COMPARISON OF DIFFERENT VERSIONS OF ASTM 1739 FOR THE MEASUREMENT OF DUST DEPOSITION IN THE SOUTH AFRICAN MINING SECTORS

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Abstract

Coarse dust particles (larger than 10 micron) are produced in the mining sector by terrain clearing, drilling, blasting tipping and loading, as well as by the movement of vehicles on unpaved roads. Fallout dust monitoring offers an economical method for determining nuisance due to this dust generation and can act as an indicator for more sophisticated and expensive monitoring methods for health impact.

The standard method for quantifying dust fallout in South Africa has for many years been ASTM 1739 and time series exist at many mines for results obtained by ASTM 1739-82, which does not have a wind shield around the opening of the bucket. SANS 1929 – 2004 does however refer to ASTM 1739-98, which has a wind shield. Most mines and monitoring contractors have however continued the use of ASTM 1739-82. In addition, some contractors have developed “directional” dust gauges in which various techniques are used to apportion measured dustfall to sources inside and outside a specific area. In most cases, the directional gauges have lids or other mechanical devices, which have the potential to influence the flow pattern around the top of the bucket.

This research reports on systematic measurements to compare results obtained with the two versions of ASTM 1739 at a gold mine and an opencast coal mine, in each case in a high dustfall and a low dustfall location. The effect of addition of water to the bucket at the beginning of the sampling period, which was part of ASTM 1739-82 but was deleted from ASTM 1739-98 was also investigated.

Keywords: dust deposition, dust fallout

1. Introduction

The measurement of the vertical flux of dust, or dust fallout has traditionally been used as an indicator of the nuisance caused by coarse suspended particulate matter. A number of countries have produced standards for allowable dust fallout rates (Vallack and Shillito 1998). Although alternative fallout measurement method have been proposed, ASTM: 1739 has remained the method most frequently used in the South African mining and industrial sectors to measure dust deposition. The Department of Environmental Affairs has not yet promulgated dust fallout standards but SANS 1929-2005 (Standards South Africa 2005) prescribes the use of ASTM 1739-98 to measurement dust deposition. The method uses a simple non-directional bucket of at least 150 mm diameter and at least twice as deep as the diameter with the top of the bucket at 2 m above ground level. A wind shield at the same level as the lip of the bucket is included. Samples are exposed for 30 ± 3 days, and results reported as a dustfall rate in units [mg m^{-2} d^{-1}], 30-day average.

Previous versions of ASTM 1739 (ASTM 1739-70, ASTM 1739-82) did not prescribe the wind shield and this version is still widely used in

South Africa. This version also allows for introduction of water into the bucket at the beginning of the sampling period (which is not mentioned in the later versions) to improve retention of collected dust. Research by Kohler and Fleck (1966) indicated that turbulence over the top lip of the bucket interferes with deposition into the container, so that at high wind speeds the deposition efficiency is reduced substantially. The addition of a wind shield is intended to deflect wind away from the lip of the container, allowing for a more laminar flow across the top of the collecting container. The version of the standard cited by SANS 1929 (ASTM 1739-98, confirmed 2004) therefore introduced a wind shield around the top edge of the bucket (see figure 1 below). However, the numerical dust fallout values proposed in SANS 1929-2005 and presumably based on the 1982 version remained unchanged when the 1998 version was introduced.

Figure 1: ASTM 1739-98 installation.

A number of “directional” bucket type gauges, using multiple vertical buckets with arrangements for different buckets to be exposed according to wind direction have also been introduced; the effect of flow modification over the buckets due to these arrangements is not well understood and the results obtained, although indicative of source directions can not be used for compliance purposes.

This paper reports on parallel measurements carried out with and without windshield and also with and without the use of water at the start of the monitoring period. This is part of an ongoing investigation which includes a comparison of the results reported here with the results obtained from simultaneous measurements of horizontal dust flux using the traditional British Standards Institution BS 1747 gauge (BSI,1972), (figure 2)] with four vertical slits facing the principal wind direction.

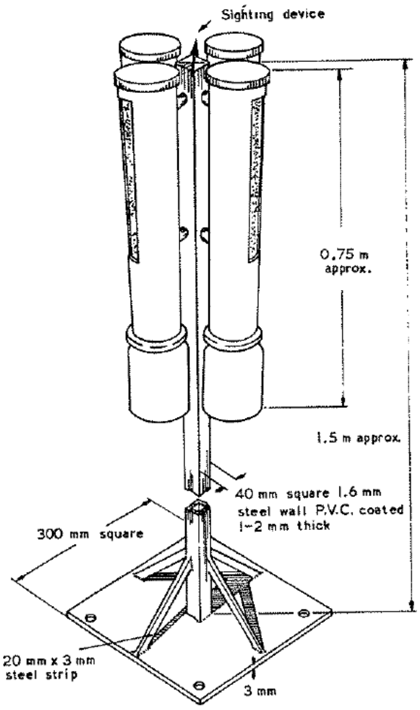

Figure 2. BS 1747 dust deposition gauge

This directional dust deposition gauge was developed in the United Kingdom. From 1974 to 1976, this gauge was selected by the South African power generation company Eskom for their first insulators pollution survey in South Africa. Although some aspects of its performance has been criticized (Ralph and Hall 1989) the performance of the proprietary directional fallout gauges by which it has largely been replaced in South Africa does not seem to have been formally tested.

2. Experimental

Dust deposition values were determined over a period of 10 months on mining sites in the gold mine sector on the western Witwatersrand and 11 months in the coal mine sector (opencast mining on the central Highveld) (Measurements will be continued to collect a full year’s data in each case). Although attempts were made to select “high” and “low” deposition rate sites in each of the sectors, results indicated that most results in the gold mining sector for both types of site were lower than results on the coal mining site selected. In the case of the gold mining sector, the “low” site did not strictly conform to the requirements of the standard in terms of the presence of vertical structures within 20 m of the dustfall gauge but was nevertheless selected for security purposes. The gold mining "high" site was adjacent to a slimes disposal facility.

At each of the four sites (gold "high", gold "low", coal "high" and coal "low") four gauges were set up using the conditions prescribed in the respective standards (ASTM 1739-82, ASTM 1739-98, BS 1747 Part 5) with the exception that water was added to one of the ASTM 1739-98 buckets at the start of the sampling period. The water volume was calculated to allow for evaporation during sampling; Copper in the form of copper sulphate was added at 4 ppm to the water to inhibit the growth of algae. Buckets were purpose-made from UV-resistant PVC to prevent deterioration and to ensure the correct depth to height ratio.

One of the sites is shown in figure 3.

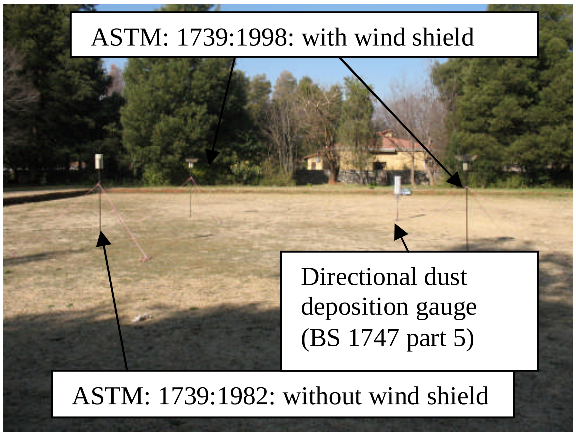

Figure 3. One of the test sites, with three types of dust monitoring equipment set up.

All samples were collected over the prescribed 28 to 33 day period and treated in the laboratory as prescribed in the standards. Dust fallout results were calculated as 30-day average dustfall rate in units [mg/m^2-day] based on the dust mass collected, the cross-sectional area of the bucket and the sampling period.

3. Results

3.1 Effect of wind shield.

Results ranged as follows

Table 1: Range of results (mg/m^2-day)

	ASTM 1739-98	ASTM 1739-82
Gold	33-212	18-287
Coal	207-2996	146-1418

The results for ASTM 1739-82 (without wind shield), for which the evaluation scale proposed by SANS 1929:2004 was set up, do not extend to the "alert" value of 2400 mg/m^2-day, but a number of values are in the "action" range and the data set is therefore fairly representative of what would be found in residential and commercial areas.

Comparison of the ASTM 1739-82 (without wind shield) and ASTM 1739-98 (with wind shield) values for the two sectors is done in figures 4 and 5, with the assumption of linear correlation and forcing of the regression line through the origin. The statistical and plotting tools of the Microsoft Excel package were used.

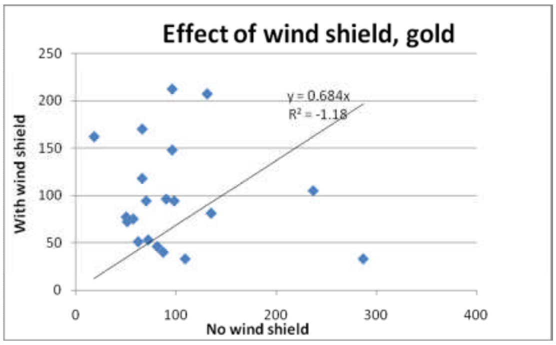

Figure 4: Effect of wind shield, gold sector

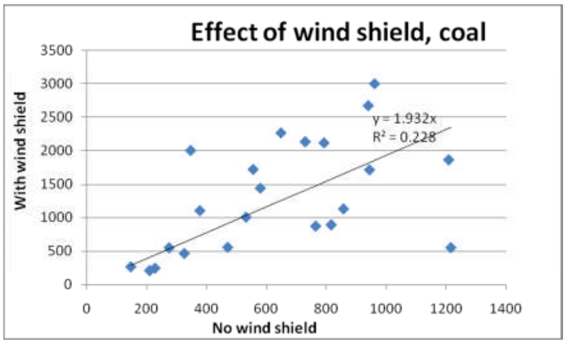

Figure 5: Effect of wind shield, coal sector

It will be noted that the correlation coefficients are low and that the slope of the line for the gold sector results would have been negative if the line had not been forced through the origin. In this sector, the results with the wind shield are lower than those without the wind shield. The standard deviation of the method seems to be fairly high, and for the low values in the gold sector the difference between the measurement methods is overwhelmed by the variability in the method itself. When all the results are combined, the correlation coefficient improves as shown in figure 6 below.

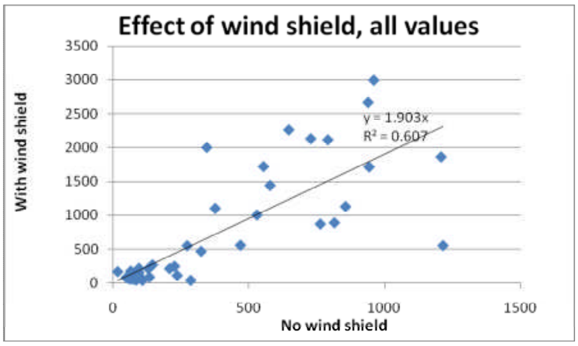

Figure 6: Effect of wind shield, both sectors

3.2 Effect of water addition

Results are given in the same format for the sectors and for the combined values in figures 7 to 9 below. The results were obtained with the ASTM 1739-98 version (with wind shield)

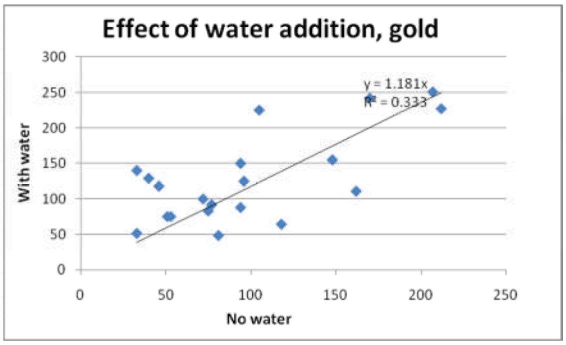

Figure 7: Effect of water addition, gold sector

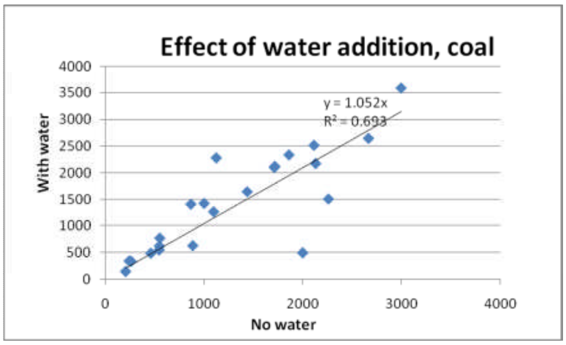

Figure 8: Effect of water addition. coal sector

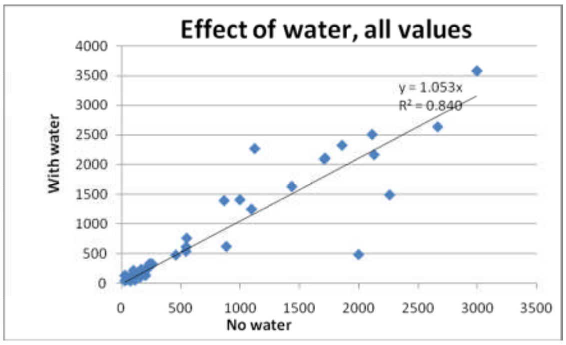

Figure 9: Effect of water addition, combined values.

4. Conclusions

There is evidence that the intent of the introduction of the wind shield viz. to reduce turbulence around the lip of the container and thereby improve capture and retention of coarse particulate matter has been met. Although further statistical analysis is required, preliminary indications are that deposition values obtained under the same conditions in the range where noticable nuisance impact may be expected are on average 90% higher when the wind shield is introduced, at least for the range of values for which some action is required in SANS 1929 - 2005.

Although there is some evidence that the addition of water improves retention of the dust and therefore leads to somewhat higher values, this evidence remains to be tested for statistical significance and the effect is probably small when compared with the inherent variability of the method.

It is therefore recommended that the latest (2004) version of ASTM 1739 (with wind shield and without the introduction of water during the monitoring period) be retained as the measurement standard for dust in South Africa. The boundaries between the evaluation bands, as well as the “action” and “alert” thresholds proposed in SANS 1929 (2005) and widely used in South Africa will then have to be re-evaluated.

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