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COPPER EMISSIONS FROM A HIGH-VOLUME AIR SAMPLER

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ABSTRACT

Many high volume air samplers (hi vols) utilize a brush-type electric motor to power the fans used for pulling air through the filter. Anomalously high copper values have been attributed to removal of copper from the commutator into the air stream due to arcing of the brushes and recirculation through the filter. Duplicate hi vols were set up in this study under three operating conditions: (1) unmodified; (2) gasketed to prevent internal recirculation; and (3) gasketed and provided with a pipe to transport the motor exhaust some 20 feet away. The results of 5 days' operation demonstrate that hi vols can suddenly start emitting increased amounts of copper with no discernible operational indication, and that recirculation and capture on the filter can take place. Copper levels found with hi vols whose exhaust was discharged at a distance downwind were among the lowest found, and apparently provides a satisfactory solution to copper contamination.

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SUMMARY

Many high volume air samplers (hi vols) utilize a brush-type electric motor to power the fans used for pulling air through the filter. Anomalously high copper values have been attributed to removal of copper from the commutator into the air stream due to arcing of the brushes and recirculation through the filter. Duplicate hi vols were set up in this study under three operating conditions: (1) unmodified; (2) gasketed to prevent internal recirculation; and (3) gasketed and provided with a pipe to transport the motor exhaust some 20 feet away. The results of 5 days' operation demonstrate that hi vols can suddenly start emitting increased amounts of copper with no discernible operational indication, and that recirculation and capture on the filter can take place. Copper levels found with hi vols whose exhaust was discharged at a distance downwind were among the lowest found, and apparently provides a satisfactory solution to copper contamination.

INTRODUCTION

A number of investigators (refs. 1 and 2) have reported anomalously high values for copper in the suspended particulate matter in the ambient air using samples collected with high volume air samples (hi vols) and have attributed them to various pollution sources. Hoffman and Duce (ref. 1) have suggested that arcing at the brush-commutator interface may cause copper to be entrained in the air stream passing through the hi vol motor

and subsequently exhausted to the immediate vicinity of the hi vol. It can then be recirculated through the hi vol, depositing the entrained copper on the filter. Since the use of hi vols with brush-type motors is well established for both total suspended particulates (TSP) and trace element determinations, it is important to determine if the hi vol itself is a copper source.

Experimental

Six hi vols were positioned north to south on a roof about 20 feet (6 m) above ground on the western edge of a building. They were divided into 3 groups about 50 feet (15 m) apart; the 2 hi vols in each group were similarly oriented and were about 8 feet (2.5 m) apart. The centrally located hi vols were unmodified as supplied by the manufacturer except that variable voltage transformers had been added to control air flow rate. The northerly positioned set had gaskets attached under the supporting edge of the funnel to prevent the exhaust from the motor from being transported vertically within the hi vol case into the air stream that passes through the filter. The exhaust from these hi vol motors was thus expelled to the air surrounding the hi vol and if it were to pass through the filter would have to travel external to the hi vol case. The southerly positioned set was also similarly gasketed but in addition had 20 feet (6 m) long 4" (10 cm) stove pipes attached to the exhaust end of the motor to carry the exhaust away to the east from the immediate vicinity of the hi vol (fig. 1). In addition, the possibility of contribution of copper by the hi vol was materially reduced since the wind blew from the west (ref. 3) on the five test days.

Particulate matter was collected upon 8" x 10" Whatman No. 41 filter medium using filter holder cassettes (ref. 4). The hi vol was operated at an initial flow rate of about 40 cubic feet per minute (0.02 m^3/sec) as described by Neustadter, et al (ref. 5). Each run was for 24 hours. Concentrations of copper and calcium on the filter were measured on a piece of the filter and determined by energy dispersive X-ray fluorescence analysis using a tungsten target X-ray tube at 60 kV and 10 milliamp current for excitation with a cadmium filter and a Si(Li) detector (ref. 6). Analytical precision for copper was ±10% and for calcium ±20%. Analyses were performed by Dr. David Liu of this laboratory.

RESULTS AND DISCUSSION

The concentrations of copper and calcium found at each of the sampling locations for the five test days are shown in Table I. Individual daily values for each hi vol sample are shown. The significant difference between the values for the unmodified set of hi vols and the values for the other hi vols should be noted. The copper levels for the gasketed and piped exhaust set of hi vols are quite low and reasonably consistent ranging from a minimum of <6.9 ng/m^3 to a maximum of 50.5 ng/m^3 for an average of about 23.6 ng/m^3. The gasketed-only set of hi vols exhibit somewhat higher copper values and are reasonably consistent on a daily basis except for one day (09/30/74). The values ranged from a minimum of 32.8 ng/m^3 to a maximum of 120 ng/m^3 for an average of 77.0 ng/m^3. In contrast to these two sets, the unmodified set of hi vols shows highly divergent values after the first day's run, the copper level of hi vol No. 1 of this set suddenly increasing. Apparently this hi vol started emitting larger amounts of copper, probably due to

increased arcing of the brushes and commutator.

The somewhat higher values of the gasketed set of hi vols could be due to higher hi vol production of copper or to a higher ambient level due to variability in TSP collected. However, comparison of the concentrations of calcium on the same filters indicates that the level of an element not associated with the brush-commutator phenomenon was about the same for all filters on a given day. This is shown specifically in Table II where the means (μ) and then standard deviation (σ) are tabulated for copper and calcium. These values were calculated using the values for all the hi vols (5 values) except that for "Unmodified Hi Vol No. 1." The data indicates that the daily values of "Unmodified Hi Vol No. 1" for copper are far outside two standard deviations from the mean, while those for calcium are well within this range. Thus, it is reasonable to assume that the copper concentration in the ambient TSP was the same for all 6 hi vols on any given day, and it is evident that the variable copper noted in unmodified hi vol No. 1 came from the hi vol motor. The scope of the experiment, however, does not permit determining unequivocally to what extent the modifications may have reduced the copper on the filter to true ambient levels.

The copper levels found are somewhat below the value of 72 ng/m^3 we previously found for suburban locations (ref. 7) -- our test site, however, is better described as rural rather than suburban. Although the brushes in the hi vols we used were not new, they had run only a few hours and should have been well seated. There was nothing in the hi vol operation to indicate that any were running abnormally, although the data suggests that at least one of them suddenly changed its copper emission rate. The low values of the other hi vol in the unmodified set indicated that hi vols can run with

low copper emission. Visual observation of the arcing of the brushes for these two motors was not rewarding - they both arced about the same. It appears then that if one wishes to make a reliable determination of the copper content of the total suspended particulate in ambient air, the exhaust from the hi vol motor should be discharged at a distance preferably downwind from the hi vol.

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TABLE I. - COPPER AND CALCIUM LEVELS, ng/m^3

Date		Piped and Gasketed Hi Vol			Gasketed Hi Vol			Unmodified Hi Vol		
		1	2	Ave	1	2	Ave	1	2	Ave
9/25	Cu	26.5	22.7	24.6	67.5	82.0	74.8	17.0	21.2	19.1
	Ca	2830	2740	2785	2580	2720	2650	<291*	2350	<1320
9/26	Cu	37.2	24.6	30.8	120	106	113	518	65.0	
		3460	2600	3030	3280	2960	3170	2600	2890	2745
9/30	Cu	24.6	<8.0*	<16.4	48.5	106	72.2	378	24.0	
	Ca	1850	1620	1735	1480	2200	1840	1320	1510	1415
10/1	Cu	14.5	<6.9*	<10.7	32.8	37.2	35.3	368	20.8	
	Ca	1070	700	885	575	775	675	788	544	666
10/3	Cu	50.5	19.0	35.3	74.4	105	89.5	584	57.4	
	Ca	1930	1500	1715	1970	1630	1800	1750	1670	1710

*Below detection limit

TABLE II. - STATISTICAL COMPARISON OF COPPER AND CALCIUM VALUES

Date		Mean (μ)	Standard Deviation σ	Unmodified Hi Vol No. 1	$\mu + 2\sigma$	$\mu - 2\sigma$
9/25	Cu	44	29	17	102	0
	Ca	2644	187	<291	3018	2270
9/26	Cu	71	42	518	155	0
	Ca	3038	338	2600	3714	2362
9/30	Cu	42	38	378	118	0
	Ca	1732	299	1320	2330	1134
10/1	Cu	23	13	368	49	0
	Ca	733	210	788	1152	313
10/3	Cu	61	32	584	125	0
	Ca	1740	202	1750	2144	1336

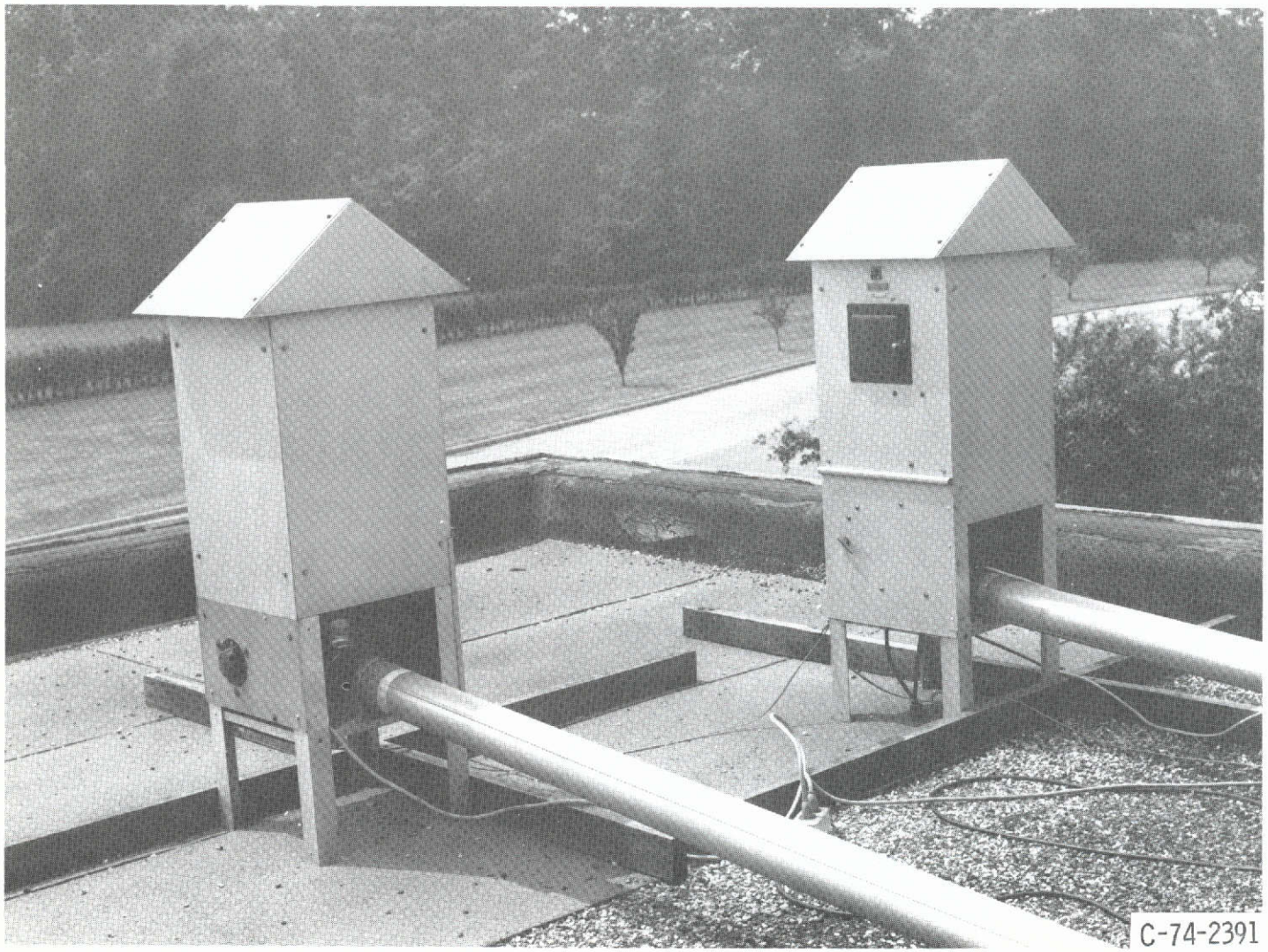

Figure 1. - Piped and gasketed hi-vol sampler.