Control of Abrasive Blasting Emissions through Improved Materials

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ABSTRACT

Abrasive blasting is widely used to clean and prepare metallic target materials. Particulate matter emissions from traditionally used abrasive materials (such as silica sand and coal slag) have long attracted the attention of regulatory agencies. This paper describes a field test program that compares particulate emissions from new Sponge Media with that from traditional abrasives. Sponge Media consists of polyurethane sponge material that has been impregnated with an abrasive material. The pliable nature of the sponge material allows it to surround the point of abrasive impact, thus forming a "microcontainment" to capture dust and airborne emissions. The sponge also increases worker safety by dramatically reducing ricochet of the abrasive particles.

The current test program compared particulate matter emissions from Sponge Media with emission data for abrasive material that form the basis for AP-42 Section 13.2.6. To the extent practical, testing mimicked the prior program to enable direct comparison with the AP-42 emission factors. Testing employed "exposure profiling" which has been recognized as the technique most appropriate to characterize the broad class of open anthropogenic particulate sources. Because the exposure profiling method isolates a single emission source, the open source emission factors with the highest quality ratings in AP-42 are typically based on this approach. The program found that Sponge Media produces up to two orders of magnitude less total particulate and PM-10 emissions than traditionally used abrasives.

INTRODUCTION

Abrasive blasting is widely used to clean and prepare metallic target materials. Particulate matter (PM) emissions from traditionally used abrasive materials (such as silica sand and coal slag) have long attracted the attention of regulatory agencies. During the 1990s, the U.S. Environmental Protection Agency (EPA) (a) developed particulate emission factors for abrasive blasting with silica sand and (b) incorporated the results in its *Compilation of Air Pollutant Emission Factors*[1] (commonly known as "AP-42").

This paper describes a Midwest Research Institute (MRI) program that compared dust emissions fro- blasting with foam-based media against traditionally used abrasive. Sponge-Jet Sponge Media is a composite of conventional abrasives and a sponge-like polyurethane foam. The most common combination of abrasive material and size sold in Sponge Media is a 30 grit aluminum oxide (known as "Silver 30").

The test program relied on "exposure profiling" which has been recognized by EPA as the technique most appropriate to characterize the broad class of open anthropogenic PM sources. Because the method isolates a single emission source, the open source emission factors with the highest quality ratings in AP-42 are typically based on this approach.

BODY

Methodology

A 1993 EPA test program[2] employed a low-speed wind tunnel to develop the silica sand emission factors. The current testing program similarly enclosed the blasting operations for testing purposes.

However, because the enclosure was sheltered from weather, it did not need to be as well constructed (e.g., marine grade plywood) as in the EPA test program. Two 20-ft portable carports formed the main part of the enclosure. Polyethylene sheeting was draped over the carports and a final section was constructed of OSB (oriented strand board). Figure 1 shows a schematic of the test enclosure.

The tested operation removed paint from automobile hoods (as in the 1993 EPA tests). The hoods were placed on a 4-ft by 10-ft steel sheet to protect the concrete floor. The main blasting equipment was positioned outside the tunnel with the hoses fed into the tunnel. The enclosure allows one to control conditions from one test to another; this aids in comparing results across different abrasive media. An axial "poultry-type" fan (rated at 22,000 cfm "free air") drew air through the enclosure and exhausted out through an overhead doorway.

The air sampling device is a standard high-volume air sampler fitted with a cyclone preseparator (Figure 2). When operated at a flow rate of 40 acfm, the cyclone preseparator exhibits a $D_{50\%}$ cutpoint of approximately 10 μmA^3. In this way, a PM-10 (particulate matter no greater than 10 microns in aerodynamic diameter) sample is collected on a tare-weighed 8-in by 10-in glass fiber filter. The cyclone also collects coarse material for comparison to the PM emission factors in AP-42 Section 13.2.6.

MRI positioned the cyclone inlet at the center of the measurement plane indicated in Figure 1. Prior to the start of testing, MRI characterized the airflow at the inlet position (with the sampler in place) with a hand-held contact anemometer.

Exposure profiling relies on a conservation of mass approach to calculate measurement-based emission rates and emission factors. For open sources, the passage of airborne particulate (i.e., the quantity of emissions per unit of source activity) is obtained by integration of distributed measurements of exposure (mass/area) over the effective cross section of the plume. Additional details involving methodology, data reduction and quality assurance are presented in the test report.[4]

Results and Discussion

Table 1 lists the parameters associated with each test run. Tests are identified with a run number of the form

M – U – Z

where M identifies the abrasive type as show below, U indicates how many times the material has been used before (i.e., "0" indicates "virgin" material and Z is used to distinguish between different tests of the same material. The material code M is as follows

Code	Abrasive Media
1	Silver 30
2	Silver 16
3	Coal slag
4	Silica sand

Sponge-Jet recommends the addition of fresh virgin material to recycled media. Test 1.9.X evaluated a mixture of 83% Silver 30 recycled after 9 previous uses mixed with 17% of virgin Silver 30. Other tests of recycled Silver 30 did not involve the addition of fresh material. Table 2 lists the test results from the runs.

Table 3 compares the silica sand emission factors and emission rates values obtained from this study to both those developed in the 1993 EPA test program and those presented in AP-42 Section 13.2.6. In order to facilitate comparisons with the silica sand results from this study, the table includes

only data involving removal of paint from auto hoods. The silica sand data in this study are comparable to the earlier EPA results, with all comparisons within a factor of three. (Most comparisons are much closer.) In four pairwise comparisons of emission factors/rates for the two size ranges, only the total particulate (TP) emission factors differ significantly between the present study and the 1993 program. Note that the TP results from the present study are expected to be somewhat greater because the earlier study employed a longer wind tunnel. In other words, the current program provides less opportunity for TP emissions to settle out before reaching the measurement plane than was the case in the 1993 program.

Table 4 presents the percent reduction observed in average emission factors for Sponge Media as compared to that for virgin silica sand and coal slag. Note that recycled Sponge Media mixed with fresh material reduces TP emissions by 94% and PM-10 emissions by 96%. In other words, when used as recommended (i.e., recycled with fresh material added), Sponge Media provides a control level essentially identical to the 95% value commonly assigned to fabric filtration. Table 5 shows similar comparisons between Sponge Media and traditional abrasives except that percent reductions are based on average emission rates measured during the present study.

CONCLUSIONS

The testing program described in this paper shows that foam-based blasting media provides up to two orders of magnitude less total particulate and PM-10 emissions than traditionally used abrasives. This level of control is essentially identical to values assumed for fabric filtration.

MRI is currently planning a second field testing program to further evaluate the emission characteristics of foam-based abrasive media. The second study will address issues such as finer particle size resolution and metal emissions.

REFERENCES

1 USEPA. Compilation of Air Pollutant Emission Factors, AP-42. Fifth Edition, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC, January 1995.

2 Kinsey, J.S. “Development of Particulate Emission Factors for Uncontrolled Abrasive Blasting Operations”; prepared for U. S. Environmental Protection Agency by Midwest Research Institute, Kansas City, MO 64110, 1993.

3 Baxter, T.E., et al. “Calibration of a Cyclone for Monitoring Inhalable Particulates,” Journal of Environmental Engineering, 1986, 112(3), 468-478.

4 Muleski, G.E. “Emission Characterization of Foam-based Abrasive Blasting Media”; prepared for Sponge-Jet, Inc. by Midwest Research Institute, Kansas City, MO 64110, 2006.

KEY WORDS

Abrasive Blasting
PM-10
Exposure Profiling
Sponge Media

Figure 1. Schematic of the test enclosure

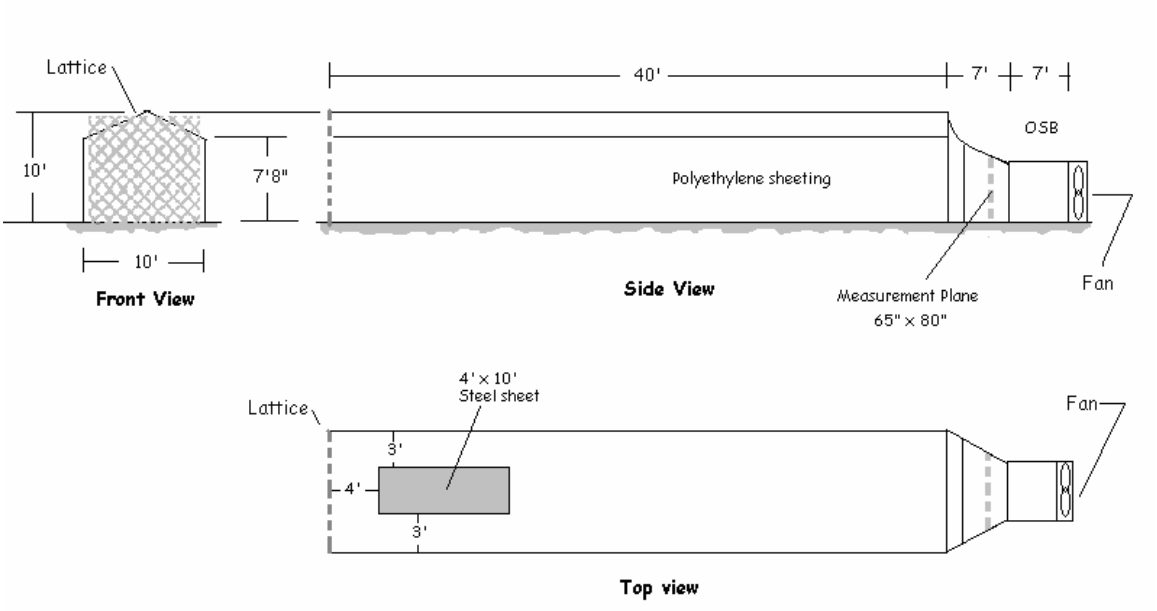

Figure 2. Cyclone preseparator

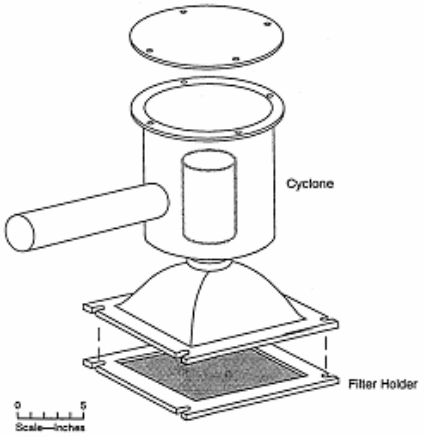

Table 1. Test parameters

Run	Date	Media	Area cleaned (ft^2)	Air sampling duration[a] (min)	Total time[a] (min) with active blasting	Cleaning rate (ft^2/min)	Ambient air temp (F)	Baro. pressure (in Hg)	Back plate pressure (in water)	Flow rate (acfm)	Intake vel. (fpm)	Raw concentration ($\mu g/m^3$)	
												TP	PM-10
1.0.1	09.26.05	Silver 30 Virgin	13.8	39.75	16.25	0.85	70	29.7	3.00	42.64	946	1560	262
1.0.2			26.2	18.00	11.50	2.28	70	29.7	3.00	42.64	946	10500	998
1.0.3			16.7	18.00	10.00	1.67	72	29.7	3.00	42.8	949	7090	664
1.0.4			18.2	24.25	8.50	2.14	72	29.7	2.95	42.53	943	7760	450
1.3.1	09.27.05	Silver 30 4th Use	11.2	9.75	3.25	3.45	70	29.7	2.90	41.95	931	28500	3110
1.3.2			11.8	10.25	5.00	2.36	70	29.7	2.90	41.95	931	25500	2370
1.3.3			11.8	6.00	5.00	2.36	70	29.7	2.90	41.95	931	23400	3060
1.9.1	09.28.05	Silver 30 10th Use	6.5	17.00	7.25	0.9	62	30.2	2.80	40.02	888	22600	2860
1.9.2			2.7	8.25	2.50	1.08	67	30.1	2.80	40.47	898	24400	1580
1.9.3			4.1	9.50	4.00	1.03	68	30.1	2.80	40.55	899	23700	2160
1.9.X		Silver 30 10th Use MIX [b]	3.1	14.75	3.50	0.89	70	30.1	2.80	40.7	903	6480	855
2.0.1		Silver 16 Virgin	8.8	25.00	16.00	0.55	71	30.1	2.80	40.78	904	1910	242
2.0.2			7.3	14.00	10.50	0.7	74	30.1	2.80	41.01	910	4350	540
3.0.1		Coal Slag	3.2	6.00	2.75	1.16	74	30.1	2.80	41.01	910	63000	5890
3.0.2			8.2	7.50	5.00	1.64	78	30.1	2.80	41.31	916	386000	59700
4.0.1		Silica Sand 50 grit	7.5	6.25	2.00	3.75	76	30.1	2.55	39.35	873	397000	84800
4.0.2			4.2	6.50	1.50	2.8	72	30.1	2.68	39.96	886	402000	76300
4.0.3			3.3	7.00	2.75	1.2	71	30.1	2.63	39.53	877	488000	111000
-	09.29.05	Background	-	69.00	-	-	66	29.9	2.78	40.49	898	304	46

[a] Times recorded to the nearest 15 s (0.25 min).
[b] The media used in this test consisted of 83% Silver 30 recycled after 9 previous uses mixed with 17% of virgin Silver 30.

Table 2. Test results

Run	Date	Media	Area cleaned (ft^2)	Air sampling duration[a] (min)	Net concentration ($\mu g/m^3$) TP	Net concentration ($\mu g/m^3$) PM-10	Air speed[b] (mph)	IFR	Emission rate[c] (g/min) TP	Emission rate[c] (g/min) PM-10	Emission factor[d] (kg/kg media) TP	Emission factor[d] (kg/kg media) PM-10
1.0.1	09.26.05	Silver 30 Virgin	13.8	39.75	1260	216	10.8	1.00	[e]	[e]	[e]	[e]
1.0.2			26.2	18.00	10200	952	10.8	1.00	9.73	0.907	0.0048	0.000447
1.0.3			16.7	18.00	6790	618	10.8	1.00	6.47	0.589	0.0037	0.000334
1.0.4			18.2	24.25	7460	404	10.8	0.99	7.11	0.385	0.0064	0.000346
1.3.1	09.27.05	Silver 30 4th Use	11.2	9.75	28200	3060	10.8	0.98	26.9	2.92	0.0254	0.00275
1.3.2			11.8	10.25	25200	2320	10.8	0.98	24	2.21	0.0155	0.00143
1.3.3			11.8	6.00	23100	3020	10.8	0.98	22.1	2.88	0.0083	0.00109
1.9.1	09.28.05	Silver 30 10th Use	6.5	17.00	22300	2820	10.8	0.93	21.2	2.68	0.0157	0.00198
1.9.2			2.7	8.25	24100	1530	10.8	0.94	23	1.46	0.0239	0.00152
1.9.3			4.1	9.50	23400	2110	10.8	0.95	22.3	2.01	0.0167	0.0015
1.9.X		Silver 30 10th Use MIX[f]	3.1	14.75	6180	809	10.8	0.95	5.89	0.771	0.0078	0.00102
2.0.1		Silver 16 Virgin	8.8	25.00	1610	196	10.8	0.95	1.53	0.187	0.0008	0.000092
2.0.2			7.3	14.00	4040	494	10.8	0.96	3.85	0.471	0.0016	0.000198
3.0.1		Coal Slag	3.2	6.00	62700	5840	10.8	0.96	[e]	[e]	[e]	[e]
3.0.2			8.2	7.50	385000	59700	10.8	0.96	367	56.9	0.0901	0.0139
4.0.1		Silica Sand 50 grit	7.5	6.25	397000	84700	7.0[b]	1.42	245	52.3	0.125	0.0267
4.0.2			4.2	6.50	402000	76200	7.0[b]	1.44	248	47.1	0.176	0.0333
4.0.3			3.3	7.00	487000	111000	7.0[b]	1.42	301	68.5	0.125	0.0285

[a] Times recorded to the nearest 15 s (0.25 min).

[b] Tunnel air speeds were measured prior to the start of the test program. Makeup airflow changed for the silica sand tests to avoid recirculation of emissions through the facility.

[c] Emissions based on “clock” time (i.e., the air sampling duration) to facilitate comparison with results from Reference 2.

[d] The amount of media used is based on 7 lb/min for Sponge-Jet products and 13.5 lb/min for materials. Blast times are given in Table 3-1.

[e] These tests served as “shakedown” tests. During the first Sponge-Jet media test, problems were encountered with the flow with the blasting system. The system was switched out for a new unit. Because of the duration, the emission rate was substantially lower than the other results. Results from that shakedown test are not included in the summary statistics. Similarly, the first test of coal slag also encountered problems with material flow and has been excluded from the summary statistics.

[f] The media evaluated in this test consisted of 83% Silver 30 recycled after 9 previous uses mixed with 17% of virgin Silver 30.

Table 3. Comparison of silica sand results with AP-42 and 1993 EPA tests

	TP		PM-10	
	Emission rate[a] (g/min)	Emission factor (kg/kg media)	Emission rate[a] (g/min)	Emission factor (kg/kg media)
1993 EPA Tests (painted hood surface)				
15/16 (5 mph tunnel speed)	140	0.027	31	0.0059
7/8 (10 mph tunnel speed)	330	0.070	240	0.052
21/22 (15 mph tunnel speed)	400	0.091	40	0.0091
Average	290	0.063	100	0.022
Average of 5 & 10 mph tests	240	0.049	140	0.029
Present Study				
Average of tests 4.0.1 through 3 (7 mph speed)	265	0.14	56	0.030
AP-42 Section 13.2.6[b]				
5 mph wind speed	-	0.027	-	0.013
10 mph wind speed	-	0.055	-	0.013
15 mph wind speed	-	0.091	-	0.013

[a] Data taken from Table 6-4 in Reference 2. Rates converted from kg/hr to g/min.
[b] Values taken from Table 13.2.6-1 and converted from lb/1,000 lb abrasive. AP-42 factors are given for "sand blasting of mild steel panels." No significant dependence of PM-10 emissions on wind speed reported.

Table 4. Percent reduction in average emission factors for sponge media

	Percent reduction based on coal slag		Percent reduction based on silica sand	
Condition	TP	PM-10	TP	PM-10
Virgin	94	97	96	99
10^{th} Use/Mix	91	93	94	96

Table 5. Percent reduction in average emission rates for sponge media

	Percent reduction based on coal slag		Percent reduction based on silica sand	
Condition	TP	PM-10	TP	PM-10
Virgin	98	99	97	99
10^{th} Use/Mix	98	99	98	99