

COMPARISON BETWEEN THE IOM SAMPLER AND TRADITIONAL METHODS DURING FLOOD DRILLING OF A390

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ABSTRACT

New technology is constantly being tested against standard methods. The 37 MM and the cyclone sampler, as defined by the National Institute of Safety and Health (NIOSH) methods 0500 and 0600, are the standards for measuring total and respirable particulates, respectively. Since the development of the IOM sampler, comparisons have been made as to which best estimates the inhalable aerosol portion. The IOM sampler now includes multidust foam discs allowing sampling for both the inhalable and respirable particulates. The inhalable and respirable particulate as measured by the IOM sampler were compared to aerosol captured by the 37 MM and the cyclone sampler during a blind hole drilling of a hypereutectic caste alloy of aluminum silicate called A390. Flood lubricating machining is the method used primarily in the manufacturing industries and therefore was used at the time of sampling. The IOM sampler under sampled for respirable particulate, as compared to the cyclone sampler, by a ratio of 0.59 during the flooding process. A series of tests were performed and the cyclone/IOM sampler ratio variation was quite small and suggests that a correction factor may become available with further studies. No statistical difference was found when comparing the results of the cyclone sampler to the IOM sampler. Conversely, the results between the 37 MM total particulate and the IOM inhalable particulate were highly variable, which makes the development of a correction factor difficult.

INTRODUCTION

Many studies have been done that compare the aerosol sampled by the 37 MM and the IOM sampler. Previous research concludes that both samplers may experience sampling error that misestimates the aerosol exposure experienced by workers.

The IOM sampler may experience sampling inaccuracy due to over sampling, projectile sampling, water absorption, and handling contamination. Studies have found that the IOM sampler over samples particles larger than 20 microns (Li, 2000). In addition, due to its large inlet, the IOM sampler can become prone to projectile sampling of aerosol that isn't normally aspirated by humans (Demange, 2002). Another consideration regarding the IOM sampler is that the plastic and aluminum bodies may absorb as much as 1-2 mg of water over the course of a few days (Smith, 1998). Laboratories may use a desiccation process to eliminate this excess

water, but researchers found that it “did not approach a stable mass” (Smith, 1998). IOM sampler consistency may increasingly suffer if laboratories have processes that differ in handling techniques and desiccation times. IOM sampler contamination may also occur due to filter exposure to the environment during handling (Demange, 2002). This contamination can still occur even when white gloves are used.

By comparison research indicates that the 37 MM underestimates the inhalable aerosol (Li, 2000; Marks, 1994; Tsai, 1995). One study argues that the 37 MM experiences particle loss due to inefficient sampling of larger sized particles and to particles that bounce off the filter (Li, 2000). The 37 MM may also experience weight loss during transportation and handling (Demange, 2002).

Much research and many modifications have been made to overcome each sampler’s weaknesses. Other research has been directed at developing estimates that will allow data from the two samplers to be comparable. Some theories include possible correction factors and others suggest different filter analysis. When comparing both samplers, researchers have found that the IOM sampler/37 MM ratios to be as high as 3:1 (Smith, 1998; Clinkenbeard, 2002). Some studies point out that a IOM/37 MM correction factor could work (Kerr, 2002). Other studies contradict this, stating that a correction factor would not be advisable because the IOM has a greater efficiency in sampling coarse aerosol as well as variability of aerosol deposition on 37 MM sampler cassettes (Demange, 2002). Another research direction has focused on modifying the analysis method to which the 37 MM is subjected. The present NIOSH 0500 method analyzes the mixed cellulose ester (MCE) filter only without accounting for the particle deposition of the cowl due to electrostatic charges, shape of the sampler, and particle transport (Demange, 2002; NIOSH, 1994). One study has found that when the filter and the cowl of the 37 MM are analyzed together there is no statistical difference between the 37 MM and the IOM sampler (Demange, 2002).

This research further compares traditional IOM sampler/37 MM findings with the new IOM sampler multidust foam disc. The multidust foam disc collects both the inhalable and the respirable fraction, thus allowing comparisons between it and the 37 MM (total dust) and the cyclone sampler (respirable dust). The material used in this study was a hypereutectic alloy of aluminum and silicon called A390. Its main constituents are aluminum (Al, 75.25-78.45%), silicon (Si, 16-18%), and copper (Cu, 4-6%). It also contains relatively small amounts of iron (Fe, 0.5%), titanium (Ti, (0.2%), magnesium (Mn, 0.1%), zinc (Zn, 0.1%), and manganese (Mg, 0.45-0.65%) (Boyer, 1985). A390 was used in this study because of its increased use in the automotive industry. The drilling was performed during wet machining processes. Metal working fluids (MWF) were administered at a rate of five liters per minute to mimic industry processes.

METHODS AND MATERIALS

The drilling was performed using a Haas VF-E CNC vertical machining center (15 hp 7500 rpm) in a blind-hole drilling operation. Each test drilled 54 holes varying depth, speed, and feed. Triplicates of each sampler were placed inside the Haas VF-E CNC vertical machining center envelope. A guard was placed between the drill work piece interface and the samplers to avoid splash contamination. Table 1 shows the sampling cassettes, analysis methods, flow rates, and

the particulate tested in each test configuration. Figure 1 shows the trial configuration. Table 2 describes the test configuration for each trial.

Table 1. Sampler Analytical Information

*Sampler Type	NIOSH Method	Flow Rates	Particulate Tested
37 MM (MCE)	0500	1.5	Total
Cyclone Sampler (CS)	0600/7500	2.5	Respirable
IOM Sampler (IOM)	Modified 0500/0600	2	Inhalable/Respirable

* The designations in parenthesis will be used instead of the full sampler names in subsequent charts.

Figure 1. Picture of Trial Configuration



Table 2. Test Configurations for Each Trial

Machining Type	Oil flow rate	Samplers Used in Triplicate	Session Length
Synthetic Oil Flooding	5 Lpm	MCE, CS, IOM	60 minutes

RESULTS

Table 3 presents the time weighted average (TWA) of the triplicate samples taken during the testing period.

Table 4 compares the mean values of the TWA results of the cyclone and 37 MM sampler to the IOM sampler. Ratios of IOM inhalable to 37 MM total, IOM inhalable to IOM respirable, 37 MM total to cyclone respirable, and IOM respirable to cyclone respirable are presented.

Table 3. Air Sampling Results

Machining Type	IOM Inhalable	IOM Respirable	37 MM	Cyclone
Synthetic Flood	9.95 mg/m ³	0.13 mg/m ³	0.44 mg/m ³	0.22 mg/m ³

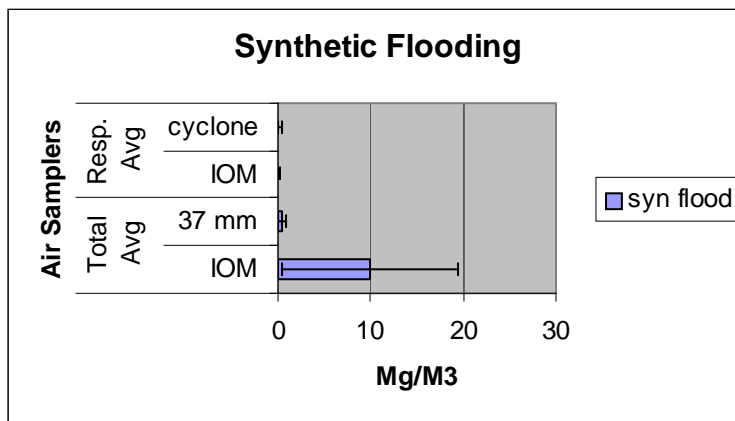
Table 4. Ratios of Air Sampling Results

Machining Type	IOM Inhalable/ 37 MM	IOM Inhalable/ IOM Respirable	37 MM/ Cyclone	IOM Respirable/ Cyclone
Synthetic Flood	22.6	76.5	2	0.59

The IOM respirable sampler undersampled as compared to the cyclone sampler by a ratio of 0.59. T-tests of unequal variance found no statistical difference between the two samplers at a 0.05 level.

Comparing the 37 MM and the IOM sampler, the t-test of unequal variances found them statistically different at the 0.0001 level. When trying to fit a line of least squares regression, there was no correction factor available to overcome the large variation in ratio (17 to 27). There was a large difference in average means between the 37 MM and IOM samplers (0.44 and 9.95 respectively). Figure 2 emphasizes the differences between the IOM sampler and the 37 MM.

Figure 2. Chart of Sampler Results during Synthetic Flooding



DISCUSSION

The IOM sampler with the multidust foam disc closely approximates the respirable portion as sampled by the cyclone sampler. Other tests done in conjunction with the flooding process

showed that the IOM sampler consistently undersampled the cyclone sampler and that IOM/cyclone ratios were quite tight. This suggests that a possible correction factor could be developed with increased research. The undersampling of the respirable particulate may be explained in part by the loading effect experienced by size selective polyurethane foam discs (Kenny, 2001). As the foam disc becomes saturated with particulate the D₅₀ value of the respirable particulate collected decreases. Contamination and subsequent erroneous sampling results may occur if there is contact between the foam disc and the filter, causing particulate shift between the two media.

In comparing the IOM sampler inhalable particulate to the 37 MM total particulate it becomes more difficult to explain the large variation found. As previously mentioned, both samplers are prone to weaknesses that may skew both the accuracy and the comparability between the two samplers. IOM distributors suggested that fugitive dust on the outside of the cassette may skew the analysis and that it should be wiped clean before opening the IOM sampler housing unit. During the flooding process, it is possible that there was projection sampling, although no large variation was found between the triplicate samples taken. DataChem[®] laboratories analyzed all of the air samples and found that the IOM mass stability during analysis was difficult to maintain.

CONCLUSIONS

The IOM sampler with the multidust foam disc was designed to collect both the inhalable and respirable mass fraction. This study found difficulty in comparing IOM inhalable data with traditional 37 MM sampling for metal cutting operations. Major issues that plague the 37 MM include its inefficiency to collect coarser particles and an analysis method that doesn't include particles collected on the cowl. Resolution of these two issues may allow greater comparability between the IOM sampler and the 37 MM. The IOM sampler is prone to contamination that may affect both the inhalable and respirable mass fraction. Despite the results differences found between the IOM and the cyclone sampler, a corrective factor may be found that can make the samplers comparable.

RECOMMENDATIONS

Further studies need to be done comparing the IOM sampler with the new multifoam disc to traditional methods of estimating the total and respirable particulate e.g. cyclone sampler and 37 MM. Possible research areas include studies done with modified sampler body design or laboratory analysis for either sampler in hopes of making them less prone to sampling inefficiency and establishing greater comparability.

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