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# WET DUST COLLECTORS AS A MEANS OF MINERAL DUST CONTROL

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# WET DUST COLLECTORS AS A MEANS OF MINERAL DUST CONTROL

by

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## ABSTRACT

A self-induced wet dust collector operating at 8.7 $m^3/s$ was evaluated at a crusher plant of an underground hard rock mine. The new dust collector replaced a bag house dust filter. The unit was evaluated for dust removal efficiency as a function of particle size. Performance was also assessed by comparing airborne respirable dust (total and silica) in the general area prior to, and after, installation of the new collector system. The use of cascade impactors and optical particle counters at the intake and the exhaust of the dust collector revealed a high efficiency (>90%) for particles greater in size than 2 $\mu m$. The efficiency dropped to approximately 70% and 25% for 1.0 $\mu m$ and 0.5 $\mu m$ particles, respectively. Results obtained showed an average total respirable dust reduction of 51% with a maximum of 64% in some areas. For respirable silica dust, the average was higher at 70% with maximum reductions of up to 79%.

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Key words: Dust control; Mining; Wet scrubber.

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# L'UTILISATION DE DÉPOUSSIÉREURS HUMIDES POUR LE CONTRÔLE DES POUSSIÈRES MINÉRALES

par

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## RÉSUMÉ

On a évalué l'efficacité de dépoussiérage en fonction de la grosseur des particules d'un dépoussiéreur humide auto-induit fonctionnant à 8,7 $m^3/s$ dans une usine de concassage d'une mine souterraine en roche dure. Ce nouveau dépoussiéreur remplace un dépoussiéreur à manches. On a également évalué le rendement en comparant la quantité de particules inhalables (poussières totales et poussières de silice) en suspension dans l'air, avant et après l'installation du nouvel appareil. L'utilisation d'impacteurs à cascade et de compteurs optiques à l'entrée et à la sortie d'air de l'appareil révèle que le rendement est élevé (supérieur à 90 %) dans le cas des particules dont les dimensions dépassent 2 µm. Le rendement baisse à près de 70 % et 25 % pour les particules de 1,0 µm et de 0,5 µm, respectivement. Les résultats montrent que l'abondance des particules inhalables baisse en moyenne de 51 %, et que la réduction maximale est de 64 %. Dans le cas des poussières de silice, la réduction moyenne est de 70 % et la réduction maximale, de 79 %.

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Mots-clés: dépoussiérage; exploitation minière; dépoussiéreur par voie humide

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# INTRODUCTION

Wet collectors have long been used as a means of dust control in industry. This type of dust collector, although less common in underground hard rock mines, may be an alternative in underground dust control where dry filtration poses a problem. Wet scrubbing is advantageous as disposal of trapped dust is a clean process with little or no dust re-entrainment. Wet or sticky materials may be collected and will not affect the performance of scrubbing units. In theory, the performance of wet dust collectors is hardly affected as the load of collected dust increases and the ease of maintenance could lead to lower operating expenses.

On the other hand, this type of dust collector is usually less efficient than comparable bag type filtration units in trapping finer particulate. Higher efficiency for small particle sizes can only be obtained at the cost of higher energy consumption. Finally, wet scrubbing may pose corrosion problems and fair amounts of water must be disposed of on a regular basis.

Several types of wet dust collectors have been designed; among these are spray towers, venturi and self-induced dust collectors. The unit evaluated here is of the self-induced type and water droplets are formed as dusty air is drawn into a wedge shaped duct whose lower horizontal plane is submerged. Air is then forced under a lip which causes fragmentation of the water to occur. The design and principles of operation of this type of dust collector require that water be maintained at a critical level and also that the unit be mounted on a perfectly horizontal surface. Except for the fan which is an external and separate unit, the wet dust collector contains no moving mechanical parts. In this type of dust collector, large particles are removed by impingement on the liquid surface while the induced spray removes smaller particulate. Wetted dust settles at the bottom of the tank which is desludged on a regular basis. The cleaned gas is released after going through dewatering plates and a felt-like filter material approximately 2 cm in thickness. This particular unit is available in a variety of models covering air volumes between 1.9 $m^3/s$ (4000 cfm) and 23.6 $m^3/s$ (50000 cfm).

The purpose of this work was to evaluate a self-induced wet dust collector in the field at an underground crushing plant. The dust collector was tested for particle removal efficiency as a function of dust particle size. The overall impact of the dust collector on air quality in the vicinity was also assessed for total and quartz respirable dust.

## AREA DESCRIPTION

The area under investigation was a crushing plant at an underground hard rock mine. The rock matrix in this area contained as much as 60% quartz. A plan view of the mine section is shown in Figure 1. The crusher was fed by two ore passes and one waste pass. Hence, there was an open flow of muck where the three passes joined to feed the crusher. The jaw crusher loaded a surge bin which was drawn by an attendant at the tail pulley of a belt conveyor in a drift approximately 15 meters below. This area was accessible from the crushing plant using a short raise. On average, the plant crushed 1360 tonnes (1500 short tons) of ore or waste daily during sampling periods throughout the evaluation. Although work habits varied from one crusher attendant to another, a typical working cycle consisted of 15 to 25 minutes of crushing and a 30 to 45 minute period when the attendant waited for the surge bin to empty sufficiently.

The plant was ventilated with approximately 9.4 $m^3/s$ (20000 cfm) of air coming from workings on an upper level. This air was always quite low in

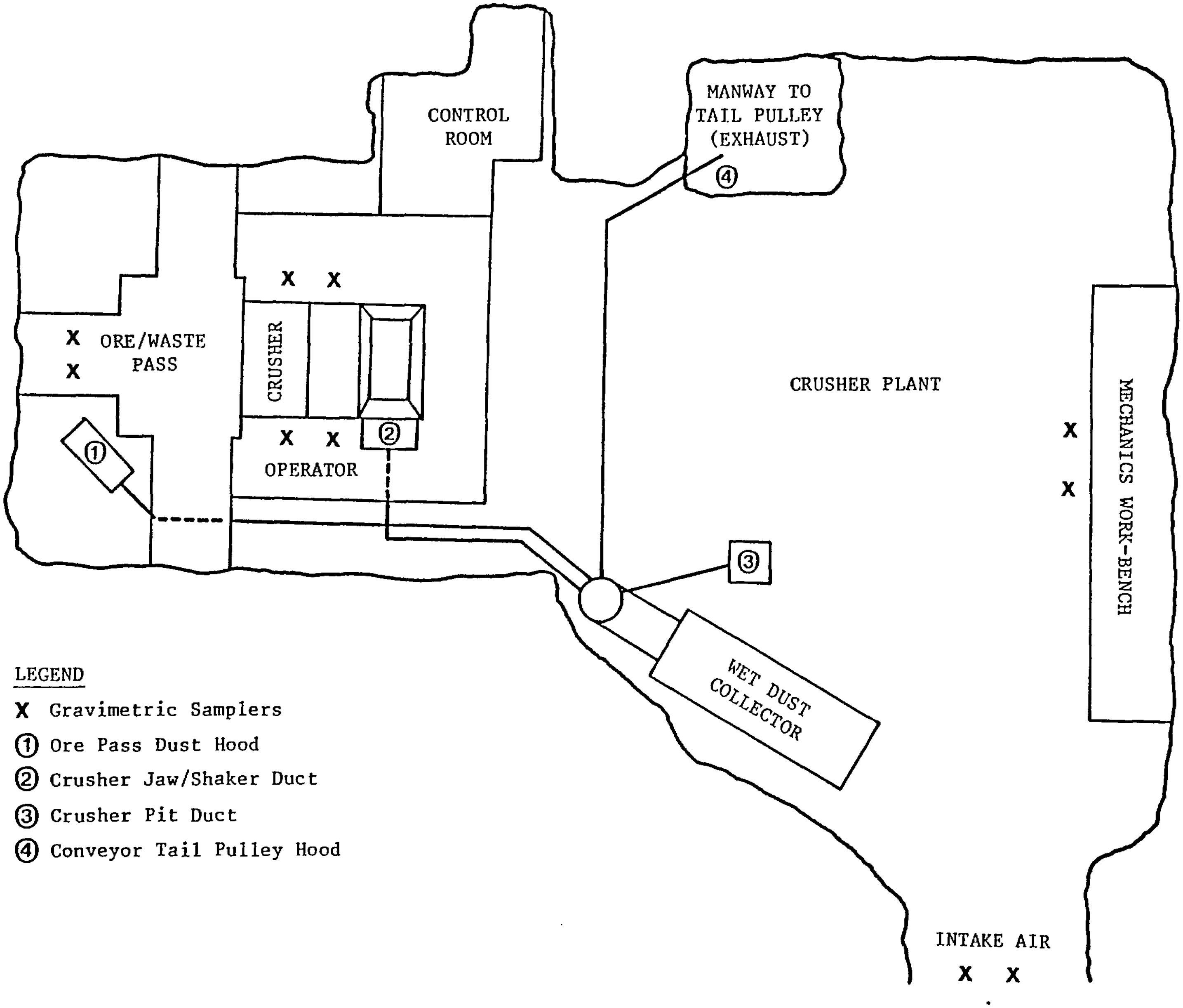


Fig. 1 - Plan section of the area tested. Shown are the positions of gravimetric sampling trains and the location of the wet dust collector and associated hoods and ducts.

mineral dust content but relatively high diesel soot concentrations were detected. Ventilation air left as it flowed out into the raise leading down to the tail pulley (see Figure 1). The dust collector caused an appreciable portion of the air to be recirculated; the exact extent of this effect could only have been assessed accurately by tracer gas techniques.

The wet dust collector was an 8.7 $m^3/s$ (18400 cfm) unit, 4.5 m in length, 1.5 m in width and 2.0 m in height. Clean air which is drawn out of the dust collector by an external fan, was exhausted back into room air. Dusty air was fed to the dust collector via an intake plenum and ducts, from four dust problem areas. More specifically, dust was channeled from below the crusher shakers and jaws, the crusher pit, a hood extracting dusty air from the open ore pass junction area above the crusher platform and a hood at the tail pulley transfer point. The dust collector operated on a continuous basis and was desludged daily at the beginning of the shift. The filter fabric at the exhaust was cleaned (hosed down) on a weekly basis as part of the regular crusher maintenance schedule. The appropriate water level for optimum operation was maintained by an automatic overflow valve system. A pitot tube traverse at the intake of the dust collector indicated that the unit was operating very close to the manufacturer's suggested 8.68 $m^3/s$ (18400 cfm). The wet dust collector might have affected meteorological variables in the area as the temperature increased slightly on average from 16 to 18$^oC$. The relative humidity remained high but constant at 95%. This temperature rise translates into a net increase in water content of the air, which went up by 13% from about 13.2 $g/m^3$ to 15.0 $g/m^3$.

The wet dust collector replaced a 7.1 $m^3/s$ (15000 cfm) bag collector drawing air from the crusher pit and from the tail pulley transfer point dust collecting hood and exhausting it into an adjacent ore pass. This system had deteriorated and was plagued with mechanical and engineering problems before being replaced.

## EXPERIMENT

Evaluation of the wet dust collector was conducted over a time span of eleven weeks. At first, a five day period was used to establish the level and characteristics of airborne dust contaminants in and around the crusher area while the bag collector was still in operation. To this end, twelve gravimetric sampling trains were used as area monitors. These sampling trains were tested separately underground prior to the beginning of the study to establish their integrity (1). Flow calibrations for the samplers were performed underground to avoid flow rate discrepancies brought about by air density increases with depth (2). Respirable dust sampling was conducted over a five hour period on each of the five days. Total respirable and quartz respirable dust concentration were measured in five areas of interest (see Figure 1). These were the air intake to the crusher plant, the crusher plant floor area (will be referred to as the mechanics' workbench), the crusher platform (crusher attendant work station), the ore passes feeding the crusher and the return air going to the tail pulley area. Since the crusher was not running continuously, individual crushing intervals were noted to enable total daily crushing time to be determined.

Cascade impactors (Anderson, 13 L/min) were used to determine the size distribution of dust at the mechanics' workbench and on the crushing platform. A GCA Miniram PDM-3 continuous dust monitor was installed on the crushing platform to measure the extent of dust concentration fluctuations close to the crusher operator. The Miniram was also previously calibrated along with gravimetric samplers. Relative humidity, temperature and ventilation flow were also measured.

The old dust collector was dismantled and the wet dust collector and the new duct work were installed approximately a month later during the mine's summer shutdown. After the shutdown the wet dust collector was allowed to run on a steady basis for a month before the second part of the evaluation took place. This was done in order to allow the mine staff to get acquainted with routine maintenance and operation of the new unit. It also allowed a "breaking in" period for the dust collector.

During the second week of evaluation (after wet collector installation) respirable dust, size distribution, continuous dust concentration on the crushing platform, relative humidity and temperature were measured as before. In this period of time the dust removal efficiency of the wet dust collector was determined with the help of cascade impactors and optical particle counters. Sampling ports were provided for this purpose at the intake and exhaust of the wet collector. A set of sampling probes was designed to allow sampling to be performed under conditions that were near isokinetic. Data from the optical counter and the cascade impactor allowed the efficiency of the wet dust collector to be determined as a function of particle size.

## WET DUST COLLECTOR - EFFICIENCY

The efficiency of collection as a function of particle size is shown graphically in Figure 2. Both instruments are in agreement for particle diameters larger than 2 $\mu m$. For smaller particulate the instruments disagree by as much as 40% (at 1 $\mu m$). These results are in agreement with efficiencies expected for self-induced water dust collectors (3).

On a total mass basis, data from cascade impactors showed an efficiency of approximately 85% and a respirable dust removal efficiency of approximately 73%. The respirable dust removal efficiency was calculated by

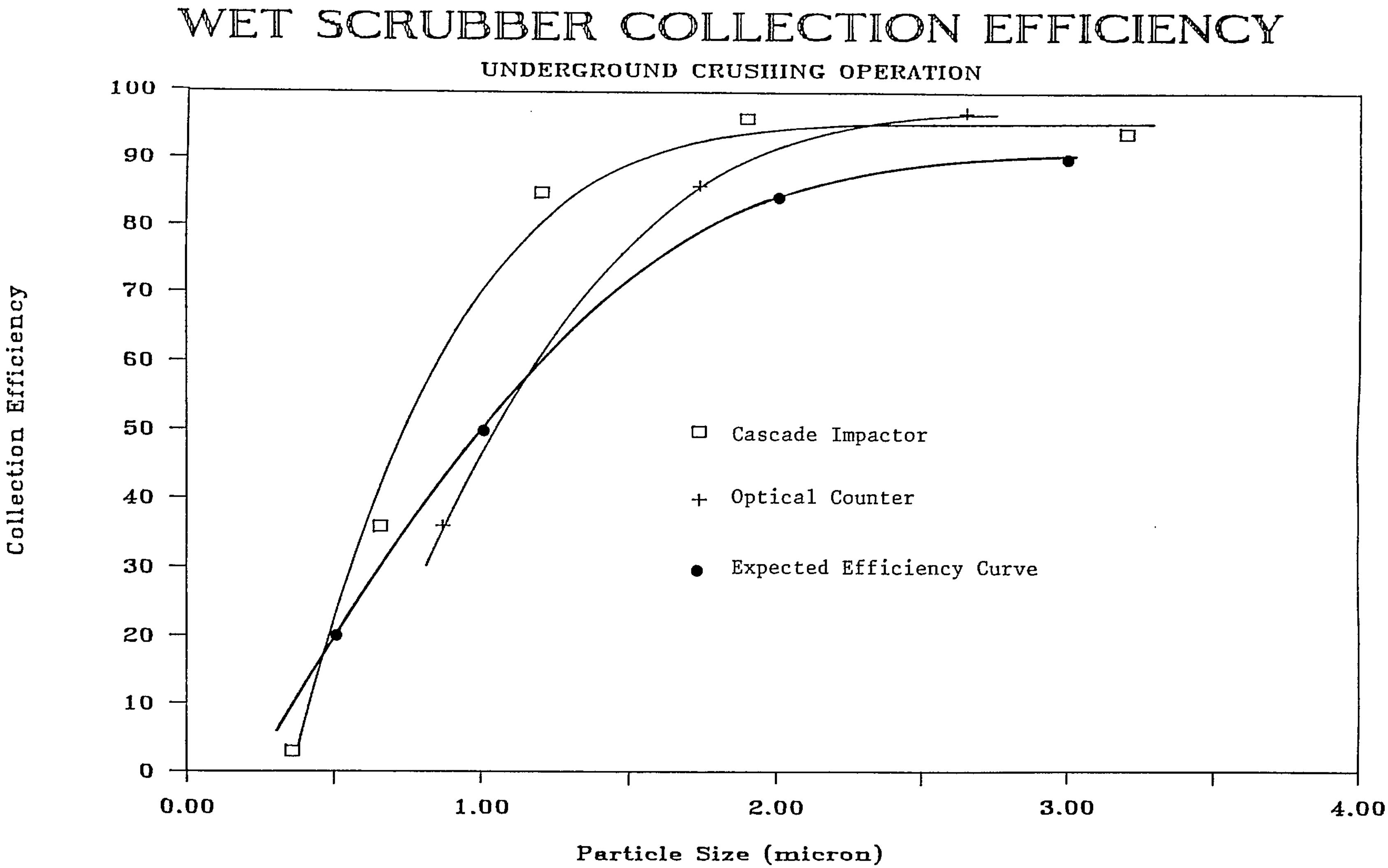


Fig. 2 - Efficiency of collection of the self-induced wet dust collector tested. The efficiency was measured by using cascade impactors (□), and optical counters (+) at the intake and the exhaust of the collector. Also shown is the expected efficiency of collection for self-induced units (●).

estimating the portion of respirable dust on each impactor stage (4). An earlier version of this wet dust collector was evaluated in the U.K. and the respirable dust removal efficiency for coal dust was reported to be between 82% and 86% (5). A recent evaluation of a 16.5 $m^3/s$ (35000 cfm) unit similar to the one tested here showed a respirable dust removal efficiency of 84% (6). The value of 73% obtained in the present study is mostly due to a large portion of the respirable dust being diesel exhaust particulate. These particles are for the most part smaller than 0.3 $\mu m$ and it is expected that the dust collector is comparatively inefficient in that size range and for this type of dust (7).

## WET DUST COLLECTOR - IMPACT ON AIR QUALITY

Time-weighted average (TWA) concentration of respirable total and quartz dust are shown in Tables 1 and 2, for both parts of the study. Before going into more detail, it should be said that these numbers do not represent personal dust samples. These area samples were collected from a five hour interval during comparatively high activity periods. The concentrations are not meant to indicate the degree of exposure of workers to total and quartz respirable dust, but rather are a measure of the improvement in the area. These data may, however, be used to give an idea of the degree of improvement to be expected from routine personal sampling in the future.

The ore pass and the crushing platform showed the most improvement. On average, total and quartz respirable dust concentrations were reduced by 60% and 76%, respectively. This large reduction is attributable to the dust collector's ability to effectively wet mineral dust and to the proper ducting and dust extraction system installed as part of the project. The return air (exhausted to the belt conveyor haulage way) improved as well but to a

Table 1 - Total respirable dust concentration (mg/m$^3$) before and after wet dust collector system installation.

| Area | Before | After | Reduction (%) |
|---|---|---|---|
| Crusher Platform | 1.21 ± 0.28 | 0.53 ± 0.19 | 56 |
| Mechanic's Bench | 0.34 ± 0.11 | 0.35 ± 0.11 | 0 |
| Ore Pass | 1.36 ± 0.49 | 0.49 ± 0.18 | 64 |
| Return Air | 0.81 ± 0.19 | 0.55 ± 0.24 | 32 |
| Intake Air | 0.25 ± 0.03 | 0.24 ± 0.08 | 4 |

Note: These are not personal sampling results.

Table 2 - Quartz respirable dust concentration (mg/m$^3$) before and after wet dust collector system installation.

| Area | Before | After | Reduction (%) |
|---|---|---|---|
| Crusher Platform | 0.70 ± 0.19 | 0.15 ± 0.08 | 79 |
| Mechanic's Bench | 0.10 ± 0.06 | 0.07 ± 0.03 | 30 |
| Ore Pass | 0.70 ± 0.24 | 0.18 ± 0.10 | 74 |
| Return Air | 0.37 ± 0.08 | 0.16 ± 0.07 | 57 |
| Intake Air | 0.05 ± 0.01 | 0.04 ± 0.01 | 20 |

Note: These are not personal sampling results.

lesser extent. The duct linking the dust collector to the tail pulley dust extraction hood is mostly responsible for the relative lack of improvement in that area. This is the smallest diameter duct in the system (30 cm compared to 48 cm and 51 cm for the crusher jaw and crusher pit duct, respectively). This 27 m duct is also the longest one. The next longest duct (11 m) links the ore pass extraction hood to the dust collector. The flow resistance encountered in the tail pulley duct is mainly responsible for a lower improvement level in that area.

The crusher room area saw no improvement in total respirable dust and only a very marginal improvement in quartz respirable dust concentration. This is because the area was in the path of incoming "fresh air" which effectively isolates the area from dust produced by the crushing operation (see Figure 1). As expected, the intake air was not affected in any way by the new dust collector. Concentration remained very constant over the evaluation period which facilitated data analysis significantly.

Some konimeter samples were taken by mine personnel at the discharge of the dust collector and in some other areas of interest. The results showed an average of 50 ppcc in incoming fresh air, 140 ppcc at the tail pulley (return air) and at the mechanics' bench, approximately 360 ppcc on the crushing platform and 420 ppcc at the dust collector discharge. The Mine Accident Prevention Association of Ontario (MAPAO) suggests that for ores containing 30% quartz or more, 200 ppcc should be the upper limit value (8). Work done on a similar unit elsewhere suggests that unless sufficient amounts of clean air are available to dilute contaminants to a level below this 200 ppcc target value, the exhaust from the dust collector should not be recirculated (9).

Although the konimeter has been and still is in some applications an invaluable engineering tool, data analysis in the case of interest here must be performed carefully and the statistical significance of the results properly assessed. It has been suggested that konimeter performance might be affected by water condensation on dust particles as air is sucked through the konimeter jet (10). If this does indeed pose a problem, it could only be compounded by high relative humidity environments and by water pick-up through the dust collector in this particular case. It is reported that water pick-up through a 16.5 $m^3/s$ unit is approximately 0.7 $g/m^3$ (9). It seems that more work is required before the health hazard posed by the discharge of wet dust collectors can be properly assessed.

Size distributions of airborne dust are shown graphically in Figures 3 and 4 for measurements taken at the crushing platform and at the mechanics' bench. Measurements were taken before and after installation of the wet collector. These data show a reduction of the mass median aerodynamic diameter (MMAD) from 4.4 $\mu m$ to 1.6 $\mu m$ at the crushing platform. This decrease is caused by the removal of the coarse dust fraction by the collector. The reduction in MMAD is not as important at the mechanic's work bench since, as was mentioned before, this area is effectively isolated from the crushing operation. In both cases, the geometric standard deviation (GSD) has increased indicating a more polydisperse cloud.

Finally, Figures 5 and 6 show typical daily airborne respirable dust concentration close to the crusher operator as a function of time before and after the wet dust collector was installed. In Figure 5 (prior to installation), crushing intervals are clearly visible as respirable dust concentration increases to values ranging between 5 $mg/m^3$ and 10 $mg/m^3$. A similar profile after the unit was put into operation has dust concentrations confined to levels below 2 $mg/m^3$.

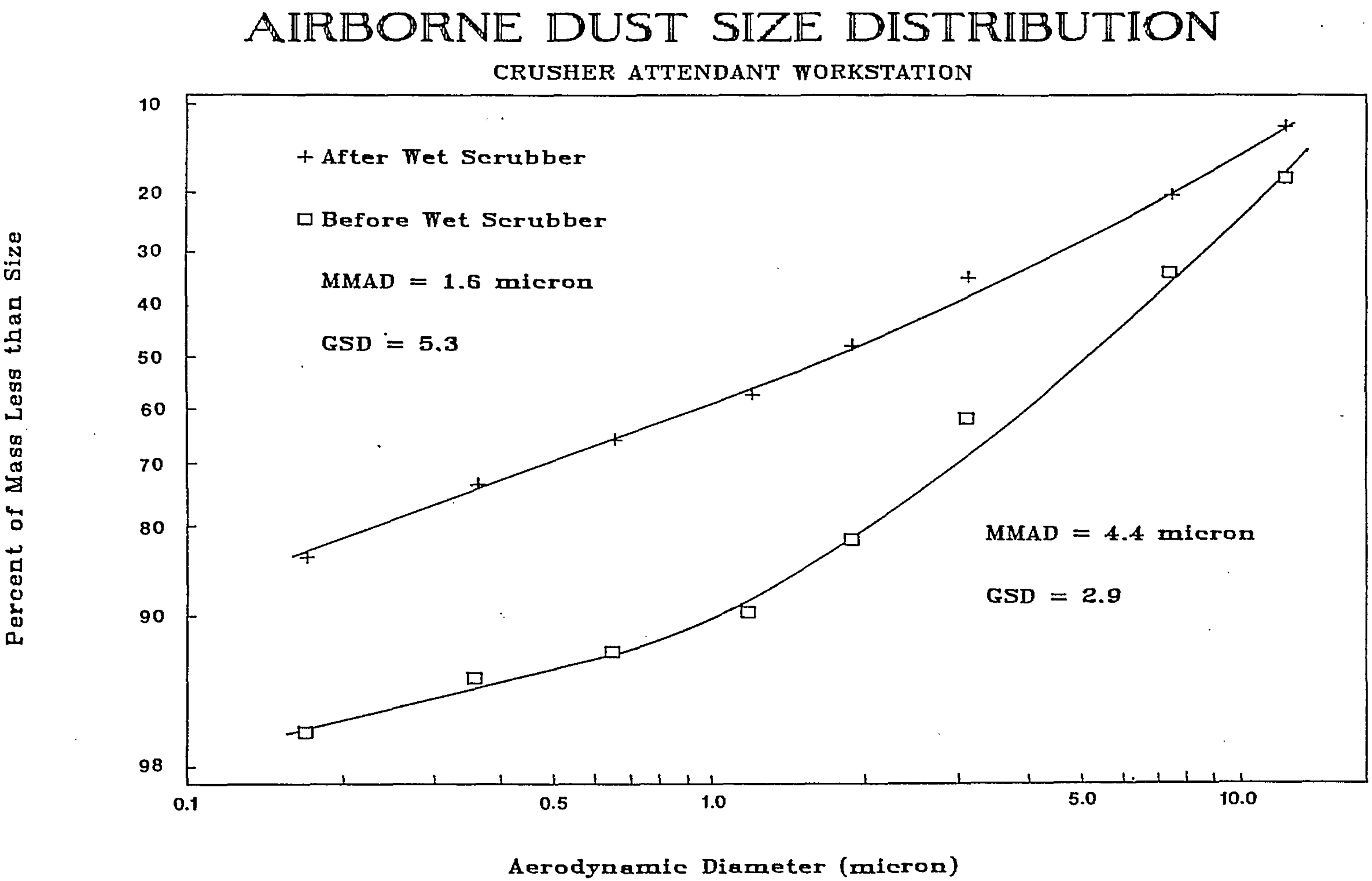


Fig. 3 - Airborne dust size distribution at the crusher operator's workplace before (□), and after (+) installation of the new dust collector system.

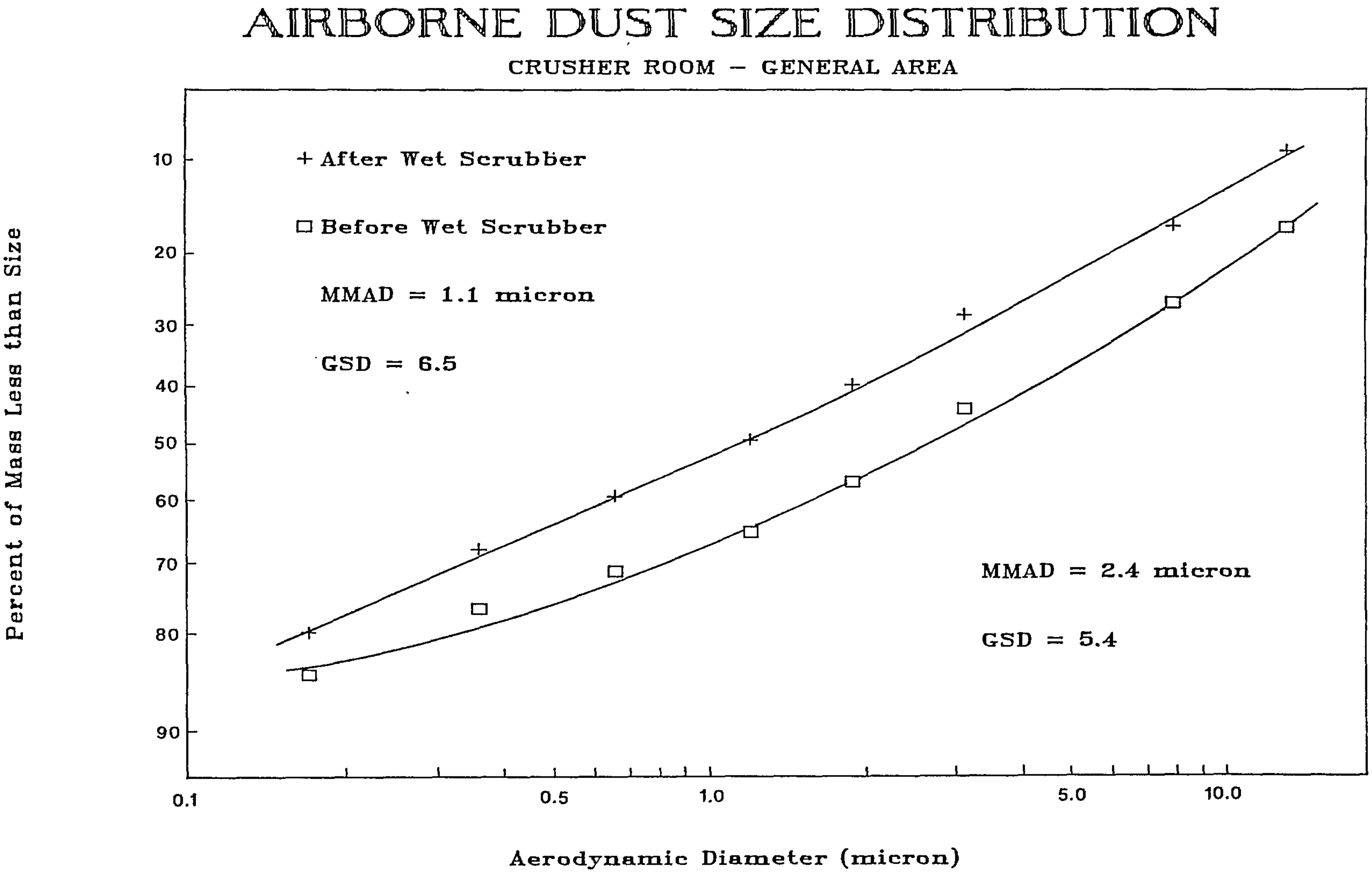


Fig. 4 - Airborne dust size distribution at the mechanic's work-bench before (□), and after (+) installation of the new dust collector system.

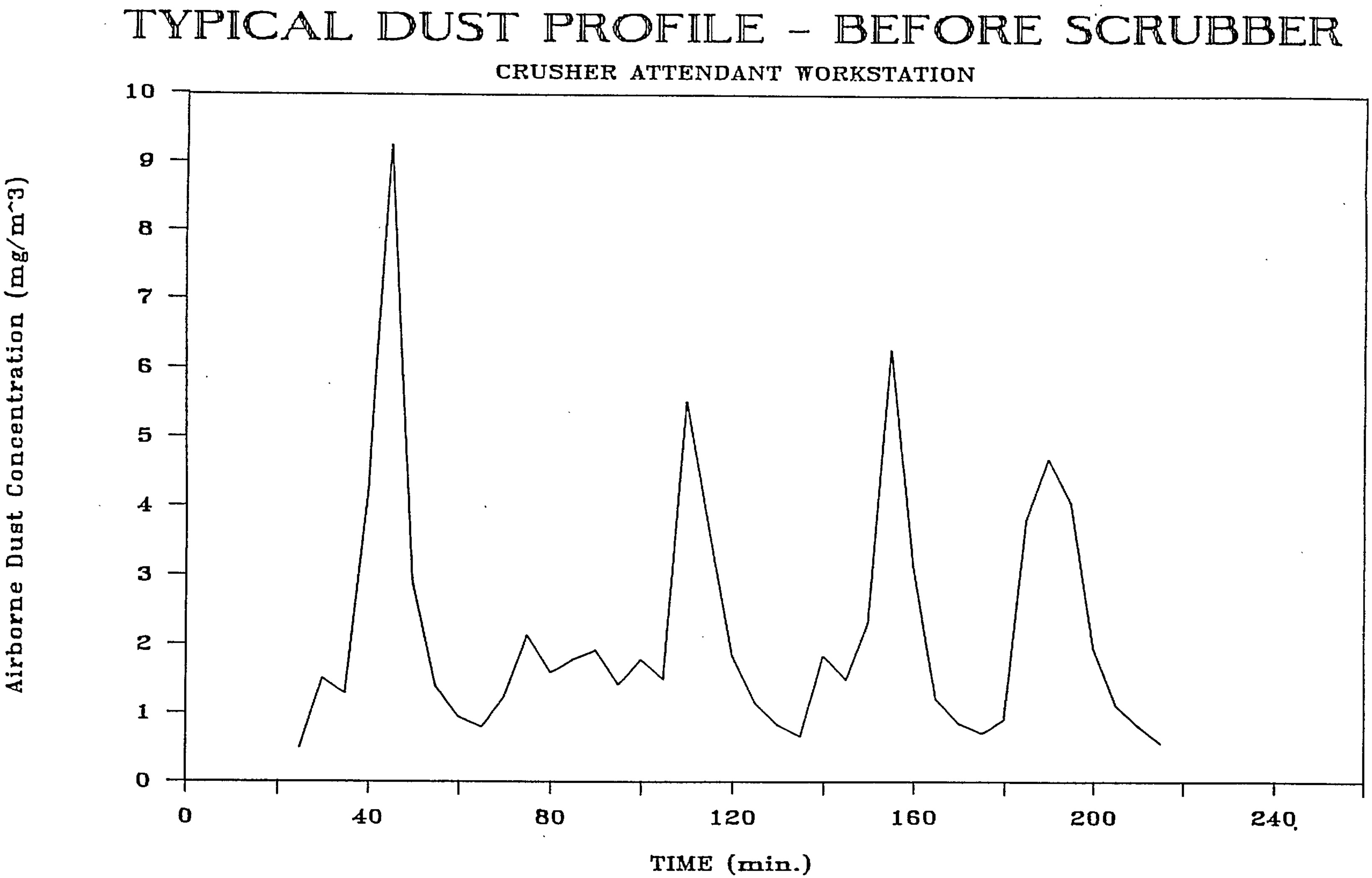


Fig 5 - Continuous airborne dust concentration measured at the crusher operator's work station before installation of the new dust collector system.

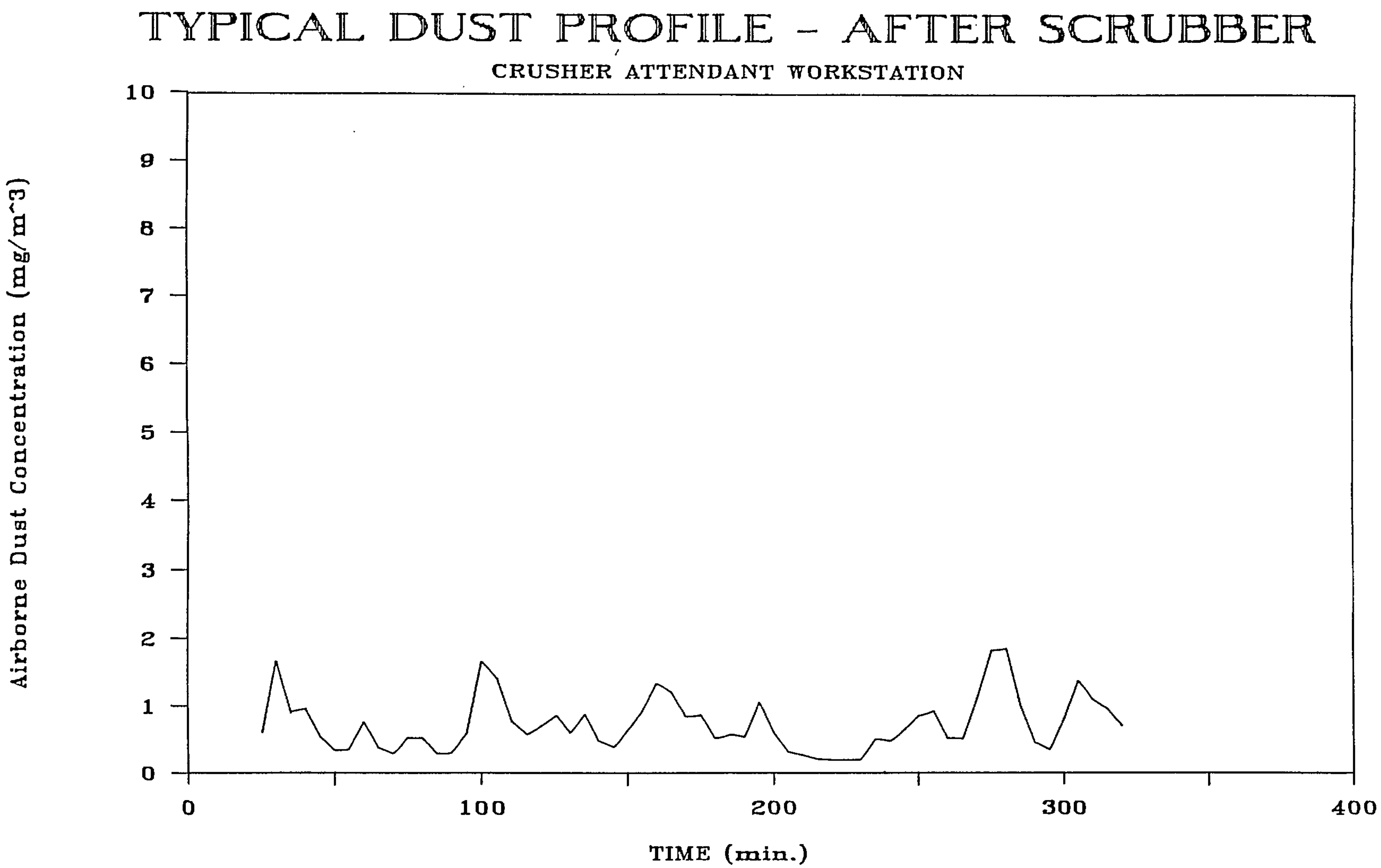


Fig. 6 - Continuous airborne dust concentration measured at the crusher operator's work station after installation of the new dust collector system.

## CONCLUSION

The self-induced wet dust collector tested as part of this study is close to 100% efficient for dust particles larger than 2 μm. The efficiency decreases rapidly for smaller particulate. Cascade impactor data show 70% and 25% efficiency for 1.0 μm and 0.5 μm dust, respectively. The total dust collection efficiency was 85% which was lower than expected. This is mainly because of the presence of diesel soot coming in with the intake air.

Total respirable dust collection efficiency was estimated to be approximately 73% by mass. But other studies have shown efficiencies as high as 85% in areas where the bulk of airborne contaminants are mineral in nature. These studies also show an efficiency of collection for respirable quartz in excess of 90%.

The average reduction of airborne respirable contaminants in areas with initially high dust concentration (return air, ore pass and crusher platform) was 51% and 70% for total and quartz dust, respectively.

Ducts and dust collecting hoods are an important part of the dust collecting system. The dust collecting apparatus used here was well designed (within the constraints of practicality) with the possible exception of the tail pulley transfer point hood/duct assembly. The ratio of diameter to length of the duct was out of proportion compared to the rest of the system.

The konimetry results obtained as part of this study seem to be in conflict with the gravimetric results collected. Konimetry guidelines set out by the MAPAO (limits of 200 ppcc) suggest that the exhaust from the dust collector not be recirculated. In view of this it seems that standard methods of assessing the efficiency and environmental impact of wet dust collectors in field applications should be developed.

Wet dust collectors are evidently not as efficient as bag type filters in removing the fine component of airborne respirable dust. Hence, they may not be the ideal device for cleaning underground general atmosphere air. But, as it exists now, this collector has a number of advantages such as the fact that with a minimum of maintenance, the collector will keep operating at constant efficiency levels. Also, this type of collector can easily handle large dust loads without fear of excessive wear and tear or overloading.

There is certainly room for improvement in efficiency characteristics, but some of the points outlined above make self-induced wet dust collectors serious candidates for dust control at rock breaking operations.

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