{ min/truck}}$ X 0.95 Fill Factor X 20 tons/truck = 365 tons per hour.

c. Caterpillar 966B Front-End Loader With 3 Yard Bucket

(1) Muckpile was 60 feet wide and 20 feet high; fragmentation was finer than average; Truck Fill Factor was 95% (20-ton Dart).

<u>Element</u>	<u>Mean Elemental Time, minutes</u>	<u>Occurrence</u>	<u>Total Time, minutes</u>
Dump	0.069	5.77	0.398
Swing	0.136	5.77	0.785
Dig	0.123	5.77	0.710
Swing	0.157	5.77	0.906
Truck Change	(0.618)	1.00	<u>0.618</u>
		Total	3.449 Minutes

Loading Rate = $\frac{60 \text{ min/hour}}{3.449 \text{ min/truck}}$ X 0.95 Fill Factor X 20 tons/truck = 330 tons per hour.

3. Remarks Concerning Time Studies on Loading Shot Rock

Examination of the time studies reveals that the loading rates were significantly affected by the fragmentation. The finer the fragmentation the faster the loading rate. Also the larger the truck being loaded the faster was the loading rate.

Bucket size did not affect the loading rate to any great degree. The smaller the bucket the quicker and easier it was to fill, but the more bucket loads were needed to fill the truck.

Comparison of the Skooper with the Front-End Loader shows only a slightly faster loading rate with the Skooper.

Approximately a half hour is required for wetting down the muckpile at intervals during the loading out of one round.

F. Time Studies of Rockbolting

1. Description of the Elements

a. Drilling

The time taken to drill the roof bolt hole using 1 5/8 inch diameter drill bits and a Gardner-Denver HRR93 rotary-percussion drill, air pressure at drill is 100 psi.

b. Removing the Steel

When the hole was drilled the steel was retracted from the hole and then removed from the drill chuck and placed in the aerial platform.

c. Installing Bolt

The rockbolt socket wrench was placed in the drill chuck then a rockbolt was taken (the shell and plate were put on the bolt while the hole was being drilled) and inserted in the hole. The bolt was inserted completely by feeding the drill machine forward until the rockbolt plate just touched the roof.

d. Tightening the Bolt

The bolt was rotated using the drill until a torque of 200 foot pounds had been applied to the bolt. Bolts used were 6 or 8 feet long, 3/4 inch diameter with forged heads and D5 expansion shells (CF&I).

e. Replacing the Steel

The drill machine was retracted downwards, the rockbolt socket wrench was removed from the machine and the drill steel taken from its clip on the aerial platform and put in the drill machine.

f. Positioning the Drill

The aerial platform was moved to the next hole site. Holes were spaced on a 6 X 6 foot pattern.

2. Elemental Times

<u>Element</u>	<u>Mean Elemental Time, (mins)</u>	<u>Variance of Sample</u>	<u>Occurrence</u>	<u>Total Time, (mins)</u>	<u>Total Variance (min)</u>
Drilling (7 feet)	1.95	0.0306	1	1.95	0.0306
Removing Steel	0.45	0.0050	1	0.45	0.0050
Putting in Bolt	0.55	0.0126	1	0.55	0.0126
Tightening Bolt	0.29	0.1976	1	0.29	0.1976
Replacing Steel	0.36	0.0055	1	0.36	0.0055
Positioning Drill	0.84	0.1587	1	0.84	0.1587
				<u>4.44</u>	<u>0.4100</u>

Time to install one 6-foot bolt = 4.44 minutes.

No allowance has been made for the time required to set up the aerial platform and to fetch bolts and plates nor to move the aerial platform from one side of the face to the other.

The drilling time for an 8-foot bolt is 2.23 minutes (9-foot deep hole) and bolt installation time was 0.68 minutes, for a total time of 4.85 minutes to install an 8-foot bolt.

Some experiments were performed with rotary percussive bits. Drilling times were reduced slightly i.e. for a 6-foot bolt (7-foot hole) the drilling time was 1.62 minutes giving an installation time of 4.11 minutes for a 6-foot bolt. For an 8-foot bolt the installation time was 4.52 minutes. The slight decrease in installation times using the rotary percussive bits was more than offset by poor bit life. Percussive bits were virtually indestructible while inserts would be lost from the rotary percussive bits after only 300 feet of drilling. During the course of the test with rotary percussive bits, the direction of rotation was reversed and the penetration rate was not affected. The fact that the bit drilled at about the same speed independent of the direction of rotation indicated that the drill was not turning fast enough. A tachometer showed that the drill was turning at 180 RPM. Rotation should be above 350 RPM to be effective. The drill had been purposely geared down to enable it to be used for tightening the rockbolts. A better drilling rate would result from having a drill capable of giving high rotational velocities and using a separate motor for torqueing the rockbolts. (See Technical Memorandum No. 66-1.)

3. Time Required to Rockbolt 25 Feet of Heading

Rockbolting must keep pace with the advance of the heading faces. Assuming a 6 X 6 foot bolt spacing is used in a 60-foot wide room, then the time required to bolt, with 6-foot bolts, the roof area exposed by one 25 foot heading round would be

$$\frac{60 \text{ ft} \times 25 \text{ ft}}{6 \text{ ft} \times 6 \text{ ft spacing}} \times 4.44 \text{ min/bolt} = 185 \text{ minutes}$$

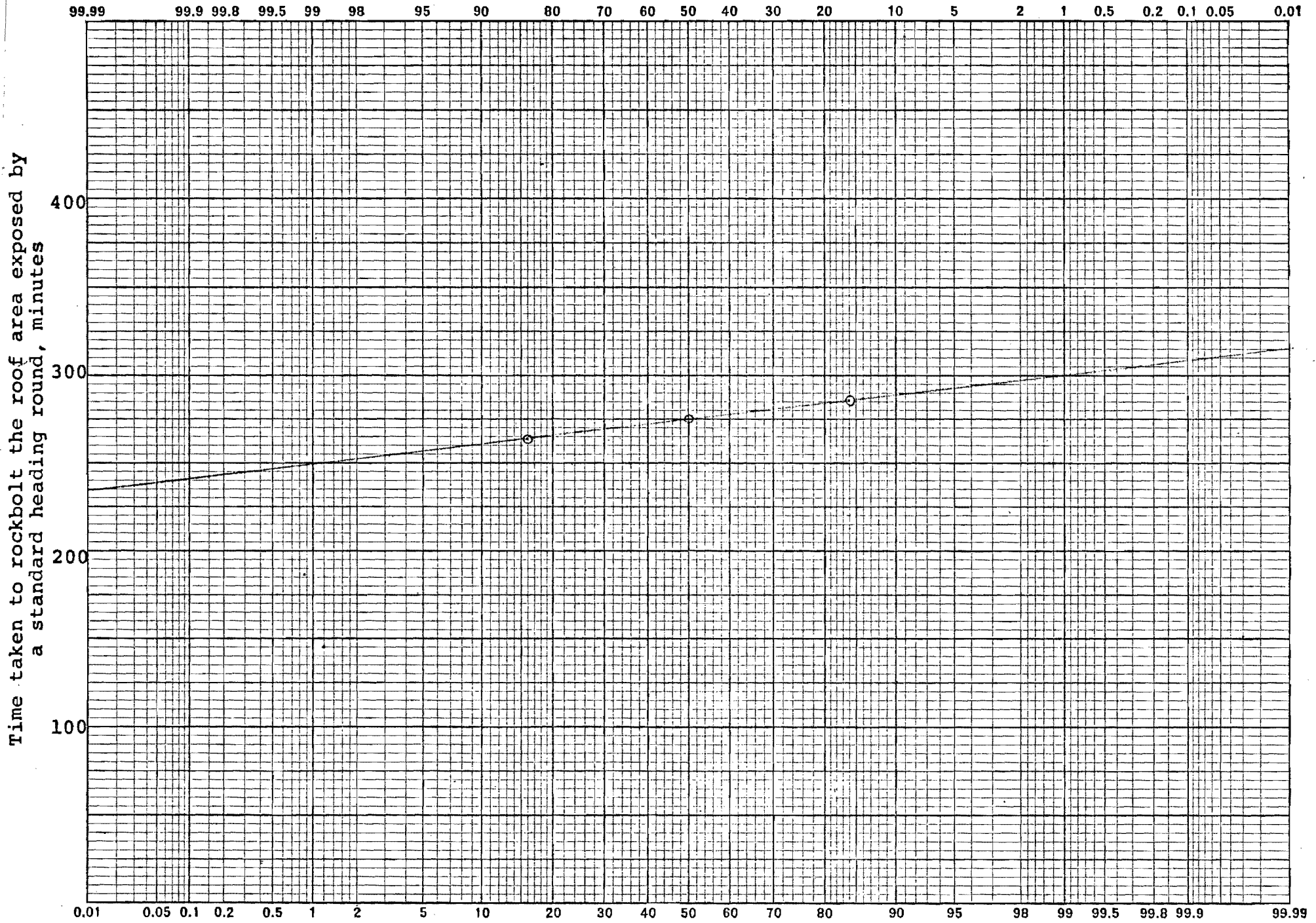
plus an estimated 90 minutes per round for moving the aerial platform from one bolting position to another and setting up i.e., a total of 275 minutes or 4 hours 35 minutes.

Assuming variance on setting up time is 100 minutes, then the variance on the total time

$$\frac{60 \times 25}{6 \times 6} \times 0.41 + 100 = 117.08 \text{ minutes}$$

hence st. dev. = 10.82 minutes. This is shown graphically in Figure 5.

PREDICTED DISTRIBUTION OF THE TIME REQUIRED TO ROCKBOLT AFTER A STANDARD HEADING ROUND



Time taken to rockbolt the roof area exposed by a standard heading round, minutes

Probability that the Rockbolting Time is less than stated

IV. APPENDIX

ACTUAL RECORDED TIMES

1. Heading Drilling

Date	Sting	Collar	Drill		Retract	Move	Change Bits	Remarks
			Row	Depth				
6/14/67	1.68	1.05	4.82	E	29	0.69	1.29	4" Diameter Gault Bits 4 Blade
	0.63	0.43	5.50	E	29	0.65	0.59	
	0.43	0.55	7.95	E	29	0.66	1.71	
	0.55	0.49	5.52	D	29	0.66	0.24	
	0.15	0.40	6.11	D	29	0.64	0.71	
	0.35	1.53	5.25	D	29	0.64		
	0.36	0.24	4.84	C	23	0.39	0.50	
	0.05	0.35	8.74	C	23	0.47		
6/16/67	1.38	0.52	4.92	E	29	0.65	0.85	7.60 7.00 1.30 1.80 4.91
	0.49	0.70	7.65	E	29	0.60	0.60	
	2.62	0.41	6.40	E	29	0.73	1.53	
	0.36	0.52	5.81	D	29	0.66	1.00	
	0.10	0.60	4.42	D	29	0.67	0.85	
	0.15	0.35	4.19	D	29	0.68		
	0.81	0.67	7.75	C	29	0.69	0.30	
	0.28	0.70	17.80	C	29			
	0.31	0.18	9.70	C	29			
	1.25	1.00	4.42	B	29	0.67		
6/20/67								2.60 1.50 2.29 0.86
	0.26	0.17	3.04	D	23	0.65		
	0.15	0.24	5.12	D	25	0.71		
	0.85	0.50	3.17	A	25	0.60		
		0.17	2.65	A	26	0.49		
			6.90	C	24	0.52		
	0.48	0.70						
6/21/67		0.40	5.89	E	29	0.58	2.70	0.80
	0.78	1.14	6.60	E	29	0.58	2.70	
	1.30	0.64	8.16	E	29	0.70	0.71	
	0.91	0.30	8.25	D	29	0.58	1.00	
	0.80	0.30	5.60	D	29	0.60	0.50	
	0.51	0.37	4.82	D	29			
			11.80	C	29	0.59	0.52	
	1.57		13.57	C	29	0.57		
8/16/67	0.07	3.25	9.87	C	22	0.45	0.42	Hughes 4 1/4" bit.
	0.25	0.47	9.85	C	23	0.46	1.35	
	0.34	1.20	9.59	B/C	25	0.48	0.65	
	0.50	0.22	2.33	B	23	0.42	0.49	
	0.09	0.26	2.33	B	24	0.39	0.39	
	0.10	0.36	2.56	B	25	0.43	1.91	
	1.31	0.21	2.17	A/B	23	0.51	0.90	
	0.91	0.31						

Heading Drilling (Continued)

Date	Sting	Collar	Drill		Retract	Move	Change Bits	Remarks	
			Row	Depth					
6/12/67			7.10	C	23	0.50		4" Diameter Gault Bits.	
	1.05	0.75	4.00	B	25	0.50	1.00		
	0.46	0.26	3.10	B	23	0.50	0.31		
	0.50	0.41	2.79	A	23	0.58	1.00		
	1.38	0.62	3.10	A	25	0.61			
		0.40	6.70	E	23	0.50			
	0.70	0.70	9.88	E	23	0.75			
		0.41	6.40	D	26				
		0.21	5.67	D	25	0.65	1.10		
	0.10	0.30	5.59	D	23	0.67			
6/5/67		0.40	9.12	D	29	0.52	0.94		12.05
	0.21	0.48	9.37	C	14	0.25			6.50
	0.40	1.42	4.26	C	15	0.52	0.50		
	0.42	0.33	8.47	C	29	0.58	0.49		
	0.33	0.33	8.82	C	29	0.58	1.30		
	0.09	0.14	2.62	B	29	0.59	0.40		
	0.21	0.20	2.91	B	29	0.57	0.50		
	0.70	0.19	2.47	B	29	0.58	1.65		
	0.25	0.30						2.77	
								Moving jumbo takes 20 minutes.	
6/6/67							1.90		
	0.71	0.41	2.56	E	20	0.48	0.70		
	0.53	0.36	3.02	E	20	0.47	1.64		
	0.18	0.34	5.91	D	14	0.95	1.13		
		0.78						6.00	
		0.27	1.98	D	22	0.58	0.88		
	0.47	0.26	2.42	D	24	0.54	0.40		
	1.28	0.18	2.84	D	28	0.74	0.88		
	0.98	0.49	7.14	C	9	0.28		5.00	
								Repairs took 10 minutes.	
							1.32		
			6.28	C	20	0.60	0.95		
	0.64	0.28	3.54	B	28	0.56			
6/7/67							2.62		
	0.15	0.35	2.87	E	20	0.45	0.85		
	0.88	0.43	4.03	E	20	0.37	2.00		
	0.10	0.10	4.11	D	23	0.59	1.38		
	0.43	0.20	3.70	D	25	0.48			
							4.75		
	0.37	0.27	1.92	E	20	0.45	1.49		
	1.29	0.38	5.07	E	22	0.52	2.79		
	0.09	0.33	4.35	D	23	20.26	1.42	Steel Stuck.	
	0.10	0.22					1.28		
	0.22	0.35	4.05	B	29	0.59	0.98		
	0.64	0.37	4.48	A	20	0.47			

Heading Drilling (Continued)

	Sting	Collar	Drill		Retract	Move	Change Bits	Remarks
			Row	Depth				
6/1/67	0.64				0.70	1.22		4 3/4" Diameter Gault Bit. Repairs 11.82 minutes.
		0.56	4.56	LM	29			
	0.13	1.50	4.48	LM	29	0.72	0.20	
	0.14	0.64	4.12	LM	29	0.65	1.39	
	0.72	0.77	4.89	B	29	0.74		
	0.79	0.34	6.39	B	29	0.56	0.37	
	1.67	1.28	4.35	B	29	0.71	1.08	
						0.68	6.80	Move Jumbo to other side of face 26.80 min.
	2.47	0.93	17.72	T				
	0.76	0.88	6.75	LM		0.28	2.21	Stopped 15.69 minutes to inspect bit.
	0.55	0.67	7.20	LM		0.50	0.76	
	4.30					0.70	1.00	10.29
	1.20	0.93	9.87	T		0.67	2.14	
	0.63	0.56	16.12	UM		0.56	1.75	
						0.73	1.08	Stopped 3.94 minutes to dig out lifters.
	0.64	0.68	4.84	B				
	0.20	0.52	4.60	B		0.67	1.47	
						0.61		
5/5/67								4" Diameter Gault Bits
		0.40	8.15	C	29	0.48	2.25	12.18
	1.14	0.58	6.59	C	29	0.65		
	2.90	1.33	7.34	C	29	0.54	1.30	
	0.77	2.79					2.67	
5/8/67	1.84	1.61	4.98	E	29	0.61	1.34	4" Diameter Gault Bits
	0.87	0.49	4.59	E	29	0.84	2.00	
	0.51	0.55	9.27	E	29	0.64	1.25	
		0.90	8.31	D	29	0.86	3.45	
	2.52	0.76	5.74	D	29	0.73	1.29	
	1.20	2.45	12.98	C	29	0.57		6.11
	1.30	1.27						
	0.46	0.74	3.96	A	29	2.36		
		5.76	3.74	A	29	0.62		Loose rubble at floor. Hard to collar.
	0.16	0.58	4.22	A	29	0.65		
5/12/67			7.50	D	29	0.66		4" Diameter Gault Bits
	0.81	0.71	7.54	D	29	0.58	1.18	7.00
	0.40	0.77	11.36	C	29	0.49	0.80	Filling water tank 18.84 min.
	0.14	0.88					0.29	

Heading Drilling (Continued)

Date	Sting	Collar	Drill		Retract	Move	Change Bits	Remarks	
			Row	Depth					
5/11/67		10.17	10.07	E	29	0.87		4" Diameter Gault Bits. Drill bit sliding on sloping face. Hard to collar.	
	1.71	0.48	12.68	E	29	0.61	1.34	9.29	
	0.58	0.79	6.38	E	29	0.65	3.28		
	6.55	0.71	9.15	D	29	0.93	1.85	7.51	Repairs 24.64 minutes.
	0.35	0.50	5.09	D	29	0.51	1.36		
	0.57	1.17	5.68	D	29	0.70	0.39		
							1.34		
5/15/67						0.74			4" Diameter Gault Bits.
	0.20	0.71	4.81	B	29	0.75	0.32	6.71	
	1.04	1.11	4.17	B	29	0.73	0.23		
	0.01	0.74	3.77	A	29	0.83	1.17		
		1.60	3.75	A	29	0.60	2.13		
	0.19	0.88	2.97	A	29	0.63	5.27		Moving Jumbo to other side of face 37.10 minutes.
	1.33	1.00	6.53	E	29	0.58	2.00		
	1.27	1.24	5.56	E	29	1.40	0.94		
	3.03	2.65	7.30	D	29	0.65	1.98		
	0.73	0.68	9.26	D	29	0.72	0.68		
	0.32	1.04					1.91		

2. Benching Drilling

Moving	4.95	4.20
Drilling top 24 feet	3.19	3.60
Extending Kelly	2.55	1.62
Drilling Bottom 11 feet	2.30	2.50
Reducing Kelly	2.15	1.67
Retracting	0.75	1.00

3. Bit Sharpening4" Gault, 4 Blade

<u>Installation</u>	<u>Sharpen</u>	<u>Change Blades</u>	<u>Change From Out To In</u>	<u>Remove Bit</u>	<u>Hone Edges</u>	<u>Dress Steel Body</u>
0.70	0.90	0.14	2.31	1.20	0.85	0.75
	0.60	0.18				
	0.50	0.25				
	0.80					
	0.50	0.15				
	0.50	0.20				
	0.95	0.25				
	0.35					
2.80	0.40	0.20	2.00	0.30	0.70	0.90
	0.40	0.15				
	0.60	0.15				
	0.70					
	0.70	0.32				
	1.70	0.24				
	0.80	0.30				
	1.05					
2.17	0.55	0.22	1.45	0.08	0.55	0.60
	0.62	0.25				
	0.52	0.25				
	0.62					
	0.52	0.18				
	0.60	0.23				
	0.47	0.25				
	0.43					
2.61	0.71	0.21	1.30	0.57	0.70	0.70
	0.81	0.17				
	0.83	0.16				
	0.61					
	0.72	0.20				
	0.67	0.25				
	0.57	0.15				
	1.40					
2.08	0.60	0.21	1.77	1.38	1.00	
	0.70	0.16				
	0.53	0.16				
	0.59					
	0.64	0.20				
	0.49	0.13				
	0.42	0.66				
	0.55					
1.51	0.74	0.17	1.94			
	0.75	0.22				
	0.78	0.13				
	0.42					
	0.54	0.16				
	0.51	0.17				

4. Powdering Heading Rounds

5/17/67

Air Pressure 40 psi
 Atlas Prill
 2" loading tube
 Primadets

<u>Push Tube In Hole</u>	<u>Load Powder Into Hole</u>	<u>Retract Tube</u>	<u>Move</u>	<u>Prepare Primer</u>	<u>Refill ANFO Tank</u>
0.67	0.64	0.13	0.56	0.44	
0.52	0.75	0.23	0.61	0.78	
0.62	0.70	0.22	0.27	0.88	
1.39	0.65	0.17	0.61	0.68	
0.81	0.34	0.21	0.62	0.63	
0.57	0.74	0.13	1.00		4.80
	0.44	0.59	0.89	0.52	
0.49	0.67	0.35	0.81	0.62	
0.99	0.74	0.42	0.91	0.94	
0.78	0.38	1.05	0.55	0.47	
0.83	0.51	0.31	0.43	0.47	
1.13	0.66	0.34			4.22
			1.63	0.75	
0.95	0.77	0.52	0.89	0.76	
0.35	0.43	0.29			
0.88	0.53	0.18			

Tying in primacord 18.00 minutes.

5. Loading Shot Rocks From Heading Rounds

Date - 5/3/67

Location - Room 4

Width - 60 feet

Height - 20 to 25 feet

Fragmentation - Average

Skooper with 6 1/2 yard bucket

Trucks - Two Darts plus occasional Mack

Observer - J. B. Sellers

Fill Factor - 95%

(1) Indicates Dart truck full.

(2) Indicates Mack truck full.

<u>Dump</u>	<u>Swing</u>	<u>Dig</u>	<u>Swing</u>	<u>Truck Change</u>
	0.17	0.36	0.08	0.18
0.08	0.20	0.36	0.08	
0.08	0.07	0.32	0.10	
0.08	0.06	0.45	0.11	
0.05(1)	0.10	0.29	0.14	0.28
0.09	0.08	0.32	0.11	
0.06	0.08	0.34	0.08	
0.09	0.10	0.17	0.11	
0.08(1)	0.10	0.23	0.14	0.10
0.08	0.08	0.20	0.13	
0.04	0.07	0.20	0.08	
0.07	0.10	0.18	0.09	
0.11(1)	0.16	0.28	0.22	0.15
0.05	0.05	0.30	0.07	
0.07	0.09	0.35	0.08	
0.05	0.08	0.43	0.09	
0.09(1)	0.10	0.30	0.10	2.50
0.05	0.10	0.44	0.07	
0.05	0.06	0.53	0.11	
0.05	0.08	0.49	0.07	
0.11(1)	0.12	0.12	0.09	0.13
0.06	0.12	0.23	0.09	
0.05	0.09	0.16	0.10	
0.07	0.09	0.38	0.11	
0.13(1)	0.16	0.33	0.09	1.61
0.07	0.08	0.57	0.05	
0.05	0.11	0.53	0.09	
0.10	0.09	0.66	0.06	
0.07(1)	0.25	0.50	0.10	
0.06	0.11	0.41	0.06	
0.06	0.11	0.30	0.09	
0.05	0.08	0.35	0.10	
0.07(1)	0.10	0.40	0.10	0.40
0.05	0.07	0.18	0.10	0.09
0.05	0.08	0.53	0.09	
0.06	0.09	0.49	0.11	
0.10(1)	0.17	0.40	0.10	2.13
0.08	0.25	0.35	0.13	
0.04	0.12	0.32	0.12	
0.09	0.46	0.20	0.12	
0.04	0.09	0.62	0.08	
0.08	0.08	0.20	0.08	
0.10	0.09	0.20	0.08	
0.26	0.09	0.76	0.10	
0.33(2)	0.10	0.59	0.05	0.58
0.06	0.07	0.30	0.06	

Loading Shot Rocks From Heading Rounds (Continued)

<u>Dump</u>	<u>Swing</u>	<u>Dig</u>	<u>Swing</u>	<u>Truck Change</u>
0.05	0.12	0.76	0.05	
0.06	0.08	0.64	0.08	
0.10(1)	0.11	0.58	0.07	0.23
0.08	0.10	0.24	0.06	
0.07	0.15	0.30	0.10	
0.08	0.11	0.44	0.05	
0.09	0.13	0.44	0.08	
0.06(1)	0.17	0.40	0.10	0.10
0.07	0.13	0.16	0.10	
0.06	0.08	0.75	0.16	
0.07	0.12	0.22	0.09	
0.11(1)	0.11	0.23	0.10	0.35
0.06	0.09	0.45	0.07	
0.05	0.15	0.23	0.09	
0.05	0.08	0.26	0.07	
0.05(1)	0.27	0.40	0.19	0.44
0.08	0.10	0.17	0.07	
0.04	0.11	0.37	0.08	
0.05	0.12	0.34	0.09	
0.10	0.19	0.30	0.05	
0.15(1)				

Date - April 13, 1967

Location - Room 2

Width of face - 60 feet

Height of Muckpile - 20 to 30 feet

Fragmentation larger than average with large boulders.

This face blasted using Acudets leaving a tight muckpile.

Skooper with 6 1/2 yard bucket.

(1) Indicates Dart full.

(2) Indicates Mack full.

Trucks - Two to three Darts and one Mack

Average fill factor estimated at 90%
of truck capacity.

<u>Dump</u>	<u>Swing</u>	<u>Dig</u>	<u>Swing</u>	<u>Truck Change</u>
				0.47
0.08	0.07	0.24	0.08	
0.05	0.08	0.32	0.06	
0.06	0.10	0.30	0.07	
0.05	0.09	0.27	0.09	
0.06	0.06	0.29	0.08	
0.05	0.07	0.32	0.06	
0.08	0.10	0.22	0.09	
0.08 (2)	0.14	0.30	0.08	1.83
0.06	0.07	0.27	0.05	
0.07	0.11	0.39	0.06	
0.09	0.11	0.30	0.09	
0.06	0.10	0.27	0.08	
0.11 (1)	0.12	0.32	0.10	1.41
0.09	0.12	0.48	0.09	
0.05	0.08	0.24	0.08	
0.08 (1)	0.12	0.42	0.12	0.59
0.06	0.11	0.34	0.12	
0.05	0.20	1.08	0.08	
0.06	0.07	0.30	0.06	
0.05	0.32	0.33	0.11	
0.06	0.09	0.31	0.10	
0.07	0.13	0.14	0.32	
0.06 (2)	0.13			
			0.08	0.97
0.14	0.12	0.24	0.08	
0.06	0.07	0.36	0.09	
0.07	0.12	0.73	0.09	
0.08 (1)				
	0.34	0.15	0.12	2.15
0.12	0.09	0.30	0.07	
0.07	0.10	0.30	0.08	
0.07	0.09	0.22	0.12	
0.08 (1)	0.12	0.31	0.17	2.67
0.07	0.08	0.28	0.10	
0.07	0.07	0.27	0.25	
0.05	0.07	0.22	0.10	
0.09 (1)	0.13	0.70	0.09	0.87
0.06	0.14	0.38	0.14	
0.07	0.13	0.42	0.10	

<u>Dump</u>	<u>Swing</u>	<u>Dig</u>	<u>Swing</u>	<u>Truck Change</u>
0.07	0.13	0.27	0.12	
0.09	0.14	0.27	0.09	
0.14 (1)	0.40			3.93
0.06	0.12	0.33	0.23	
0.06	0.11	0.25	0.16	
0.08	0.11	0.48	0.14	
0.07	0.15	0.22	0.13	
0.08	0.17	0.30	0.17	
0.08	0.17	0.68	0.07	
0.05 (2)	0.18	0.47	0.08	0.21
0.07	0.10	0.25	0.08	
0.06	0.12	0.27	0.07	
0.09	0.20	0.30	0.10	0.73
0.06	0.12	0.35	0.09	
0.07	0.14	0.27	0.06	
0.05	0.11	0.33	0.07	
0.11 (1)	0.17			0.00
		0.24	0.12	
0.07	0.10	0.26	0.10	
0.07	0.17	0.18	0.10	
0.08	0.16	0.26	0.12	
0.11	0.15	0.24	0.10	
0.07 (1)	0.21	0.37	0.23	0.49
0.07	0.15	0.75	0.12	
0.08	0.08	0.97	0.08	
0.07	0.37	1.56	0.08	
0.05	0.09	0.26	0.08	
0.05	0.12	1.05	0.08	
0.07	0.08	0.38	0.08	
0.06	0.15	0.32	0.09	
0.06	0.13	0.27	0.07	
0.06 (2)	0.26	0.75	0.07	0.23
0.07	0.08	0.18	0.05	
0.05	0.11	0.22	0.10	
0.05	0.12	0.22	0.10	
0.06	0.13	0.24	0.07	
0.06 (1)	0.16			
		0.52	0.08	0.32
0.06	0.05	0.44	0.08	
0.05	0.33	0.31	0.10	
0.08	0.10	0.35	0.05	
0.05	0.09	0.46	0.08	
0.10 (1)	0.20	1.85	0.05	0.00
0.04	0.04	0.30	0.07	
0.05	0.08	0.25	0.10	
0.07	0.41	0.25	0.06	
0.06	0.13	0.27	0.07	
0.03 (1)	0.10			
		0.47	0.08	0.34
0.06	0.23	1.13	0.08	
0.06	0.09	0.34	0.10	
0.04	0.10	1.43	0.07	
0.05	0.09	3.70	0.07	
0.05 (1)	0.18			
		0.21	0.08	0.37

Right Muckpile.

<u>Dump</u>	<u>Swing</u>	<u>Dig</u>	<u>Swing</u>	<u>Truck Change</u>
0.04	0.12	0.70	0.07	
0.05	0.16	0.36	0.05	
0.03	0.21	0.65	0.22	
0.85	0.14	0.94	0.07	
				Dump slow because of big boulders.
0.04	0.11	0.41	0.07	
0.07	0.10	0.31	0.30	
0.04	0.10	1.58	0.07	
0.12	0.11	0.42	0.47	
0.08 (2)	0.18	0.87	0.29	0.66
0.07	0.06	0.24	0.11	
0.08	0.09	0.32	0.07	
0.06	0.12	0.25	0.07	
0.07	0.09	0.21	0.06	
0.07 (1)	0.12	0.73		
			0.12	0.18
0.13	0.11	0.32	0.12	
0.07	0.14	0.45	0.07	
0.06	0.09	0.29	0.06	
0.05 (1)	0.08	0.81	0.10	0.25
0.09	0.11	0.29	0.13	
0.06	0.09	0.25	0.09	
0.11 (1)	0.12	0.33	0.08	0.29
0.07	0.09	0.29	0.07	
0.08	0.12	0.32	0.06	
0.05	0.08	0.41	0.16	
0.07	0.31	0.35	0.06	
0.07	0.26	0.29	0.16	
0.14	0.72	0.37	0.07	
0.07	0.10	0.23	0.12	
0.09 (2)	0.09	0.42	0.13	0.54
0.11	0.14	0.33	0.17	
0.06	0.09	0.17	0.09	
0.06	0.09	0.23	0.08	
0.08	0.11	0.53	0.08	
0.09 (1)	0.24	0.19	0.21	0.17
0.06	0.08	0.18	0.09	
0.05	0.10	0.29	0.11	
0.06 (1)	0.12	0.95	0.08	0.00
0.06	0.15	0.18	0.09	
0.06	0.13	0.30	0.09	
0.06	0.10	0.64	0.10	
0.06	0.15	0.26	0.10	
0.05	0.07	0.36	0.04	
0.04	0.12	0.37	0.13	
0.08 (1)	0.57	0.46	0.12	0.00
0.06	0.12	0.25	0.07	
0.06	0.10	0.16	0.15	
0.06	0.10	0.47	0.09	
0.10 (1)				
	0.10	0.52	0.07	0.23
0.07	0.12	0.27	0.13	
0.07	0.14	0.20	0.10	
0.07	0.10	0.22	0.08	
0.10 (1)	0.46	0.63	0.07	0.11

<u>Dump</u>	<u>Swing</u>	<u>Dig</u>	<u>Swing</u>	<u>Truck Change</u>
0.07	0.17	0.19	0.10	
0.08	0.07	0.32	0.08	
0.07	0.20	0.37	0.06	
0.05	0.09	0.58	0.08	
0.08	0.53	0.31	0.15	
0.09	0.12	0.22	0.14	
0.07	0.13	0.21	0.10	
0.09 (2)	0.12	0.66	0.13	0.17
0.05	0.09	0.41	0.21	
0.08	0.13	0.26	0.07	
0.05	0.17	0.26	0.08	
0.05 (1)	0.15			
		0.40	0.08	0.44
0.07	0.11	0.22	0.09	
0.08	0.10	0.15	0.07	
0.05	0.11	0.17	0.11	
0.07 (1)	0.31	0.95	0.18	0.00
0.06	0.14	0.30	0.09	
0.08	0.15	0.23	0.13	
0.10	0.11	0.28	0.13	
0.07 (1)	0.14	0.32	0.14	0.17
0.07	0.11	0.28	0.11	
0.06	0.16	0.20	0.12	
0.06	0.14	0.17	0.17	
0.13 (1)	0.21			

Loading Shot Rock With Skooper and 6 1/2 Yard Bucket

Location - Room 4
 Face Width - 60 feet
 Height of Muckpile - 20 feet
 Fragmentation - Much finer than
 average.

Trucks - Two Darts
 Average fill factor - 90%
 Hauling distance one way - 2500 feet
 Floor very lumpy.
 *Indicates Dart Full.

<u>Date</u>	<u>Dump</u>	<u>Swing</u>	<u>Dig</u>	<u>Swing</u>	<u>Truck Change</u>
6/7/67	0.05	0.11	0.18	0.08	
	0.04	0.12	0.22	0.08	
	0.05	0.12	0.18	0.07	
	0.07*				1.02
	0.05	0.12	0.12	0.15	
	0.04	0.05	0.11	0.10	
	0.14	0.10	0.18	0.09	
	0.09*				0.90
	0.07	0.09	0.26	0.08	
	0.04	0.14	0.22	0.08	
	0.04	0.08	0.27	0.06	
	0.08*				1.02
	0.07	0.09	0.20	0.10	
	0.03	0.29	0.43	0.06	
	0.04	0.11	0.29	0.08	
	0.07*				0.97
	0.07	0.08	0.13	0.13	
	0.04	0.11	0.15	0.08	
	0.04	0.12	0.17	0.08	
	0.07*				1.02
	0.03	0.08	0.21	0.13	
	0.05	0.08	0.32	0.08	
	0.09	0.09	0.15	0.09	
	0.10*				0.98
	0.04	0.12	0.16	0.08	
	0.04	0.11	0.18	0.07	
	0.06	0.10	0.11	0.09	
	0.07*				1.07
	0.04	0.12	0.15	0.12	
	0.04	0.08	0.38	0.10	
	0.06	0.11	0.11	0.10	
	0.06*				0.86
	0.04	0.12	0.20	0.13	
	0.04	0.09	0.17	0.09	
	0.07*				1.13
	0.08	0.09	0.27	0.07	
	0.04	0.09	0.32	0.09	
	0.04	0.09	0.25	0.09	
	0.08*				1.20
	0.04	0.14	0.15	0.09	
0.04	0.08	0.18	0.09		
0.04	0.15	0.12	0.12		
0.05*				1.63	
0.05	0.10	0.13	0.11		
0.05	0.10	0.20	0.10		
0.05	0.13	0.25	0.08		
0.08*				1.38	

Loading Shot Rock With Skooper and 6 1/2 Yard Bucket (Continued)

<u>Date</u>	<u>Dump</u>	<u>Swing</u>	<u>Dig</u>	<u>Swing</u>	<u>Truck Change</u>
6/7/67	0.08	0.13	0.16	0.07	
	0.04	0.09	0.14	0.11	
	0.05	0.14	0.15	0.09	
	0.08*				1.20
	0.06	0.10	0.27	0.09	
	0.04	0.09	0.28	0.13	
	0.04	0.08	0.16	0.09	
	0.04*				1.11
	0.06	0.08	0.48	0.11	
	0.06	0.12	0.14	0.09	
	0.08	0.10	0.10	0.11	
	0.08*				0.96
	0.08	0.14	0.14	0.09	
	0.04	0.11	0.14	0.09	
	0.04	0.11	0.13	0.08	
	0.07*				1.10
	0.08	0.10	0.20	0.07	
	0.07	0.13	0.18	0.10	
	0.04	0.11	0.12	0.11	
	0.09*				1.17
	0.06	0.11	0.13	0.13	
	0.06	0.14	0.20	0.11	
	0.05	0.11	0.14	0.11	
	0.05*				
	0.07	0.12	0.16	0.12	
	0.04	0.10	0.18	0.08	
	0.05	0.15	0.11	0.08	
	0.06*				
	0.06	0.09	0.21	0.09	
	0.05	0.08	0.32	0.08	
	0.04	0.15	0.13	0.13	
	0.06*				1.24
	0.07	0.21	0.25	0.10	
	0.07	0.13	0.23	0.40	
	0.06	0.07	0.18	0.11	
	0.05*				

Time Study Koehring Skooper
3 1/2 Yard Bucket

Date - July 18, 1967
 Location - Room 1
 Face Width - 60 feet
 Height of Muckpile - 6 to 8 feet
 Fragmentation - Good

Trucks - Three Darts (20 Ton)
 Fill Factor - 90%
 *Indicates Dart full.

<u>Dump</u>	<u>Swing</u>	<u>Dig</u>	<u>Swing</u>	<u>Truck Change</u>
				1.05
0.05	0.06	0.18	0.08	
0.05	0.09	0.14	0.11	
0.05	0.10	0.18	0.16	
0.04	0.08	0.14	0.12	
0.06	0.07	0.24	0.07	
0.06*				0.84
0.07	0.07	0.13	0.09	
0.05	0.06	0.11	0.09	
0.04	0.07	0.15	0.08	
0.05	0.06	0.15	0.09	
0.04	0.07	0.24	0.07	
0.07*				(2.28)
0.05	0.08	0.12	0.14	
0.04	0.08	0.12	0.12	
0.04	0.09	0.18	0.12	
0.04	0.10	0.17	0.10	
0.06*				0.60
0.05	0.07	0.24	0.09	
0.04	0.07	0.20	0.08	
0.04	0.13	0.33	0.09	
0.04	0.15	0.29	0.08	
0.04	0.10	0.44	0.09	
0.26*				1.38

Time Study Koehring Skooper
3 1/2 Yard Bucket

<u>Swing Dump</u>	<u>Swing Dump Swing</u>	<u>Dump Swing</u>	<u>Dig</u>	<u>Truck Change</u>
		0.12	0.21	
	0.17		0.18	
	0.15		0.24	
	0.18		0.35	
0.17*	0.39		0.20	
		0.17	0.10	
	0.18		0.22	
	0.16		0.21	
0.16*	0.18		0.18	0.77
		0.13	0.18	
	0.30		0.15	
	0.15		0.19	
	0.24		0.16	
0.16*	0.33		0.48	(---?)
		0.12	0.14	
	0.19		0.40	
	0.20		0.20	
0.14*	0.23		0.15	1.17
		0.12	0.18	
	0.17		0.20	
	0.19		0.14	
0.15*	0.23		0.18	0.73
		0.10	0.09	
	0.23		0.16	
	0.23		0.24	
0.18*	0.20		0.16	1.61
		0.12	0.13	
	0.22		0.19	
	0.21		0.14	
0.15*	0.21		0.31	(6.82)
		0.04	0.14	
	0.24		0.15	
	0.34		0.18	
0.10*	0.23		0.20	2.48
		0.10	0.14	
	0.22		0.25	
	0.23		0.40	
	0.26		0.20	
0.20*	0.44		0.42	0.57
		0.12	0.28	
	0.20		0.24	
	0.18		1.58	

Time Study Koehring Skooper
3 1/2 Yard Bucket (Continued)

<u>Swing Dump</u>	<u>Swing Dump Swing</u>	<u>Dump Swing</u>	<u>Dig</u>	<u>Truck Change</u>
	0.16		0.23	
	0.26		0.21	
0.18*		0.20	0.44	1.59
	0.43		0.42	
	0.21		0.29	
	0.33		0.39	
0.18*		0.14	0.17	0.57
	0.15		0.24	
	0.16		0.21	
	0.16		0.18	
0.15*		0.12	0.21	0.65
	0.21		0.18	
	0.15		0.18	
	0.22		0.20	
	0.25		0.19	
0.20*		0.20	0.28	(4.20)
	0.18		0.17	
	0.17		0.24	
	0.16		0.24	
	0.16		0.18	
0.13*		0.08	0.14	1.00
	0.17		0.15	
	0.16		0.15	
	0.26		0.17	
	0.19		0.18	
	0.21		0.21	
0.17*		0.12	0.16	0.54
	0.21		0.31	
	0.22		0.24	
	0.18		0.24	
	0.26		0.22	
0.18*		0.13	0.17	1.20
	0.16		0.28	
	0.18		0.13	
	0.26		0.24	
	0.15		0.16	
0.24*		0.12	0.23	(----)
	0.17		0.33	
	0.21		0.20	
	0.22		0.17	
	0.23		0.20	
0.21*				0.62

Time Study Koehring Skooper
3 1/2 Yard Bucket (Continued)

<u>Swing Dump</u>	<u>Swing Dump Swing</u>	<u>Dump Swing</u>	<u>Dig</u>	<u>Truck Change</u>
		0.11	0.19	
	0.19		0.22	
	0.21		0.17	
0.16*	0.17		0.19	1.09
		0.11	0.14	
	0.17		0.18	
	0.21		0.23	
	0.22		0.17	
0.21*	0.17		0.11	1.52
		0.10	0.14	
	0.21		0.15	
	0.24		0.10	
	0.20		0.16	
0.24*	0.25		0.14	1.18
		0.11	0.14	
	0.19		0.14	
	0.20		0.16	
	0.21		0.13	
0.19*	0.20		0.15	0.71
		0.11	0.10	
	0.18		0.14	
	0.19		0.18	
	0.22		0.17	
0.19*	0.19		0.15	3.35
		0.08	0.13	
	0.22		0.18	
	0.23		0.15	
0.22*	0.23		0.14	1.11
		0.08	0.14	
	0.20		0.21	
	0.22		0.16	
	0.26		0.18	
0.20*	0.22		0.14	0.82
		0.09	0.38	
	0.22		0.16	
	0.23		0.34	
	0.23		0.44	
0.16*	0.23		0.25	0.73
		0.12	0.13	
	0.19		0.16	
	0.22		0.36	
	0.23		0.14	
	0.24		0.15	

Time Study Koehring Skooper
3 1/2 Yard Bucket (Continued)

<u>Swing Dump</u>	<u>Swing Dump Swing</u>	<u>Dump Swing</u>	<u>Dig</u>	<u>Truck Change</u>
0.24*		0.11	0.11	1.19
	0.23		0.14	
	0.20		0.14	
	0.28		0.18	
	0.24		0.18	
	0.26		0.12	
0.22*		0.09	0.13	0.64
	0.22		0.14	
	0.26		0.13	
	0.26		0.14	
	0.26		0.15	
0.20*		0.09	0.18	0.71
	0.22		0.14	
	0.27		0.15	
	0.22		0.13	
	0.25		0.14	
	0.29		0.14	
0.19*		0.10	0.37	2.68
	0.26		0.18	
	0.27		0.16	
	0.21		0.22	
0.22*		0.10	0.38	1.18
	0.22		0.18	
	0.23		0.44	
	0.20		0.21	
	0.21		0.16	
	0.26		0.20	
0.19*		0.12	0.21	0.73
	0.23		0.17	
	0.26		0.16	
	0.26		0.18	
	0.24		0.24	
0.20*		0.14	0.14	0.71
	0.26		0.16	
	0.28		0.12	
	0.24		0.25	
0.17*		0.11	0.16	1.31
	0.27		0.18	
	0.21		0.19	
	0.26		0.14	
	0.25		0.14	
0.17*		0.10	0.14	0.62

Time Study Koehring Skooper
3 1/2 Yard Bucket (Continued)

<u>Swing Dump</u>	<u>Swing Dump Swing</u>	<u>Dump Swing</u>	<u>Dig</u>	<u>Truck Change</u>
	0.19		0.21	
	0.24		0.21	
	0.20		0.15	
0.16*	0.24		0.14	1.71
		0.12	0.18	
	0.14		0.16	
	0.22		0.19	
	0.25		0.13	
	0.22		0.16	
0.20*	0.27		0.16	1.05
		0.08	0.14	
	0.24		0.15	
	0.20		0.11	
	0.24		0.20	
0.21*	0.26		0.15	0.85
		0.09	0.14	
	0.23		0.24	
	0.25		0.18	
	0.16		0.20	
	0.26		0.14	
0.20*	0.27		0.20	0.74
		0.11	0.22	
	0.21		0.17	
	0.24		0.18	
	0.23		0.17	
0.17*	0.22		0.18	0.61
		0.08	0.20	
	0.18		0.24	
	0.18		0.18	
	0.18		0.16	
	0.28		0.13	
0.18*	0.22		0.30	0.82

Time Study Koehring Skooper
3 1/2 Yard Bucket

Date - August 16, 1967

Location - Room 1

Face Width - 60 feet

Height of Muckpile - 8 to 15 feet

Fragmentation - Slightly finer than average.

Trucks - One Dart, Two Euclids R20's

Observer - J. B. Sellers

Fill Factor - 95%

(1) Indicates Dart full.

(2) Indicates Euclid full.

<u>Dump</u>	<u>Swing</u>	<u>Dig</u>	<u>Swing</u>	<u>Truck Change</u>
0.05	0.09	0.15	0.10	
0.04	0.08	0.17	0.08	
0.04	0.08	0.17	0.08	
0.05	0.11	0.18	0.09	
0.07 (2)				0.90
0.06	0.09	0.21	0.06	
0.06	0.09	0.20	0.09	
0.07	0.15	0.18	0.08	
0.09	0.09	0.18	0.12	
0.08 (1)				2.70
0.06	0.08	0.19	0.11	
0.04	0.07	0.22	0.12	
0.04	0.09	0.17	0.13	
0.05	0.10	0.19	0.07	
0.06 (2)				1.17
0.06	0.07	0.16	0.10	
0.04	0.07	0.20	0.09	
0.04	0.09	0.17	0.12	
0.05	0.09	0.17	0.10	
0.06 (2)				0.72
0.06	0.10	0.19	0.09	
0.04	0.08	0.22	0.13	
0.05	0.10	0.11	0.13	
0.08	0.11	0.14	0.11	
0.05 (1)				1.25
0.07	0.08	0.15	0.13	
0.05	0.08	0.20	0.10	
0.05	0.08	0.27	0.32	
0.10	0.10	0.18	0.11	
0.10 (2)				1.28
0.06	0.07	0.17	0.11	
0.04	0.09	0.17	0.12	
0.04	0.08	0.17	0.11	
0.05	0.10	0.24	0.10	
0.07 (2)				1.08
0.05	0.07	0.16	0.12	
0.05	0.07	0.14	0.10	
0.04	0.08	0.16	0.10	
0.05	0.06	0.16	0.11	
0.05 (1)				1.06
0.04	0.08	0.22	0.08	
0.04	0.06	0.22	0.09	
0.04	0.08	0.18	0.12	
0.09	0.15	0.22	0.11	

Time Study Koehring Skooper
3 1/2 Yard Bucket (Continued)

<u>Dump</u>	<u>Swing</u>	<u>Dig</u>	<u>Swing</u>	<u>Truck Change</u>
0.07 (2)				1.13
0.06	0.09	0.15	0.08	
0.04	0.07	0.22	0.09	
0.04	0.09	0.15	0.08	
0.06	0.07	0.16	0.11	
0.07 (2)				0.89
0.06	0.08	0.18	0.09	
0.04	0.10	0.23	0.07	
0.04	0.09	0.17	0.08	
0.05	0.10	0.17	0.08	
0.06 (1)				1.24
0.06	0.07	0.19	0.07	
0.04	0.07	0.20	0.08	
0.04	0.09	0.15	0.11	
0.05	0.13	0.17	0.09	
0.05 (2)				1.07
0.06	0.07	0.17	0.10	
0.04	0.07	0.25	0.08	
0.04	0.10	0.17	0.07	
0.04	0.11	0.13	0.10	
0.07 (2)				1.07
0.05	0.08	0.28	0.07	
0.04	0.08	0.22	0.09	
0.04	0.09	0.17	0.10	
0.04	0.09	0.17	0.08	
0.07 (1)				1.32
0.05	0.09	0.13	0.09	
0.04	0.07	0.16	0.07	
0.05	0.09	0.14	0.09	
0.05	0.11	0.23	0.09	
0.09 (2)				1.99
0.06	0.09	0.16	0.11	
0.04	0.09	0.22	0.08	
0.04	0.10	0.21	0.12	
0.04	0.10	0.18	0.11	
0.04	0.09	0.22	0.10	
0.05	0.09	0.17	0.09	
0.05Mack				1.12
0.04	0.10	0.14	0.10	
0.04	0.06	0.19	0.17	
0.04	0.07	0.39	0.09	
0.04	0.08	0.32	0.09	
0.05 (2)				1.53
0.05	0.30	0.16	0.09	
0.04	0.08	0.37	0.08	
0.04	0.09	0.24	0.09	
0.04	0.09	0.18	0.10	
0.08 (2)				
0.06	0.09	0.32	0.08	
0.04	0.05	0.22	0.08	
0.04	0.09	0.18	0.08	
0.04	0.08	0.20	0.08	
0.04 (1)				

Time Study Koehring Skooper
3 1/2 Yard Bucket (Continued)

<u>Dump</u>	<u>Swing</u>	<u>Dig</u>	<u>Swing</u>	<u>Truck Change</u>
				0.96
0.06	0.08	0.18	0.08	
0.04	0.08	0.28	0.09	
0.04	0.08	0.20	0.07	
0.04 (2)				5.27
0.06	0.11	0.25	0.10	
0.04	0.09	0.21	0.08	
0.04	0.09	0.17	0.09	
0.06	0.09	0.24	0.12	
0.07 (1)				0.88
0.07	0.08	0.19	0.10	
0.06	0.07	0.22	0.08	
0.05	0.11	0.16	0.12	
0.06	0.11	0.20	0.10	
0.10 (2)				

Loading With 3 Yard Loader

Trucks - Two Darts

Average fill factor - 95%

Location - Room 3

Width - 60 feet

Fragmentation - Slightly finer than average.

Height of Muckpile - 20 feet

*Indicates Dart full.

<u>Dump</u>	<u>Swing</u>	<u>Dig</u>	<u>Swing</u>	<u>Truck Change</u>
0.08	0.10	0.13	0.10	
0.07	0.09	0.12	0.07	
0.05	0.08	0.10	0.13	
0.06	0.08	0.15	0.13	
0.07	0.14	0.09	0.09	
0.07	0.14	0.09	0.15	
0.10*	0.17	0.10	0.18	
				6.00
0.07	0.17	0.10	0.05	
0.05	0.07	0.12	0.12	
0.06	0.13	0.09	0.13	
0.07	0.13	0.10	0.15	
0.10*	0.13	0.12	0.17	
0.04	0.13	0.09	0.10	0.47
0.04	0.10	0.08	0.15	
0.06	0.09	0.12	0.14	
0.08	0.11	0.14	0.15	
0.07	0.13	0.11	0.16	
0.10*	0.16	0.10	0.15	
				5.30
0.06	0.09	0.07	0.11	
0.05	0.13	0.08	0.13	
0.05	0.11	0.07	0.13	
0.11	0.09	0.09	0.15	
0.08*	0.13	0.20	0.13	
0.08	0.10	0.07	0.14	0.93
0.06	0.11	0.08	0.16	
0.06	0.11	0.12	0.17	
0.06	0.12	0.12	0.16	
0.08*	0.12	0.09	0.15	
0.10*	0.15	0.18	0.15	
				3.93
0.05	0.13	0.06	0.09	
0.06	0.09	0.19	0.13	
0.05	0.14	0.19	0.14	
0.05	0.13	0.15	0.15	
0.05	0.12	0.07	0.14	
0.11*	0.20	0.10	0.15	
				3.35
0.04	0.10	0.13	0.14	
0.06	0.12	0.07	0.14	
0.06	0.12	0.14	0.16	
0.05	0.11	0.14	0.14	
0.05	0.10	0.14	0.16	
0.13*	0.19	0.15	0.15	
				2.14
0.05	0.11	0.06	0.15	
0.06	0.14	0.06	0.15	

Loading With 3 Yard Loader (Continued)

<u>Dump</u>	<u>Swing</u>	<u>Dig</u>	<u>Swing</u>	<u>Truck Change</u>
0.06	0.11	0.12	0.18	
0.07	0.22	0.04	0.13	
0.07	0.12	0.20	0.13	
0.08*	0.23	0.15	0.15	1.08
0.05	0.10	0.12	0.17	
0.05	0.12	0.15	0.14	
0.04	0.12	0.09	0.15	
0.04	0.13	0.13	0.18	
0.06	0.13	0.16	0.14	
0.13*	0.21	0.15	0.15	3.59
0.05	0.10	0.09	0.14	
0.05	0.11	0.11	0.14	
0.06	0.10	0.13	0.14	
0.04	0.12	0.12	0.15	
0.05	0.15	0.11	0.17	
0.10*	0.20	0.14	0.18	0.26
0.06	0.13	0.15	0.12	
0.05	0.17	0.08	0.16	
0.04	0.12	0.14	0.14	
0.04	0.14	0.11	0.14	
0.07*	0.14	0.13	0.18	
0.10*	0.21	0.21	0.28	3.91
0.13	0.21	0.12	0.25	
0.05	0.18	0.24	0.23	
0.09	0.18	0.11	0.23	
0.08	0.18	0.17	0.20	
0.10	0.15	0.18	0.24	
0.13*	0.23	0.13	0.30	
				0.14
0.06	0.16	0.15	0.27	
0.08	0.17	0.12	0.22	
0.08	0.16	0.21	0.27	
0.08	0.18	0.22	0.24	
0.11*				

Rockbolting

HRR 93 rotary percussive drill
 1 5/8" holes with regular
 Air pressure 110 psi while drilling cross bits
 6 foot bolts
 DS shells (holes drilled 8 feet deep)
 Poor operator technique
 Drill not operated at maximum thrust

<u>Drill</u>	<u>Remove Steel</u>	<u>Put In Bolt</u>	<u>Tighten Bolt</u>	<u>Replace Steel</u>	<u>Move</u>	
	0.32	0.79	0.18	0.35	2.15	
3.09	0.48	0.58	0.22	0.33	0.96	
3.71	0.38	0.50	0.18	0.32	0.67	
3.90	0.52	0.40	0.18	0.30	0.94	
4.18	0.49	0.54	0.16	0.32	1.73	
3.93	0.52	0.54	0.21	0.39	1.10	
3.72	0.58	0.60	0.18	0.37	1.72	
3.84	0.44	0.50	0.18	0.46	0.78	
3.84	0.42	0.50	0.16	0.31	0.74	
3.98	0.39	0.48	0.22	0.29	1.17	
3.84	0.45	0.46	0.60	0.40	2.32	
4.47	0.50	0.55	0.71	0.36	0.66	
3.65	0.45	0.61	0.20	0.35		
2.52	0.54	0.58	0.29	0.43	0.81	
2.62	0.44	0.62	0.29	0.35	0.80	
2.80	0.40	0.69	0.28	0.35	0.89	
3.55	0.51	0.53	0.27	0.33	0.88	6 foot bolts
2.89	0.51	0.56	0.19	0.37	0.78	
2.46	0.49	0.61	0.28	0.36	1.12	
2.38	0.58	0.73	0.19	0.45	1.24	
2.46	0.36	0.75	0.24	0.25	1.48	
2.47	0.42	0.54	0.21	0.36	0.64	
2.38	0.42	0.55	0.21	0.35	0.50	
2.45	0.45	0.64	9.21	0.30	0.96	
2.31	0.38	0.55	0.29	0.34	0.74	
2.47	0.43	0.89	0.22	0.38	0.92	
2.37	0.37	0.62	0.20	0.33	0.82	
2.31	0.48	0.72	3.66	0.35	0.65	
2.34	0.36	0.62	0.17	0.34	0.53	
2.44	0.37	0.87	0.21	0.47		
2.20	0.48	0.55	0.32	0.82	0.63	Percussive Bits
2.35	0.56	0.49	0.17	0.34	0.60	
1.98	0.54	0.63	0.16	0.77	0.52	
1.96	0.54	0.56	0.26	0.95	0.39	
1.86	0.47	0.67	0.14	0.81	0.36	
1.94	0.41	0.68	0.29	0.88	0.47	
1.92	0.46	0.65	0.17	0.59	0.30	
1.87	0.58	0.47	0.15	0.79		
1.87	0.46	0.58	0.15	0.73	0.38	
1.75	0.40	0.58	0.20			
				0.64	0.47	
2.19	0.55	0.71	0.22	0.63	0.33	
2.17	0.48	0.68	0.48	0.51	0.32	8 foot bolts
2.17	0.41	0.64	0.18	0.30	0.33	

Rockbolting (Continued)

<u>Drill</u>	<u>Remove Steel</u>	<u>Put In Bolt</u>	<u>Tighten Bolt</u>	<u>Replace Steel</u>	<u>Move</u>	
2.26	0.48	0.68	0.19	0.62	0.37	
2.30	0.41	0.66	0.09	0.79	0.27	
2.17	0.44	0.66	0.16	0.48	0.24	
2.24	0.45	0.69	0.30	0.37	0.23	8 foot bolts
2.32	0.45	0.71	0.23	0.52	0.24	
2.26	0.48	0.67	0.17	1.83	0.33	
2.26	0.46	0.67	0.27			
1.94	0.67	0.49	0.23	0.39	1.16	
1.78	0.32	0.44	1.59	0.24	0.63	
1.55	0.41	0.42	0.18	0.32	0.66	
1.73	0.41	0.47	0.16	0.31	0.33	
1.69	0.39	0.38	0.22	0.45	0.79	Rotary Percussive Bit Backwards.
1.77	0.54	0.42	0.17	0.30	0.67	
1.61	0.38	0.47	0.17	0.32	0.58	
1.69	0.48	0.46	0.17	0.32	0.82	
1.65	0.39	0.50	0.20	0.30	0.55	
1.87	0.38	0.44	0.20	0.30	0.77	
1.50	0.39	0.42	0.17	0.32		
1.61	0.39	0.50	0.14	0.31	0.39	
1.62	0.38	0.42	0.18	0.38	0.62	Rotary Percussive Bit In Right Direction.
1.64	0.35	0.52	0.17	0.33	0.58	
1.60	0.54	0.45	0.17	0.29		
1.56	0.47	0.48	0.18	0.30	0.90	
1.58	0.34	0.48	0.18	0.33	0.97	Rotary Percussive Bit Backwards.
1.65	0.48	0.37	0.22	0.27		
1.81	0.42	0.52	0.23	0.30	0.94	
1.83	0.42	0.46	0.17	0.35	0.57	
2.25	0.34	0.47	0.15	0.35	0.88	Percussive Bit.
1.90	0.41	0.43	0.14	0.35	0.58	
1.82						