



May 15, 2006

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(913) 338-2739
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Mr. Aaron Zack
Sunlight Saunas, Inc.
14119 Marshall Drive
Lenexa, Kansas 66215

Tel: (913) 754-0831
Fax: (775) 514-4314

RE: Air Sampling Armana Sauna
Sunlight Saunas, Inc.
14119 Marshall Drive
Lenexa, Kansas 66215

APEX Project No. 60125I

Dear Mr. Zack:

In response to your request and authorization, APEX Environmental Consultants, Inc. conducted air sampling in an Armana Sauna on May 2nd and 3rd, 2006. The purpose of the sampling effort was to determine if heater contaminants were being liberated inside the sauna during operation. It is our understanding that this work was initiated due to one of your competitors making claims that your saunas are unsafe due to the liberation of various contaminants from the heater system.

Per your request, air sampling for carbon, silicon, and sulfur dioxide was performed inside an operating Armana sauna. The samples were collected over a 420 to 480 minute sampling period with the sauna adjusted to 150 degrees Fahrenheit. Background air samples were also collected to determine normal background levels for these contaminants outside the sauna. The Armana sauna is equipped with a far infrared Solocarbon heater.

Based on laboratory results, no silicon was detected in the sauna air sample at an instrument detection limit of 1.0 microgram/sample. At this detection limit, we can say that the air concentration in the operating sauna was at least less than 0.0005 mg/m³. This airborne concentration is less than 30,000 times what the Occupational Safety and Health Administration (OSHA) considers a safe exposure limit for silicon. The OSHA permissible exposure limit (PEL) for silicon is 15 mg/m³ (average total concentration).



No sulfur dioxide was detected in the sauna air sample at an instrument detection limit of 1.3 micrograms/sample. At this detection limit, we can say that the air concentration in the operating sauna was at least less than 0.69 parts per billion. This airborne concentration is less than 7000 times what the Occupational Safety and Health Administration (OSHA) considers a safe exposure limit for sulfur dioxide. The OSHA permissible exposure limit (PEL) for sulfur dioxide is 5000 parts per billion.

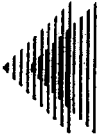
Carbon was detected in the operating sauna at 0.06 milligrams/sample. Based on the volume of air sampled, we can say the air concentration in the operating sauna was 0.07 mg/m^3 . However, the background air sample collected outside the sauna showed an even higher airborne concentration of carbon at 0.08 mg/m^3 . This is likely the result of carbon being a common outdoor pollutant, the largest source being internal combustion engines (automobile). Based on these sample results, the Solocarbon heater does not appear to be contributing to any type of carbon contamination inside the sauna. The OSHA permissible exposure limit (PEL) for carbon black is 3.5 mg/m^3 (average total concentration). The measured concentration is less than 50 times what the Occupational Safety and Health Administration (OSHA) considers a safe exposure limit for carbon.

As you can see from the sampling data, there should be absolutely no concerns regarding exposure to the subject contaminates during the operation of your saunas. If you have questions about the information contained in this report or require additional services, we would be happy to assist you in any way we can.

Respectfully submitted,
APEX Environmental Consultants, Inc.

David Nold, M.S., CIH, REHS
Industrial Hygienist

APPENDIX A
LABORATORY ANALYSIS REPORTS



APEX Environmental Consultants, Inc.

06-SW2-2057

14955 W. 101st Terrace • Lenexa, Kansas 66215 • (913) 338-2739 • FAX (913) 338-2741

Sample Chain of Custody

Sample Date: May 3, 2006

Page: 1 of 1

Project Name: Sunlight Saunas, Lenexa, KS

Contact: David Nold

Project #: 60125I

Sample ID	Location Description	Sample Type	Flow Rate	Total Volume	Notes
CB-01	Inside Armana Sauna at 150 ^o F	Carbon Black / NIOSH 5000	2 L/min x 420 min	840 Liters	12488
CB-02	Background sample	Carbon Black / NIOSH 5000	2 L/min x 420 min	840 Liters	12489
Si-01	Inside Armana Sauna at 150 ^o F	Silicon / NIOSH 7300	4 L/min x 480 min	1920 Liters	12490
Si-02	Background sample	Silicon / NIOSH 7300	4 L/min x 480 min	1920 Liters	12491
S02-01	Inside Armana Sauna at 150 ^o F	Sulfur Dioxide / OSHA ID 200	1.5 L/min x 480 min	720 Liters	12492
S02-02	Background sample	Sulfur Dioxide / OSHA ID 200	1.5 L/min x 480 min	720 Liters	12493

Additional Instructions:

- Standard Turnaround Please
- E-mail results to: dnold@apex.com

- Please Fax results to Attn. Dave at (913) 338-2741
- Send invoice to: Accts. Payable, APEX Environmental Consultants

Relinquished By: *[Signature]* Date: 5-4-06 Received by: *[Signature]* Date: 5/5/06 1037

Relinquished By: _____ Date: _____ Received by: _____ Date: _____

Relinquished By: _____ Date: _____ Received by: _____ Date: _____



Submitted To: Dave Nold
Apex Environmental
14955 W. 101st Terrace
Lenexa, KS 66215

Reference Data:	Carbon Black
Client Sample No.:	CB-01 through CB-02
P.O. No.:	Not Available
Sample Location:	Sunlight Saunas, Lenexa, KS,
Project Number:	60125I
Sample Type:	Filter
Method Reference:	NIOSH 5000
DCL Set ID No.:	06-W-2057
DCL Sample ID No.:	06-12488 through 06-12489
Sample Receipt Date:	5/5/2006
Analysis Date:	5/8/2006

The samples were analyzed in accordance with NIOSH method 5000.

Sample condition was acceptable upon receipt except where noted.

The results are provided in the enclosed data table. Results relate only to the items tested and are not blank corrected unless indicated in the data table.

This report shall not be reproduced except in full, without the written approval of the laboratory.

A handwritten signature in black ink, appearing to read "Rob Nieman", written over a horizontal line.

Rob Nieman
Analyst

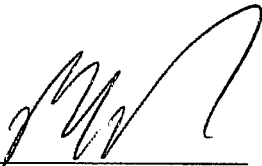
A handwritten signature in black ink, appearing to be initials, written over a horizontal line.

Reviewer

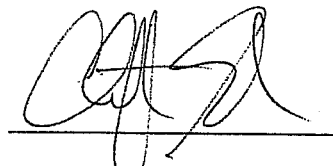
Results Carbon Black

Client #	DCL #	Sample Volume (L)	mg/sample	mg/m ³
CB-01	06-12488	840	0.06	0.07
CB-02	06-12489	840	0.07	0.08
EQL			0.05	

ND indicates not detected at or above the estimated quantitation limit (EQL).



Rob Nieman
Analyst



Reviewer



Submitted To: Dave Nold
Apex Environmental
14955 W. 101st Terrace
Lenexa, KS 66215

Reference Data: **Silicon**
Client Sample No.: Si-01 through Si-02
P.O. No.: Not Available
Sample Location: Sunlight Saunas, Lenexa, KS
Project Number: 601251
Sample Type: Filter
Method Reference: NIOSH 7300
DCL Set ID No.: 06-S-2057
DCL Sample ID No.: 06-12490 through 06-12491
Sample Receipt Date: 5/5/2006
Preparation Date: 05/10/06
Analysis Date: 05/10/06

The samples were prepared and analyzed in accordance with NIOSH method 7300 using a Perkin Elmer 3000XL ICP.

The sample condition upon receipt was acceptable except where noted.

The results are in the enclosed data table. Results relate only to the items tested and are not blank corrected unless indicated in the data table.

This report shall not be reproduced except in full, without the written approval of the laboratory.

A handwritten signature in black ink, appearing to read "Chris", written over a horizontal line.

Chris Baugues
Analyst

A handwritten signature in black ink, appearing to be a stylized name, written over a horizontal line.

Reviewer

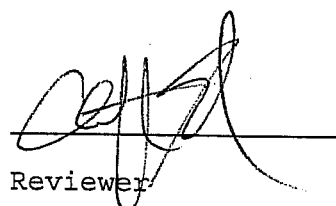
Results Silicon

Client #	DCL #	Sample Volume (L)	µg/sample	mg/m ³
Si-01	06-12490	1920	ND	<0.0005
Si-02	06-12491	1920	ND	<0.0005
	Prep Blank		ND	
% Recovery	LCS 1		102.	
% Recovery	LCS 2		96.	
RPL			1.	

ND = not detected at or above the reporting limit (RPL).
LCS = laboratory control sample.



Chris Baugues
Analyst



Reviewer



Submitted To: Dave Nold
Apex Environmental
8600 W. 110th St.
Overland Park, KS
66210

Reference Data: **Sulfur Dioxide**
Sample Location: Sunlight Saunas, Lenexa, KS, Project Number:
601251
Sample Type: IABC tube
Client Sample No.: SO2-01 through SO2-02
PO #: Not Available
Method Reference: OSHA 200
Sample Set ID#: 06-L-2057
DATACHEM Lab No.: 06-12492 through 06-12493
Date Received: 05/05/06
Preparation Date: 05/09/06
Analysis Date: 05/10/06


Sample condition was acceptable upon receipt except where noted.


Analysis was completed on a Dionex IC2000 Ion Chromatograph equipped with a Dionex AS18-AG18 column and a conductance detector. The eluent used was 35mM Potassium Hydroxide at a flow rate of 1.0 mL per minute.

Compound identification is based upon retention time matching only. Any compound with a similar retention time will interfere.

The results are provided in the enclosed data table. Results relate only to the items tested and are not blank corrected.

This report shall not be reproduced except in full, without the written approval of the laboratory.

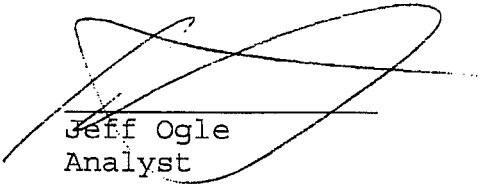

Jeff Ogle
Analyst


Reviewer

Data Table Sulfur Dioxide

Client ID	Lab ID	Air Volume (L)	µg/sample	ppb
SO2-01	06-12492	720.	ND	<.69
SO2-02	06-12493	720.	ND	<.69
	EQL		1.3	

ND indicates analyte was not detected at or above the estimate quantitation limit (EQL).



Jeff Ogle
Analyst



E. J. Slick
Reviewer

APPENDIX B
PHOTO LOG

PROJECT NAME: Air Sampling
PROJECT LOCATION: Sunlight Saunas, Lenexa, Kansas

PHOTO LOG
PHOTO DATE: May 2, 2006
APEX Proj. No.: 60125I



Photo No. 1

View of showroom at Sunlight Saunas, Lenexa, Kansas.



Photo No. 2

View of Armana sauna. Note doors were sealed with masking tape during testing.

APPENDIX C
NIOSH ANALYTICAL METHODS

CARBON BLACK

5000

C

MW: 12.01

CAS: 1333-86-4

RTECS: FF5800000

METHOD: 5000, Issue 2

EVALUATION: FULL

Issue 1: 15 May 1989

Issue 2: 15 August 1994

OSHA : 3.5 mg/m³

NIOSH: 3.5 mg/m³ (in presence of PAHs: carcinogen/PAHs
to 0.1 mg/m³, cyclohexane extractable fraction)

ACGIH: 3.5 mg/m³

PROPERTIES: solid; may contain polynuclear aromatic hydrocarbons (PAH)

SYNONYMS: acetylene black; amorphous carbon; furnace black; lamp black

SAMPLING		MEASUREMENT	
SAMPLER:	FILTER (tared 5-µm PVC membrane)	TECHNIQUE:	GRAVIMETRIC (FILTER WEIGHT)
FLOW RATE:	1 to 2 L/min	ANALYTE:	airborne particulate material
VOL-MIN:	30 L @ 3.5 mg/m ³	BALANCE:	0.001 mg sensitivity; use same balance before and after sample collection
-MAX:	570 L	CALIBRATION:	National Institute of Standards and Technology, Class S-1.1 weights or ASTM Class 1 weights
SHIPMENT:	routine	RANGE:	0.1 to 2 mg per sample
SAMPLE STABILITY:	indefinitely	ESTIMATED LOD:	0.03 mg per sample
BLANKS:	2 to 10 field blanks per set	PRECISION (\hat{S}_r):	0.025 @ 3.5 mg/m ³ [1, 2]
ACCURACY			
RANGE STUDIED:	2 to 8 mg/m ³ (100-L samples)		
BIAS:	0.01%		
OVERALL PRECISION (\hat{S}_r):	0.056 [1]		
ACCURACY:	± 11.0%		

APPLICABILITY: The working range is 0.5 to 10 mg/m³ for a 200-L air sample. This method is not applicable for the determination of "cyclohexane-solubles" [3]. This analysis is simple but the method is nonspecific. Information on any other particulate materials present should be assessed. The method may be extended to higher air concentrations (e.g., nuisance dust levels) by collecting a smaller sample volume [4].

INTERFERENCES: The presence of any other particulate material in the air being sampled will be a positive interference since this is a gravimetric method.

OTHER METHODS: This is Method S262 [5] in a revised format. It is similar, except for collecting device, to the method described in the carbon black criteria document [3].

EQUIPMENT:

1. Sampler: 37-mm, 5- μ m pore size PVC filter and stainless steel support screen in 37-mm, cassette filter holder (preferably, conductive).
2. Personal sampling pump, 1 to 2 L/min, with flexible connecting tubing.
3. Microbalance capable of weighing to 0.001 mg.
4. Static neutralizer; e.g. Po-210; replace nine months after production date.
5. Forceps (preferably nylon).
6. Environmental chamber or room for balance (e.g. 20 ± 1 °C and $50 \pm 5\%$ RH).

SPECIAL PRECAUTIONS: Carbon black containing polynuclear aromatic hydrocarbons (cyclohexane extractable materials) in excess of 0.1% (w/w) should be treated as a suspect carcinogen [3].

PREPARATION OF FILTERS BEFORE SAMPLING:

1. Equilibrate the filters in an environmentally controlled weighing area or chamber for at least 2 h.
NOTE: An environmentally controlled chamber is desirable, but not required.
2. Number the backup pads with a ballpoint pen and place them, numbered side down, in filter cassette bottom sections.
3. Weigh the filters in an environmentally controlled area or chamber. Record the filter tare weights, W_1 , (mg).
 - a. Zero the balance before each weighing.
 - b. Handle the filter with forceps. Pass the filter over an antistatic radiation source. Repeat this step if filter does not release easily from the forceps or if filter attracts balance pan. Static electricity can cause erroneous weight readings.
4. Assemble the filters in the filter cassettes and close firmly so that leakage around the filter will not occur. Place a plug in each opening of the filter cassette. Place a cellulose shrink band around the filter cassette, allow to dry, and mark with the same number as the backup pad.

SAMPLING:

5. Calibrate each personal sampling pump with a representative sampler in line.
6. Sample at 1 to 2 L/min for a total sample volume of 30 to 570 L. Do not exceed a filter loading of approximately 2 mg total dust. Take two to four replicate samples for each batch of field samples for quality assurance on the sampling procedures.

SAMPLE PREPARATION:

7. Wipe dust from the external surface of the filter cassette with a moist paper towel to minimize contamination. Discard the paper towel.
8. Remove the top and bottom plugs from the filter cassette. Equilibrate for at least 2 h in the balance room.
9. Remove the cassette band, pry open the cassette, and remove the filter gently to avoid loss of dust.
NOTE: If the filter adheres to underside of cassette top, gently lift using the dull side of scalpel blade. Take care not to tear the filter.

CALIBRATION AND QUALITY CONTROL:

10. Zero the microbalance before all weighings. Use the same microbalance for weighing filters before and after sample collection. Calibrate the balance with National Institute of Standards and Technology Class S-1.1 or ASTM Class 1 weights.
11. The set of replicate samples should be exposed to the same dust environment, either in a laboratory dust chamber [6] or in the field [7]. The quality control samples must be taken with the same equipment, procedures and personnel used in the routine field samples. Calculate precision from these replicates and record \bar{S}_r on control charts. Take corrective action when the precision is out of control [6].

MEASUREMENT:

12. Weigh each filter, including field blanks. Record the post-sampling weight, W_2 (mg). Record anything remarkable about a filter (e.g., overload, leakage, wet, torn, etc.).

CALCULATIONS:

13. Calculate the concentration, C (mg/m^3), of carbon black in the air volume sampled, V (L):

$$C = \frac{(W_2 - W_1) - (B_2 - B_1)}{V} \cdot 10^3, \text{ mg}/\text{m}^3.$$

where: W_1 = tare weight of filter before sampling (mg)
 W_2 = post-sampling weight of sample-containing filter (mg)
 B_1 = tare weight of blank filter (mg)
 B_2 = post-sampling weight of blank filter (mg)

EVALUATION OF METHOD:

Method S262 [5] was issued on January 30, 1976, and validated over the range 1.9 to 7.7 mg/m^3 for a 200-L sample and over the range 7.8 to 28 mg/m^3 for a 100-L sample using Vulcan XC72 (0.03- μm particle size; Cabot Corp.) in a Wright Dust Feeder [1]. Overall precision, \bar{S}_{rT} , was 0.056. Collection efficiency was between 99 and 100%.

REFERENCES:

- [1] Documentation of the NIOSH Validation Tests, S262 and S349, U.S. Department of Health, Education, and Welfare, Publ. (NIOSH) 77-185 (1977).
- [2] Unpublished data from Non-textile Cotton Study, NIOSH/DRDS/EIB.
- [3] NIOSH Criteria for a Recommended Standard ... Occupational Exposure to Carbon Black, U.S. Department of Health, Education, and Welfare, Publ. (NIOSH) 78-204, 80-88 (1978).
- [4] NIOSH Manual of Analytical Methods, 2nd ed., V. 3, S349, U.S. Department of Health, Education, and Welfare, Publ. (NIOSH) 77-157-C (1977).

- [5] NIOSH Manual of Analytical Methods, 2nd ed., V. 3, S262, U.S. Department of Health, Education, and Welfare, Publ. (NIOSH) 77-157-C (1977).
- [6] Bowman, J.D., D.L. Bartley, G.M. Breuer, L.J. Doemeny, D.J. Murdock. Accuracy Criteria Recommendation for the Certification of Gravimetric Coal Mine Dust Personal Samplers. U.S. Department of Health and Human Services, NTIS Pub. No. 85-222446 (1984).
- [7] Breslin, J.A., S.J. Page, R.A. Jankowski. Precision of Personal Sampling of Respirable Dust in Coal Mines, U.S. Bureau of Mines Reports of Investigations #8740 (1983).

METHOD REVISED BY:

Frank Hearl, P.E., NIOSH/DRDS; S262 and S349 originally validated under NIOSH Contract CDC-99-74-45.

SULFUR DIOXIDE

6004

SO₂

MW: 64.06

CAS: 7446-09-5

RTECS: WS4550000

METHOD: 6004, Issue 2

EVALUATION: PARTIAL

Issue 1: 15 May 1989

Issue 2: 15 August 1994

OSHA : 5 ppm
 NIOSH: 2 ppm; STEL 5 ppm; Group I Pesticide
 ACGIH: 2 ppm; STEL 5 ppm
 (1 ppm = 2.62 mg/m³ @ NTP)

PROPERTIES: gas; vapor density 2.26 (air = 1);
 BP -10 °C; MP -72.7 °C;
 nonflammable

SYNONYMS: none

SAMPLING

SAMPLER: FILTER + TREATED FILTER
 (cellulose + Na₂CO₃; preceded by
 0.8-µm cellulose ester membrane)

FLOW RATE: 0.5 to 1.5 L/min

VOL-MIN: 4 L @ 5 ppm
-MAX: 200 L

SHIPMENT: routine

SAMPLE STABILITY: not determined

FIELD BLANKS: 2 to 10 field blanks per set

MEASUREMENT

TECHNIQUE: ION CHROMATOGRAPHY

ANALYTE: sulfite and sulfate ions

EXTRACTION: 10 mL 1.75 mM NaHCO₃/2.0 mM Na₂CO₃

INJECTION LOOP VOLUME: 50 µL

ELUENT: 1.75 mM NaHCO₃/2.0 mM Na₂CO₃,
 2 to 3 mL/min

COLUMNS: Ion Pac AS4A separator, Ion Pac AG4A
 guard; micromembrane suppressor [2]

CONDUCTIVITY SETTING: 10 µS full scale

CALIBRATION: standard solutions of SO₃²⁻ and SO₄²⁻
 in eluent

RANGE: 11 to 200 µg SO₂ per sample

ESTIMATED LOD: 3 µg SO₂ per sample [2]

PRECISION (S_r): 0.042 [2]

ACCURACY

RANGE STUDIED: not studied

BIAS: not determined

OVERALL PRECISION (S_r): not determined

ACCURACY: not determined

APPLICABILITY: The working range is 0.2 to 8 ppm (0.5 to 20 mg/m³) for a 100-L air sample. The method is applicable to STEL samples. SO₂ is collected on the back (treated) filter. Sulfuric acid, sulfate salts, and sulfite salts are collected on the front filter and may be quantitated as total particulate sulfate.

INTERFERENCES: Sulfur trioxide gas, if present in dry atmospheres, may give a positive interference for SO₂.

OTHER METHODS: This revises P&CAM 268 [3], P&CAM 146 [4], P&CAM 163 [5], and S308 [6] use 0.3 N H₂O₂ for sampling, followed by titration with NaOH or barium perchlorate. P&CAM 160 [7] uses tetrachloromercurate solution and visible spectrophotometry. P&CAM 204 [8] uses a solid sorbent (molecular sieve 5A), thermal desorption, and mass spectrometry.

REAGENTS:

1. Water, deionized, filtered, specific conductance ≤ 10 $\mu\text{S}/\text{cm}$.
2. Fixative solution. Dissolve 25 g Na_2CO_3 in deionized water. Add 20 mL glycerol and dilute with deionized water to 1 L.
3. Eluent: 1.75 mM NaHCO_3 /2.0 mM Na_2CO_3 . Dissolve 0.588 g NaHCO_3 and 0.848 g Na_2CO_3 in 4 L filtered deionized water.
4. Calibration stock solutions, 1 mg/mL (as the anion). Prepare in duplicate.
 - a. **Sulfite:** dissolve 0.1575 g Na_2SO_3 in water. Add 2 mL glycerol. Dilute to 100 mL. Prepare fresh daily.
 - b. **Sulfate:** dissolve 0.1479 g Na_2SO_4 in deionized water. Dilute to 100 mL. Stable several weeks.

* See SPECIAL PRECAUTIONS.

EQUIPMENT:

1. Sampler: two 37-mm diameter cassette filter holders (connected in series by a M-M Luer adapter, e.g., Millipore XX1102503, or a short piece of plastic tubing) containing:
 - a. (Front cassette) cellulose ester membrane filter, 0.8- μm pore size, supported by a backup pad.
 - b. (Back cassette) cellulose filter (Whatman 40 or equivalent) which has been saturated with fixative solution and dried 20 to 30 min at 100 °C, supported by a porous plastic support pad.
2. Personal sampling pump, 0.5 to 1.5 L/min, with flexible connecting tubing.
3. Vials, glass, 20-mL, screw-cap, such as scintillation vials.**
4. Ion chromatograph, HPIC-AS4A anion separator and HPIC-AG4A guard, anion micromembrane suppressor, conductivity detector, and strip chart recorder. (Optional: integrator.)
5. Syringes, 10-mL, polyethylene, with luer tip.**
6. Filters, in-line, luer-tip holder with membrane filter, 13- or 25-mm, 0.45- μm pore size.
7. Micropipets, 50- to 1000- μL , with disposable tips.**
8. Volumetric flasks, 50- and 100-mL.**
9. Pipet, 10-mL.**
10. Polyethylene bottles, 250-mL.**

** Clean by rinsing thoroughly with deionized water.

SPECIAL PRECAUTIONS: None.

SAMPLING:

1. Calibrate each personal sampling pump with a representative sampler in line.
2. Remove end caps of sampler immediately before sampling. Attach sampler to personal sampling pump with flexible tubing.
3. Sample at an accurately known flow rate between 0.5 and 1.5 L/min for a total sample size of 40 to 200 L. Do not exceed a total particulate loading of 2 mg on the front filter.
4. Seal the sampler and pack securely for shipment.

NOTE: If determination of sulfuric acid is required, transfer the front (membrane) filter to a clean vial within 4 h to avoid low recovery of sulfate. Handle the filter with tweezers to avoid contamination.

SAMPLE PREPARATION:

5. Put the two filters from the sampler into separate, clean vials. Discard the backup pads. Add 10.0 mL eluent to each vial and let stand, with occasional vigorous shaking, for 30 min.

- NOTE: The SO₂ collected on the treated (back) filter is present as sulfite, which oxidizes in air slowly (over several weeks) to sulfate. The contributions of sulfite and sulfate found on the back filter must be summed, with appropriate stoichiometric factors applied, to give the SO₂ concentration (step 11).
6. Pour each sample into a syringe fitted with an in-line filter.

CALIBRATION AND QUALITY CONTROL:

7. Calibrate daily with at least six working standards.
 - a. Add known aliquots of sulfate calibration stock solution to eluent in 50-mL volumetric flasks and dilute to the mark to produce solutions containing 1 to 20 µg/mL SO₄²⁻.
 - b. Prepare sulfite standards in the same manner over the same range.
 - c. Store working standards in tightly-capped polyethylene bottles. Prepare fresh working standards daily.
 - d. Analyze working standards with samples and blanks (steps 8 through 10). Prepare a calibration graph for each anion [peak height (mm or µS) vs. µg sulfite or sulfate].

MEASUREMENT:

8. Set ion chromatograph to conditions given on page 6004-1, according to manufacturer's instructions.
9. Inject sample aliquot. For manual operation, inject 2 mL of sample from syringe to ensure complete rinse of sample loop.

NOTE: All samples, eluents, and water flowing through the ion chromatograph must be filtered to avoid plugging system valves or columns.
10. Measure peak heights of sulfite and sulfate peaks.

NOTE: If peak height exceeds linear calibration range, dilute with eluent, reanalyze, and apply the appropriate dilution factor in calculations.

CALCULATIONS:

11. Determine the mass, µg, of sulfate equivalent found on the front (W_f) and back (W_b) filters and in the corresponding average media blanks (B_f and B_b).

NOTE: The sulfate equivalent is the sum of the sulfate peak, µg, and 1.200 times the sulfite peak, µg, on the chromatogram (1.200 = MW SO₄²⁻/MW SO₃²⁻): µg_{sulfate equivalent} = µg_{sulfate} + 1.200 µg_{sulfite}.
12. Calculate the concentration, C_{SO₂}, of sulfur dioxide, applying the factor 0.667 (MW SO₂/MW SO₄²⁻):

$$C_{SO_2} = \frac{(W_b - B_b)}{V} \cdot 0.667, \text{ mg/m}^3.$$

13. Calculate the concentration, C_{SO₄}, of particulate sulfate (including sulfuric acid) in the air volume sampled, V (L):

$$C_{SO_4} = \frac{(W_f - B_f)}{V}, \text{ mg/m}^3.$$

EVALUATION OF METHOD:

The sampler was adapted from that of Pate, et al. [9]. In experiments in which SO₂ was generated by permeation tube and collected in impingers containing H₂O₂, untreated 0.8- μ m cellulose ester membrane filters were shown to allow complete passage of SO₂ [10]. In subsequent sampling of an atmosphere containing ca. 10 ppm SO₂ at 1 L/min for 30 min, two treated filters were placed in series following a cellulose ester membrane filter. Recoveries were: 0.667 mg SO₂ from the first treated filter, 0.02 mg SO₂ from the second treated filter, and less than 0.003 mg SO₂ in the backup impinger containing 0.3 N H₂O₂ [11]. Cellulose ester filters spiked with 0.2 mg H₂SO₄ gave the following recoveries: 83.5% using H₂O extraction, 98.5% using hot H₂O extraction, and 82.5% using 0.01 M HCl for extraction.

A study on filter impregnating solutions compared NaHCO₃ and KOH. The chromatograms of samples from the KOH-treated filters had noticeably flattened and broadened peak shapes as well as retention times reduced by approximately 10% when compared to the chromatograms of H₂SO₄ spiked on filters impregnated with NaHCO₃[1].

REFERENCES:

- [1] Williamson, G.Y. NIOSH/MRSB Sequence 7452-B (unpublished, July 6, 1992).
- [2] Williamson, G.Y. NIOSH/MRSB Sequence 7452-C (unpublished, July 22, 1992).
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METHOD REVISED BY:

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**ELEMENTS by ICP
(Nitric/Perchloric Acid Ashing)**

7300

MW: Table 1

CAS: Table 2

RTECS: Table 2

METHOD: 7300, Issue 3

EVALUATION: PARTIAL

Issue 1: 15 August 1990

Issue 3: 15 March 2003

OSHA: Table 2

NIOSH: Table 2

ACGIH: Table 2

PROPERTIES: Table 1

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

*Some compounds of these elements require special sample treatment.

SAMPLING

MEASUREMENT

SAMPLER: FILTER
(0.8- μ m, cellulose ester membrane, or
5.0- μ m, polyvinyl chloride membrane)

FLOWRATE: 1 to 4 L/min

VOL-MIN: Table 1

-MAX: Table 1

SHIPMENT: routine

SAMPLE STABILITY: stable

BLANKS: 2 to 10 field blanks per set

TECHNIQUE: INDUCTIVELY COUPLED ARGON
PLASMA, ATOMIC EMISSION
SPECTROSCOPY (ICP-AES)

ANALYTE: elements above

ASHING REAGENTS: conc. HNO₃/ conc. HClO₄ (4:1), 5 mL;
2mL increments added as needed

CONDITIONS: room temperature, 30 min; 150 °C to near
dryness

FINAL SOLUTION: 4% HNO₃, 1% HClO₄, 25 mL

WAVELENGTH: depends upon element; Table 3

BACKGROUND CORRECTION: spectral wavelength shift

CALIBRATION: elements in 4% HNO₃, 1% HClO₄

RANGE: varies with element [1]

ESTIMATED LOD: Tables 3 and 4

PRECISION (δ): Tables 3 and 4

ACCURACY

RANGE STUDIED: not determined

BIAS: not determined

OVERALL PRECISION (δ_{rr}): not determined

ACCURACY: not determined

APPLICABILITY: The working range of this method is 0.005 to 2.0 mg/m³ 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 ashing procedure selected.

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 [1-4].

OTHER METHODS: This issue updates issues 1 and 2 of Method 7300, which replaced P&CAM 351 [3] for trace elements. Flame atomic absorption spectroscopy (e.g., Methods 70XX) is an alternate analytical technique for many of these elements. Graphite furnace AAS (e.g., 7102 for Be, 7105 for Pb) is more sensitive.

REAGENTS:

1. Nitric acid (HNO₃), conc., ultra pure.
2. Perchloric acid (HClO₄), conc., ultra pure.*
3. Ashing acid: 4:1 (v/v) HNO₃:HClO₄. Mix 4 volumes conc. HNO₃ with 1 volume conc. HClO₄.
4. Calibration stock solutions, 1000 µg/mL. Commercially available, or prepared per instrument manufacturer's recommendation (see step 12).
5. Dilution acid, 4% HNO₃, 1% HClO₄. Add 50 mL ashing acid to 600 mL water; dilute to 1 L.
6. Argon.
7. Distilled, deionized water.

* See SPECIAL PRECAUTIONS.

EQUIPMENT:

1. Sampler: cellulose ester membrane filter, 0.8-µm pore size; or polyvinyl chloride membrane, 5.0-µm pore size; 37-mm diameter, in cassette filter holder.
2. Personal sampling pump, 1 to 4 L/min, with flexible connecting tubing.
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 watchglass covers.**
6. Volumetric flasks, 10-, 25-, 100-mL, and 1-L**
7. Assorted volumetric pipets as needed.**
8. Hotplate, surface temperature 150 °C.

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

SPECIAL PRECAUTIONS: All perchloric acid digestions are required to be done in a perchloric acid hood. When working with concentrated acids, wear protective clothing and gloves.

SAMPLING:

1. Calibrate each personal sampling pump with a representative sampler in line.
2. Sample at an accurately known flow rate between 1 and 4 L/min for a total sample size of 200 to 2000 L (see Table 1) for TWA measurements. Do not exceed a filter loading of approximately 2 mg total dust.

SAMPLE PREPARATION:

3. Open the cassette filter holders and transfer the samples and blanks to clean beakers.
4. Add 5 mL ashing acid. Cover with a watchglass. Let stand 30 min at room temperature.
NOTE: Start a reagent blank at this step.
5. Heat on hotplate (120 °C) until ca. 0.5 mL remains.
NOTE 1: Recovery of lead from some paint matrices may require other digestion techniques. See Method 7082 (Lead by Flame AAS) for an alternative hotplate digestion procedure or Method 7302 for a microwave digestion procedure.
NOTE 2: Some species of Al, Be, Co, Cr, Li, Mn, Mo, V, and Zr will not be completely solubilized by this procedure. Alternative solubilization techniques for most of these elements can be found elsewhere [5-10]. For example, aqua regia may be needed for Mn [6,12].
6. Add 2 mL ashing acid and repeat step 5. Repeat this step until the solution is clear.
7. Remove watchglass and rinse into the beaker with distilled water.
8. Increase the temperature to 150 °C and take the sample to near dryness (ca. 0.5 mL).
9. Dissolve the residue in 2 to 3 mL dilution acid.
10. Transfer the solutions quantitatively to 25-mL volumetric flasks.
11. Dilute to volume with dilution acid.
NOTE: If more sensitivity is required, the final sample volume may be held to 10 mL.

CALIBRATION AND QUALITY CONTROL:

12. Calibrate the spectrometer according to the manufacturers recommendations.
NOTE: Typically, an acid blank and 1.0 µg/mL multielement working standards are used. The following multielement combinations are chemically compatible in 4% HNO₃/1% HClO₄:
 - 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, Ti, V, Y, Zn, Sc
 - c. Mo, Sb, Sn, Te, Tl, W, Zr
 - d. Acid blank
13. Analyze a standard for every ten samples.
14. Check recoveries with at least two spiked blank filters per ten samples.

MEASUREMENT:

15. Set spectrometer to conditions specified by manufacturer.
16. Analyze standards and samples.
NOTE: If the values for the samples are above the range of the standards, dilute the solutions with dilution acid, reanalyze and apply the appropriate dilution factor in the calculations.

CALCULATIONS:

17. Obtain the solution concentrations for the sample, C_s (µg/mL), and the average media blank, C_b (µg/mL), from the instrument.
18. Using the solution volumes of sample, V_s (mL), and media blank, V_b (mL), calculate the concentration, C (mg/m³), of each element in the air volume sampled, V (L):

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

NOTE: µg/L = mg/m³

EVALUATION OF METHOD:

Issues 1 and 2

Method, 7300 was originally evaluated in 1981 [2,3]. The precision and recovery data were determined at 2.5 and 1000 µg of each element per sample on spiked filters. The measurements used for the method evaluation in Issues 1 and 2 were determined with a Jarrell-Ash Model 1160 Inductively Coupled Plasma Spectrometer operated according to manufacturer's instructions.

Issue 3

In this update of NIOSH Method 7300, the precision and recovery data were determined at approximately 3x and 10x the instrumental detection limits on commercially prepared spiked filters [12] using 25.0 mL as the final sample volume. Tables 3 and 4 list the precision and recovery data, instrumental detection limits, and analytical wavelengths for mixed cellulose ester (MCE) and polyvinyl chloride (PVC) filters. PVC Filters which can be used for total dust measurements and then digested for metals measurements were tested and found to give good results. The values in Tables 3 and 4 were determined with a Spectro Analytical Instruments Model End On Plasma (EOP)(axial) operated according to manufacturer's instructions.

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Method originally written by Mark Millson, NIOSH/DART, and R. DeLon Hull, Ph.D., NIOSH/DSHEFS, James B. Perkins, David L. Wheeler, and Keith Nicholson, DataChem Laboratories, Salt Lake City, UT.

TABLE 1. PROPERTIES AND SAMPLING VOLUMES

Element (Symbol)	Properties		Air Volume, L @ OSHA PEL	
	Atomic Weight	MP, °C	MIN	MAX
Silver (Ag)	107.87	961	250	2000
Aluminum (Al)	26.98	660	5	100
Arsenic (As)	74.92	817	5	2000
Barium (Ba)	137.34	710	50	2000
Beryllium (Be)	9.01	1278	1250	2000
Calcium (Ca)	40.08	842	5	200
Cadmium (Cd)	112.40	321	13	2000
Cobalt (Co)	58.93	1495	25	2000
Chromium (Cr)	52.00	1890	5	1000
Copper (Cu)	63.54	1083	5	1000
Iron (Fe)	55.85	1535	5	100
Potassium (K)	39.10	63.65	5	1000
Lanthanum	138.91	920	5	1000
Lithium (Li)	6.94	179	100	2000
Magnesium (Mg)	24.31	651	5	67
Manganese (Mn)	54.94	1244	5	200
Molybdenum (Mo)	95.94	651	5	67
Nickel (Ni)	58.71	1453	5	1000
Phosphorus (P)	30.97	44	25	2000
Lead (Pb)	207.19	328	50	2000
Antimony (Sb)	121.75	630.5	50	2000
Selenium (Se)	78.96	217	13	2000
Tin (Sn)	118.69	231.9	5	1000
Strontium (Sr)	87.62	769	10	1000
Tellurium (Te)	127.60	450	25	2000
Titanium (Ti)	47.90	1675	5	100
Thallium (Tl)	204.37	304	25	2000
Vanadium (V)	50.94	1890	5	2000
Tungsten (W)	183.85	3410	5	1000
Yttrium (Y)	88.91	1495	5	1000
Zinc (Zn)	65.37	419	5	200
Zirconium (Zr)	91.22	1852	5	200

TABLE 2. EXPOSURE LIMITS, CAS #, RTECS

Element (Symbol)	CAS #	RTECS	Exposure Limits, mg/m ³ (Ca = carcinogen)		
			OSHA	NIOSH	ACGIH
Silver (Ag)	7440-22-4	VW3500000	0.01 (dust, fume, metal)	0.01 (metal, soluble)	0.1 (metal) 0.01 (soluble)
Aluminum (Al)	7429-90-5	BD0330000	15 (total dust) 5 (respirable)	10 (total dust) 5 (respirable fume) 2 (salts, alkyls)	10 (dust) 5 (powders, fume) 2 (salts, alkyls)
Arsenic (As)	7440-38-2	CG0525000	varies	C 0.002, Ca	0.01, Ca
Barium (Ba)	7440-39-3	CQ8370000	0.5	0.5	0.5
Beryllium (Be)	7440-41-7	DS1750000	0.002, C 0.005	0.0005, Ca	0.002, Ca
Calcium (Ca)	7440-70-2	--	varies	varies	varies
Cadmium (Cd)	7440-43-9	EU9800000	0.005	lowest feasible, Ca	0.01 (total), Ca 0.002 (respir.), Ca
Cobalt (Co)	7440-48-4	GF8750000	0.1	0.05 (dust, fume)	0.02 (dust, fume)
Chromium (Cr)	7440-47-3	GB4200000	0.5	0.5	0.5
Copper (Cu)	7440-50-8	GL5325000	1 (dust, mists) 0.1 (fume)	1 (dust) 0.1 (fume)	1 (dust, mists) 0.2 (fume)
Iron (Fe)	7439-89-6	NO4565500	10 (dust, fume)	5 (dust, fume)	5 (fume)
Potassium (K)	7440-09-7	TS6460000	--	--	--
Lanthanum	7439-91-0	--	--	--	--
Lithium (Li)	7439-93-2	--	--	--	--
Magnesium (Mg)	7439-95-4	OM2100000	15 (dust) as oxide 5 (respirable)	10 (fume) as oxide	10 (fume) as oxide
Manganese (Mn)	7439-96-5	OO9275000	C 5	1; STEL 3	5 (dust) 1; STEL 3 (fume)
Molybdenum (Mo)	7439-98-7	QA4680000	5 (soluble) 15 (total insoluble)	5 (soluble) 10 (insoluble)	5 (soluble) 10 (insoluble)
Nickel (Ni)	7440-02-0	QR5950000	1	0.015, Ca	0.1 (soluble) 1 (insoluble, metal)
Phosphorus (P)	7723-14-0	TH3500000	0.1	0.1	0.1
Lead (Pb)	7439-92-1	OF7525000	0.05	0.05	0.05
Antimony (Sb)	7440-36-0	CC4025000	0.5	0.5	0.5
Selenium (Se)	7782-49-2	VS7700000	0.2	0.2	0.2
Tin (Sn)	7440-31-5	XP7320000	2	2	2
Strontium (Sr)	7440-24-6	--	--	--	--
Tellurium (Te)	13494-80-9	WY2625000	0.1	0.1	0.1
Titanium (Ti)	7440-32-6	XR1700000	--	--	--
Thallium (Tl)	7440-28-0	XG3425000	0.1 (skin) (soluble)	0.1 (skin) (soluble)	0.1 (skin)
Vanadium (V)	7440-62-2	YW2400000	--	C 0.05	--
Tungsten	7440-33-7	--	5	5 10 (STEL)	5 10 (STEL)
Yttrium (Y)	7440-65-5	ZG2980000	1	N/A	1
Zinc (Zn)	7440-66-6	ZG8600000	--	--	--
Zirconium (Zr)	7440-67-7	ZH7070000	5	5, STEL 10	5, STEL 10

TABLE 3. MEASUREMENT PROCEDURES AND DATA [1].
Mixed Cellulose Ester Filters (0.45 µm)

Element (a)	wavelength nm	Est. LOD µg/ Filter	LOD ng/mL	Certified 3x LOD (b)	% Recovery (c)	Percent RSD (N=25)	Certified 10x LOD (b)	% Recovery (c)	Percent RSD (N=25)
Ag	328	0.042	1.7	0.77	102.9	2.64	3.21	98.3	1.53
Al	167	0.115	4.6	1.54	105.4	11.5	6.40	101.5	1.98
As	189	0.140	5.6	3.08	94.9	2.28	12.9	93.9	1.30
Ba	455	0.005	0.2	0.31	101.8	1.72	1.29	97.7	0.69
Be	313	0.005	0.2	0.31	100.0	1.44	1.29	98.4	0.75
Ca	317	0.908	36.3	15.4	98.7	6.65	64.0	100.2	1.30
Cd	226	0.0075	0.3	0.31	99.8	1.99	1.29	97.5	0.88
Co	228	0.012	0.5	0.31	100.8	1.97	1.29	98.4	0.90
Cr	267	0.020	0.8	0.31	93.4	16.3	1.29	101.2	2.79
Cu	324	0.068	2.7	1.54	102.8	1.47	6.40	100.6	0.92
Fe	259	0.095	3.8	1.54	103.3	5.46	6.40	98.0	0.95
K	766	1.73	69.3	23.0	90.8	1.51	96.4	97.6	0.80
La	408	0.048	1.9	0.77	102.8	2.23	3.21	100.1	0.92
Li	670	0.010	0.4	0.31	110.0	1.91	1.29	97.7	0.81
Mg	279	0.098	3.9	1.54	101.1	8.35	6.40	98.0	1.53
Mn	257	0.005	0.2	0.31	101.0	1.77	1.29	94.7	0.73
Mo	202	0.020	0.8	0.31	105.3	2.47	1.29	98.6	1.09
Ni	231	0.020	0.8	0.31	109.6	3.54	1.29	101.2	1.38
P	178	0.092	3.7	1.54	84.4	6.19	6.40	82.5	4.75
Pb	168	0.062	2.5	1.54	109.4	2.41	6.40	101.7	0.88
Sb	206	0.192	7.7	3.08	90.2	11.4	12.9	41.3	32.58
Se	196	0.135	5.4	2.3	87.6	11.6	9.64	84.9	4.78
Sn	189	0.040	1.6	0.77	90.2	18.0	3.21	49	21.79
Sr	407	0.005	0.2	0.31	101.0	1.55	1.29	97.3	0.65
Te	214	0.078	3.1	1.54	102.0	2.67	6.40	97.4	1.24
Ti	334	0.050	2.0	0.77	98.4	2.04	3.21	93.4	1.08
Tl	190	0.092	3.7	1.54	100.9	2.48	6.40	99.1	0.80
V	292	0.028	1.1	0.77	103.2	1.92	3.21	98.3	0.84
W	207	0.075	3.0	1.54	72.2	10.1	6.40	57.6	14.72
Y	371	0.012	0.5	0.31	100.5	1.80	1.29	97.4	0.75
Zn	213	0.310	12.4	4.60	102.2	1.87	19.3	95.3	0.90
Zr	339	0.022	0.9	0.31	88.0	19.4	1.29	25	57.87

(a) Bold values are qualitative only because of low recovery.

(b) Values are certified by Inorganic Ventures INC. at 3x and 10x the approximate instrumental LOD

(c) Values reported were obtained with a Spectro Analytical Instruments EOP ICP; performance may vary with instrument and should be independently verified.

TABLE 4. MEASUREMENT PROCEDURES AND DATA [1].
Polyvinyl Chloride Filter (5.0 µm)

Element (c)	wavelength nm	Est. LOD µg per filter	LOD ng/mL	Certified 3x LOD (b)	% Recovery (a)	Percent RSD (N=25)	Certified ¹⁷ 10x LOD (b)	% Recovery (a)	Percent RSD (N=25)
Ag	328	0.042	1.7	0.78	104.2	8.20	3.18	81.8	18.9
Al	167	0.115	4.6	1.56	77.4	115.24	6.40	92.9	20.9
As	189	0.140	5.6	3.10	100.7	5.13	12.70	96.9	3.2
Ba	455	0.005	0.2	0.31	102.4	3.89	1.270	99.8	2.0
Be	313	0.005	0.2	0.31	106.8	3.53	1.270	102.8	2.1
Ca	317	0.908	36.3	15.6	68.1	12.66	64.00	96.8	5.3
Cd	226	0.0075	0.3	0.31	105.2	5.57	1.27	101.9	2.8
Co	228	0.012	0.5	0.31	109.3	4.67	1.27	102.8	2.8
Cr	267	0.020	0.8	0.31	109.4	5.31	1.27	103.4	4.1
Cu	324	0.068	2.7	1.56	104.9	5.18	6.40	101.8	2.4
Fe	259	0.095	3.8	1.56	88.7	46.82	6.40	99.1	9.7
K	766	1.73	69.3	23.4	96.4	4.70	95.00	99.2	2.2
La	408	0.048	1.9	0.78	45.5	4.19	3.18	98.8	2.6
Li	670	0.010	0.4	0.31	107.7	4.80	1.27	110.4	2.7
Mg	279	0.098	3.9	1.56	54.8	20.59	6.40	64.5	5.7
Mn	257	0.005	0.2	0.31	101.9	4.18	1.27	99.3	2.4
Mo	202	0.020	0.8	0.31	106.6	5.82	1.27	98.1	3.8
Ni	231	0.020	0.8	0.31	111.0	5.89	1.27	103.6	3.2
P	178	0.092	3.7	1.56	101.9	17.82	6.40	86.5	10.4
Pb	168	0.062	2.5	1.56	109.6	6.12	6.40	103.2	2.9
Sb	206	0.192	7.7	3.10	64.6	22.54	12.70	38.1	30.5
Se	196	0.135	5.4	2.30	83.1	26.23	9.50	76.0	17.2
Sn	189	0.040	1.6	0.78	85.7	27.29	3.18	52.0	29.4
Sr	407	0.005	0.2	0.31	71.8	4.09	1.27	81.2	2.7
Te	214	0.078	3.1	1.56	109.6	7.49	6.40	97.3	3.8
Ti	334	0.050	2.0	0.78	101.0	9.46	3.18	92.4	5.5
Tl	190	0.092	3.7	1.56	110.3	4.04	6.40	101.9	2.0
V	292	0.028	1.1	0.78	108.3	3.94	3.18	102.5	2.6
W	207	0.075	3.0	1.56	74.9	15.79	6.40	44.7	19.6
Y	371	0.012	0.5	0.31	101.5	3.63	1.27	101.4	2.5
Zn	213	0.310	12.4	4.70	91.0	68.69	19.1	101.0	9.6
Zr	339	0.022	0.9	0.31	70.7	54.20	1.27	40.4	42.1

- (a) Values reported were obtained with a Spectro Analytical Instruments EOP ICP; performance may vary with instrument and should be independently verified.
- (b) Values are certified by Inorganic Ventures INC. at 3x and 10x the approximate instrumental LOD [12].
- (c) Bold values are qualitative only because of low recovery. Other digestion techniques may be more appropriate for these elements and their compounds.