

## Supplementary Information

# X-Ray Fluorescence Method for Direct-on-Filter quantification of Airborne Particulate Metals using a Handheld Analyzer \*

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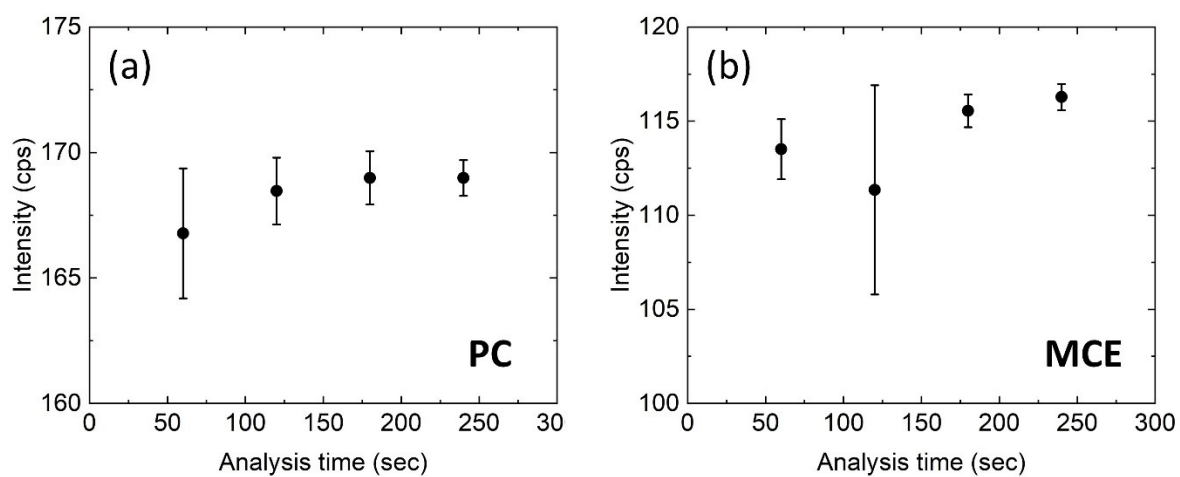
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**Figure S-1** Intensity (cps) acquired by the handheld XRF analyzer as a function of the time of the analysis (sec). (a)  $\text{Fe}(\text{NO}_3)_3$  solution was vacuum-filtered through a polycarbonate (PC) nucleopore membrane filter. The deposition diameter of the sample on the filter was 14 mm. (b) Certified Reference Material (CRM) solution containing high purity Fe salt (Spex Certiprep, Metuchen NJ) was used to spike a Mixed Cellulose Ester (MCE) membrane filter. The deposition diameter of the sample was < 8 mm. The same spot (center of the filter) was analyzed across analysis times. Ten consecutive measurements were acquired. The error bars represent the standard deviation of the replicate measurements.

**Table S-1** Mass density ( $\mu\text{g cm}^{-2}$ ), raw intensity (cps), calculated z-scores for the three X-ray beam positions on each filter, and relative standard deviation (RSD; %) of the measured XRF intensities for the 25-mm-diameter, 0.4- $\mu\text{m}$  pore-sized Nucleopore® polycarbonate (PC), single-element certified commercial calibration filters (SE-CCFs) obtained from Micromatter Inc.

Element (Energy level)	Mass density ( $\mu\text{g cm}^{-2}$ ) $\pm$ 5%	Raw Intensity (cps)	z-score	RSD %
Cr (5.41 keV)	1.47	9.51, 10.33, 10.29	-1.2, 0.6, 0.5	4.6
	5.9	20.82, 19.81, 19.77	1.2, -0.5, -0.6	3.0
	21.5	60.05, 59.18, 61.16	-0.08, -1.0, 1.0	1.6
	58.5	137.59, 138.90, 137.15	-0.3, 1.1, -0.8	0.7
	110.1	270.76, 271.03, 269.25	0.4, 0.7, -1.1	0.4
Ni (7.48 keV)	1.1	7.63, 7.61, 7.70	-0.4, -0.7, 1.1	0.6
	5.8	32.79, 32.14, 32.71	0.7, -1.1, 0.5	1.1
	24.2	135.76, 137.23, 136.08	-0.8, 1.1, -0.4	0.6
	52.6	265.80, 264.75, 262.82	0.9, 0.2, -1.1	0.6
	87.9	453.42, 424.74, 438.19	1.0, -1.0, -0.04	3.3
Pb (10.55 keV)	0.83	4.28, 4.26, 3.87	0.6, 0.5, -1.2	5.6
	4.7	20.38, 20.97, 20.26	-0.4, 1.1, -0.7	1.8
	18.4	81.48, 79.13, 78.85	1.1, -0.5, -0.7	1.8
	46.6	212.90, 211.35, 211.79	1.1, -0.8, -0.3	0.4
	118.2	474.88, 471.28, 474.10	0.8, -1.1, 0.4	0.4
Zn as ZnTe (8.64 keV)	1.51	2.46, 2.53, 2.62	-0.9, -0.1, 1.1	3.2
	6.2	12.18, 11.95, 11.98	1.1, -0.7, -0.5	1.1
	21.6	42.40, 42.04, 41.49	0.9, 0.1, -1.1	1.1
	48.3	94.74, 95.26, 94.00	0.1, 0.9, -1.1	0.7
	89.7	176.75, 180.11, 179.07	-1.1, 0.9, 0.2	1.0
Mn (5.89 keV)	1.08	5.12, 5.04, 4.84	0.8, 0.3, -1.1	2.8
	7.3	20.02, 19.63, 19.92	0.8, -1.1, 0.3	1.0
	18.6	48.73, 48.87, 48.40	0.3, 0.8, -1.1	0.5
	53.8	138.95, 138.30, 137.38	0.9, 0.1, -1.1	0.6
	102.7	262.09, 258.40, 257.59	1.1, -0.4, -0.7	0.9
Fe (6.40 keV)	1.42	26.06, 25.72, 25.88	1.0, -1.0, -0.03	0.7
	5.1	38.69, 38.78, 39.42	-0.7, -0.5, 1.1	1.0
	20.9	90.78, 88.91, 89.29	1.1, -0.8, -0.4	1.1
	55.7	207.48, 210.87, 206.47	-0.3, 1.1, -0.8	1.1
	100.8	379.79, 384.12, 380.256	-0.7, 1.1, -0.5	0.6

**Table S-2** Raw XRF intensity (cps) measured in blank 25-mm-diameter, 0.4- $\mu\text{m}$  pore-sized Nucleopore® polycarbonate (PC) particulate filters obtained from Micromatter Inc. These blank filters were analyzed alongside the single-element certified commercial calibration filters (SE-CCFs). The first seven measurements were used for the calculation of the limits of detection (LODs).

Energy level	Raw Intensity (cps)
5.41 keV	6.94, 6.90, 7.45, 7.53, 6.62, 7.16, 7.23, 6.94, 5.54, 7.31
7.48 keV	2.38, 2.36, 2.45, 2.30, 2.35, 2.35, 2.46, 2.32, 2.07, 2.54
10.55 keV	0.47, 0.41, 0.53, 0.55, 0.54, 0.59, 0.52, 0.56, 0.53, 0.49
8.64 keV	0.51, 0.60, 0.65, 0.57, 0.54, 0.54, 0.70, 0.52, 0.58, 0.48
5.89 keV	2.20, 2.08, 2.22, 2.36, 2.17, 2.32, 2.19, 2.35, 1.92, 2.17
6.40 keV	22.73, 22.29, 21.93, 21.74, 20.93, 21.88, 22.43, 21.58, 17.58, 22.64

**Table S-3** Mass density ( $\mu\text{g cm}^{-2}$ ), raw intensity (cps), calculated z-scores for the three X-ray beam positions on each filter, and the corresponding relative standard deviation (RSD; %) of the measured XRF intensities for the 25-mm-diameter, 0.4- $\mu\text{m}$  pore-

sized Nucleopore® polycarbonate (PC), multi-element certified commercial calibration filters (ME-CCFs) obtained from Micromatter Inc.

Sample #	Element	Mass Density ( $\mu\text{g cm}^{-2}$ ) $\pm$ 5%	Raw Intensity (cps)	z-score	RSD %
1 (S/N: 63548)	Cr (5.41 keV)	1.64	10.87, 11.28, 11.59	-1.0, 0.1, 0.9	3.2
	Mn (5.89 keV)	1.19	5.85, 6.19, 5.94	-0.8, 1.1, -0.3	2.9
	Fe (6.40 keV)	0.92	24.25, 25.33, 25.40	-1.2, 0.5, 0.6	2.6
	Ni (7.48 keV)	0.98	8.20, 8.23, 8.05	0.4, 0.7, -1.1	1.2
	Zn as ZnTe (8.64 keV)	0.97	2.55, 2.39, 2.36	1.1, -0.4, -0.7	4.2
2 (S/N: 63549)	Cr (5.41 keV)	1.67	11.01, 11.22, 10.99	-0.5, 1.1, -0.7	1.2
	Mn (5.89 keV)	1.31	5.98, 5.87, 6.10	0, -1.0, 1.0	1.9
	Fe (6.40 keV)	0.91	24.32, 25.23, 25.21	-1.2, 0.6, 0.6	2.1
	Ni (7.48 keV)	0.94	7.91, 7.82, 7.79	1.1, -0.3, -0.8	0.8
	Zn as ZnTe (8.64 keV)	1.00	2.60, 2.51, 2.41	1.0, 0.06, -1.0	3.9
3 (S/N: 63550)	Cr (5.41 keV)	18.10	52.29, 52.53, 52.28	-0.6, 1.2, -0.6	0.3
	Mn (5.89 keV)	19.50	56.95, 58.81, 58.55	-1.1, 0.7, 0.4	1.7
	Fe (6.40 keV)	21.30	101.28, 100.54, 101.77	0.1, -1.1, 0.9	0.6
	Ni (7.48 keV)	21.80	120.79, 121.49, 120.02	0.04, 1.0, -1.0	0.6
	Zn as ZnTe (8.64 keV)	20.60	45.83, 44.78, 44.95	1.1, -0.7, -0.4	1.3
4 (S/N: 63551)	Cr (5.41 keV)	16.90	48.53, 49.53, 48.46	-0.5, 1.2, -0.6	1.2
	Mn (5.89 keV)	19.60	58.01, 58.28, 56.31	0.4, 0.7, -1.1	1.9
	Fe (6.40 keV)	21.80	100.73, 101.15, 100.38	-0.05, 1.0, -1.0	0.4
	Ni (7.48 keV)	22.10	119.23, 120.21, 120.21	-1.2, 0.6, 0.6	0.5
	Zn as ZnTe (8.64 keV)	21.80	47.60, 47.39, 46.91	0.8, 0.3, -1.1	0.7

**Table S-4** Raw XRF intensity (cps) measured in blank 25-mm-diameter, 0.4- $\mu\text{m}$  pore-sized Nucleopore® polycarbonate (PC) particulate filters obtained from Micromatter Inc. These blank filters were analyzed alongside the multi-element certified commercial calibration filters (ME-CCFs).

Energy level (keV)	Raw Intensity (cps)
5.41	6.77, 6.89, 6.84
7.48	2.16, 2.29, 2.25
8.64	0.53, 0.53, 0.67
5.89	2.16, 2.21, 2.23
6.40	22.45, 21.35, 21.50

## S1. Measurement uncertainty

The uncertainty of the predicted measurand,  $u_c(x_{pred})$ , was calculated in accordance with the EURACHEM/CITAC Guide.<sup>3</sup> The calculation is based on the calibration data used in a linear, least-squares regression (LSR) model.

For a weighted LSR model, the uncertainty is given by:

$$u_c(x_{pred}) = \left[ \frac{var(y_{obs})}{b_1^2} + \frac{S_y^2}{b_1^2} \left( \frac{1}{\sum w_i} + \frac{(x_{pred} - \bar{x})^2}{\left( \sum (w_i x_i^2) - \left( \sum w_i x_i \right)^2 / \sum w_i \right)} \right) \right]^{1/2} \quad (S-1)$$

For an unweighted LSR model, the uncertainty is:

$$u_c(x_{pred}) = \left[ \frac{S_y^2}{b_1^2} \left( \frac{1}{p} + \frac{1}{n} + \frac{(x_{pred} - \bar{x})^2}{\left( \sum (x_i^2) - \left( \sum x_i \right)^2 / n \right)} \right) \right]^{1/2} \quad (S-2)$$

where  $var(y_{obs})$  is the variance of the observed measurement used for the prediction,  $b_1$  is the slope of the calibration curve,  $w_i$  is the weight assigned to  $y_i$  (the response corresponding to the  $i^{\text{th}}$  measurand value),  $\bar{x}$  is the mean measurand value from the calibration,  $x_i$  is the  $i^{\text{th}}$  measurand value,  $n$  is the number of calibration points, and  $p$  is the number of replicates to quantify the measurand.

The residual standard deviation of the regression,  $S_y$ , is defined as:

$$S_y = \sqrt{\frac{\sum w_i (y_i - \hat{y}_i)^2}{n - 2}} \quad (\text{weighted LSR}) \quad (S-3)$$

$$S_y = \sqrt{\frac{\sum (y_i - \hat{y}_i)^2}{n - 2}} \quad (\text{unweighted LSR}) \quad (S-4)$$

where  $\hat{y}_i$  is the predicted response at each  $x_i$ .

Eq. S-1 and Eq. S-3 were used to calculate the measurement uncertainty of the mass density ( $m_p/A_d$ ) obtained using the XRF analyzer for ME-CCFs, MSWF-PM and SSWF-PM test samples. In this context,  $y_i$  represents the XRF intensity corresponding to the  $i^{\text{th}}$  mass density of the calibration standards, and  $b_l$  corresponds to the slope of the calibration curve,  $S$ , from Eq. 3.

The uncertainty of particulate mass on MSWF-PM and SSWF-PM test samples for ICP-OES measurements was calculated using Eq. S-2 and S-4.

**Table S-5** Mass density ( $\mu\text{g cm}^{-2}$ ) and raw intensity (cps) of in-house calibration standards prepared by spiking Mixed Cellulose Ester (MCE) particulate filters with high concentration single-element metal solutions (SE-Spiked). Each mass density was prepared in triplicates, and from each filter, three replicate measurements were obtained.

Element (Energy level)	Mass Density ( $\mu\text{g cm}^{-2}$ )	Raw Intensity (cps)
Cr (5.41 keV)	$0.20 \pm 0.01$	6.77, 6.68, 6.74, 6.86, 6.32, 7.18, 6.83, 7.08, 7.14
	$2.38 \pm 0.07$	11.64, 11.70, 12.09, 11.18, 11.71, 11.11, 11.58, 11.19, 11.19

	8.92 ± 0.26	25.26, 25.31, 25.51, 26.08, 26.86, 26.78, 25.52, 25.89, 26.10
	29.76 ± 0.86	69.61, 70.17, 69.79, 66.66, 66.31, 64.68, 69.99, 68.66, 68.92
	89.28 ± 1.92	177.24, 176.56, 174.62, 171.38, 173.39, 171.74, 159.38, 158.68, 157.49
	148.81 ± 2.57	273.36, 273.62, 274.10, 271.07, 270.34, 270.82, 279.05, 282.74, 280.90
Mn (5.89 keV)	0.12 ± 0.00	2.19, 2.30, 2.30, 2.28, 2.21, 2.38, 3.42, 3.67, 3.35
	2.38 ± 0.07	8.70, 8.35, 8.31, 8.54, 8.82, 8.53, 8.28, 8.17, 8.83
	8.93 ± 0.26	27.20, 26.64, 27.06, 25.07, 25.84, 24.94, 26.40, 26.60, 26.35
	29.77 ± 0.86	83.31, 83.44, 83.69, 79.53, 81.19, 80.63, 84.63, 86.02, 83.87
	89.30 ± 1.92	216.59, 215.44, 216.64, 197.82, 198.40, 197.16, 202.41, 200.95, 200.84
	148.84 ± 2.57	340.91, 339.89, 342.86, 321.93, 324.06, 322.80, 314.81, 316.65, 316.77
Fe (6.40 keV)	0.20 ± 0.01	22.25, 21.69, 21.48, 21.91, 21.59, 21.56, 20.82, 21.54, 21.27
	2.39 ± 0.07	27.15, 27.13, 27.70, 28.97, 29.43, 28.39, 29.40, 29.65, 29.49
	8.96 ± 0.26	51.30, 49.96, 50.26, 49.20, 49.39, 49.50, 52.26, 50.47, 51.10
	29.88 ± 0.87	102.46, 101.76, 101.92, 111.81, 110.82, 111.81, 108.79, 110.73, 109.88
	89.64 ± 1.93	257.83, 257.26, 257.99, 249.94, 250.71, 248.90, 245.57, 246.81, 246.37
	149.40 ± 2.58	432.40, 434.18, 435.86, 418.20, 416.11, 418.04, 423.32, 426.61, 426.86
Co <sup>1</sup> (6.93 keV)	0.06 ± 0.00	1.35, 1.41, 1.26, 0.96, 0.93, 0.99, 1.16, 1.07, 1.04
	2.38 ± 0.07	8.95, 9.04, 8.84, 7.96, 7.78, 8.20, 8.22, 7.99, 8.03
	8.94 ± 0.26	28.65, 28.14, 29.32, 29.47, 29.88, 28.35, 26.39, 26.75, 26.70
	29.80 ± 0.86	93.63, 92.39, 96.22, 99.47, 99.96, 100.40, 83.19, 84.06, 83.91
	89.41 ± 1.92	256.53, 257.26, 256.30, 267.02, 269.10, 269.18, 259.11, 261.27, 260.92
Ni <sup>1</sup> (7.48 keV)	0.12 ± 0.00	2.15, 2.50, 2.33, 3.01, 2.82, 2.56, 2.65, 2.64, 2.64
	2.38 ± 0.07	7.89, 8.15, 8.41, 10.42, 10.23, 10.31, 10.07, 10.18, 10.03
	8.93 ± 0.26	36.66, 35.75, 36.35, 33.22, 33.60, 33.30, 36.56, 36.49, 37.02
	29.77 ± 0.86	121.36, 123.02, 122.60, 114.58, 113.66, 113.08, 118.45, 117.30, 118.32
	89.31 ± 1.92	333.31, 334.77, 333.60, 335.28, 331.75, 339.72, 314.52, 314.15, 317.38
	148.85 ± 2.57	572.34, 575.92, 576.01, 566.64, 564.28, 564.82, 582.63, 586.07, 583.44
Zn <sup>1</sup> (8.64 keV)	0.04 ± 0.00	0.82, 0.88, 0.74, 0.79, 0.84, 0.86, 0.88, 0.77, 0.84
	2.39 ± 0.07	13.96, 13.58, 13.79, 13.98, 13.83, 14.12, 14.59, 14.60, 15.66
	8.94 ± 0.26	52.34, 52.48, 52.44, 48.33, 49.52, 48.77, 54.87, 54.79, 55.76
	29.83 ± 0.86	169.66, 171.50, 172.54, 157.65, 158.67, 157.05, 168.82, 166.52, 166.06
	89.49 ± 1.92	449.24, 452.26, 451.51, 493.94, 495.36, 491.41, 468.83, 467.21, 464.13
As <sup>1</sup> (10.52 keV)	0.02 ± 0.00	0.95, 0.83, 0.83, 0.99, 0.97, 0.91, 0.88, 0.92, 0.80
	2.39 ± 0.07	14.23, 15.11, 14.78, 14.35, 14.04, 14.68, 15.79, 15.36, 15.27
	8.94 ± 0.26	52.13, 51.88, 52.34, 48.18, 49.16, 49.17, 54.40, 54.36, 55.03
	29.82 ± 0.86	173.90, 173.72, 174.39, 163.20, 161.52, 162.63, 178.01, 174.98, 176.27
	89.45 ± 1.92	479.82, 486.90, 493.77, 522.11, 520.36, 515.58, 546.36, 541.65, 541.17
Pb <sup>1</sup> (10.54 keV)	0.06 ± 0.00	1.16, 1.27, 1.15, 0.74, 0.57, 0.74, 0.81, 0.77, 0.85
	2.38 ± 0.07	7.33, 7.08, 6.90, 7.56, 7.34, 7.38, 8.54, 8.33, 8.20
	8.94 ± 0.26	25.71, 25.88, 25.69, 26.46, 26.78, 27.32, 23.25, 23.97, 24.11
	29.80 ± 0.86	66.67, 67.25, 68.49, 93.98, 92.75, 94.75, 88.65, 88.01, 87.50
	89.41 ± 1.92	326.90, 236.02, 236.35, 262.55, 262.00, 259.64, 256.08, 256.54, 255.21
	149.02 ± 2.57	432.99, 434.96, 437.54, 423.15, 420.78, 423.12, 415.33, 415.00, 414.36

<sup>13</sup> μL of chromium solution containing 4.5 μg were also spiked on the MCE filters. This was due to the clear color of the cobalt, nickel, zinc, arsenic, and lead solutions, that hindered the ability to visually see the deposited spot on the filters, and thus, the ability to accurately position the filter samples on the XRF analyzer where the X-ray beam illuminates the deposit. The mass of chromium remained the same across all the deposits, to minimize any potential interference with the peaks of interest.



**Figure S-2** Internal camera view from the software used to operate the portable XRF analyzer. The XRF beam diameter is approximately 8 mm. The filter is spiked with 3 µL solution containing 45 µg of Cr. The mass density is assumed to be 89.46 µg cm<sup>2</sup>, based on the X-ray beam illumination area (0.503 cm<sup>2</sup>).

**Table S-6** Stock solution prepared for the extraction of calibration curves for mild-steel welding fumes. The total volume of the stock solution was 6.598 mL.

Element	Composition (% m/m)	Volume added (mL)	Elemental Concentration (µg mL <sup>-1</sup> )
Fe	42.80	4.28	6499.8 ± 103.2
Mn	1.48	0.148	223.4 ± 97.3
Zn	21.70	2.17	3295.5 ± 60.0

**Table S-7** Stock solution prepared for the extraction of calibration curves for stainless-steel welding fumes. The total volume of the stock solution was 6.480 mL.

Element	Composition (% m/m)	Volume added (mL)	Elemental Concentration (µg mL <sup>-1</sup> )
Fe	29.8	2.98	4608.0 ± 78.9
Mn	22.9	2.29	3527.6 ± 81.0
Cr	8.4	0.84	1293.7 ± 33.3
Ni	3.7	0.37	570.0 ± 20.9

**Table S-8** Mass density ( $\mu\text{g cm}^{-2}$ ) and raw intensity (cps) of in-house calibration standards prepared by spiking MCE filters with multi-element metal solutions, replicating the composition of HSE mild-steel welding fume (MSWF-Spiked). Each row represents one filter. From each filter, three replicate measurements were obtained.

Fe (6.38 keV)		Mn (5.88 keV)		Zn (8.62 keV)	
Mass Density ( $\mu\text{g cm}^{-2}$ )	Raw Intensity (cps)	Mass Density ( $\mu\text{g cm}^{-2}$ )	Raw Intensity (cps)	Mass Density ( $\mu\text{g cm}^{-2}$ )	Raw Intensity (cps)
3.88 ± 0.13	31.15, 31.17, 31.71	0.13 ± 0.06	2.14, 2.24, 2.25	1.98 ± 0.07	9.81, 10.05, 10.09
3.88 ± 0.13	24.88, 24.79, 25.03	0.13 ± 0.06	1.89, 1.74, 1.93	1.98 ± 0.07	8.70, 8.48, 8.13
3.88 ± 0.13	15.80, 15.85, 15.68	0.13 ± 0.06	1.10, 1.12, 1.13	1.98 ± 0.07	10.83, 10.71, 10.41
7.75 ± 0.28	44.33, 44.91, 44.52	0.27 ± 0.12	2.55, 2.48, 2.68	3.93 ± 0.14	22.06, 22.44, 22.88
7.75 ± 0.28	47.38, 47.88, 46.64	0.27 ± 0.12	2.75, 2.84, 2.69	3.93 ± 0.14	24.62, 24.77, 24.80
7.75 ± 0.28	47.29, 45.92, 46.70	0.27 ± 0.12	2.73, 2.72, 2.49	3.93 ± 0.14	24.25, 23.93, 23.47
19.38 ± 0.64	74.96, 75.82, 75.67	0.67 ± 0.29	3.70, 3.76, 3.66	9.83 ± 0.33	50.42, 50.28, 50.15
19.38 ± 0.64	70.33, 70.79, 69.04	0.67 ± 0.29	3.14, 3.21, 3.33	9.83 ± 0.33	45.24, 43.78, 44.91
19.38 ± 0.64	75.79, 72.54, 73.22	0.67 ± 0.29	3.52, 3.53, 3.25	9.83 ± 0.33	48.68, 48.75, 48.26
38.77 ± 1.12	113.43, 113.80, 110.99	1.34 ± 0.20	4.63, 4.65, 4.30	19.66 ± 0.57	84.47, 82.21, 82.03
38.77 ± 1.12	133.23, 132.20, 132.84	1.34 ± 0.20	4.99, 5.00, 5.13	19.66 ± 0.57	99.56, 98.52, 99.50
38.77 ± 1.12	130.15, 130.72, 130.15	1.34 ± 0.20	4.81, 5.00, 5.22	19.66 ± 0.57	97.57, 96.68, 97.24
77.53 ± 1.58	228.83, 230.40, 228.41	2.67 ± 0.28	7.93, 7.82, 7.43	39.31 ± 0.81	182.10, 180.44, 179.57
77.53 ± 1.58	237.79, 236.20, 233.42	2.67 ± 0.28	7.92, 7.71, 7.50	39.31 ± 0.81	197.13, 196.22, 192.26
77.53 ± 1.58	213.98, 213.39, 213.52	2.67 ± 0.28	7.10, 7.09, 6.86	39.31 ± 0.81	165.29, 171.50, 174.74
116.30 ± 1.94	341.23, 338.75, 335.94	4.01 ± 0.34	9.96, 10.57, 10.03	58.96 ± 0.99	273.23, 274.40, 267.75
116.30 ± 1.94	338.66, 342.30, 341.92	4.01 ± 0.34	9.95, 10.33, 10.09	58.96 ± 0.99	285.43, 281.48, 284.31
116.30 ± 1.94	325.19, 324.35, 327.31	4.01 ± 0.34	10.23, 10.47, 10.44	58.96 ± 0.99	263.32, 265.34, 264.94

**Table S-9** Mass density ( $\mu\text{g cm}^{-2}$ ) and raw intensity (cps) of in-house calibration standards prepared by spiking MCE filters with multi-element metal solutions, replicating the composition of HSE stainless-steel welding fume (SSWF-Spiked). From each filter, three replicate measurements were obtained.

Fe (6.38 keV)			Mn (5.88 keV)		
Filter #	Mass Density ( $\mu\text{g cm}^{-2}$ )	Raw Intensity (cps)	Filter #	Mass Density ( $\mu\text{g cm}^{-2}$ )	Raw Intensity (cps)
1	2.75 ± 0.09	26.56, 25.99, 26.23	1	2.10 ± 0.08	5.60, 5.43, 5.29
2	2.75 ± 0.09	26.51, 26.15, 25.79	2	2.10 ± 0.08	6.49, 6.61, 6.21
3	2.75 ± 0.09	27.54, 27.48, 27.36	3	2.10 ± 0.08	5.81, 6.32, 6.27
4	5.50 ± 0.20	35.04, 35.37, 35.25	4	4.21 ± 0.17	10.89, 11.31, 10.94
5	5.50 ± 0.20	36.57, 36.68, 36.53	5	4.21 ± 0.17	11.81, 11.96, 11.68
6	5.50 ± 0.20	35.89, 36.38, 36.64	6	4.21 ± 0.17	11.38, 11.49, 11.28
7	13.74 ± 0.46	52.96, 52.06, 51.87	7	10.52 ± 0.39	24.86, 25.83, 24.71
8	13.74 ± 0.46	59.46, 59.57, 59.43	8	10.52 ± 0.39	26.55, 26.13, 26.56
9	13.74 ± 0.46	55.01, 56.00, 56.37	9	10.52 ± 0.39	24.55, 24.18, 24.17
10	27.48 ± 0.79	92.69, 92.83, 93.47	10	21.04 ± 0.65	50.80, 51.01, 50.58
11	27.48 ± 0.79	92.78, 93.17, 95.10	11	21.04 ± 0.65	48.13, 48.61, 48.98
12	27.48 ± 0.79	88.67, 89.00, 90.14	12	21.04 ± 0.65	49.44, 49.92, 50.33
13	54.97 ± 1.12	167.01, 165.84, 164.31	13	42.08 ± 0.92	96.92, 95.89, 97.09
14	54.97 ± 1.12	179.04, 178.56, 179.29	14	42.08 ± 0.92	102.91, 102.51, 101.57
15	54.97 ± 1.12	180.70, 181.70, 180.49	15	42.08 ± 0.92	102.85, 102.42, 100.93
16	82.45 ± 1.38	246.73, 244.27, 246.88	16	63.12 ± 1.13	146.04, 145.57, 145.67
17	82.45 ± 1.38	232.66, 232.02, 231.99	17	63.12 ± 1.13	135.29, 137.11, 137.97
18	82.45 ± 1.38	232.13, 232.98, 233.93	18	63.12 ± 1.13	138.51, 139.85, 137.89
Cr (5.41 keV)			Ni (7.46 keV)		
Filter #	Mass Density ( $\mu\text{g cm}^{-2}$ )	Raw Intensity (cps)	Filter #	Mass Density ( $\mu\text{g cm}^{-2}$ )	Raw Intensity (cps)
1	0.77 ± 0.03	7.38, 7.15, 6.90	1	0.34 ± 0.02	3.49, 3.59, 3.45
2	0.77 ± 0.03	6.77, 6.54, 6.61	2	0.34 ± 0.02	3.65, 3.47, 3.72
3	0.77 ± 0.03	7.43, 7.54, 7.38	3	0.34 ± 0.02	3.52, 3.64, 3.59
4	1.54 ± 0.06	8.65, 8.71, 8.96	4	0.68 ± 0.03	4.73, 4.82, 4.90
5	1.54 ± 0.06	9.17, 9.45, 9.38	5	0.68 ± 0.03	5.32, 4.93, 5.51
6	1.54 ± 0.06	9.06, 9.50, 9.43	6	0.68 ± 0.03	5.01, 5.14, 5.07
7	3.86 ± 0.15	11.47, 11.15, 10.82	7	1.70 ± 0.08	8.39, 8.37, 8.29
8	3.86 ± 0.15	13.19, 13.59, 13.48	8	1.70 ± 0.08	9.45, 8.86, 9.14
9	3.86 ± 0.15	12.50, 12.39, 12.18	9	1.70 ± 0.08	8.39, 8.41, 8.69
10	7.72 ± 0.23	18.40, 18.93, 18.88	10	3.40 ± 0.11	14.93, 15.40, 14.60
11	7.72 ± 0.23	19.48, 19.99, 20.35	11	3.40 ± 0.11	14.77, 14.90, 14.33
12	7.72 ± 0.23	17.91, 18.30, 17.76	12	3.40 ± 0.11	14.50, 14.60, 14.47
13	15.43 ± 0.32	33.00, 33.13, 33.47	13	6.80 ± 0.15	27.40, 27.05, 27.02
14	15.43 ± 0.32	35.42, 35.73, 36.22	14	6.80 ± 0.15	28.89, 28.06, 28.78
15	15.43 ± 0.32	37.04, 36.33, 35.87	15	6.80 ± 0.15	28.59, 29.15, 29.39
16	23.15 ± 0.40	49.91, 49.75, 49.50	16	10.20 ± 0.18	39.53, 39.43, 39.47
17	23.15 ± 0.40	47.01, 46.28, 47.25	17	10.20 ± 0.18	36.89, 38.05, 37.65
18	23.15 ± 0.40	47.87, 46.64, 46.71	18	10.20 ± 0.18	37.60, 37.67, 38.65

**Table S-10** Raw intensity (cps) measured in seven blank MCE particulate filters, used for the background correction of the SE-Spiked, MSWF-Spiked and SSWF-Spiked calibration filters, and the calculation of the limits of detection (LODs). From each filter, three replicate measurements were obtained.

Energy level (keV)	Blank #	Raw Intensity (cps)	Energy level (keV)	Blank #	Raw Intensity (cps)
5.41	1	6.47, 6.33, 6.57	7.48	1	2.12, 2.37, 2.30
	2	6.43, 6.46, 6.43		2	2.24, 2.33, 2.66
	3	6.32, 6.38, 6.35		3	2.19, 2.42, 2.66
	4	6.26, 6.28, 6.45		4	2.19, 2.35, 2.45
	5	6.56, 6.64, 6.54		5	2.52, 2.41, 2.36
	6	6.71, 6.27, 6.44		6	2.41, 2.60, 2.41
	7	6.39, 6.19, 6.58		7	2.48, 2.68, 2.19
5.89	1	1.92, 2.07, 1.86	8.64	1	0.57, 0.73, 0.72
	2	1.88, 1.97, 1.89		2	0.70, 0.57, 0.60
	3	1.96, 1.99, 2.05		3	0.65, 0.62, 0.74
	4	2.07, 1.85, 1.99		4	0.66, 0.57, 0.71
	5	1.95, 2.01, 1.95		5	0.57, 0.71, 0.66
	6	1.94, 1.95, 1.96		6	0.67, 0.61, 0.58
	7	1.97, 1.92, 1.69		7	0.73, 0.50, 0.55
6.40	1	20.90, 20.96, 20.39	10.52	1	0.56, 0.51, 0.55
	2	20.57, 21.02, 20.38		2	0.61, 0.55, 0.60
	3	20.86, 20.98, 20.44		3	0.57, 0.65, 0.52
	4	21.27, 20.78, 21.38		4	0.54, 0.63, 0.60
	5	20.93, 21.30, 20.80		5	0.60, 0.58, 0.64
	6	21.33, 20.55, 20.89		6	0.48, 0.63, 0.60
	7	21.05, 20.64, 20.88		7	0.64, 0.63, 0.70
6.93	1	1.06, 1.03, 1.34	10.54	1	0.62, 0.53, 0.54
	2	1.13, 1.16, 1.14		2	0.60, 0.59, 0.54
	3	0.98, 1.29, 1.01		3	0.59, 0.53, 0.56
	4	1.13, 1.06, 1.17		4	0.61, 0.51, 0.64
	5	1.07, 1.03, 1.14		5	0.56, 0.50, 0.47
	6	1.07, 1.14, 1.14		6	0.64, 0.63, 0.61
	7	1.26, 1.23, 1.09		7	0.66, 0.58, 0.57

## S2. Mass density uncertainty

The mass density uncertainty of the SE- MSWF- and SSWF-Spiked calibration standards was calculated and included as x-error bars in Fig. S-7, S-8 and S-9. The calculated uncertainty depends on the standard uncertainty of each input variable involved in the preparation of the standards.

High-concentration certified reference material (CRM) solutions were used as stock solutions. These were aliquoted and diluted to prepare standard solutions, which were then used to spike filters and generate calibration standards for the XRF analyzer. The mass ( $m_p$ ) deposited on each calibration filter was calculated as:

$$m_p = \frac{C_0 V_0 V_s}{V_0 + V_{H_2O}} \quad (\text{S-5})$$

where  $C_0$  is the elemental concentration of the stock (CRM) solution,  $V_0$  is the aliquot volume of the stock solution used for dilution,  $V_s$  is the spike volume applied to the filter (3  $\mu\text{L}$ ), and  $V_{H_2O}$  is the volume of water used for dilution. All quantities are assumed to be independent; therefore, covariance terms were not included.

The combined standard uncertainty of  $m_p$  was calculated using the law of propagation of uncertainty, as described by Taylor and Kuyatt (1994):

$$u_c(m_p) = \left[ \left( \frac{\partial m_p}{\partial C_0} \right)^2 u^2(C_0) + \left( \frac{\partial m_p}{\partial V_0} \right)^2 u^2(V_0) + \left( \frac{\partial m_p}{\partial V_s} \right)^2 u^2(V_s) + \left( \frac{\partial m_p}{\partial V_{H_2O}} \right)^2 u^2(V_{H_2O}) \right]^{1/2} \quad (\text{S-6})$$

The uncertainty of the stock solution concentration was provided by the manufacturer, whereas the uncertainties in aliquot and spike volumes were estimated by propagating the maximum permissible systematic and random errors of the pipettes used, in accordance to ISO 8655.<sup>2</sup>

To achieve higher mass loadings, multiple (up to three) applications of stock or standard solutions were deposited on a single filter:

$$m_p = \sum_{i=1}^N m_{p,i} \quad (\text{S-7})$$

where  $m_{p,i}$  is the particulate mass deposited during the  $i^{\text{th}}$  application, and  $N$  is the number of applications. The combined uncertainty was calculated as:

$$u_c(m_p) = \left[ \sum_{i=1}^N u^2(m_{p,i}) \right]^{1/2} \quad (\text{S-8})$$

Multi-element CRM solutions were also prepared by combining individual metal stock solutions to replicate the composition of Mild-Steel Welding Fume (MSWF) and Stainless-Steel Welding Fume (SSWF). The mass of each metal  $j$  deposited on the filter after a single spike is:

$$m_{p,j} = \frac{V_s V_j C_{0,j}}{V_T} \quad (\text{S-9})$$

where  $V_j$  is the aliquot volume of the stock solution metal  $j$ ,  $C_{0,j}$  is its concentration in the multi-element CRM solution (Tables S-6 and S-7), and  $V_T$  is the total volume of all aliquots used to prepare the multi-element solution. The corresponding mass uncertainty, e.g., for Fe, was calculated using the propagation of uncertainty, accounting for all contributing variables:

$$u_c(m_{p,Fe}) = \left[ \left( \frac{\partial m_{p,Fe}}{\partial V_s} \right)^2 u^2(V_s) + \left( \frac{\partial m_{p,Fe}}{\partial V_{Fe}} \right)^2 u^2(V_{Fe}) + \left( \frac{\partial m_{p,Fe}}{\partial C_{0,Fe}} \right)^2 u^2(C_{0,Fe}) \right]^{1/2} \quad (\text{S-10})$$

Uncertainty for additional spikes or dilution steps was calculated as described above. Finally, all mass uncertainties were converted to mass density uncertainties by normalizing with the XRF beam area.

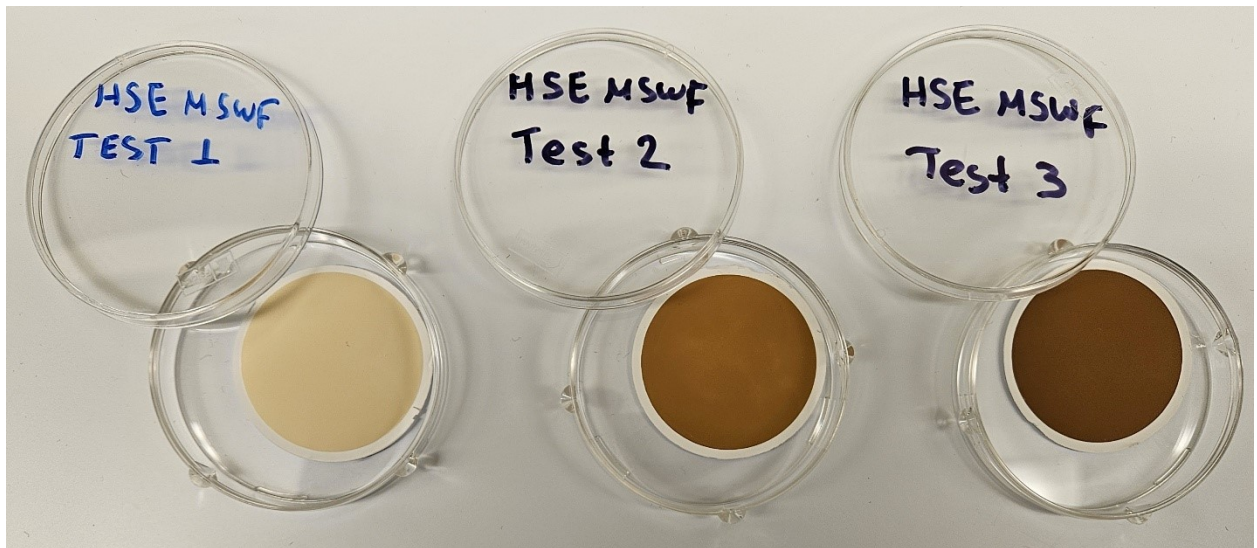


Figure S-3 Photo of the MSWF-PM samples.



Figure S-4 Photo of the SSWF-PM samples.

**Table S-11** Raw XRF intensity (cps) and corresponding z-scores obtained from six X-ray beam positions on each 37-mm-diameter, 0.8- $\mu$ m-pore sized MCE MSWF-PM filter sample. The table also reports the relative standard deviation (RSD; %) of the measured XRF intensities for each element on each filter. From each beam position, three replicate measurements were obtained.

	Element	Beam Position	Raw Intensity (cps)	z-score	Beam Position	Raw Intensity (cps)	z-score	RSD %
Test 1	Fe	Top	36.28, 35.22, 35.99	0.9	Right	35.64, 36.04, 35.21	-0.1	1.4
		Center	35.98, 35.74, 35.77	0.9	Center	35.33, 35.21, 36.05	-0.5	
		Bottom	35.88, 36.03, 35.39	0.6	Left	35.68, 34.83, 35.33	-1.7	
	Zn	Top	13.93, 14.46, 13.84	0.1	Right	13.87, 14.25, 13.85	-0.3	1.5
		Center	14.01, 14.47, 14.82	1.8	Center	13.85, 13.99, 14.02	-0.5	
		Bottom	14.26, 14.27, 13.75	0.1	Left	14.02, 13.55, 13.90	-1.2	
	Mn	Top	2.16, 2.41, 2.19	-1.7	Right	2.35, 2.32, 2.42	0.02	13.7
		Center	2.53, 2.36, 2.33	0.8	Center	2.26, 2.39, 2.36	-0.4	
		Bottom	2.46, 2.49, 2.36	1.2	Left	2.42, 2.58, 2.07	-0.01	
Test 2	Fe	Top	139.50, 137.84, 139.81	0.8	Right	139.10, 139.36, 136.37	0.4	1.7
		Center	139.51, 140.75, 139.68	1.3	Center	134.39, 135.08, 135.08	-1.4	
		Bottom	137.01, 136.11, 135.22	-0.7	Left	136.78, 136.50, 136.60	-0.4	
	Zn	Top	108.47, 105.40, 106.76	0.8	Right	105.84, 105.37, 106.05	0.09	1.6
		Center	108.62, 108.99, 106.43	1.5	Center	102.66, 105.05, 103.43	-1.1	
		Bottom	104.75, 104.07, 103.16	-1.0	Left	104.65, 105.61, 105.42	-0.2	
	Mn	Top	5.84, 5.49, 5.59	0.9	Right	5.56, 5.57, 5.63	0.4	2.8

		Center	5.72, 5.37, 5.79	0.7	Center	5.54, 5.39, 5.41	-1.0	
		Bottom	5.37, 5.37, 5.43	-1.5	Left	5.65, 5.41, 5.74	0.5	
Test 3	Fe	Top	216.81, 216.85, 216.40	1.0	Right	218.97, 219.50, 218.12	1.4	2.3
		Center	212.15, 213.37, 212.04	0.03	Center	208.96, 207.66, 210.56	-0.7	
		Bottom	208.12, 210.08, 208.40	-0.8	Left	208.30, 207.78, 208.68	-0.9	
	Zn	Top	196.02, 196.59, 196.06	0.9	Right	200.76, 197.50, 199.25	1.5	2.5
		Center	190.64, 191.11, 190.39	-0.3	Center	185.90, 187.68, 187.27	-1.1	
		Bottom	191.73, 191.02, 190.28	-0.2	Left	185.72, 190.39, 188.71	-0.8	
	Mn	Top	7.69, 7.93, 7.92	-0.3	Right	7.87, 8.34, 7.89	0.9	2.5
		Center	7.91, 7.91, 7.87	0.02	Center	7.62, 7.51, 7.78	-1.7	
		Bottom	7.95, 7.99, 8.19	1.0	Left	7.98, 7.82, 7.92	0.08	

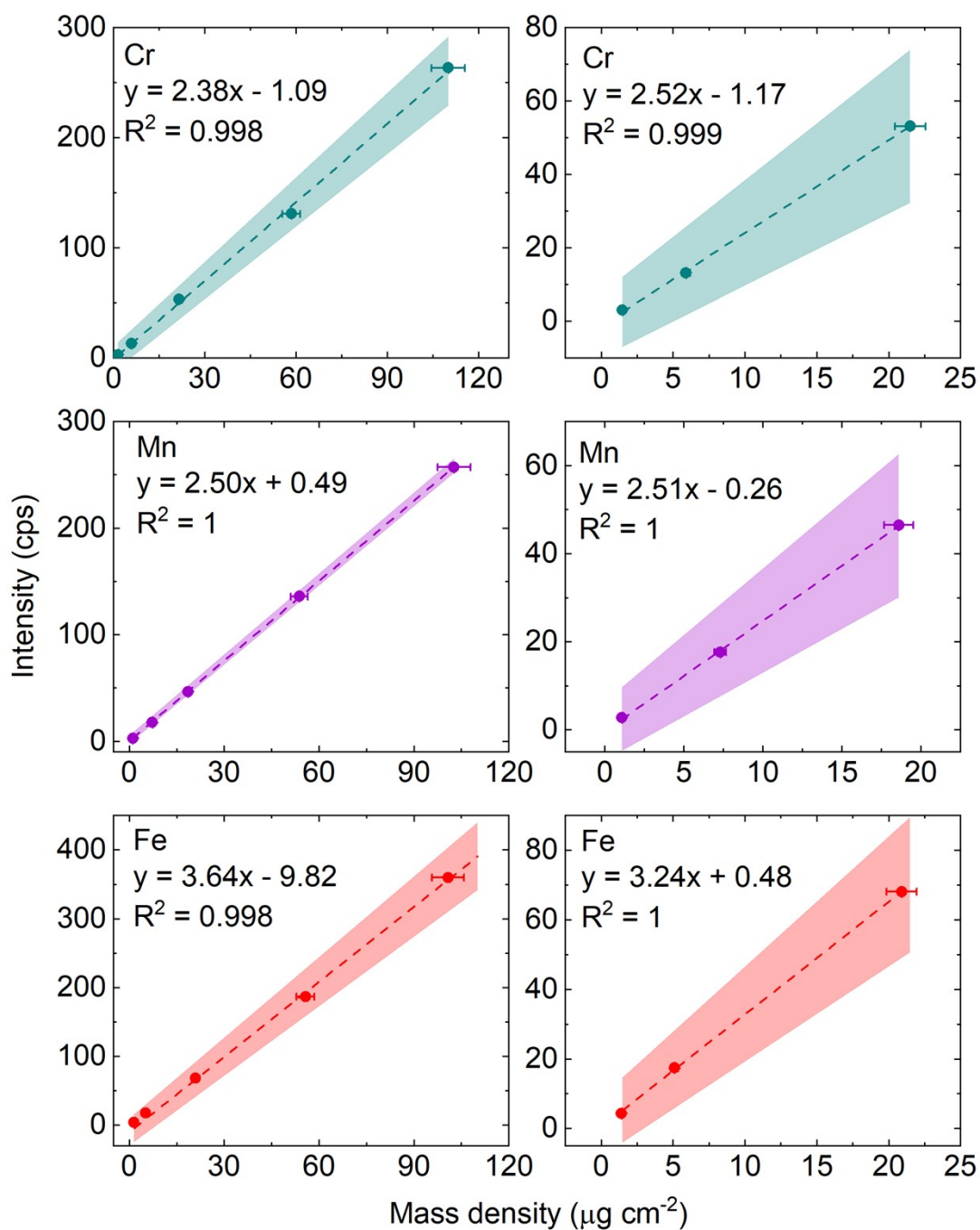
**Table S-12** Raw XRF intensity (cps) and corresponding z-scores obtained from six X-ray beam positions on each 37-mm-diameter, 0.8- $\mu$ m-pore sized MCE SSWF-PM filter sample. The table also reports the relative standard deviation (RSD; %) of the measured XRF intensities for each element on each filter. From each beam position, three replicate measurements were obtained.

	Element	Beam Position	Raw Intensity (cps)	z-score	Beam Position	Raw Intensity (cps)	z-score	RSD %
Test 1	Fe	Top	34.24, 35.34, 34.21	-1.3	Right	34.46, 34.45, 34.91	-1.3	3.3
		Center	35.33, 35.37, 35.81	0.6	Center	35.49, 34.97, 35.83	0.4	
		Bottom	36.02, 35.83, 34.82	0.7	Left	36.14, 34.95, 35.80	0.8	
	Mn	Top	15.03, 14.93, 14.93	-1.5	Right	15.06, 15.04, 15.41	-0.6	1.6
		Center	15.22, 15.47, 15.23	0.06	Center	15.52, 15.54, 14.88	0.08	
		Bottom	15.31, 15.88, 15.62	1.4	Left	15.26, 15.43, 15.58	0.6	
	Ni	Top	4.96, 4.83, 4.55	-1.6	Right	4.92, 4.83, 5.10	-0.2	4.7
		Center	4.72, 5.34, 5.07	0.5	Center	5.30, 5.13, 5.02	1.4	
		Bottom	4.85, 4.95, 4.99	-0.4	Left	5.29, 4.76, 4.98	0.3	
Cr	Top	8.99, 8.86, 8.71	-1.3	Right	9.56, 8.83, 9.05	0.3	6.3	
	Center	9.24, 9.00, 8.98	-0.1	Center	9.35, 9.34, 8.91	0.6		
	Bottom	9.04, 9.02, 8.70	-0.9	Left	9.28, 9.43, 9.38	1.4		
Test 2	Fe	Top	74.47, 75.32, 75.23	-1.5	Right	76.80, 75.81, 75.68	-0.7	2.4
		Center	76.91, 77.38, 77.28	0.1	Center	77.75, 77.57, 77.32	0.4	
		Bottom	77.65, 77.37, 76.94	0.2	Left	78.98, 78.71, 79.28	1.4	
	Mn	Top	52.58, 51.23, 51.88	-1.3	Right	51.82, 52.94, 52.77	-0.7	2.2
		Center	53.20, 53.14, 53.65	0.01	Center	54.15, 54.44, 54.53	0.9	
		Bottom	53.59, 52.74, 52.42	-0.4	Left	55.29, 54.40, 54.96	1.4	
	Ni	Top	12.25, 12.29, 12.78	-1.7	Right	13.52, 12.93, 12.63	0.3	2.8

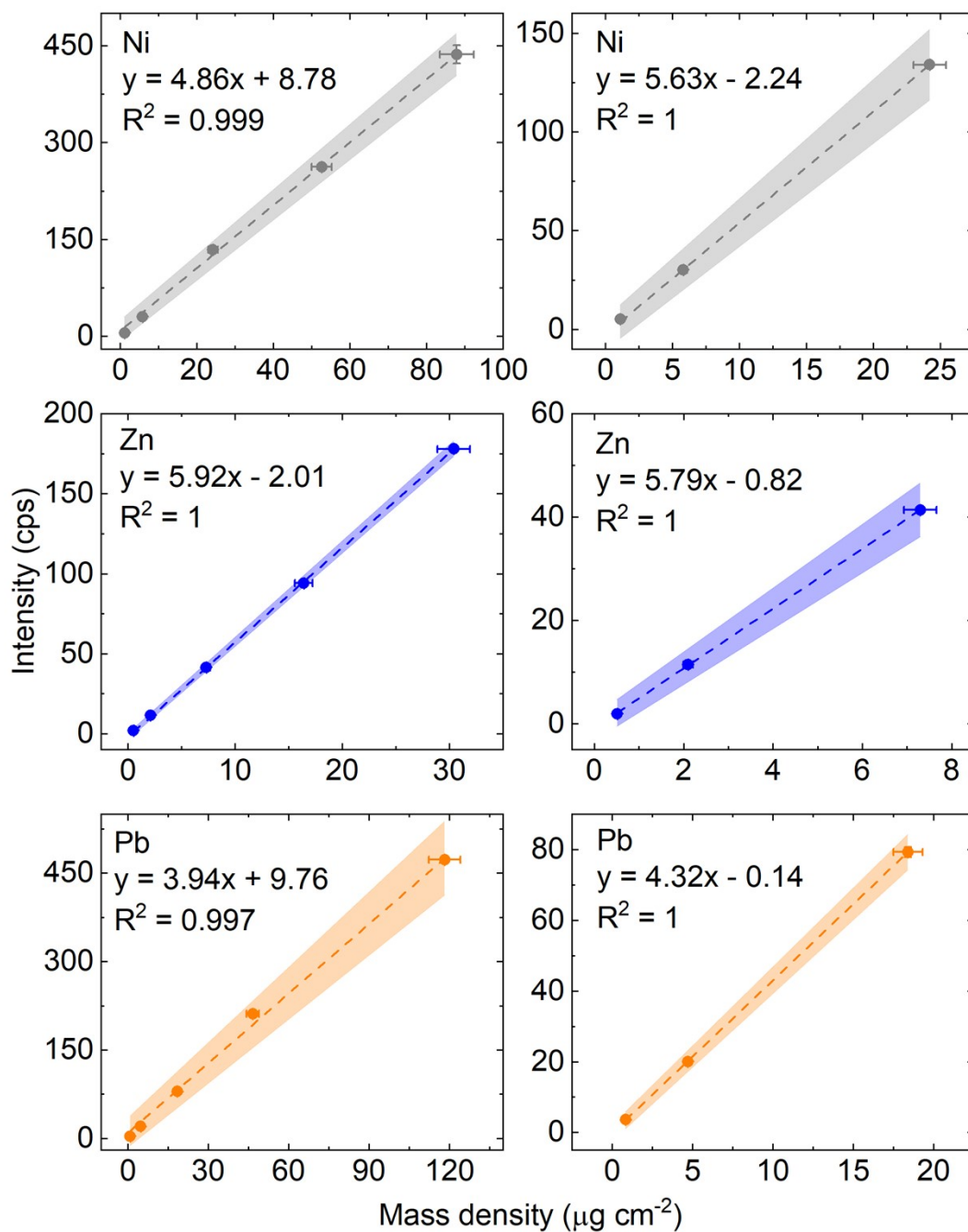
		Center	13.37, 13.07, 13.18	0.9	Center	13.02, 12.86, 12.96	-0.01	
		Bottom	12.81, 12.74, 12.88	-0.5	Left	13.85, 12.83, 13.09	1.0	
	Cr	Top	17.39, 17.08, 17.39	-1.6	Right	17.90, 17.67, 17.55	-0.3	2.9
		Center	18.51, 18.04, 18.06	1.2	Center	18.05, 18.21, 18.19	1.0	
		Bottom	17.53, 17.75, 17.89	-0.3	Left	18.10, 17.81, 17.49	-0.04	
Test 3	Fe	Top	92.96, 92.67, 91.92	0.9	Right	90.62, 92.37, 91.25	-0.3	1.3
		Center	91.65, 91.98, 91.88	0.2	Center	91.19, 90.46, 90.44	-1.0	
		Bottom	90.43, 90.27, 91.04	-1.1	Left	92.92, 93.30, 92.41	1.3	
	Mn	Top	67.38, 67.49, 67.36	1.2	Right	65.61, 66.73, 66.29	-1.0	0.9
		Center	67.02, 67.13, 67.17	0.6	Center	66.23, 65.92, 66.94	-0.7	
		Bottom	66.26, 66.18, 66.22	-1.0	Left	66.36, 67.64, 67.84	0.9	
	Ni	Top	15.37, 15.48, 15.26	1.2	Right	14.57, 14.63, 14.73	-0.6	3.2
		Center	15.06, 15.18, 15.63	1.0	Center	14.88, 14.55, 14.85	-0.3	
		Bottom	14.05, 13.98, 14.86	-1.5	Left	15.27, 14.99, 14.79	0.3	
	Cr	Top	20.97, 20.74, 21.10	0.1	Right	20.79, 20.28, 20.76	-1.3	1.6
		Center	21.39, 20.78, 21.34	1.1	Center	20.96, 20.71, 20.86	-0.3	
		Bottom	20.98, 20.45, 20.74	-0.8	Left	21.41, 21.15, 21.03	1.2	

**Table S-13** Raw intensity (cps) measured in blank 37-mm-diameter, 0.8- $\mu$ m-pore sized MCE filters. Five filters were used and two measurements were obtained on different spots, on each filter.

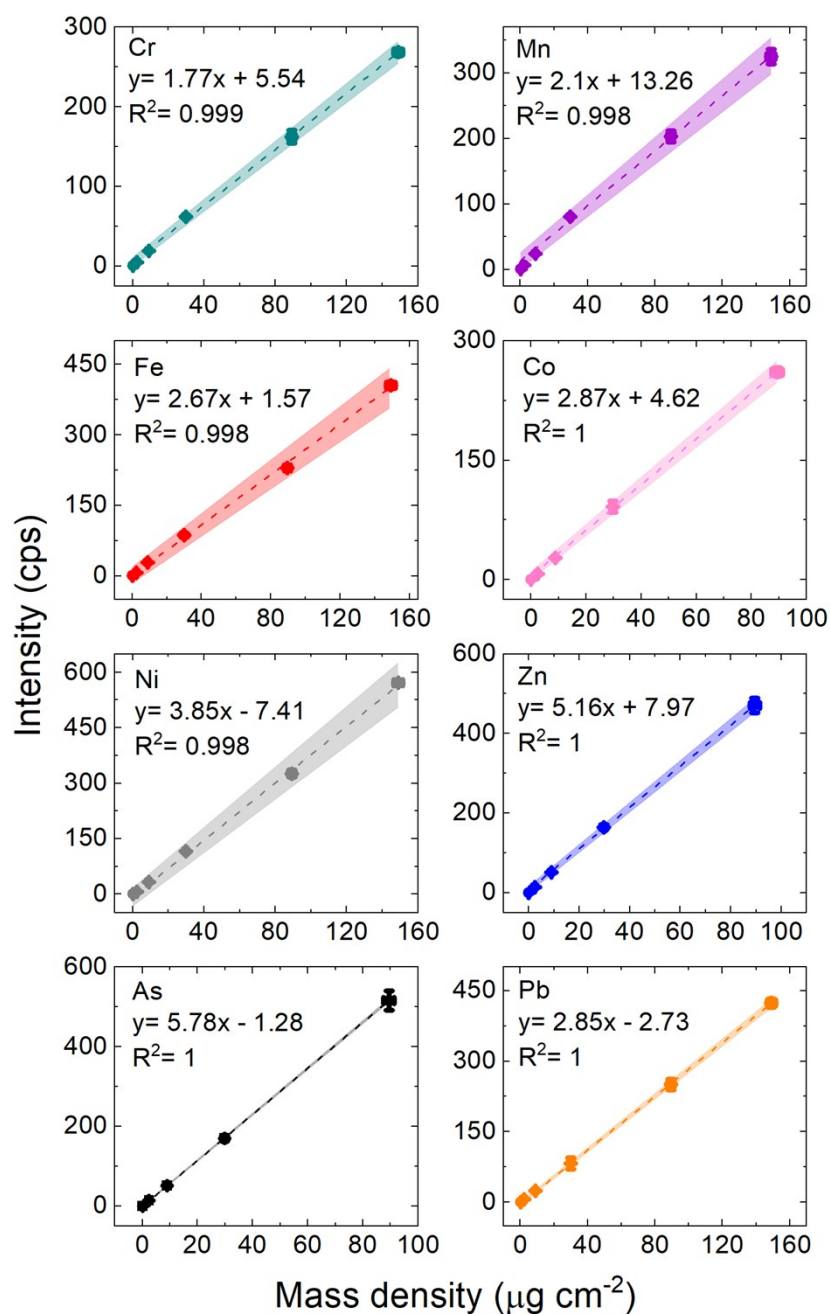
Energy level	Raw Intensity (cps)
5.41 keV	6.94, 6.90, 7.45, 7.53, 6.62, 7.16, 7.23, 6.94, 5.54, 7.31
7.48 keV	2.38, 2.36, 2.45, 2.30, 2.35, 2.35, 2.46, 2.32, 2.07, 2.54
10.55 keV	0.47, 0.41, 0.53, 0.55, 0.54, 0.59, 0.52, 0.56, 0.53, 0.49
8.64 keV	0.51, 0.60, 0.65, 0.57, 0.54, 0.54, 0.70, 0.52, 0.58, 0.48
5.89 keV	2.20, 2.08, 2.22, 2.36, 2.17, 2.32, 2.19, 2.35, 1.92, 2.17
6.40 keV	22.73, 22.29, 21.93, 21.74, 20.93, 21.88, 22.43, 21.58, 17.58, 22.64



**Figure S-5** XRF intensity (cps) plotted as a function of mass density ( $\mu\text{g cm}^{-2}$ ) for the single-element certified commercial calibration filters (SE-CCFs) obtained from Micromatter Inc. for chromium (Cr), manganese (Mn), and iron (Fe). A broad mass density range, covering both low and high mass loadings (up to approximately  $120 \mu\text{g cm}^{-2}$ ), is shown on the left, while a limited range including only light loadings, is shown on the right, for each element. The y-error bars represent the standard deviation of three XRF intensity measurements obtained at three different locations on each filter. The x-error bars represent the uncertainty in elemental mass, specified as 5% by Micromatter Inc. The dashed lines indicate the linear fits to the experimental data, and the shaded areas represent the 95 % confidence intervals of the fitted curves.

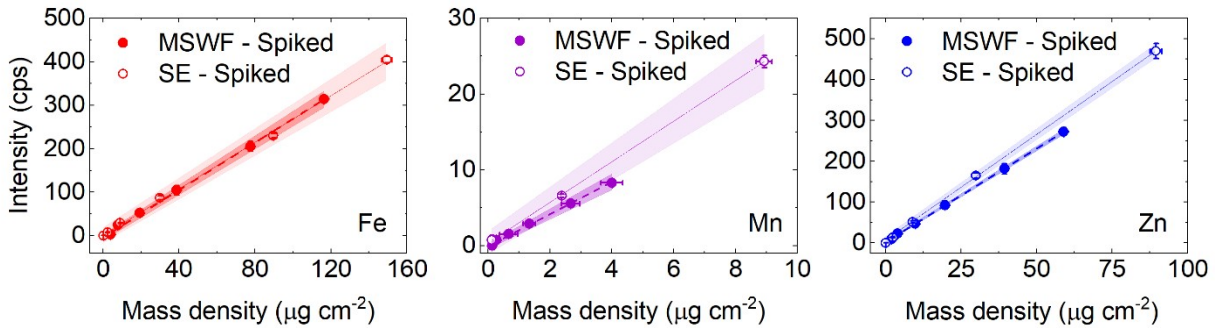


**Figure S-6** XRF intensity (cps) plotted as a function of mass density ( $\mu\text{g cm}^{-2}$ ) for the single-element certified commercial calibration filters (SE-CCFs) obtained from Micromatter Inc. for nickel (Ni), zinc (Zn), and lead (Pb). A broad mass density range, covering both low and high mass loadings (up to approximately  $120 \mu\text{g cm}^{-2}$  for Pb,  $90 \mu\text{g cm}^{-2}$  for Ni, and  $30 \mu\text{g cm}^{-2}$  for Zn), is shown on the left, while a limited range including only light loadings, is shown on the right, for each element. The y-error bars represent the standard deviation of three XRF intensity measurements obtained at three different locations on each filter. The x-error bars represent the uncertainty in elemental mass, specified as 5% by Micromatter Inc. The dashed lines indicate the linear fits to the experimental data, and the shaded areas represent the 95 % confidence intervals of the fitted curves.



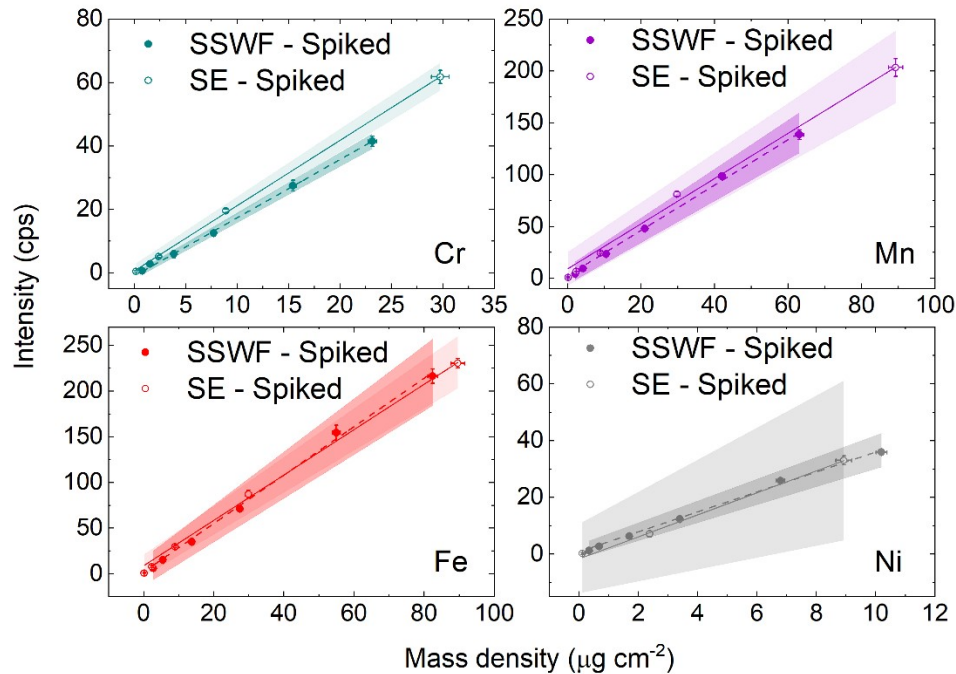
**Figure S-7** XRF intensity (cps) plotted as a function of mass density ( $\mu\text{g cm}^{-2}$ ) for in-house calibration standards prepared by spiking Mixed Cellulose Ester (MCE) particulate filters with high concentration single-element metal solutions (SE-Spiked). The y-error bars represent the standard deviation of three XRF intensity measurements obtained from each of the three replicate filters. The x-error bars represent the calculated uncertainty in elemental mass. The dashed lines indicate the linear fits to the experimental data, and the shaded areas represent the 95 % confidence intervals of the fitted curves.

## Mild Steel Welding Fume (MSWF)



**Figure S-8** XRF intensity (cps) plotted as a function of mass density ( $\mu\text{g cm}^{-2}$ ) for in-house calibration standards prepared by spiking MCE filters with single-element (SE-Spiked) and multi-element metal solutions, replicating the composition of HSE mild-steel welding fume (MSWF-Spiked). The y-error bars represent the standard deviation of three XRF intensity measurements obtained from each of the three replicate filters. The x-error bars represent the calculated uncertainty in elemental mass. The dashed/solid lines indicate the linear fits to the experimental data, and the shaded areas represent the 95 % confidence intervals of the fitted curves.

## Stainless Steel Welding Fume (SSWF)



**Figure S-9** XRF intensity (cps) plotted as a function of mass density ( $\mu\text{g cm}^{-2}$ ) for in-house calibration standards prepared by spiking MCE filters with single-element (SE-Spiked) and multi-element metal solutions, replicating the composition of HSE stainless-steel welding fume (SSWF-Spiked). The y-error bars represent the standard deviation of three XRF intensity measurements obtained from each of the three replicate filters. The x-error bars represent the calculated uncertainty in elemental mass. The dashed/solid lines indicate the linear fits to the experimental data, and the shaded areas represent the 95 % confidence intervals of the fitted curves.

**Table S-14** Elemental mass measured on the MSWF-PM and SSWF-PM filter samples by the XRF and the ICP-OES method.

	Element	Measured mass by XRF method ( $\mu\text{g}/\text{filter}$ )		Measured mass by ICP-OES method ( $\mu\text{g}/\text{filter}$ )	
		Single-element calibration	Multi-element calibration		
Mild Steel Welding Fumes (MSWF)	Test 1	Fe	41.59 $\pm$ 12.84	56.80 $\pm$ 6.05	49.37 $\pm$ 0.23
		Zn	8.65 $\pm$ 2.23	20.29 $\pm$ 1.24	24.42 $\pm$ 0.29
		Mn	0.27 $\pm$ 0.51	2.19 $\pm$ 0.66	1.81 $\pm$ 0.23
	Test 2	Fe	353.74 $\pm$ 11.92	362.09 $\pm$ 7.37	335.35 $\pm$ 0.23
		Zn	153.83 $\pm$ 3.35	183.85 $\pm$ 3.30	175.31 $\pm$ 0.29
		Mn	10.01 $\pm$ 0.55	14.44 $\pm$ 0.68	12.77 $\pm$ 0.23
	Test 3	Fe	583.29 $\pm$ 17.24	586.60 $\pm$ 13.89	627.56 $\pm$ 0.23
		Zn	290.95 $\pm$ 7.45	338.34 $\pm$ 8.22	362.12 $\pm$ 0.29
		Mn	17.17 $\pm$ 0.63	23.45 $\pm$ 0.85	23.79 $\pm$ 0.23
Stainless Steel Welding Fumes (SSWF)	Test 1	Fe	19.81 $\pm$ 8.51	39.73 $\pm$ 11.03	42.28 $\pm$ 0.14
		Mn	16.89 $\pm$ 10.27	41.29 $\pm$ 16.35	47.71 $\pm$ 0.09
		Ni	9.15 $\pm$ 1.39	4.40 $\pm$ 1.45	5.21 $\pm$ 0.10
		Cr	9.70 $\pm$ 5.33	18.02 $\pm$ 1.54	12.84 $\pm$ 0.12
	Test 2	Fe	157.20 $\pm$ 8.21	168.83 $\pm$ 9.30	171.13 $\pm$ 0.14
		Mn	159.62 $\pm$ 9.47	184.02 $\pm$ 6.64	178.52 $\pm$ 0.09
		Ni	25.96 $\pm$ 1.34	22.99 $\pm$ 1.37	21.81 $\pm$ 0.10
		Cr	44.33 $\pm$ 1.73	56.79 $\pm$ 1.81	54.55 $\pm$ 0.12
	Test 3	Fe	205.28 $\pm$ 7.58	214.01 $\pm$ 8.50	216.16 $\pm$ 0.14
		Mn	210.10 $\pm$ 8.64	234.51 $\pm$ 5.73	230.59 $\pm$ 0.09
		Ni	30.07 $\pm$ 1.41	27.53 $\pm$ 1.44	27.83 $\pm$ 0.10
		Cr	56.65 $\pm$ 1.51	70.58 $\pm$ 1.57	68.92 $\pm$ 0.12

## References

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