Energy, Mines and Resources Canada
Energie, Mines et Ressources Canada

CANMET
Canada Centre for Mineral and Energy Technology
Centre canadien de la technologie des minéraux et de l'énergie

EFFICIENCY TESTS ON A WET DUST COLLECTOR IN A HARD ROCK MINE

G. KNIGHT AND S. HARDCASTLE

ELLIOT LAKE LABORATORY

MAY 1986

MINING RESEARCH LABORATORIES
DIVISIONAL REPORT MRL 87-95 (TR)

1-7992796

EFFICIENCY TESTS ON A WET DUST COLLECTOR IN A HARD ROCK MINE

by

G. Knight* and S. Hardcastle*

ABSTRACT

Tests on a Mark III Precipitaire wet dust collector drawing dust laden air from an ore pass showed a collection efficiency ranging from 43% to 99%. This depended on the size fraction and composition of dust cloud assessed, and on the time period in relation to the unit's operation cycle. Full shift gravimetric determinations demonstrated the unit as 84% efficient in removing total respirable dust and 95% efficient for respirable quartz, however, on loading the total efficiency reduced to 65%.

Particle counter analysis of the collector showed the unit to be least efficient in the 0.5 to 1.5 μm range at 43%, 84% efficient in the 1.5 to 3.0 μm range and >95% efficient for larger sizes. The optical analysis also indicated that dust emissions persist 15 to 20 min beyond a dump operation.

During an average full shift the collector allowed 0.1 mg/m^3 total respirable dust containing 0.015 mg/m^3 quartz to re-enter the ambient air. An optical assessment showed a peak exhaust of 300 ppcc and a full shift average of 68 ppcc.

---

*Research Scientist, Elliot Lake Laboratory, CANMET, Energy, Mines and Resources Canada, Elliot Lake, Ontario.

ESSAIS DE RENDEMENT D'UN COLLECTEUR HUMIDE DE POUSSIÈRES DANS UNE MINE DE ROCHE DURE

par

G. Knight* et S. Hardcastle*

RÉSUMÉ

Les résultats d'essais, réalisés à l'aide du collecteur humide de poussières Mark III Precipitaire aspirant de l'air chargé de poussières provenant d'une cheminée à minerai, ont démontré que le rendement du collecteur se situait dans la gamme de 43 à 99 %. La différence entre les résultats dépendait de la fraction granulométrique et de la composition du nuage de poussière étudié ainsi que de la période de temps par rapport au cycle d'opération de l'unité. Les résultats des mesures gravimétriques effectuées au cours d'une période de travail complète ont démontré que l'unité a un rendement de 84 % pour l'enlèvement des poussières respirables totales, et de 95 % pour le quartz aéroporté; cependant, le rendement total lors du chargement est réduit à 65 %.

Une analyse du collecteur effectuée à l'aide d'un compteur de particules a indiqué que le rendement de l'unité est à son moindre soit 43 % pour les particules dans la gamme de 0,5 à 1,5 µm, mais par contre s'élève à 84 % pour les particules dans la gamme 1,5 à 3,0 µm et à >95 % pour les particules plus grossières. L'analyse optique a indiqué en outre que les émissions de poussière se poursuivent 15 à 20 minutes après l'opération de déchargement.

Au cours d'une période moyenne de travail, le collecteur a laissé 0,1 mg/m^3 de poussières respirables totales contenant 0,015 mg/m^3 de quartz réintégrer l'air ambiant. Une évaluation optique a montré un échappement maximal de 300 ppcc, et une moyenne de 68 ppcc pour une période de travail complète.

---

*Chercheur scientifique, Laboratoire d'Elliot Lake, CANMET, Énergie, Mines et Ressources Canada, Elliot Lake, Ontario.

CONTENTS

TABLES

FIGURES

INTRODUCTION

Filters are commonly used to remove dust from the air in underground mining. Wet dust collectors only require a little maintenance and are promising from some points of view. This report is concerned with testing a particular unit, the Mark III Precipitaire*, based on development carried out in the British coal mines and marketed in Canada by Tenace Corporation, Sudbury, Ontario. The model examined, PV 35, is installed underground and draws 16.5 m^3/s of air from an ore dump. It is operated continuously for most of the shift. The tests were requested by the Mines Accident Prevention Association of Ontario to verify their test results.

The layout of the test site is shown in Figure 1. It should be noted that there is substantial recirculation through the filter and that the ore dump is probably not the only dust source.

MEASUREMENT TECHNIQUES

Dust measurements were made with size selective gravimetric samplers and optical particle counters, both within the inlet duct carrying dusty air to the dust collector and outside in the discharge room which is swept by the air being blown against the roof on leaving the collector.

The dust samplers used were experimental 4 L/min and 30 L/min two-stage gravimetric samplers as developed from the CAMPEDS program (1-3). The first stage consists of an impaction size selector designed to collect the dust fraction coarser than respirable and weighable. The second stage on the 4 L/min samplers consists of a 25 mm diameter silver membrane filter suitable for direct-on-filter assessment of quartz by X-ray diffraction as well as gravimetric assessment (1-3). A glass fibre filter, suitable for assessment

---

*Brand Name.

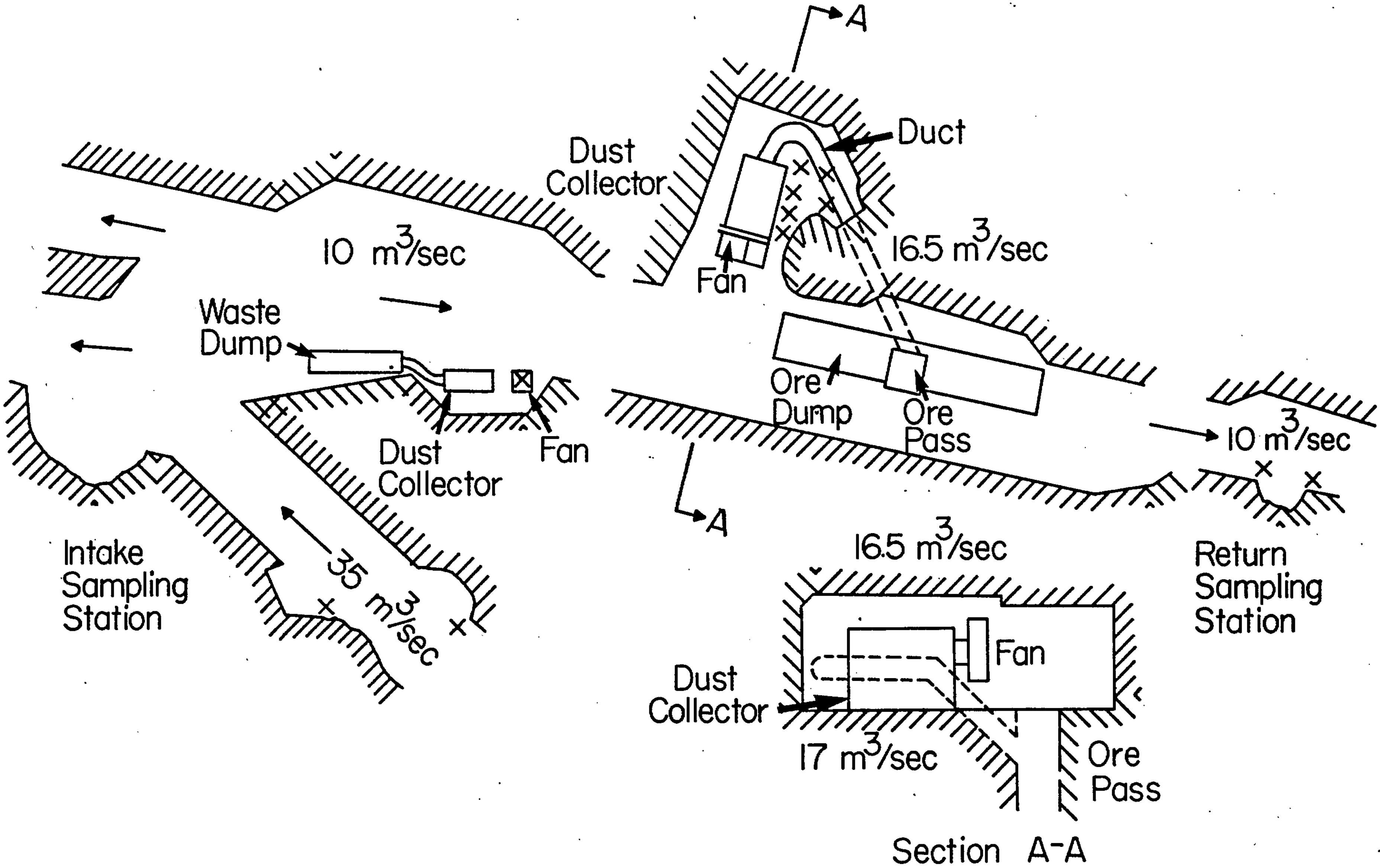

Fig. 1 - Test site.

of long-lived radionuclide dusts, is used for the second stage of the 30 L/min samplers.

These samplers were calibrated against a standard instrument (1) to give a respirable dust concentration close to that of a sampler designed to the British Medical Research Council respirable dust specification. Where necessary the sampler flow rates were adjusted. The standard instrument was a horizontal elutriator size selective sampler.

Duplicate 4 L/min and single 30 L/min samplers were run in the inlet duct and in the discharge room. These sampled the inlet and outlet air to and from the scrubber, respectively, for the entire sampling period. In addition one pair of 4 L/min samplers were operated only during the dumping period.

Concurrently, room samples were collected with horizontal elutriators and nylon cyclone samplers.

The opportunity was taken to evaluate a pair of optical size fractionating instruments during these tests. The units consisted of HIAC/ROYCO's 4100 Particle Counter and 1200 Sensor customized for the arduous underground surroundings by Mono Research Laboratories Ltd., Brampton, Ontario.

The optical units sized the dust cloud entering and leaving the dust collector installation.

GRAVIMETRIC RESULTS

The tests were carried out over a total of three days. The results of gravimetric analyses are given for the two stage impactors in Table 1. Although not included, the nylon cyclone and elutriator showed reasonable agreement at these low weights. Averages for the complete tests and the gravimetric assessments of dust collection efficiency are shown in Table 2.

Table 1 - Gravimetric sampling results

		Day 1 Wt. mg	Day 1 Conc. mg/m^3	Day 2 Wt. mg	Day 2 Conc. mg/m^3	Day 3 Wt. mg	Day 3 Conc. mg/m^3
Full shift samples							
Sampling time runs, min		308		251		269	
Inlet							
4 L/min	Total resp. dust	0.51	0.41	0.74	0.74	0.68	0.69
4 L/min	" " "	0.48	0.39	0.81	0.81	0.71	0.66
30 L/min	" " "	5.88	0.63	5.17	0.68	4.88	0.60
4 L/min	Resp. quartz dust	0.248	0.201	0.387	0.387	0.332	0.308
4 L/min	" " "	0.261	0.212	0.437	0.437	0.394	0.364
Outlet							
4 L/min	Total resp. dust	0.08	0.065	0.09	0.09	0.14	0.13
4 L/min	" " "	0.09	0.07	0.15	0.15	0.09	0.08
30 L/min	" " "	0.68	0.073	1.02	0.13	0.90	0.11
4 L/min	Resp. quartz dust	0.013	0.010	0.021	0.021	0.019	0.018
4 L/min	" " "	0.011	0.009	0.019	0.019	0.014	0.013
Dumping period samples							
Sampling time min, min		55		39		27	
Inlet							
	Total resp. dust	0.12	0.54	0.24	1.5	0.14	1.3
	Resp. quartz dust	0.093	0.42	0.114	0.73	0.075	0.7
Outlet							
	Total resp. dust	0.05	0.23	0.11	0.7	0.03	0.3
	Resp. quartz dust	0.005	0.023	0.003	0.019	0.003	0.03
	No. ore cars dumped	73		97		74	

Table 2 - Gravimetric survey averages and collection efficiency

	Total Resp. Dust mg/m^3	Resp. Quartz Dust mg/m^3	% Total
Full shift samples			
Inlet	0.62 ± 0.14	0.32 ± 0.10	53.3 ± 0.3
Outlet	0.10 ± 0.03	0.015 ± 0.005	15.6 ± 4.0
Collection efficiency	84%	95%	
Dumping period samples (standard deviation not available)			
Inlet	1.11	0.62	60.0
Outlet	0.41	0.024	7.6
Collection efficiency	65%	95%	

The 30 and 4 L/min two-stage impactors correlated well excepting the inlet concentrations of Day 1. Excluding extremes the average deviation for both collector inlet and outlet samples was <0.05 mg/m^3.

The results in Table 2 show the unit to be 84-95% efficient at removing dust, dependent on type, during the full shift. The collector appears more efficient at removing the quartz, which is shown by the relative change in composition between inlet and outlet samples. The inlet quartz value, 52%, is typical of fresh airborne breakage products from the ore. The disproportionate decrease of total respirable dust could be due to a weighting of non-quartz elements to the smaller size ranges at which the collection efficiency drops. The samples taken only during dumping operations showed a similar efficiency for quartz and inlet composition but a lower total collection efficiency. This again could be a function of dust size.

OPTICAL PARTICLE COUNTER RESULTS

A selection of results from the optical counter are presented in Figures 2 to 6 for Day 2 of the investigation. These include time histories of: i) particle counts at the inlet and outlet; ii) the outlet concentration converted to particles per cubic cm (ppcc); and iii) the outlet concentration on conversion into equivalent mass. Also presented are the relative size distributions of the dust clouds measured at the inlet and outlet and the collector's efficiency by size range.

The time history of particle counts for the size range 3 to 5 μm are given in Figure 2 for the inlet and outlet of the collector. These counts are for a 30 sec sample time at a nominal flow rate of 2.8 μm. The y-axis is given as a logarithm for compactness. The break between 3 and 4 hours corresponds with a lunch break and the collector being non-operational. Dumping operations which lasted up to 2 min are shown on the x-axis.

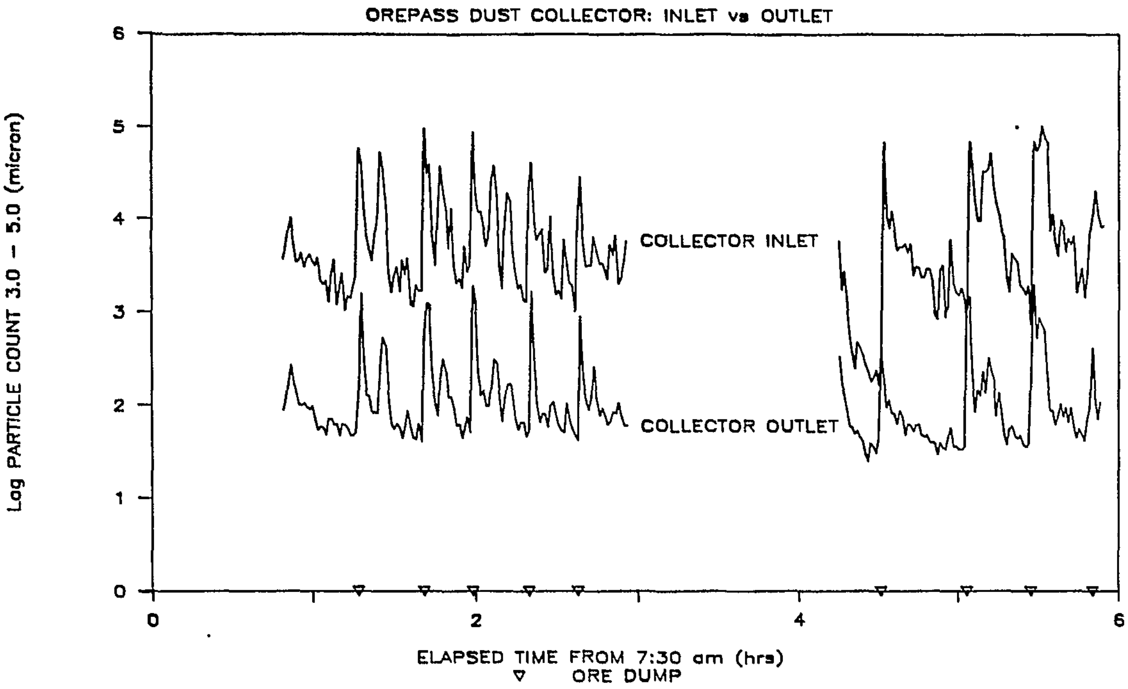

Fig. 2 - Optical particle counts by size range.

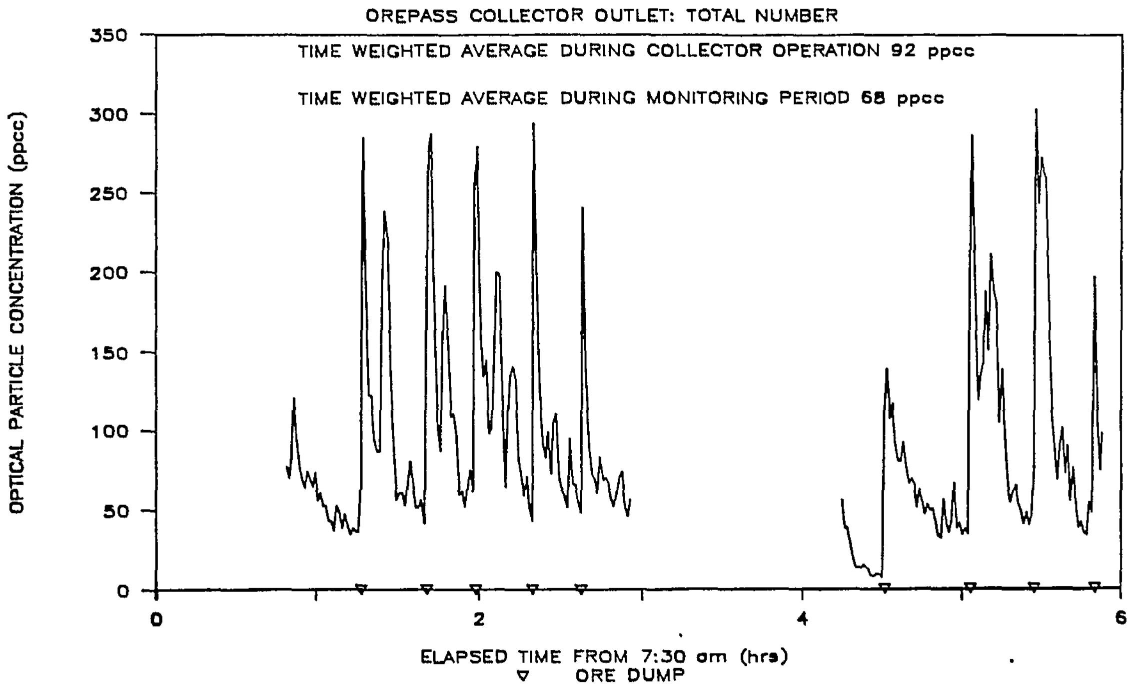

Fig. 3 - Total particle count number concentration.

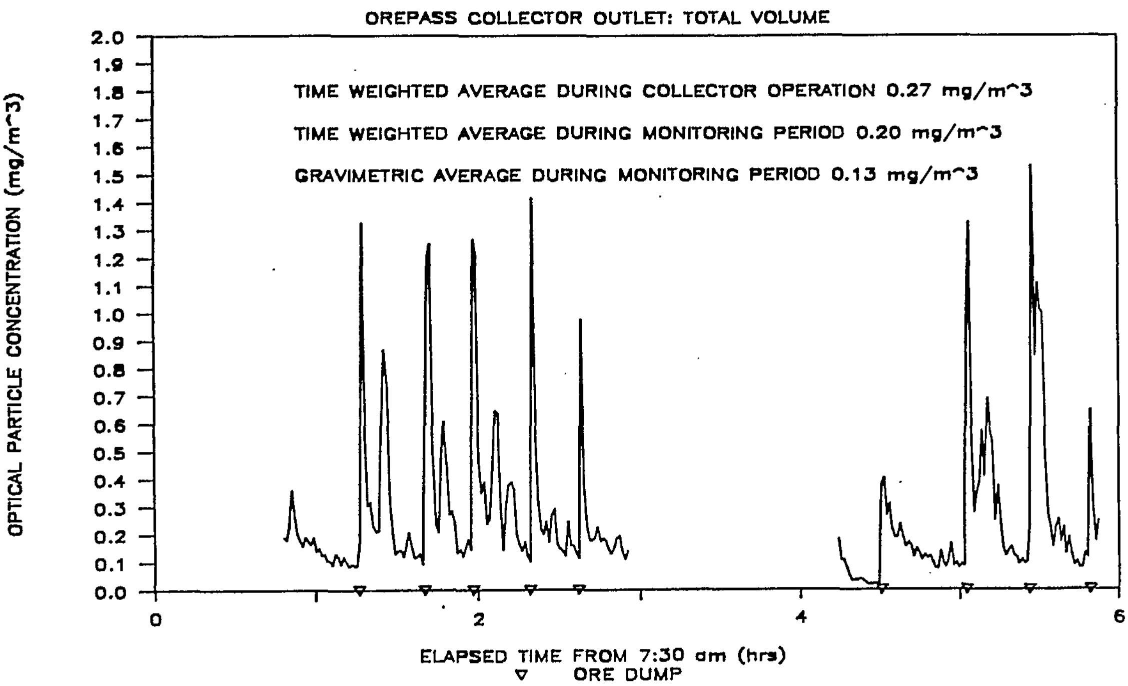

Fig. 4 - Total particle count mass concentration.

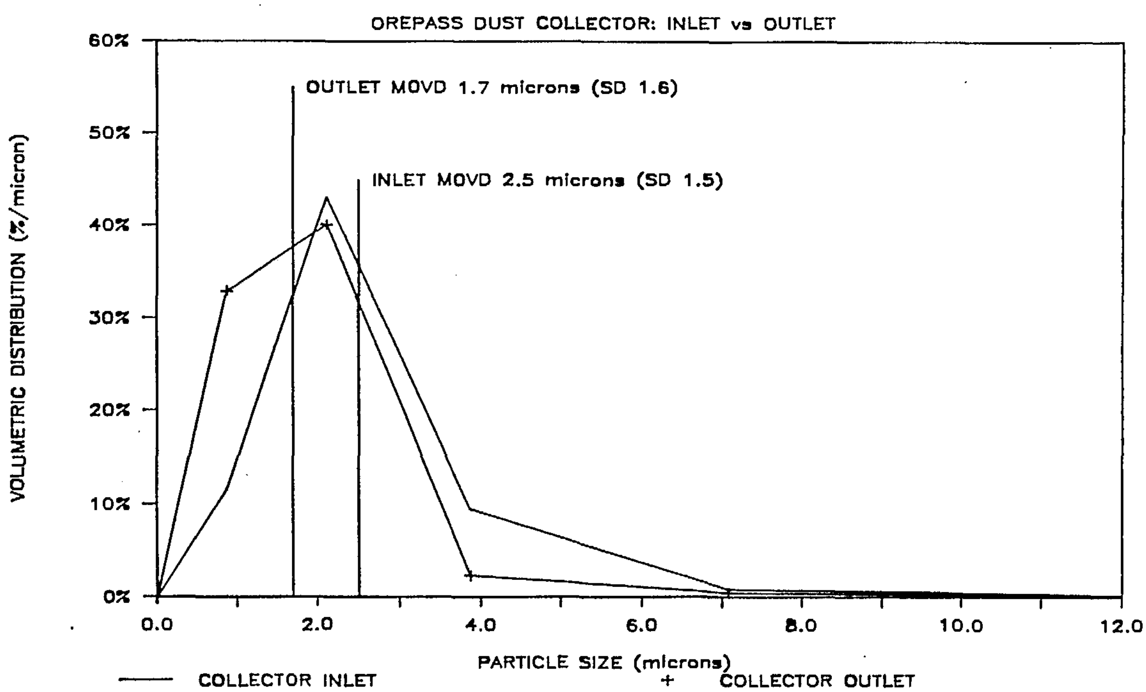

Fig. 5 - Differential particle size distribution.

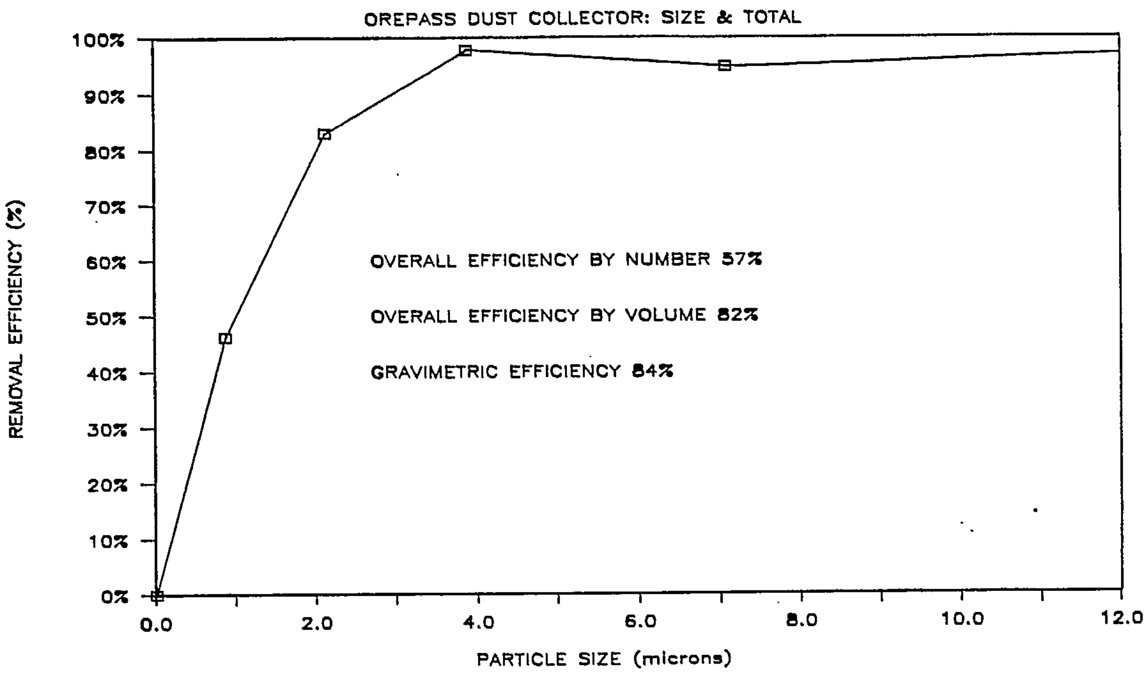

Fig. 6 - Particle removal efficiencies.

Both the inlet and outlet traces show similar trends; their separation is indicative of the collector's efficiency for this size range. Both counters show high counts on ore dumping with up to a 15 to 20 min period for the dust counts to decay. In the first section the decay can contain up to 3 secondary peaks at 7 min intervals. No explanation was available for this phenomenon which was only significant during the period presented.

Similar traces to Figure 2 could be obtained for the 5 other channels of the particle counters. However, at lower size ranges the inlet counter has problems with oversaturation and coincidence causing unrepresentative counts when an ore dump occurs. No overestimation or coincidence occurred at the outlet counter and its counts have been converted into concentrations.

The particle count concentration, Figure 3, is directly produced from the total particles counted, sampling flow rate and sample period. The counter was operational 30 sec in every min. The trace shows high outlet concentrations, up to 300 ppcc occurring on dumping, but time-weighted averages of 92 ppcc for the two periods of collector operation, and only 68 ppcc for the full sampling shift ~5 hours. These counts were taken within 1.8 m of the outlet, while the whole room was swept by the discharge air.

On converting each channel count into volume or unit mass, a total mass concentration trace may be obtained, Figure 4. This trace is very similar in profile to Figure 3, but provides a time-weighted average in mass form, namely 0.2 mg/m^3 for the full sampling shift, which is higher than the gravimetric determination of 0.13 mg/m^3. The difference in masses is probably a function of the analysis for the optical counter, the conversion using a true sphere calculation to obtain the volume and no shape factor correction. At present this is the least reliable representation of the counter results.

The volumetric analysis also provides the particle size distribution of the inlet and outlet dust clouds, Figure 5. These are independent of shape factors. From the cumulative representation of this data the mean optical volumetric diameters (MOVD) and their geometric standard deviations have been obtained. The inlet has a higher mean diameter than the outlet, which is as expected as the collector is most efficient for large particles. Thus the outlet size distribution will be concentrated towards the finer particle sizes.

An indication of the collector's preferential removal is shown in the collector efficiency curve, Figure 6. This curve is from direct channel to channel comparison of the inlet and outlet counts. The curve shows that for the smallest size range, 0.5 to 1.5 μm, the average removal efficiency is below 50%. However, beyond 1.5 μm the efficiency reaches 84% for 1.5 to 3.0 μm and >95% for subsequent sizes.

Through the volume analysis a volumetric removal efficiency of 82% was obtained for the collector. This compares favourably with that from gravimetric analysis, namely 84%.

DISCUSSION

It is clear that the Precipitaire underground wet type dust collector has a good dust collection efficiency, about 85 to 95% for respirable sized mineral dust. There are some difficulties in the dust measurements which lead to uncertainties in the estimation of filter efficiency:

1. the high air velocity, 22 m/sec, at the dust collector intake sampling station may have led to sampling errors.
2. the low weight of dust on the filters at the dust collector outlet sampling station leads to errors.
3. the unusually fine size of the quartz dust on the outlet sampling station filters may have led to an underestimate of the respirable quartz dust concentration by X-ray diffraction.

The mine has found very high konimeter counts, up to 1000 ppcc, in the direct exhaust of the wet dust collector. However, the optical particle counter, in close proximity to the exhaust and sampling discharged air, only monitored peak concentrations up to 300 ppcc. The counter also gave a shift time-weighted average of 68 ppcc on the heaviest dumping day of the three monitored.

Previous sampling by mine personnel would also indicate that high exhaust concentration does not persist far beyond the discharge room. Routine sampling, 60 m down wind of the collector, shows the outlet concentration to have decayed substantially. In the two years prior to this investigation only 2 out of 12 measurements exceeded the 'fresh air limit' of 50 ppcc and these are reported to have been when the collector was non-operative.

ACKNOWLEDGEMENTS

The authors wish to thank the mine staff for permission to test the dust collector and for their assistance.

REFERENCES

1. Knight, G., "Mine dust sampling system - CAMPEDS"; CANMET Report 78-7; CANMET, Energy, Mines and Resources Canada; 1978.

2. Knight, G., "A four litre per minute size selective personal dust sampler"; Report in preparation.

3. Knight, G., "A thirty litre per minute size selective sampler for assessment of long-lived radionuclides"; Report in preparation.