



AW: Table 1

CAS: Table 2

RTECS: Table 2

METHOD: 7306, Issue 1

EVALUATION: FULL

Issue 1: 10 September 2015

OSHA PELs: Table 2  
 NIOSH RELs: Table 2  
 OTHER OELs: [1,2]

PROPERTIES: Table 1

<b>ELEMENTS:</b>	aluminum	cadmium	indium	magnesium	potassium	tellurium	yttrium
	antimony	calcium	iron	manganese	selenium	thallium	zirconium
	arsenic	chromium	lanthanum	molybdenum	silver	titanium	zinc
	barium	cobalt	lead	nickel	strontium	tungsten	
	beryllium	copper	lithium	phosphorus	tin	vanadium	

**SAMPLING**

**MEASUREMENT**

**SAMPLER:** Internal capsule, cellulose acetate dome with inlet opening, attached to 0.8- $\mu$ m pore size mixed cellulose ester (MCE) membrane filter and housed within a 2-piece, closed-face cassette (CFC) filter holder, 37-mm diameter

**FLOWRATE:** 1 to 4 L/min

**VOL-MIN:** Table 1  
**-MAX:** Table 1

**SHIPMENT:** Routine

**SAMPLE STABILITY:** Stable

**BLANKS:** Minimum of 2 field blanks per set

**TECHNIQUE:** INDUCTIVELY COUPLED PLASMA – ATOMIC EMISSION SPECTROMETRY (ICP-AES)

**ANALYTES:** Elements above

**SAMPLE DISSOLUTION:** Hotplate digestion (NIOSH 7300 or 7301), microwave digestion (NIOSH 7302) or hot block extraction (NIOSH 7303)

**SOLUTION:** Dependent upon sample preparation method

**WAVELENGTH:** Depends upon element; See Table 3

**BACKGROUND CORRECTION:** Spectral wavelength shift

**CALIBRATION:** Elements in acid matrix-matched to the sample; varies depending on sample preparation method

**RANGE:** Varies with element

**ESTIMATED LOD:** Table 3

**PRECISION (  $\bar{S}_r$  ): Table 4**

**ACCURACY**

**RANGES STUDIED:** Tables 3 and 4

**BIAS:** Table 4

**OVERALL PRECISION (  $\bar{S}_{rt}$  ) Table 4**

**ACCURACY:** Table 4

**APPLICABILITY:** The working range of this method is  $4 \times 10^{-5}$  mg/m<sup>3</sup> to 10 mg/m<sup>3</sup> for each element in a 500-L air sample. This is simultaneous elemental analysis, not compound specific. Verify that the types of compounds in the samples are soluble with the dissolution procedure selected. Some compounds of these elements require special sample treatment.

**INTERFERENCES:** Spectral interferences are the primary interferences encountered in ICP-AES analysis. These are minimized by judicious wavelength selection, interelement correction factors and background correction [3,4].

**OTHER METHODS:** The internal capsule sampler used in this method is a recommended alternative to filter-only sampling [5] of NIOSH methods 7300 [6], 7301 [7], 7302 [8] and 7303 [9]. Use of an internal capsule sampler is an efficient means to account for sampler wall deposits that would otherwise be excluded by filter-only sampling. Unless other means are used to account for non-filter deposits inside the cassettes (e.g. within-cassette extraction, rinsing or wiping), internal capsule samplers should be used. OSHA method ID-125G [10] describes ICP-AES multielement analysis after hotplate digestion using nitric acid, sulfuric acid and hydrogen peroxide. ASTM D7035 [11] and ISO 15202 [12] are related voluntary consensus standard ICP-AES methods for multielement sampling and analysis of workplace atmospheres.

**REAGENTS:**

1. Nitric acid (HNO<sub>3</sub>)\*, concentrated, Trace metal grade
2. Hydrochloric acid (HCl)\*, conc., Trace metal grade (only required if hydrochloric acid digestion is to be carried out)
3. Perchloric acid (HClO<sub>4</sub>)\*, conc., optima (only required if perchloric acid digestion is to be carried out)
4. Calibration stock solutions, 1000 µg/L: Commercially available; or prepared per instrument manufacturer's recommendation
5. Dilution acid: 20% nitric acid\* (7302); 4% nitric acid:1% perchloric acid\* (7300); 5% aqua regia (7301)\*; or 5% nitric acid: 5% hydrochloric acid\* (7303) [dilution acid is dependent upon sample preparation method used]
6. Argon, as specified by ICP-AES manufacturer
7. Deionized water, ASTM Type II [13] or equivalent

\* See SPECIAL PRECAUTIONS

**EQUIPMENT:**

1. Sampler: cellulose acetate internal capsule attached to mixed cellulose ester membrane filter, 0.8-µm pore size; 37-mm diameter, in 2-piece, closed-face cassette filter holder
2. Personal sampling pump, 1 to 4 L/min, with flexible connecting tubing, capable of maintaining constant flow
3. Inductively coupled plasma-atomic emission spectrometer, equipped as specified by the manufacturer for analysis of elements of interest
4. Regulator, two-stage, for argon
5. Beakers, Phillips, 125-mL, or Griffin, 50-mL, with watch glass covers\*\*
6. Volumetric flasks, 10-, 25-, 100-mL, and 1-L\*\*
7. Assorted volumetric pipets, as needed\*\*
8. Forceps, plastic or plastic-tipped
9. Hotplate (NIOSH 7300 or 7301), microwave oven (NIOSH 7302) or hot block (NIOSH 7303) [6-9].
10. Centrifuge tubes, 50-mL or sized appropriately for hot block apparatus.

\*\* Clean all glassware with conc. nitric acid and rinse thoroughly in deionized water before use

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**SPECIAL PRECAUTIONS:** All perchloric acid digestions must be carried out in a perchloric acid fume hood. When working with concentrated acids, wear protective clothing, safety goggles and gloves. All work should be performed with adequate ventilation for personnel and equipment. It is imperative that acid be added to water in order to avoid a violent exothermic reaction.

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**SAMPLING:**

1. Calibrate each personal sampling pump with a representative sampler in line.  
NOTE: See NMAM guidance chapters for discussion on sampling.
2. Sample at an accurately known flow rate between 1 and 4 L/min (± 5%) for a total sample size of <1 to 2000 L (see Table 1) for TWA measurements. Do not exceed a sampler loading of approximately 5 mg total dust.  
NOTE: Filter overloading can be assessed by periodic visual checks. See NMAM guidance chapters for additional discussion on filter capacity.

**SAMPLE PREPARATION:**

3. Open the cassette filter holders and, using nonmetal forceps, transfer the samples and blanks to clean digestion vessels.  
NOTE: Samples may not easily fit into the digestion vessels. Care must be taken to ensure no sample is lost during the placement of the samples in the digestion vessels.

4. Carry out sample dissolution in accordance with one of the sample preparation procedures described in NIOSH 7300, 7301, 7302, or 7303 [6-9].  
NOTE: The dissolution acid level within the vessel should cover the internal capsule.
5. After allowing to cool to room temperature, transfer the solutions quantitatively to 25-mL volumetric flasks.
6. Dilute to volume.  
NOTE: If greater sensitivity is required, the final sample volume may be held to 10 mL.

#### CALIBRATION AND QUALITY CONTROL:

7. Calibrate the spectrometer according to the manufacturer recommendations.  
NOTE: Typically, an acid blank and 1.0 µg/mL multielement calibration standards are used. The following multielement combinations are chemically compatible in 5% HNO<sub>3</sub>:
  - a. Al, As, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, La, In, Na
  - b. Ag, K, Li, Mg, Mn, Ni, P, Pb, Se, Sr, Tl, V, Y, Zn, Sc
  - c. Mo, Sb, Sn, Te, Ti, W, Zr
8. Analyze at least one calibration standard per ten samples.
9. Check recoveries with at least one media blank and two spiked media blanks per twenty samples. Media should be spiked with analytes of interest.  
NOTE: Whenever possible, QA/QC samples should be prepared from certified reference materials in a matrix similar to the bulk material sampled. Liquid spiked filters are only surrogates for real world samples and QC data based upon certified samples are preferred.

#### MEASUREMENT:

10. Set ICP-AES spectrometer to conditions specified by manufacturer.
11. Analyze standards and samples by ICP-AES in accordance with manufacturer recommendations.  
NOTE: If the values for the samples are above the range of the standards, dilute the solutions (ensuring the samples remain acid matrix-matched to the calibration standards), reanalyze and apply the appropriate dilution factor in the calculations.

#### CALCULATIONS:

12. Obtain the solution concentrations for the sample,  $C_s$  (µg/mL), and the average media blank,  $C_b$  (µg/mL), from the instrument.
13. Using the solution volumes of sample,  $V_s$  (mL), and media blank,  $V_b$  (mL), calculate the concentration,  $C$  (mg/m<sup>3</sup>), of each element in the air volume sampled,  $V$  (L):

$$C = \frac{(C_s V_s) - (C_b V_b)}{V}, \text{ mg/m}^3$$

NOTE: µg/L is approximately equal to mg/m<sup>3</sup>

#### EVALUATION OF METHOD:

A previous interlaboratory investigation of aerosol-loaded cellulosic capsules (provided by SKC, Inc., Eighty-Four, PA) provided the background information for the development of this method [14]. That investigation yielded data for Cd, Cr, Co, Cu, Fe, Mn, Ni and Pb [14]. Recoveries for these elements were quantitative and values of overall relative standard deviation were <0.20 [14], which compare favorably with the variability typically observed in interlaboratory multielement analysis of air samples [15,16].

To obtain performance data for additional elements, interlaboratory performance data were obtained using 37-mm diameter cellulose acetate internal capsules attached to mixed-cellulose ester filters (Solu-sert™ from

Zefon International, Ocala, FL). Solu-sert™ capsules were dosed with 33 elements at three different spiking levels (spike levels certified by High-Purity Standards, North Charleston, SC), listed in Table 3. Sets of the spiked samples were conveyed to participating volunteer laboratories and analyzed by ICP-AES after sample dissolution. A variety of sample preparation procedures were used by the labs including NIOSH 7300, 7301, 7302, 7303, hot plate digestion utilizing nitric acid, sulfuric acid and hydrogen peroxide (modified NIOSH 7300), and microwave assisted digestion using nitric acid and hydrogen peroxide (modified NIOSH 7302). Results were received from 9 laboratories; however, not every spiked element was reported by each laboratory. Individual sample results may be found in the backup data report [17]. Statistical calculations were performed using SAS Software (version 9.2, SAS Institute Inc., Cary, NC). For each data subset, Grubbs' test at 1% confidence level was used to identify outliers, which if identified, were removed prior to further statistical calculations. No statistically significant differences were found between the laboratory results for the spiked samples; therefore, all reported data (regardless of the sample preparation method) are included in Tables 3 & 4. Recoveries were quantitative (as defined in Kennedy, et al. [18]) and interlaboratory variability was <0.20 for most elements and loading levels (Table 3). Mean overall recoveries below 90% were found only for Cr, K, and W at low loadings and for Ag at medium and high spike levels and for In at the high spike level. RSD values > 0.20 were found only for Sn at the low spike level, Ag at medium and high spike levels, and In and K at all loadings. Results for precision, bias and accuracy are summarized in Table 4.

With the domed top, the internal capsule can be difficult to fit into standard sample digestion vessels. One way to achieve this is to place the samplers into the vessels by bending them slightly inward (using coated forceps) and to push them into the bottom of the vessel to ensure they are covered with the digestion acids. Care must be taken to ensure that sample is not lost in this process. Additional guidance is available from the internal capsule manufacturer [19].

While no statistically significant differences were found based upon the sample preparation, it is important to note that interlaboratory variation is included in those calculations. Some differences in the sample preparation methods may have been statistically significant without that variability. Of particular importance are the less than quantitative recoveries for Sb, Sn, and Ti using NIOSH 7300. This sample preparation (as written) may not be amenable to the analysis of those elements. While this method lists several options for sample preparation, it is imperative that the suitability of the particular sample preparation method for the analytes of interest be considered.

Appreciable (>0.5 µg) media background levels were reported by Certified Reference Material (CRM) provider and/or the participating laboratories for several elements, notably Al, Ca, Cr, Fe, In, K, Mg, P, Sb, Se, and Tl. Trace media background levels of a few other elements, i.e., Ba, Cu and Zn, were also obtained. This background was effectively corrected for, as evidenced by the quantitative recoveries obtained for the vast majority of the elements and loading levels. Where the background levels may pose a greater influence is in the calculation of the method LOD. Method LODs (calculated using the standard deviation of blank responses) for internal capsule samples were greater than those calculated for MCE filters alone for many of the elements [17]. Care should be taken in choosing the appropriate media in concert with the expected sample concentrations.

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<b>TABLE 1. PROPERTIES AND SAMPLING VOLUMES [21]</b>				
<b>Element (Symbol)</b>	<b>Atomic Weight (AW)</b>	<b>MP, °C</b>	<b>Volume, L @ OSHA PEL<sup>A</sup></b>	
			<b>MIN<sup>B</sup></b>	<b>MAX<sup>C</sup></b>
Silver (Ag)	107.87	961	6	>2000 <sup>D</sup>
Aluminum (Al)	26.98	660	<1	330
Arsenic (As)	74.92	817	32	>2000
Barium (Ba)	137.34	727	3	>2000
Beryllium (Be)	9.01	1287	10	>2000
Calcium (Ca)	40.08	842	--	--
Cadmium (Cd)	112.41	321	3	>2000
Cobalt (Co)	58.93	1495	<1	>2000
Chromium (Cr)	52.00	1907	1	>2000
Copper (Cu)	63.54	1083	<1	>2000
Iron (Fe)	55.85	1538	2	500
Indium (In)	114.82	156	8	>2000
Potassium (K)	39.10	64	--	--
Lanthanum (La)	138.91	920	--	--
Lithium (Li)	6.94	181	--	--
Magnesium (Mg)	24.31	651	<1	330
Manganese (Mn)	54.94	1246	<1	1000
Molybdenum (Mo)	95.94	2623	<1	330
Nickel (Ni)	58.71	1455	2	>2000
Phosphorus (P)	30.97	44	9	>2000
Lead (Pb)	207.19	328	4	>2000
Antimony (Sb)	121.75	631	1	>2000
Selenium (Se)	78.96	221	2	>2000
Tin (Sn)	118.69	232	<1	>2000
Strontium (Sr)	87.62	777	--	--
Tellurium (Te)	127.60	450	7	>2000
Titanium (Ti)	47.87	1668	--	--
Thallium (Tl)	204.37	304	1	>2000
Vanadium (V)	50.94	1910	--	--
Tungsten (W)	183.85	3422	--	--
Yttrium (Y)	88.91	1522	<1	>2000
Zinc (Zn)	65.37	419	--	--
Zirconium (Zr)	91.22	1855	<1	1000

<sup>A</sup> Exposure limits listed in Table 2.  
<sup>B</sup> Min calculated using the method quantitation limits following NIOSH 7302 sample preparation.  
<sup>C</sup> Max calculated using 5 mg of sample collected.  
<sup>D</sup> Indicates that the calculated maximum volume is greater than the volume collected at the maximum flow rate (4 L/min) of the method for an 8-hour shift.

TABLE 2. EXPOSURE LIMITS, CAS#, RTECS [22]				
Element (Symbol)	CAS #	RTECS #	Exposure Limits	
			OSHA PEL (mg/m <sup>3</sup> )	NIOSH REL (mg/m <sup>3</sup> )
Silver (Ag)	7440-22-4	VW3500000	0.01 (dust, fume, metal)	0.01 (metal, soluble)
Aluminum (Al)	7429-90-5	BD0330000	15 (total dust) 5 (respirable)	10 (total dust) 5 (respirable fume) 2 (soluble)
Arsenic (As)	7440-38-2	CG0525000	0.010	C <sup>E</sup> 0.002 (15 min), Ca <sup>F</sup> 0.5
Barium (Ba)	7440-39-3	CQ8370000	0.5	
Beryllium (Be)	7440-41-7	DS1750000	0.002, C 0.005	C 0.0005, Ca
Calcium (Ca)	7440-70-2	--	--	--
Cadmium (Cd)	7440-43-9	EU9800000	0.005	lowest feasible, Ca
Cobalt (Co)	7440-48-4	GF8750000	0.1 (dust, fume)	0.05 (dust, fume)
Chromium (Cr)	7440-47-3	GB4200000	1 (metals, insoluble salts) 0.5 (Cr II & Cr III)	0.5
Copper (Cu)	7440-50-8	GL5325000	1 (dust, mists) 0.1 (fume)	1 (dust, mists) 0.1 (fume)
Iron (Fe)	7439-89-6	NO4565500	10 (fume) as oxide	5 (dust, fume) oxide as Fe
Indium (In)	7440-74-6	NL1050000	0.1	0.1
Potassium (K)	7440-09-7	TS6460000	--	--
Lanthanum	7439-91-0	--	--	--
Lithium (Li)	7439-93-2	OJ5540000	--	--
Magnesium (Mg)	7439-95-4	OM2100000	15 (dust) as oxide	--
Manganese (Mn)	7439-96-5	OO9275000	C 5	C 1; STEL <sup>G</sup> 3
Molybdenum (Mo)	7439-98-7	QA4680000	5 (soluble) 15 (total insoluble dust)	--
Nickel (Ni)	7440-02-0	QR5950000	1	0.015, Ca
Phosphorus (P)	7723-14-0	TH3500000	0.1	0.1
Lead (Pb)	7439-92-1	OF7525000	0.05	0.05
Antimony (Sb)	7440-36-0	CC4025000	0.5	0.5
Selenium (Se)	7782-49-2	VS7700000	0.2	0.2
Tin (Sn)	7440-31-5	XP7320000	2	2
Strontium (Sr)	7440-24-6	WK7700000	--	--
Tellurium (Te)	13494-80-9	WY2625000	0.1	0.1
Titanium (Ti)	7440-32-6	XR1700000	15 as dioxide	Ca as the oxide
Thallium (Tl)	7440-28-0	XG3425000	0.1 (skin) (soluble)	0.1 (skin) (soluble)
Vanadium (V)	7440-62-2	YW1355000	C 0.5 (respirable) as pentoxide	C 0.05 as pentoxide
Tungsten (W)	7440-33-7	YO7175000	--	5; STEL 10
Yttrium (Y)	7440-65-5	ZG2980000	1	1
Zinc (Zn)	7440-66-6	ZG8600000	5 (fume, respirable dust) as oxide 15 (total dust) as oxide	5 (dust, fume) as oxide C 15 (dust) as oxide STEL 10 (fume) as oxide
Zirconium (Zr)	7440-67-7	ZH7070000	5	5; STEL 10

<sup>E</sup> C: ceiling  
<sup>F</sup> Ca: carcinogen  
<sup>G</sup> STEL: short-term exposure limit



TABLE 3. MEASUREMENT WAVELENGTHS ( $\lambda$ ), DETECTION LIMITS (LOD) AND RECOVERY DATA FROM INTERLABORATORY RESULTS								
Element	Wavelength <sup>H</sup> ( $\lambda$ , nm)	LOD <sup>I</sup> (ug/sample)	Low Level (ug/sample)	% Recovery (%RSD; N <sup>J</sup> )	Medium level (ug/ sample)	% Recovery (%RSD; N <sup>J</sup> )	High Level (ug/ sample)	% Recovery (%RSD; N <sup>J</sup> )
Ag	328.068	0.020	5.0	93.2 (17; 7)	10.1	83.5 (26; 7)	20.1	68.2 (52; 7)
Al	396.152	0.38	10.6	95.7 (6.1; 7)	30.9	95.7 (3.1; 7)	60.8	96.2 (2.4; 7)
As	189.042	0.099	5.0	99.4 (7.3; 7)	20.2	103 (5.3; 8)	40.1	102 (5.8; 8)
Ba	455.404	0.55	2.21	97.0 (8.4; 8)	7.3	96.9 (2.5; 7 <sup>K</sup> )	15.2	99.9 (5.0; 8)
Be	313.042	0.0064	2.01	101 (4.4; 9)	7.0	101 (6.8; 9)	14.9	100 (5.1; 9)
Ca	315.887	3.9	114	95.8 (16; 8)	165	97.4 (15; 8)	215	95.8 (13; 8)
Cd	226.502	0.0052	2.01	101 (3.6; 9)	7.0	101 (4.0; 9)	14.9	102 (1.9; 8)
Co	228.616	0.0090	2.01	103 (6.8; 9)	7.0	102 (5.7; 9)	14.9	102 (5.8; 9)
Cr	267.716	0.28	2.91	80.2 (16; 8)	7.9	96.3 (7.2; 9)	15.8	97.2 (3.5; 9)
Cu	324.754	0.15	3.16	100 (4.5; 8 <sup>K</sup> )	15.1	101 (4.0; 9)	29.9	100 (3.2; 9)
Fe	259.941	5.3	21.3	107 (15; 9)	41.0	104 (5.5; 9)	80.5	103 (5.4; 9)
In	230.606	0.26	5.0	92.1 (33; 5)	14.9	90.8 (27; 5 <sup>K</sup> )	39.7	86.2 (32; 5)
K	766.491	0.70	10.6	89.0 (36; 5)	15.7	98.0 (24; 6)	20.7	106 (20; 6)
La	408.672	0.026	3.01	101 (8.1; 4)	10.1	102 (7.2; 4)	20.1	99.9 (7.9; 4)
Li	670.780	0.010	2.01	93.0 (8.5; 7)	7.0	94.9 (7.0; 7)	14.9	98.6 (5.2; 7)
Mg	279.079	1.1	12.7	93.9 (16; 7)	27.9	98.7 (9.1; 7)	103	101 (7.2; 7)
Mn	294.921	0.031	2.01	99.8 (7.6; 9)	7.0	100 (6.1; 9)	14.9	100 (5.7; 9)
Mo	202.095	0.021	2.01	101 (6.2; 9)	7.1	102 (4.8; 9)	15.0	102 (5.2; 9)
Ni	231.604	0.56	2.01	108 (9.6; 9)	7.0	104 (7.4; 9)	14.9	103 (7.0; 9)
P	178.287	0.27	10.1	104 (9.0; 5)	24.9	103 (8.9; 6)	99	102 (1.7; 5 <sup>K</sup> )
Pb	220.353	0.062	10.0	101 (6.2; 9)	25.2	100 (5.3; 9)	100	100 (7.3; 9)
<sup>H</sup> Commonly used wavelength; choose wavelength appropriate for your instrument settings [3,4] <sup>I</sup> LOD values calculated using the responses of 7 media blanks, prepared following the microwave sample preparation in NIOSH 7302 <sup>J</sup> Mean recovery & relative standard deviation for N = number of laboratories reporting results for each element <sup>K</sup> Excludes outlier(s) (Grubbs' test)								

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TABLE 3. MEASUREMENT WAVELENGTHS ( $\lambda$ ), DETECTION LIMITS (LOD) AND RECOVERY DATA FROM INTERLABORATORY RESULTS								
Element	Wavelength <sup>H</sup> ( $\lambda$ ), nm	LOD <sup>I</sup> (ug/sample)	Low Level (ug/sample)	% Recovery (%RSD; N <sup>J</sup> )	Medium level (ug/ sample)	% Recovery (%RSD; N <sup>J</sup> )	High Level (ug/ sample)	% Recovery (%RSD; N <sup>J</sup> )
Sb	206.833	0.11	5.0	99.1 (6.7; 8)	25.1	99.0 (5.7; 9)	40.2	100 (3.6; 8 <sup>K</sup> )
Se	196.090	0.14	3.0	112 (15; 6)	15.1	109 (8.7; 8)	30.1	104 (10; 8)
Sn	189.991	0.065	2.01	98.7 (26; 4)	7.0	96.9 (18; 6)	14.9	103 (5.0; 5 <sup>K</sup> )
Sr	407.771	0.014	2.01	100 (1.9; 6 <sup>K</sup> )	7.1	102 (7.5; 7)	15.0	101 (6.1; 7)
Te	214.281	0.22	3.0	104 (18; 5)	12.6	103 (7.7; 5)	20.1	101 (12; 5)
Ti	334.941	0.042	2.01	105 (5.7; 7)	7.0	101 (10; 7)	14.9	103 (3.4; 6 <sup>K</sup> )
Tl	190.864	0.046	3.0	102 (7.1; 6)	10.1	99.6 (5.8; 7)	20.1	98.3 (7.5; 7)
V	311.071	0.0091	3.02	101 (5.7; 9)	7.0	102 (6.2; 9)	14.9	102 (5.8; 9)
W	207.911	0.055	10.1	83.0 (12; 5)	25.1	97.6 (12; 5)	40.2	96.4 (16; 5)
Y	371.030	0.0039	2.01	101 (3.8; 5)	7.1	102 (5.9; 5)	15.0	101 (4.8; 5)
Zn	213.856	0.69	5.2	101 (6.0; 9)	25.1	101 (4.9; 9)	59.7	101 (4.8; 9)
Zr	339.198	0.0099	2.01	101 (6.2; 5)	7.0	99.5 (9.2; 6)	14.9	93.1 (19; 6)

<sup>H</sup> Commonly used wavelength; choose wavelength appropriate for your instrument settings [3,4]  
<sup>I</sup> LOD values calculated using the responses of 7 media blanks, prepared following the microwave sample preparation in NIOSH 7302  
<sup>J</sup> Mean recovery & relative standard deviation for N = number of laboratories reporting results for each element  
<sup>K</sup> Excludes outlier(s) (Grubbs' test)

**TABLE 4. RANGE, BIAS, PRECISION ( $\bar{S}_r$  and  $\hat{S}_{rt}$ ) AND ACCURACY DATA FROM INTERLABORATORY RESULTS**

Element	n <sup>L</sup>	Range, ug/sample	Bias	$\bar{S}_r^M$	$\hat{S}_{rt}^N$	Accuracy (%)
Ag	21	5.0 to 20.1	-0.184	0.041	0.065	29.0
Al	21	10.6 to 60.8	-0.0414	0.006	0.050	12.4
As	23	5.0 to 40.1	0.0141	0.016	0.052	10.7
Ba	23	2.21 to 15.2	-0.0206	0.036	0.062	12.8
Be	27	2.01 to 14.9	0.00536	0.025	0.056	11.0
Ca	24	114 to 215	-0.0367	0.001	0.050	11.9
Cd	26	2.01 to 14.9	0.0133	0.022	0.055	11.1
Co	27	2.01 to 14.9	0.0238	0.036	0.062	12.9
Cr	26	2.91 to 15.8	-0.0281	0.046	0.068	14.4
Cu	26	3.16 to 29.9	0.00347	0.017	0.053	10.4
Fe	27	21.3 to 80.5	0.0476	0.011	0.051	13.2
In	15	5.0 to 39.7	-0.103	0.056	0.075	22.6
K	17	10.6 to 20.7	-0.0239	0.029	0.058	12.3
La	12	3.01 to 20.1	0.0119	0.025	0.056	11.2
Li	21	2.01 to 14.9	-0.0447	0.039	0.064	14.9
Mg	21	12.7 to 103	-0.0219	0.012	0.051	10.9
Mn	27	2.01 to 14.9	0.00127	0.039	0.063	12.4
Mo	27	2.01 to 15.0	0.0169	0.032	0.060	12.1
Ni	27	2.01 to 14.9	0.0498	0.055	0.074	17.2
P	16	10.1 to 99	0.0310	0.010	0.051	11.5
Pb	27	10.0 to 100	0.00439	0.006	0.050	9.9
Sb	25	5.0 to 40.2	-0.00631	0.013	0.052	10.2
Se	22	3.0 to 30.1	0.0864	0.055	0.075	20.9
Sn	15	2.01 to 14.9	-0.00541	0.117	0.128	25.0
Sr	20	2.01 to 15.0	0.00930	0.011	0.051	10.2
Te	15	3.0 to 20.1	0.0256	0.063	0.081	16.6
Ti	20	2.01 to 14.9	0.0305	0.032	0.059	13.1
Tl	20	3.0 to 20.1	0.00128	0.030	0.058	11.4
V	27	3.02 to 14.9	0.0143	0.020	0.054	10.9
W	15	10.1 to 40.2	-0.0240	0.010	0.051	11.0
Y	15	2.01 to 15.0	0.00971	0.020	0.054	10.7
Zn	27	5.2 to 59.7	0.00873	0.013	0.052	10.3
Zr	17	2.01 to 14.9	-0.0206	0.033	0.060	12.4

<sup>L</sup> n = total number of results reported for each element by up to 9 participating laboratories minus outliers (Grubbs' test, 1% confidence level)

<sup>M</sup>  $\bar{S}_r$  = precision [17]

<sup>N</sup>  $\hat{S}_{rt}$  = overall precision =  $\sqrt{\bar{S}_r^2 + (0.05)^2}$  ; same as total precision as defined in [18,20]