Emission Factors for Abrasive Materials

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Objectives

- Present PM respirable metal emission factors (EFs) for 5 abrasive materials
- Compare EFs for silica sand
  - USEPA 1995 report
  - NIOSH 1998 reports
- Identify trends and similarities

Abrasive Materials

- Abrasive materials used to clean metal surfaces include:
  - Mineral Slags (e.g., copper slag, coal slag)
  - Manufactured Materials (e.g., steel grit, steel shot, and aluminum oxide)
  - Natural Occurring (e.g., silica sand and garnet)

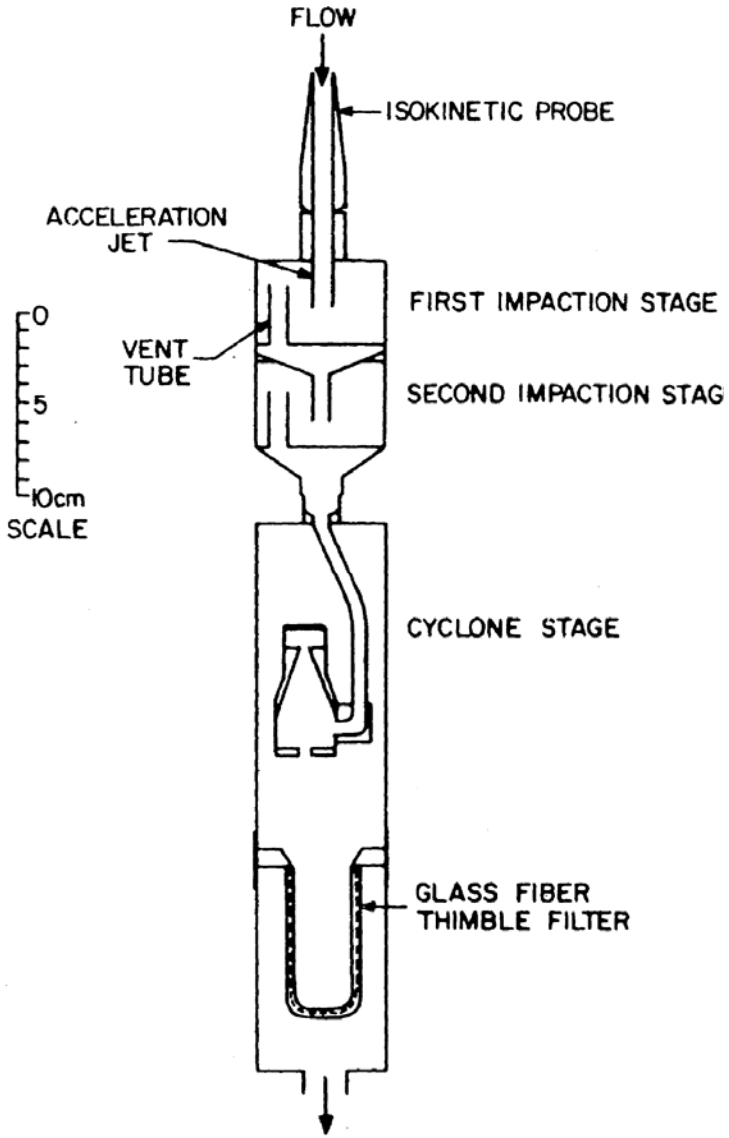
USEPA 1995 Report

- Study aimed at developing fugitive emission factors for silica sand.
- 3 surfaces (blast cleaned, painted, and oxidized)
- 3 flow rates (2.2 m/s, 4.5 m/s, and 6.7 m/s)
- Low wind speed tunnel 21 m (66ft) long with a 2.4-x2.4-m^2 cross section made of wood

US EPA 1995 Report (Cont.)

- **Figure 1.**

  Schematics of the Anderson HCSS high grain-loading impactor.



NIOSH 1998 Reports

- **Study aimed at developing fugitive emission factors for 11 types of abrasive materials**

- **Phase1**
  - Uncoated carbon steel plates each 0.5 cm thick and 61x61-cm^2 of surface area, containing intact mil scale.
  - Enclosure 3.6 m long with a 2.4-x2.4-m square cross walk-in room.
  - Target air flow rate around 0.20 m/s (40 fpm).
  - abrasives included 9 coal slags, 10 copper slags, 4 steel grit abrasives, 13 garnet abrasives, and 10 silica sand abrasives).

- **Phase 2**
  - Surface area cleaned contained corrosion products (8 similar pieces selected)
  - Enclosure design close to that used in Phase .
  - Target flow rate 0.25 to 0.36 m/s.
  - Abrasives included 2 coal slags, 2 copper slags, 2 steel grit abrasives, 2 garnet abrasives, and 2 silica sand abrasives).

NIOSH 1998 (cont.)

- PM respirable
  - Sampled at 1.7 L/min, collected using MSA 10 mm nylon cyclone
- Metals
  - Sampled at 2 L/min, collected on a 37 mm filter

PMresp. Metal Emission Factors (95 % UCL)

Abrasive Materials	Chromium (mg/kg-abr.)	Manganese (mg/kg-abr.)	Nickel (mg/kg-abr.)	Lead mg/kg-abr.)
Coal Slag	7.82	20.4	6.65	0.99
Copper Slag	28.2	218	4.75	48.3
Garnet	2.51	261	0.684	0.224
Silica Sand	**0.71**	**9.65**	**0.476**	**0.232**
Steel Grit	22.5	125	11.6	0.15

Table 1. Emission Factors and PM Respirable Cr in Exhaust (based on the NIOSH 1998 data, Refs. 7 and 8)

NIOSH 1998 Reports	Abrasive Media	Abrasive Media (kg/min)	Exhaust Fixed Station #3 Cr Concentration (µg/m^3)	PMresp.- Cr Concentration (mg/kg-abr.)	PMresp. Emission Factor (mg/kg-abr.)	PM-Cr to PM-resp. Ratio µg/g (ppm)
Phase 1	SS-01	2.66	10.34	0.472	3119	151
	SS-02	4.92	10.35	0.226	756	299
	SS-03	2.94	10.22	0.391	152	2566
	SS-04	2.54	14.64	0.591	426	1387
	SS-05	2.37	24.94	1.218	2545	479
	SS-06	3.03	10.49	0.384	2314	166
	SS-07	2.63	27.16	0.939	1510	622
	SSDS-01	2.81	10.72	0.394	1123	351
	SSDS-02	2.57	15.27	0.636	568	1120
	SSDS-03	2.74	9.95	0.419	630	665
Phase 2.	SS-04	8.16	63.17	0.578	2303	251
	SS-DS	9.73	46.81	0.316	485	652

Table 2. Emission Factors and PM Respirable Mn in Exhaust (based on the NIOSH 1998 data, Refs. 7 and 8)

NIOSH 1998 Reports	Abrasive Media	Abrasive Media (kg/min)	Exhaust Fixed Station # 3 Mn Concentration ($\mu g/m^{3)}$	PMresp.- Mn Concentration (mg/kg-abr.)	PMresp. Emission Factor (mg/kg-abr.)	PM-Mn to PMresp. Ratio µg/g (ppm)
Phase 1	SS-01	2.66	60.0	2.74	3119	878
	SS-02	4.92	47.6	1.04	756	1375
	SS-03	2.94	53.1	2.03	152	13342
	SS-04	2.54	355.7	14.35	426	33704
	SS-05	2.37	135.1	6.60	2545	2593
	SS-06	3.03	4.6	0.17	2314	73.0
	SS-07	2.63	181.7	6.28	1510	4163
	SSDS-01	2.81	92.8	3.41	1123	3034
	SSDS-02	2.57	350.8	14.61	568	25734
	SSDS-03	2.74	61.7	2.60	630	4125
Phase 2.	SS-04	8.16	947.0	8.64	2303	3752
	SS-DS	9.73	326.0	2.20	485	4536

Table 5. Emission Factors and Cr PM10 Concentrations (US EPA 1995, Ref. 6)

Net sand use rate lb/min	Net sand use rate kg/min	Gas flow rate dscm/min	PM10-Cr Emission concentration µg/dscm	PM10 Concentration mg/dscm	PM10-Cr to PM10 µg/g	PM10-Cr to PM10 %	PM10-Cr Emission factor mg/kg	PM10 Emission factor kg/kg
6.5	2.95	690	10.4	73.6	141	0.0141	2.4	0.017
9.9	4.50	1802	15.9	20.2	787	0.0787	6.4	0.0081
9.8	4.45	2562	16.4	7.86	2087	0.2087	9.5	0.0045
11.5	5.23	842	24.5	36.7	668	0.0668	4.0	0.0059
10.3	4.68	1876	20	129.6	154	0.0154	8.0	0.052
9.7	4.41	2525	31.6	15.8	2000	0.2000	18	0.0091
11.3	5.14	901	7.8	32.5	240	0.0240	1.4	0.0057
9.6	4.36	1766	12.5	33.4	374	0.0374	5.1	0.014
11.5	5.23	2413	14.9	6.44	2314	0.2314	6.9	0.003

Table 6. Emission Factors and Mn PM10 Concentrations (US EPA 1995, Ref. 6)

Net sand use rate lb/min	Net sand use rate kg/min	Gas flow rate dscm/min	PM10-Mn Emission concentration µg/dscm	PM10 Concentration mg/dscm	PM10-Mn to PM10 µg/g	PM10-Mn to PM10 %	PM10-Mn Emission factor mg/kg	PM10 Emission factor kg/kg
6.5	2.95	690	5.4	73.6	73.4	0.0073	1.3	0.017
9.9	4.50	1802	5.1	20.2	252	0.0252	2.1	0.0081
9.8	4.45	2562	2.8	7.86	356	0.0356	1.6	0.0045
11.5	5.23	842	8.7	36.7	237	0.0237	1.4	0.0059
10.3	4.68	1876	8	129.6	62	0.0062	3.2	0.052
9.7	4.41	2525	5.2	15.8	329	0.0329	3	0.0091
11.3	5.14	901	13.7	32.5	422	0.0422	2.4	0.0057
9.6	4.36	1766	16.3	33.4	488	0.0488	6.6	0.014
11.5	5.23	2413	4.3	6.44	668	0.0668	2	0.003

Table 9. Concentration of Cr in bulk abrasive, PMresp., and PM10

	NIOSH 1998			EPA 1995
Abrasive Media	Virgin (Pre-blast) Bulk Cr (µg/g)	Virgin (Post-blast) Bulk Cr (µg/g)	PM-Cr to PMresp. µg/g (ppm)	PM10-Cr to PM10 (µg/g)
SS-01	2.0	2.0	151	141
SS-02	2.0	2.0	299	787
SS-03	2.0	2.0	2566	2087
SS-04	2.7	3.2	1387	668
SS-05	3.7	2.6	479	154
SS-06	2.8	2.5	166	2000
SS-07	2.0	2.0	622	240
SSDS-01	2.0	2.0	351	374
SSDS-02	2.8	2.9	1120	2314
SSDS-03	2.0	2.0	665	
SS-04	3.0	5.0	251	
SS-DS	2.0	2.0	652	

Table 10. Concentration of Mn in bulk abrasive, PMresp., and PM10

	NIOSH 1998			EPA 1995
Abrasive Media	Virgin (Pre-blast) Bulk Mn (µg/g)	Virgin (Post-blast) Bulk Mn (µg/g)	PM-Mn to PMresp. µg/g (ppm)	PM10-Mn to PM10 (µg/g)
SS-01	0.13	5.0	878	73
SS-02	0.61	4.4	1375	252
SS-03	0.31	2.4	13342	356
SS-04	88	440	33704	237
SS-05	2.1	5.0	2593	62
SS-06	16	20	73	329
SS-07	14	5.8	4163	422
SSDS-01	2	6.0	3034	488
SSDS-02	80	57	25734	668
SSDS-03	0.38	3.6	4125	
SS-04	110	65	3752	
SS-DS	0.17	26	4536	

Discussion

- **95 % UCL PMresp. metal EFs for Cr, Mn, and Pb for silica sand (based on the data in the NIOSH 1998) data are lower than the corresponding (arithmetic) average EFs in USEPA 1995 report.**
  - **Cr: 0.71 mg/kg vs. 4.5mg/kg**
  - **Mn: 9.65 mg/kg vs. 3.7 mg/kg**
  - **Ni: 0.476 mg/kg vs. 5.1mg/kg**
  - **Pb: 0.232 mg/kg vs. 7.0 mg/kg**
- **EFs based on Pre-blast (bulk) metal composition are likely to be much lower than those based on gas phase composition (see Ref. 5).**

Discussion (cont.)

- Concentrations of Cr, Ni, and Pb in PMresp. (12 silica slags) were comparable to those in PM10 (1 silica sand, 3 different surfaces).
- Mn concentration in a few sand abrasives was high, resulting in a higher 95 % UCL EF (NIOSH data).
- 99 % of Cr and Ni in the airborne particles (USEPA 1995 Report) were in the PM10 fraction. Percentage of Mn and Pb in PM10 was ~ 50% or >.

Discussion (cont.)

- PM10/PM4.0 (or PM10/PMresp.) ratio varied by abrasive type and for one type of abrasive.

- The average PM10/PMresp. (or PM10/PM4.0) value for an abrasive material may provide an adjustment factor for the PMresp. based metal EFs when PM10 metal EFs are not available.

Future Work

- There is a need to further our understanding on the effect of, e.g., air flow rate, size of the abrasive material used, and blasting chamber dimensions on the PM fractions generated and emission factors.