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INTERNAL REPORT

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CHARACTERIZATION OF AIRBORNE DUST IN A BELT CONVEYOR DRIFT

by

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ABSTRACT

This study was undertaken in a belt conveyor drift of an underground hard rock mine. The conveyor transported ore or waste from a crushing operation located upwind from the drift sampling locations. A 250 m section of this drift was selected and several types of measurements were taken. Average respirable concentrations in the drift were 0.43 mg/m^3 and 0.19 mg/m^3 for total and silica dust, respectively. From the respirable dust concentration profile along the drift it may be possible to estimate the contribution from extended sources such as dust produced by the belt and return idlers.

The airborne dust in the drift had an average mass-median aerodynamic diameter of 4.2 μm. A continuous dust monitor showed that the crushing operation produced fairly high dust concentrations (sometimes greater than 4 mg/m^3) over short periods of time.

Key words: Dust measurement; Mine environment.

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CARACTÉRISATION DE LA POUSSIÈRE AÉROPORTÉE DANS UNE GALERIE OÙ UN TRANSPORTEUR À COURROIE EST EN SERVICE

par

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RÉSUMÉ

L'étude dont il est question dans ce rapport a été effectuée dans la galerie d'une mine souterraine de roche dure où un transporteur à courroie est en service. Le transporteur transporte du minerai ou des déchets depuis un site de broyage situé en amont des sites d'échantillonnage de la galerie. On a sélectionné une section de la galerie d'une longueur de 250 m, en vue d'y prendre des mesures diverses. Les concentrations moyennes de poussière inhalable dans la galerie étaient de 0,43 mg/m^3 et de 0,19 mg/m^3 pour ce qui est de la poussière totale et de la poussière de silice, respectivement. En étudiant le profil des concentrations de poussière inhalable le long de la galerie, il sera peut-être possible d'évaluer la quantité de poussière provenant de sources connexes, tels les guides de courroie et de marche arrière du transporteur.

La diamètre aérodynamique moyen de la masse de poussière qui se trouve dans la galerie est de 4,2 µm. Un dispositif utilisé pour le contrôle continu de la poussière indique que l'installation de broyage produit des concentrations de poussière passablement élevées (parfois supérieures à 4 mg/m^3), dans de très courts délais.

Mots-clé : Mesure de la poussière; Environnement minier.

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INTRODUCTION

Airborne dust in the respirable range is known to be the cause of the various forms of lung ailments. In underground mines, respirable dust sources are created at many stages of production. All mining operators are responsible for designing and establishing means of reducing airborne dust. In some cases, sources of dust are well defined and suppression methods are standard.

In the location studied the airborne dust cloud was formed from the contribution from many sources which may be either discrete or extended. At the experimental site, the discrete or point sources were the crushing operation and the belt conveyor transfer point (tail pulley). These sources may be controlled by proper dust capture and scrubbing systems as well as dilution by ventilation. Examples of extended dust sources in the area include dust produced by the re-entrainment of settled particles along the drift. Ventilation air movement and vehicle movement both contribute to this phenomenon. Dust produced by the conveyor is another example of an extended dust source. Caked deposits on the return strand and idlers as well as the transportation of dry material on the belt can be major contributors. Proper wetting of roadways and muck as well as proper belt cleaning techniques can help reduce these emissions. The belt cleaning apparatus at the experimental site is shown in Figure 1. These and other belt cleaning techniques are described in more detail elsewhere (1,2).

Work conducted in the course of this study was aimed at characterizing the dust cloud along a belt conveyor drift downstream from a crushing operation in a hard rock mine. An attempt was made to discriminate between the various dust sources found in the area.

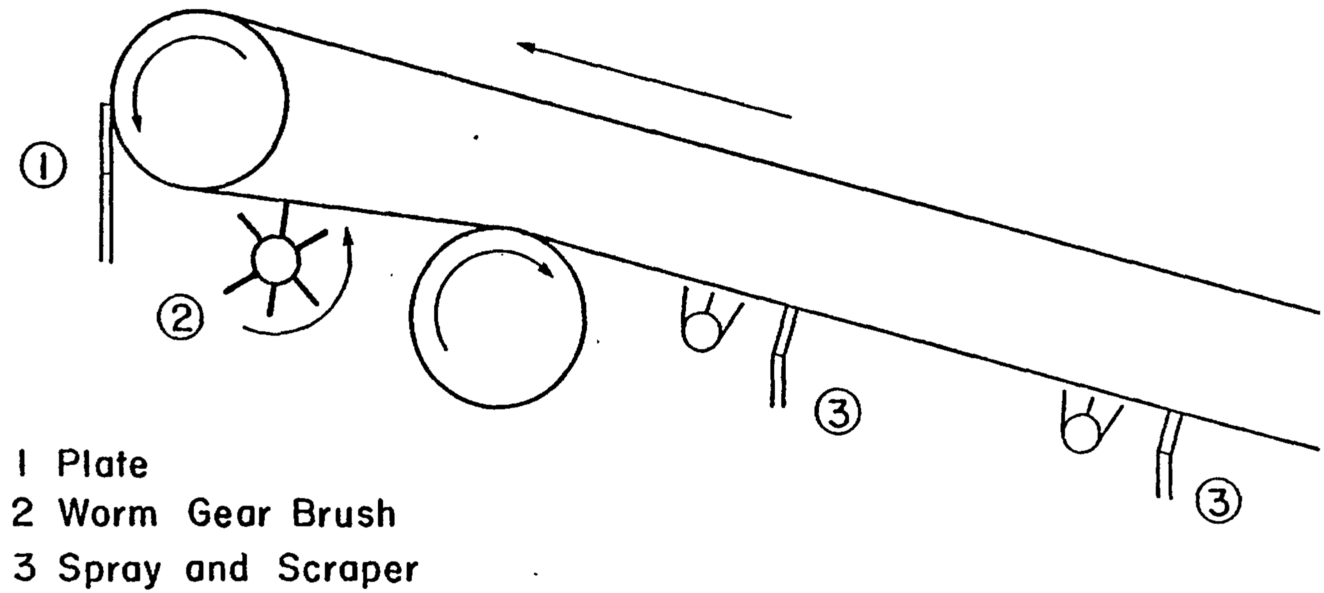


Fig. 1 - Belt cleaning devices used on the conveyor.

SITE DESCRIPTION, INSTRUMENTS AND PROCEDURES.

Figure 2 is a plan view of the area studied. The portion of the drift investigated had a cross-section of approximately 15 m^2 at an 11.3 degree incline starting from the tail pulley. The tail pulley was located approximately 7 m from the end of the drift where a manway allowed access up to the crusher area. Return air from the crushing operation also entered the conveyor drift by this route. The belt was used to transport ore or waste crushed above. Four sampling stations, located at 37 m, 116 m, 203 m and 238 m from the tail pulley, were designated STN1 to STN4, respectively. Air flow of approximately 7.0 m^3/s was measured in the drift. The direction of flow is indicated in Figure 2.

Time-weighted average (TWA) total and silica respirable dust were measured with CAMPEDS (3) personal dust samplers. Real-time determination of respirable airborne dust was performed with continuous dust monitors. The GCA Miniram PDM-3 personal dust monitor and the Metrex diesel/mineral dust sensor were used to correlate any sudden changes in dust concentration with changes in mining activity in the area.

The size distribution of airborne dust was measured with two Sierra model 210-K cascade impactors. Size distribution characteristics of airborne dust were measured on a daily basis at various locations along the drift. Other variables of interest monitored included daily ore or waste tonnage transported by the belt and daily crushing time during sampling. On average, tests were conducted over a 5 hour period on a daily basis.

RESULTS

SIZE DISTRIBUTION

The size distribution of dust was measured at different locations along

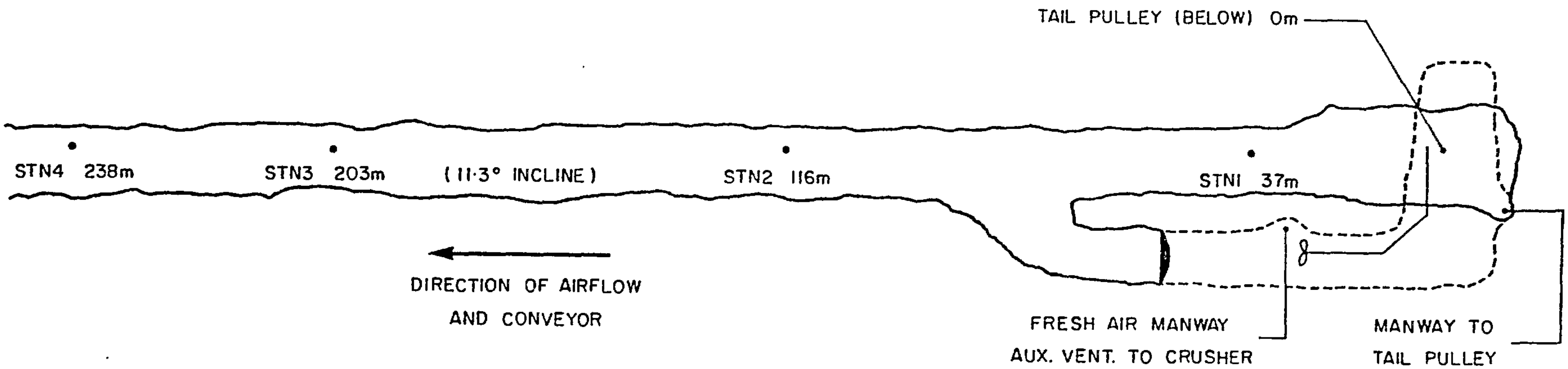


Fig. 2 - Plan of the mine section studied. Shown are the sampling station locations and the direction of airflow. The portion shown in dotted line is the crusher area located above the tail pulley.

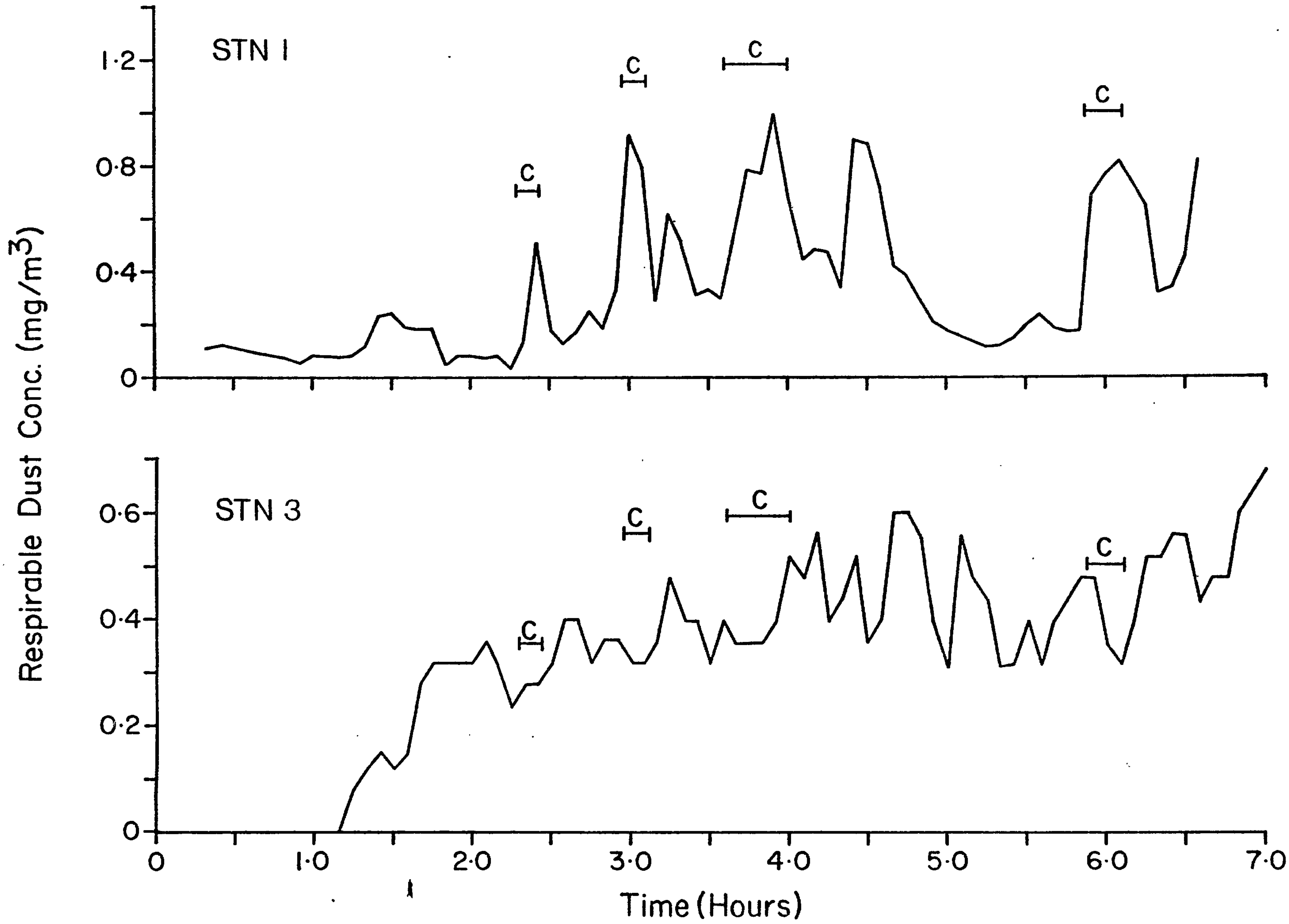
the drift. Results from four days of measurements showed only marginal differences as a function of distance from the tail pulley, therefore an average value was calculated as representative of the dust profile in the area.

The average mass-median aerodynamic diameter (MMAD) was 4.2 μm. This means that 50% of the airborne dust mass is associated with particles having an aerodynamic diameter of 4.2 μm or less. The geometric standard deviation (GSD) was 2.8. This is a measure of the degree of spread in dust particle size about the MMAD value. A value of 1.0 for the GSD would indicate a monodispersed cloud in which all particles were 4.2 μm in size. In most underground mine settings, the MMAD value may vary depending on the proximity to crushing or rock breaking operations and values of GSD will typically be larger than 2.0 (4).

CONTINUOUS RESPIRABLE DUST MONITORING

Respirable dust was measured in a continuous fashion, at STN1 and STN3. One set of these data is shown in Figure 3. On these graphs, the intervals of crusher operation were superimposed in order to show their effect on airborne dust concentration. Results from STN1 (closer to the crusher) show that the concentration varied greatly with time. In most instances, peak dust concentrations corresponded to periods when the crusher was operated. These results show that a better dust capture system at the crusher would not only improve air quality in the crushing plant, but would also reduce airborne dust down the ventilation network.

Dust profiles measured at STN3 (170 m down from STN1) show that the peaks corresponding to crushing intervals were not as well defined as they were when measured closer to the crusher. This was expected, since dust peaks are being diluted and dispersed by turbulent airflow between STN1 and STN3. Some peaks, however, are visible and by comparing both graphs in Figure 3 it is


STN 1
STN 3
C
Respirable Dust Conc. (mg/m3)
1·2
0·8
0·4
0
0·6
0·4
0·2
0
0
1·0
2·0
3·0
4·0
5·0
6·0
7·0
Time (Hours)

possible to observe a lag of about 15 min between peaks originating from the same crushing interval. This gives a good estimate of the air residence time between these stations.

TIME-WEIGHTED AVERAGE (TWA) RESPIRABLE DUST CONCENTRATION

Data from personal dust samplers revealed that silica formed 44% of the airborne respirable dust mass. The mineral matrix for mines in this region contains about 65% quartz. Previous work performed in these mines show that respirable silica should account for approximately 50% of airborne respirable dust, close to crushing operations (5). The lower percentage measured here may be caused by a proportionally higher sedimentation rate for silica dust. Previous work (6) has shown that the silica portion of airborne dust is formed of larger individual particles, and hence is likely to settle more rapidly. It is possible, also, that non-mineral dust (oil mists and diesel soot) accounted for some of the mass of airborne respirable dust collected by samplers. This has been observed before (7), and it has been shown to reduce the percentage of airborne silica observed.

A typical graph of TWA total (top curve), and silica (bottom curve) dust concentration as a function of distance from the tail pulley is shown in Figure 4. This graph shows a 28.3% decrease in the collected mass of total respirable dust over a 201 m distance. This decrease is caused by a number of factors, the most important of which was leakage of fresh air at the ventilation door located at the crusher access cross-cut. Air flow measurements made in the main drift before and after the cross-cut showed that this factor alone could account for a 20 to 25% decrease in respirable dust concentration between stations 1 and 2.

The remainder of the decrease is mostly attributable to sedimentation, which, according to Fuch's work on theoretical deposition of particles under the action of gravity, could account for a 4.5% decrease over the 201 m

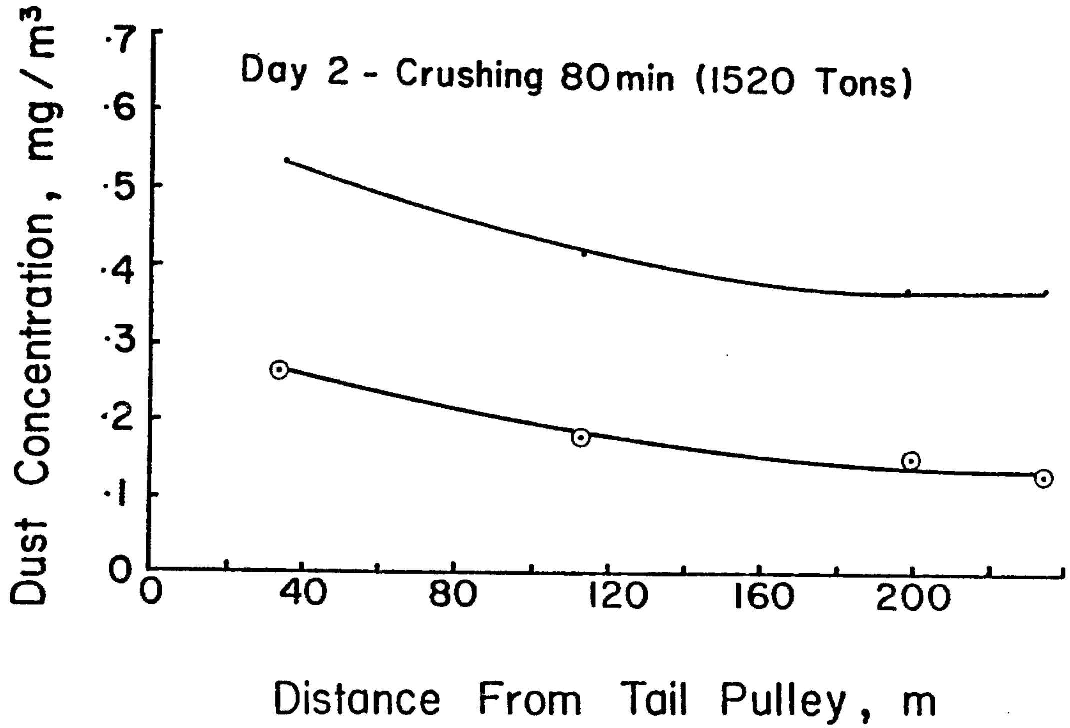


Fig. 4 - Time-weighted average respirable total (top curve), and silica (bottom curve), dust concentration as a function of distance from the tail pulley.

section of the drift (8,9).

In an attempt to analyze the gravimetric data further, Figure 5 shows the total respirable dust concentration plotted for each station, as a function of crushing time for each day. Data from station 1 were omitted in order to avoid discrepancies caused by the dilution effect from air leakage at the crusher cross-cut. This graph shows a linear relationship between each set of points and lines were extended linearly back to the y-axis. These lines show that the crusher is the main dust source in the area and that the amount of airborne dust is a linear function of the crushing time. The y-intercepts, on the other hand seem to indicate that there are other dust sources at work in the area which are not necessarily directly linked to the crushing operation. These could well be extended sources of dust, more specifically, in this case, re-entrainment of settled dust or dust produced by belt movement.

If these y-intercepts are plotted as a function of distance from the tail pulley, a linear relationship is observed as shown in Figure 6. This, as well as showing a contribution from sources other than crushing, indicates a linearly increasing effect as a function of distance from the tail pulley. This is an observation which is consistent with the pattern of dust production expected from extended sources along the drift. Hence, although this could not be quantified with any degree of accuracy (more data would be required to give these results higher statistical significance), it would seem that mechanisms such as re-entrainment of dust and belt movement are contributors to the overall dust profile in the drift.

CONCLUSIONS

The size distribution of dust was relatively constant along the drift, at least up to 250 m from the tail pulley. On average, the mass-median

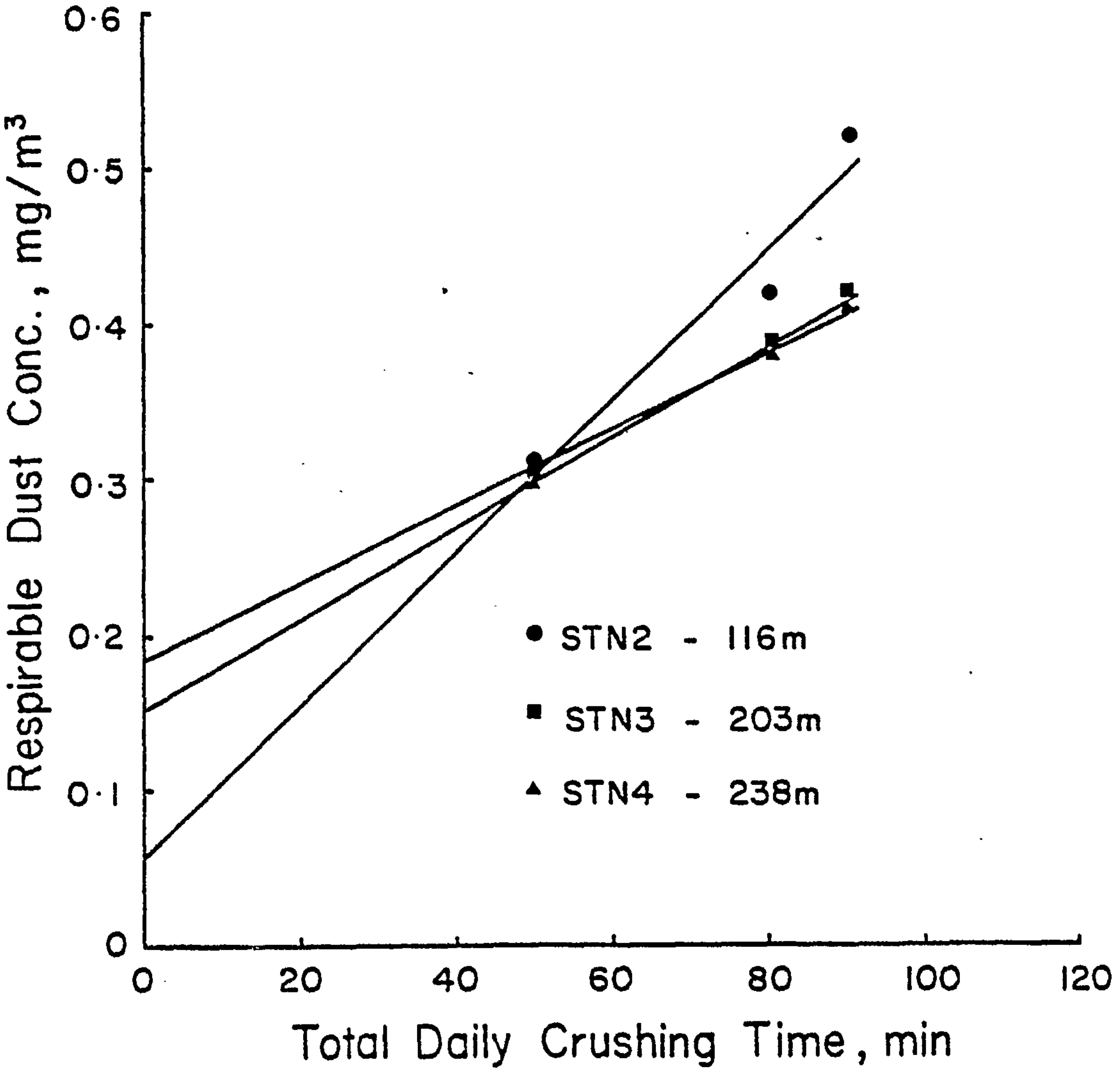


Fig. 5 - Respirable dust concentration at various distances from the tail pulley plotted as a function of the total daily crushing time.

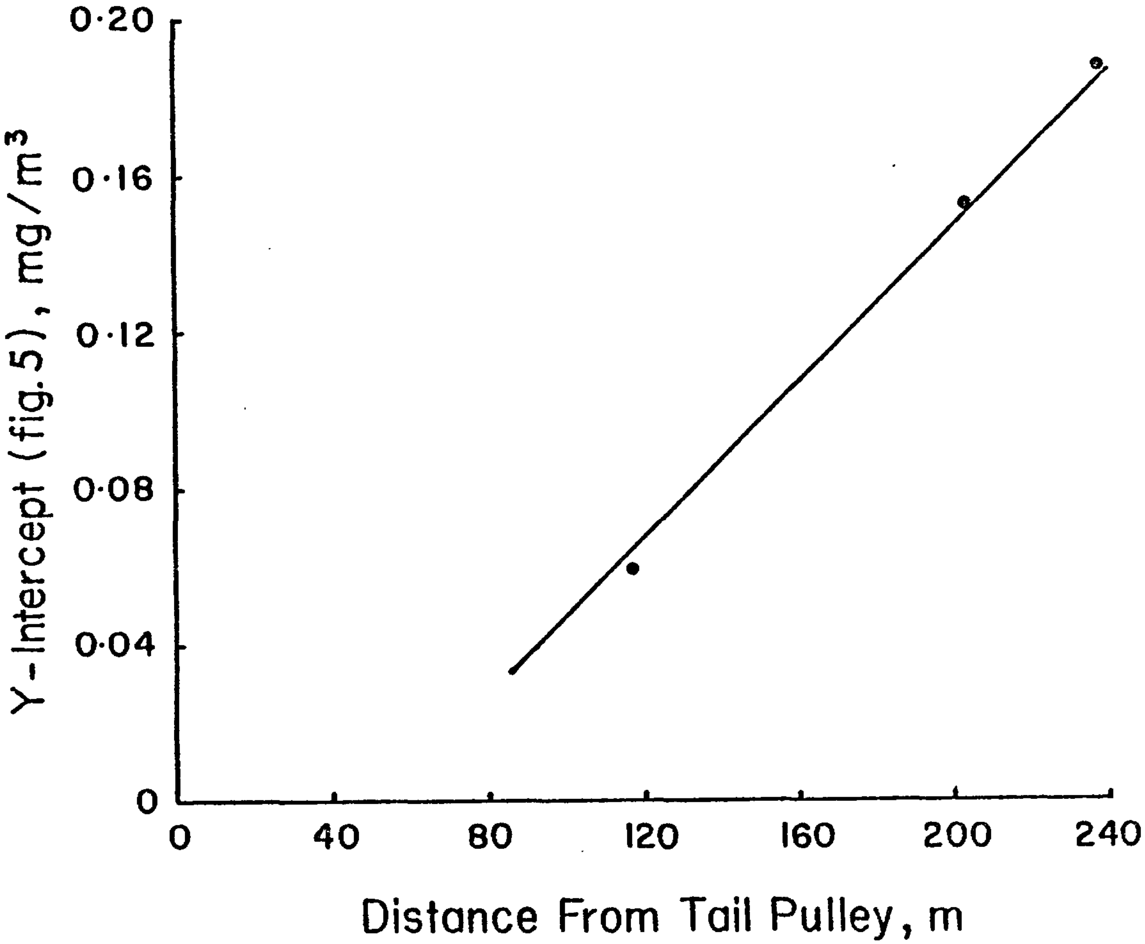


Fig. 6 - Value of respirable dust concentration at zero daily crushing time (y-axis intercept obtained from Figure 5) as a function of distance from the tail pulley.

aerodynamic diameter of airborne dust particles was 4.2 μm with a geometric standard deviation of 2.8. Continuous monitors showed that the crushing operation was a large contributor to the dust values in the drift. The peak dust concentrations were very noticeable close to the tail pulley and they could very easily be linked to time intervals when the crusher was in operation.

According to data obtained from TWA measurements of dust concentration, respirable silica accounted for 44% of the mass collected by samplers. Between STN1 and STN4, the total respirable dust concentration dropped by about 28%. Leakage of air at the ventilation door leading to the crusher accounted for 20 to 25% of the reduction. Sedimentation could account for approximately 4% of the decrease. Finally, some evidence suggested that dust sources other than the crusher were likely to exist in the area investigated. Furthermore, these sources could well be of the non-discrete or extended type, such as re-entrainment of settled dust and/or dust produced by belt operation.

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