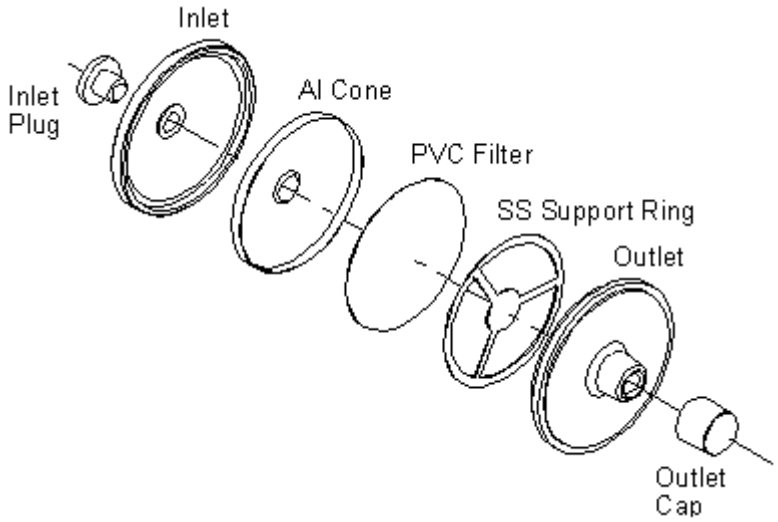
APPENDIX A

PRE–WEIGHED FILTERS

The SLTC provides pre-weighed filters for gravimetric analysis. Filter/cassette units, when assembled in a cassette by the manufacturer, are tested for leaks. These filter/cassette units reduce sample preparation time by CSHOs because the filters are weighed at the SLTC and the units are shipped to the field fully assembled and ready for use. The filter/cassette units are returned to the SLTC for gravimetric determinations and additional analyses as needed. The filter medium is 5-µm, 37-mm diameter, low-ash PVC or PTFE (TEFLON). The PVC filters should be used for silica (quartz) analysis, aluminum, and other appropriate substances having high PELs or requiring gravimetric analysis. The PTFE filters are used for asphalt fumes. The filters may be used with or without a cyclone. Other than for silica, if the gravimetric analysis yields a result less than the PEL for the requested substance(s), no further analysis will be provided unless specifically requested. The filter/cassette unit is shown below in Figure A-1. Appendix B includes a partial listing of substances that should be sampled and analyzed gravimetrically using pre-weighed cassettes.

FIGURE A-1. FILTER/CASSETTE UNIT



Due to the slightly smaller size of the filter, check it frequently to avoid overloading. This can be accomplished by looking into the inlet sampling port of the cassette. Use a flashlight, if necessary. Visual observation of the airborne dust in the workplace may assist in determining how frequently to check the filter for overloading. If used with a cassette, do not lift the cyclone in such a way that particles from the grit pot could be deposited on the filter.

As shown in Figure A-1, the inlet side of the cassette is marked on the polystyrene cassette. This is the side of the filter cassette with the aluminum cone antistatic shield. The stainless steel support (Figure A-2) is visible from the outlet side of the assembly. Each of the filter assemblies is bar coded for weighing purposes (Figure A-4). To aid in tracking the filters, please use the barcode number as the sample submission number when completing the OIS air sampling worksheet. A blank should be included with every set of samples.

FIGURE A-2. STAINLESS STEEL FILTER SUPPORT

FIGURE A-3 OUTLET VIEW OF A FILTER CASSETTE (connect to sampling pump)

FIGURE A-4. INLET VIEW OF A FILTER CASSETTE (open to atmosphere, pointed downward during sampling)

The filter/cassette assembly can be used with both nylon cyclone and holder assemblies currently in field use; however, the standard MSA coupler (used with a standard 2- or 3-piece cassette) will not fit these cassettes. Another coupler available from MSA (part #457391), which is plastic instead of stainless steel, can be obtained from the CTC.

APPENDIX B

SUBSTANCES FOR GRAVIMETRIC DETERMINATION

TABLE B-1. PARTIAL LIST OF SUBSTANCES FOR GRAVIMETRIC DETERMINATION

Substance	IMIS	PEL (mg/m^3)
alpha-Alumina		
Total dust	0160	15
Respirable fraction	A201	5
Aluminum metal (as Al)		
Total dust	A100	15
Respirable fraction	A110	5
Ammonium sulfamate		
Total dust	0185	15
Respirable fraction	A111	5
Barium sulfate		
Total dust	B101	15
Respirable fraction	B104	5
Bismuth telluride Undoped		
Total dust	0370	15
Respirable fraction	B110	5
Boron oxide		
Total dust	0380	15
Calcium carbonate		
Total dust	0505	15
Respirable fraction	C130	5
Calcium hydroxide		
Total dust	0515	15
Respirable fraction	C330	5
Calcium oxide	0520	5
Calcium silicate		
Total dust	C112	15
Respirable fraction	C122	5
Calcium sulfate		
Total dust	C104	15
Respirable fraction	C123	5
Carbon black	0527	3.5
Cellulose		
Total dust	0575	15
Respirable fraction	C124	5
Dicyclopentadienyl iron		
Total dust	0904	15
Respirable fraction	D100	5
Emery		
Total dust	1016	15
Respirable fraction	E102	5
Grain dust (oat, wheat, barley)	G109	10
Glycerin (mist)		
Total dust	1363	15
Respirable fraction	G115	5
Graphite, synthetic		
Total dust	1366	15
Respirable Fraction	G100	5
Gypsum		
Total dust	1367	15
Respirable fraction	G101	5
Kaolin		
Total dust	1568	15
Respirable fraction	K100	5
Limestone		
Total dust	1593	15
Respirable fraction	L100	5
Magnesite		
Total dust	M113	15
Respirable fraction	1615	5

Substance (mg/m^3)	IMIS	PEL
Magnesium oxide fume		
Total dust	1610	15
Marble		
Total dust	1626	15
Respirable fraction	M114	5
Oil mist (mineral)	5010	5
Particulates not otherwise regulated (PNOR)		
Total dust	9135	15
Respirable fraction	9130	5
Pentaerythritol		
Total dust	1987	15
Respirable fraction	P157	5
Perlite		
Total dust	2035	15
Respirable fraction	P101	5
Plaster of Paris		
Total dust	2127	15
Respirable fraction	P102	5
Portland cement		
Total dust	0557	15
Respirable fraction	P104	5
Rouge		
Total dust	2229	15
Respirable fraction	R102	5
Silica Fused		
Total dust		15
Respirable fraction	9013	5

Substance (mg/m^3)	IMIS	PEL
Silicon		
Total dust	2235	15
Respirable fraction	S120	5
Silicon carbide		
Total dust	2236	15
Respirable fraction	S123	5
Starch		
Total dust	2263	15
Respirable fraction	S124	5
Sucrose		
Total dust	2285	15
Respirable fraction	S130	5
Tantalum, metal and oxide dust	2325	5
Titanium dioxide		
Total dust	2440	15
Vegetable oil mist		
Total dust	V126	15
Respirable fraction	V127	5
Zinc oxide fume	2610	5
Zinc oxide		
Total dust	Z102	15
Respirable fraction	Z103	5
Zinc stearate		
Total dust	2616	15
Respirable fraction	Z104	5
Zirconium compounds (as Zr)		
Total dust		15
Respirable fraction	2620	5

APPENDIX C

ANALYTES USING IMPINGER OR BUBBLER AS PRIMARY METHOD (REFERENCE: CSI)

TABLE C-1. IMPINGER METHODS	
Chemical Name	**Chemical Abstracts Service (CAS) Number**
Amitrole	61-82-5
Benzoyl Chloride	98-88-4
Bladex	21725-46-2
Bromacil	314-40-9
Cumene Hydroperoxide	80-15-9
Dibutylamine	111-92-2
Diethylaminopropylamine	104-78-9
Diglycolamine	929-06-6
Diisopropylamine	108-18-9
4-Dimethylaminoazobenzene	60-11-7
N-[3-Dimethylamino) propyl]-N,N',N'-trimethyl-1,3-Propanediamine	3855-32-1
Dinitro-o-cresol	534-52-1
Hexamethylenetetramine	100-97-0
Isopropyl m-Chlorocarbaniliate	101-21-3
Kepone	143-50-0
Lindane	58-89-9
Maleic Acid	110-16-7
beta-Naphthol	135-19-3
Oryzalin	19044-88-3
Pentac	2227-17-0
Pentamethyldiethylenetriamine	3030-47-5
Pipron	3478-94-2
p-Nitrophenol	100-02-7
2,3,7,8-Tetrachlorodibenzofuran	51207-31-9
N,N,N',N'-Tetramethylethylenediamine	110-18-9
Tetranitromethane	509-14-8
Thioglycolic Acid	68-11-1
p-Toluenesulfonic Acid	104-15-4
Tributylphosphorotrithioate	78-48-8

TABLE C-1. BUBBLER METHODS	
Chemical Name	**Chemical Abstracts Service (CAS) Number**
Aldrin	309-00-2
Boron Tribromide	10294-33-4
Boron Trifluoride	7/2/7637
Bromine	7726-95-6
Carbonyl Fluoride	353-50-4
Chlorine	7782-50-5
Chlorine (as Available Chlorine)	7782-50-5 **See note in CSI
Chlorine Dioxide	10049-04-4
Chlorine Trifluoride	7790-91-2
Cyanide (as CN)	57-12-5
1,1-Dimethylhydrazine	57-14-7
Ethyleneimine	151-56-4
Fluoboric Acid	16872-11-0
Fluorine	7782-41-4
Hydrogen Peroxide	7722-84-1
Hydrogen Selenide (as Se)	7/5/7783
Iron Pentacarbonyl (as Fe)	13463-40-6
Isopropylamine	75-31-0
Ketene	463-51-4
Lindane	58-89-9 **See note in CSI
Manganese Cyclopentadienyl Tricarbonyl (as Mn)	12079-65-1
Monomethyl Aniline	100-61-8
Nickel Carbonyl	13463-39-3
N-Nitrosodiphenylamine	86-30-6
Osmium Tetroxide (as Os)	20816-12-0
Pentaborane	19624-22-7
Perchloric Acid	7601-90-3
Perchloryl Fluoride	7616-94-6
Phenylhydrazine	100-63-0
Phosphorus Oxychloride	10025-87-3
Phosphorus Pentachloride	10026-13-8
Phosphorus Trichloride	12/2/7719
Propylene Imine	75-55-8
Rubidium	7440-17-7
Silicon Tetrahydride	7803-62-5
Sulfur dioxide	9/5/7446
Sulfur Monochloride	10025-67-9
Sulfur Tetrafluoride	7783-60-0
Thionyl Chloride	9/7/7719
Triphenylamine	603-34-9

APPENDIX D

SHELF LIFE OF SAMPLING MEDIA

The SLTC will provide an expiration date for sampling media shipped to the field. The date will be printed either on the media itself, on its container, or on its packaging. Return liquid media to the SLTC in the same outer packaging in which it was received.

TABLE D-1. SHELF LIFE OF SAMPLING MEDIA PROVIDED BY THE SLTC

Sampling medium	Shelf Life	Comments
Sodium hydroxide	1 year	Same for all normalities
Hydrochloric acid Sulfuric acid Methanol in water	1 year	Same for all concentrations
Solution for bis-chloromethyl ether (BCME) and chloromethyl methyl ether (CMME)	2 months	Prepared on request*
Hydroxylammonium chloride solutions (for ketene collection)**	2 weeks	Prepared on request*
Hydroxylammonium chloride-sodium hydroxide mixed solutions (for ketene collection)	Stable only 2 hours	CSHO must prepare solution from two component solutions just before use*
Folin's reagent	5 days	Prepared on request*
Diffusive samplers	As per manufacturer	Must be used before the expiration date printed on the monitor package
Nitrogen oxides collection tubes	2 years as per manufacturer	Should be stored in a refrigerator
Sampler for ozone (Nitrite-treated filter collection device)	28 days	Prepared on request*
Coated filter sampler for diisocyanates (MDI, HDI, TDI, etc.)	1 year	Prepared on request*
NaOH coated binderless quartz fiber filters	3 months	Prepared on request*
Treated filter sampler for collection of anhydrides	30 days	Prepared on request*

* Give the SLTC at least two days' notice to allow time for reagent preparation.
**Hazardous goods shipment required both from the SLTC to the field and from the field to the SLTC; Corrosive Liquid, Toxic, UN 2922, Class 8, PGIII.

APPENDIX E

SAMPLING MEDIA FOR MOST FREQUENTLY REQUESTED ANALYSES FROM THE SLTC AND THE CTC (REFERENCE: CSI)

TABLE E-1. SAMPLING MEDIA FOR MOST FREQUENTLY REQUESTED ANALYSES

IMIS Code #	Analysis	Media
A624	Acetoin (Acetyl Methyl Carbinol)	Two specially dried Silica Gel Tubes in series; each tube has single 600-mg 20/40 mesh section and glass-fiber filter[1]
0040	Acetone	Carbosieve S-III Tube (130/65 mg sections, 60/80 mesh)
A100	Aluminum (as Al), Metal (Total Dust)	Tared Low-Ash Polyvinyl Chloride (LAPVC) filter, 37-mm diameter
		Mixed Cellulose Ester Filter (MCEF) 0.8 µm
0170	Ammonia	Sulfuric Acid-Impregnated Carbon Bead (Supelco ORBO-77 tube or equivalent)
0230	Antimony and Compounds (as Sb)	Mixed Cellulose Ester Filter (MCEF) 0.8 µm
		Wipe: Whatman Smear Tab Filter; Solvent: distilled water
0260	Arsenic, Inorganic	Mixed Cellulose Ester Filter (MCEF) 0.8 µm
		Wipe: Whatman Smear Tab Filter; Solvent: distilled water
9020	Asbestos (All Forms)	Mixed Cellulose Ester Filter (MCEF) 0.8 µm (open face), 25-mm cassette with 50-mm conductive cowl
		Wipe: Do not use Whatman or other paper filters; bulk samples preferred
		Bulk: Collect bulk in 20 mL scintillation vial
0320	Benzene	Charcoal Tube (100/50 mg sections)
		Diffusive Sampler
		Wipe: Charcoal pad from 3M 3500 or 3520 Organic Vapor Monitor; Solvent: none
0726	Benzo [a] Pyrene	Pre-cleaned Glass Fiber Filter (GFF) 37-mm
		Bulk: Limit bulk to one gm or one ml
0360	Beryllium and Beryllium Compounds (as Be)	Mixed Cellulose Ester Filter (MCEF) 0.8 µm
0430	2-Butanone	Anasorb CMS
		Diffusive Sampler
		Carbosieve S-III Tube (130/65 mg sections, 60/80 mesh)
		Two Silica Gel Tubes in series (150/75 mg sections, 20/40 mesh)
		Anasorb 747 (150/75 mg sections, 20/40 mesh)
0435	2-Butoxyethanol	Charcoal Tube (100/50 mg sections, 20/40 mesh)
		Wipe: Charcoal pad; Seal in glass vial for shipment
0440	n-Butyl Acetate	Charcoal Tube (100/50 mg sections, 20/40 mesh)
		Diffusive Sampler
0460	n-Butyl Alcohol	Charcoal Tube (100/50 mg sections, 20/40 mesh)
C141	Cadmium	Mixed Cellulose Ester Filter (MCEF) 0.8 µm
0527	Carbon Black	Tared Low-Ash Polyvinyl Chloride (LAPVC) filter, 5 µm, closed face

[1] Filter faces forward when sampling (SKC 226-183, or equivalent). Use opaque tube holder or wrap tubes with aluminum foil or other opaque material while sampling.

TABLE E-1. SAMPLING MEDIA FOR MOST FREQUENTLY REQUESTED ANALYSES		
IMIS Code #	**Analysis**	**Media**
C730	Carbon Monoxide (by COHb)	Determined by calculation based on COHb measurements provided by medical professionals (calculation performed and peer-reviewed by trained SLTC staff)
0686	Chromic Acid and Chromates (as CrO_3)	Low-Ash Polyvinyl Chloride (LAPVC) filter, 37-mm or 25-mm diameter in polystyrene cassette
		Wipe: 37-mm PVC filter or 37-mm binderless quartz fiber filters
		Bulk: Solids require approximately 10 gm, liquids 10 mL; place in 20-mL glass vials with PTFE-lined caps
0689	Chromium (VI) (Hexavalent Chromium)	Low-Ash Polyvinyl Chloride (LAPVC) filter, 37-mm or 25-mm diameter in polystyrene cassette; collect chromium plating samples on low-background PVC filters or quartz fiber filters coated with sodium hydroxide
		Wipe: 37-mm PVC filter or 37-mm binderless quartz fiber filters
		Bulk: Solids require approximately 10 gm, liquids 10 mL; place in 20-mL glass vials with PTFE-lined caps
0685	Chromium, Metal and Insoluble Salts	Mixed Cellulose Ester Filter (MCEF) 0.8 µm
0692	Chrysene	Pre-cleaned Glass Fiber Filter (GFF) 37-mm
		Bulk: Limit bulk to one gm or one mL
0700	Coal Tar Pitch Volatiles (Benzene Soluble Fraction)	Pre-cleaned Glass Fiber Filter (GFF) Gelman Type A/E
		Bulk: Limit bulk to one gm or one mL
0720	Cobalt, Metal, Dust and Fume (as Co)	Mixed Cellulose Ester Filter (MCEF) 0.8 µm
0725	Coke Oven Emissions	Pre-cleaned Glass Fiber Filter (GFF) 37 mm
		Bulk: Limit bulk to one gm or one mL
E200	Combustible Dust (%)	Call the SLTC for instructions (bulk analysis)
0731	Copper Fume (as Cu)	Mixed Cellulose Ester Filter (MCEF) 0.8 µm
0810	Cyclohexane	Charcoal Tube (100/50 mg sections, 20/40 mesh)
D740	Diacetyl	Two specially dried Silica Gel Tubes in series; each tube has single 600-mg 20/40 mesh section and glass-fiber filter[2]
		Two Silica Gel Tubes in series (150/75 mg sections, 20/40 mesh)[3]
1030	Ethanolamine	Coated XAD-2 Tube (80/40 sections, 20/60 mesh); coated with 10% (w/w) 1-Naphthylisothiocyanate (NITC)
1040	Ethyl Acetate	Charcoal Tube (100/50 mg sections, 20/40 mesh)
1060	Ethyl Alcohol	Two Anasorb 747 Tubes (First Tube 400 mg / Second Tube 200 mg)
		Charcoal Tube (100/50 mg sections, 20/40 mesh)
1080	Ethyl Benzene	Charcoal Tube (100/50 mg sections, 20/40 mesh)
		Diffusive Sampler
1100	Ethyl Butyl Ketone	Charcoal Tube (100/50 mg sections, 20/40 mesh)
1190	Ethylene Oxide	Coated Carbon Beads Tube (100/50 mg sections, 20/40 mesh); coated with HBr

[2] Filter faces forward when sampling (SKC 226-183, or equivalent). Use opaque tube holder or wrap tubes with aluminum foil or other opaque material while sampling.
[3] Use opaque tube holder or wrap tubes with aluminum foil or other opaque material while sampling.

TABLE E-1. SAMPLING MEDIA FOR MOST FREQUENTLY REQUESTED ANALYSES		
IMIS Code #	**Analysis**	**Media**
		Coated Petroleum Base Charcoal Tube (100/50 mg sections, 20/40 mesh); coated with HBr
		Ethylene Oxide Monitor
		Two Charcoal Tubes in Series (100/50 mg sections)
E101	Explosion Severity	Call the SLTC for instructions (bulk analysis)
1280	Fluorides (as F)	Mixed Cellulose Ester Filter (MCEF) 0.8 µm
		Wipe: Whatman Smear Tab Filter; Solvent: deionized water
1290	Formaldehyde	Coated XAD-2 Tube (150/75 mg sections, 20/60 mesh); coated with 10% (w/w) 2-(Hydroxymethyl)piperidine
		Diffusive Sampler
8120	Fungi	Call the SLTC for instructions
1361	Glutaraldehyde	Two Coated Glass Fiber Filters (GFF) (Open Face) in one cassette separated by a spacer; filters coated with 2,4-Dinitrophenylhydrazine (DNPH) and Phosphoric Acid
1371	Heptane (n-Heptane)	Charcoal Tube (100/50 mg sections, 20/40 mesh)
1377	Hexamethylene Diisocyanate	Glass Fiber Filter (GFF) (37-mm open face); coated with 1.0 mg 1-(2-pyridyl)piperazine
		Bulk: Limit bulk to one gm or one mL
H130	1,6-Hexamethylene Diisocyanate Homopolymer	Glass Fiber Filter (GFF) (37-mm open face); coated with 1.0 mg 1-(2-pyridyl)piperazine
1380	Hexane (n-Hexane)	Charcoal Tube (100/50 mg sections, 20/40 mesh)
1385	Hexone	Anasorb CMS
		Diffusive Sampler
		Charcoal Tube (100/50 mg sections, 20/40 mesh)
1430	Hydrogen Chloride	Specially Cleaned Silica Gel Tube (400/200 mg sections with glass fiber filter) (Supelco, ORBO-53; SKC, 226-10-03; or equivalent)
		Wipe: Whatman Smear Tab Filter; Solvent: deionized water
1460	Hydrogen Fluoride (as F)	Mixed Cellulose Ester Filter (MCEF) 0.8 µm; filter spacer (SKC 225-9001); and Na_2CO_3 Impregnated Backup Pad in 3-piece cassette
I200	Iron (Bulk)	Bulk: 1) a high volume (> 1,000 liter) Mixed Cellulose Ester Filter (MCEF) sample of the workplace area; 2) a representative settled dust (rafter) sample; or 3) a sample of bulk material in the workplace[4]
1520	Iron Oxide Fume	Mixed Cellulose Ester Filter (MCEF) 0.8 µm
1534	Isobutyl Acetate	Charcoal Tube (100/50 mg sections, 20/40 mesh)
		Diffusive Sampler
1560	Isopropyl Alcohol	Two Anasorb 747 Tubes (First Tube 400 mg / Second Tube 200 mg)
		Charcoal Tube (100/50 mg sections, 20/40 mesh)
1591	Lead, Inorganic (as Pb)	Mixed Cellulose Ester Filter (MCEF) 0.8 µm
		Wipe: Ghostwipe, Whatman Smear Tab Filter; moistened with distilled water
1620	Manganese Fume (as Mn)	Mixed Cellulose Ester Filter (MCEF) 0.8 µm
1631	Mercury (Vapor) (as Hg)	Hydrar or Hopcalite tube (200 mg) SKC brand with a prefilter/cassette

[4] Transfer bulk material or filter into a 20-ml scintillation vial and seal with vinyl or electrical tape.

TABLE E-1. SAMPLING MEDIA FOR MOST FREQUENTLY REQUESTED ANALYSES		
IMIS Code #	**Analysis**	**Media**
1660	Methyl Alcohol	Two Anasorb 747 Tubes (First Tube 400 mg / Second Tube 200 mg); separate tubes and seal each after sampling
		Silica Gel Tube (520/260 mg sections, 20/40 mesh)
1675	Methyl (n-amyl) Ketone	Charcoal Tube (100/50 mg sections, 20/40 mesh)
1774	Methyl Methacrylate	Coated Charcoal Tube (110/55 mg sections; 20/40 mesh); coated with 10% (w/w) 4-t-Butylcatechol
		XAD-2 Tube (400/200 mg sections, 20/50 mesh)
1073	Methylene Bisphenyl Isocyanate	Coated Glass Fiber Filter (GFF) (37-mm open face); coated with 1.0 mg 1-(2-Pyridyl)piperazine
		Bulk: Limit bulk to one gm or one mL
1730	Methylene Chloride	Carbosieve S-III Tube (130/65 mg sections, 60/80 mesh)
		Charcoal Tube (350/350/350 mg sections, 20/40 mesh)
M104	Moisture Content	Call the SLTC for instructions (bulk analysis)
1790	Molybdenum (as Mo), Insoluble Compounds (Total Dust)	Tared Low-Ash Polyvinyl Chloride (LAPVC) filter
1810	Naphthalene	Chromosorb 106 Tube (100/50 mg sections, 60/80 mesh)
1840	Nickel, Metal and Insoluble Compounds (as Ni)	Mixed Cellulose Ester Filter (MCEF) 0.8 µm
1860	Nitric Acid	Treated Silica Gel Tube (Supelco, ORBO-53; SKC, 226-10 or equivalent)
		Wipe: Whatman Smear Tab; Solvent: deionized water
1957	Octane	Charcoal Tube (100/50 mg sections, 20/40 mesh)
5010	Oil Mist, Mineral	Tared Low-Ash Polyvinyl Chloride (LAPVC) filter, 37-mm Diameter
1980	Ozone	Two Impregnated Glass Fiber Filters (37-mm polystyrene cassette); coated with a solution containing $NaNO_2$, K_2CO_3 and Glycerol in water
9130	Particulates Not Otherwise Regulated (Respirable Fraction)	Tared Low-Ash Polyvinyl Chloride (LAPVC) filter, 37-mm Diameter, preceded by 10 mm Nylon Cyclone
9135	Particulates Not Otherwise Regulated (Total Dust)	Tared Low-Ash Polyvinyl Chloride (LAPVC) filter, 37-mm Diameter
2037	Petroleum Distillates (Naphtha) (Rubber Solvent)	Charcoal Tube (100/50 mg sections, 20/40 mesh)
2040	Phenol	XAD-7 Tube (100/50 mg sections, 15/50 mesh)
		Bulk: Limit bulk to one gm or one mL
2085	Phosphoric Acid	Mixed Cellulose Ester Filter (MCEF) 0.8 µm
		Treated Silica Gel Tube (Supelco ORBO-53; SKC, 226-10-03 or equivalent)
		Wipe: Whatman Smear Tab; Solvent: deionized water
P125	Polymeric MDI (PAPI)	Coated Glass Fiber Filter (GFF) (37-mm open face); coated with 0.1 mg 1-(2-Pyridyl)piperazine
2170	n-Propyl Alcohol	Charcoal Tube (100/50 mg sections, 20/40 mesh)

TABLE E-1. SAMPLING MEDIA FOR MOST FREQUENTLY REQUESTED ANALYSES		
IMIS Code #	**Analysis**	**Media**
R251	Refractory Ceramic Fibers	Call the SLTC for instructions
S103	Silica (Quartz, Total)	Tared Low-Ash Polyvinyl Chloride (LAPVC) filter, 37-mm diameter[5]
9015	Silica, Crystalline Cristobalite, Respirable Dust	Tared Low-Ash Polyvinyl Chloride (LAPVC) filter, 5 µm, preceded by 10 mm Nylon Cyclone
		Bulk: High volume or settled dust sample is preferred; any sample weight between 0.10 mg and 5.0 mg is acceptable (0.5 to 3.0 mg is preferred)
9010	Silica, Crystalline Quartz (Respirable Fraction)	Tared Low-Ash Polyvinyl Chloride (LAPVC) filter, 5 µm, preceded by 10 mm Nylon Dorr-Oliver Cyclone
		Bulk: High volume area or settled dust sample is preferred. Collect at least 5 gm of dust if submitting high volume sample; for settled dust, any sample weight between 0.10 mg and 5.0 mg is acceptable (0.5 to 3.0 mg is preferred).
2240	Silver, Metal and Soluble Compounds (as Ag)	Mixed Cellulose Ester Filter (MCEF) 0.8 µm
2260	Sodium Hydroxide	Mixed Cellulose Ester Filter (MCEF) 0.8 µm
		Wipe: Whatman Smear Tab Filter; Solvent: deionized water
S777	Soil	Call the SLTC for instructions
2270	Stoddard Solvent	Charcoal Tube (100/50 mg sections, 20/40 mesh)
2280	Styrene	Coated Charcoal Tube (100/50 mg sections, 20/40 mesh); coated with p-tert-Butylcatechol
		Diffusive Sampler
2290	Sulfur Dioxide	Mixed Cellulose Ester Filter (MCEF) followed by a cellulose filter coated with sodium carbonate (SKC 225-9005, or equivalent)
		Special sampling tube containing uncoated glass fiber filter (GFF), followed by sodium carbonate coated glass fiber filter, followed by two beds of silver nitrate coated silica gel (200/200 mg) (SKC 226-177, or equivalent)
		Impregnated Activated Beaded Carbon (100/50 mg sections) (SKC 226-80, or equivalent)
		Mixed Cellulose Ester Filter in series with Midget Fritted Glass Bubbler (MFGB) containing 15 mL 0.3N hydrogen peroxide
2310	Sulfuric Acid	Mixed Cellulose Ester Filter (MCEF) 0.8 µm
		Treated Silica Gel Tube (Supelco, ORBO-53; SKC, 226-10-03 or equivalent)
		Wipe: Whatman Smear Tab Filter; Solvent: deionized water
2020	Tetrachloroethylene (Perchloroethylene)	Charcoal Tube (100/50 mg sections, 20/40 mesh)
		Diffusive Sampler
2430	Tin, Inorganic Compounds (Except Oxides) (as Sn)	Mixed Cellulose Ester Filter (MCEF) 0.8 µm
2460	Toluene	Charcoal Tube (100/50 mg sections, 20/40 mesh)
		Anasorb 747 (140/70 mg sections)
		Diffusive Sampler

[5] Note: Lab does not recommend taking non-respirable (total) quartz air samples. Total quartz sample results are reported only semi-quantitatively.

TABLE E-1. SAMPLING MEDIA FOR MOST FREQUENTLY REQUESTED ANALYSES		
IMIS Code #	**Analysis**	**Media**
2470	Toluene-2,4-Diisocyanate (TDI)	Coated Glass Fiber Filter (GFF) (37-mm open face); coated with 1.0 mg 1-(2-Pyridyl)piperazine
T177	Toluene-2,6-Diisocyanate	Coated Glass Fiber Filter (GFF) (37-mm open face); coated with 1.0 mg 1-(2-Pyridyl)piperazine
T405	1,3,5-Triglycidyl Isocyanurate	Coated Glass Fiber Filter (GFF) (37-mm); coated with Hydrobromic Acid
2505	Trimethylbenzene (mixed isomers)	Charcoal Tube (100/50 mg sections, 20/40 mesh)
V125	Vanadium	Mixed Cellulose Ester Filter (MCEF) 0.8 µm
2571	Vanadium Fume (as V_2O_5)	Mixed Cellulose Ester Filter (MCEF) 0.8 µm
		Tared Low-Ash Polyvinyl Chloride (LAPVC) filter, 5 µm
V109	VM and P Naphtha	Charcoal Tube (100/50 mg sections, 20/40 mesh)
2590	Xylene	Charcoal Tube (100/50 mg sections, 20/40 mesh)
		Diffusive Sampler
Z100	Zinc	Mixed Cellulose Ester Filter (MCEF) 0.8 µm
2610	Zinc Oxide Fume	Tared Low-Ash Polyvinyl Chloride (LAPVC) filter, 5 µm

APPENDIX F

CALIBRATION

A. Sampling Pump Calibration

Calibrate personal sampling pumps before and after each day of sampling using one of the techniques described below. Assure that the calibration equipment is within its prescribed calibration interval, and record the serial number of the calibration equipment in your case file and the OIS air sampling worksheet. The SLTC's chemists sometimes use sampling pump calibration data to verify air sample volumes.

If the sampling pump is equipped with a rotameter or digital flow readout, record the reading in the OIS air sampling worksheet. Bear in mind that the accuracy of a pump rotameter is only approximate; it is intended primarily to facilitate setting the flow rate for calibration.

Most of the following examples in this appendix use filter cassettes as the sampling media, but the examples are generally applicable to adsorbent tubes as well.

NOTE: Precision rotameters are no longer used by OSHA for calibration due to the potential for measurement error (e.g., tests with precision rotameters have indicated significant error due to pump pulsation). Inverted burets may still be useful, but their use is discouraged because they are no longer considered a primary calibration standard.

Before pre-calibration, replace or recharge sampling pump batteries as needed. Check the rechargeable Ni-Cad batteries in older pumps before use under load (i.e., turn pump on and check voltage at the charging jack with the sampling device in-line).

Place the same **type** of sampling media in-line during sampling pump calibration that will be used to sample in the field. Do not use the actual cassette and filter intended for sampling use to perform calibration.

B. Pump Calibration for use with Cyclone

The "Jarless Cyclone Calibration" procedure is the recommended method for calibrating a cyclone. A one-liter jar should no longer be used due to technical issues such as leakage of the jar lid.

The purpose of the procedure is to determine whether the sampling pump will be able to maintain the required flow rate as the drop in static pressure grows due to particulates loading up on the filter. The typical pressure drop across a clean 5-µm filter is 2 inches of water pressure. The additional pressure drop from the cyclone is approximately 0.25 inches. As a filter loads up, the additional pressure drop may be as high as 20 inches of water pressure.

The procedure is demonstrated in the video "Jarless Cyclone Calibration Method" on the OSHA intranet.

Below is a summary of the basic steps of the procedure:

- Adjust and calibrate the pump to a flow rate of 1.7 L/min with a light load attached;
- Increase the load to 25–35 inches and check to be sure the flow rate is within +/- 5%;
- Remove the load and attach the cyclone to the sampling pump, then verify that the load is at between 2 and 5 inches of water pressure;

Detailed Step-By-Step Instructions

1. Connect the sampling train:

    - Connect the sampling pump to a Tee fitting.
    - Connect the Tee to a pressure gauge and the light load (i.e., a clean 5-µm filter or an adjustable bonnet valve).
    - Connect the load to the air outlet of the pump calibrator (bubble meter).
    - Turn on the sampling pump.
    - If a bonnet valve is used, adjust to create a load of 2–5 inches of water pressure. If a 5-µm filter is used, verify that the pressure drop is 2–5 inches of water pressure. If not, this may indicate leakage around the filter.
    - Set the pump flow rate to 1.7 L/min.
    - Take at least three flow readings and record the average flow rate. Readings should be within +/- 2% of each other.

2. Increase the load:

    - If a bonnet valve is used, adjust to increase the load to 25–35 inches of water pressure. If a 5-µm filter was used for the light load, remove it and replace it with a set of six 0.8-µm filters connected in series (i.e., sandwiched in a four-piece cassette with four backup pads). If the load is not at least 25 inches of water pressure, ensure the cassette is tightly compressed to prevent air from bypassing the filters.
    - Turn on the pump, and then check and record the average flow rate. If the flow is not within +/- 5% under increased load, return the pump to the CTC for repair with a note explaining the problem.

3. Add the cyclone to the sampling train:
    - Disconnect the pump calibrator and remove the load.
    - Attach the cyclone with a clean 5-µm filter in place of the load.
    - Turn the pump on and confirm that the pressure drop is 2–5 inches of water pressure with the cyclone attached.

Refer to the cyclone leak test and cyclone cleaning procedures as described in Appendix I.

C. Electronic Flow Calibrators

The Gilian Gilibrator® I and II by Sensidyne® (see Figure F-1) are electronic bubble flow meters, used to calibrate sampling pumps, that provide instantaneous air-flow readings and cumulative averaging of multiple measurements. These calibrators measure the flow rate and display the results as volume per unit of time (e.g., mL/min) and can be used to calibrate most air sampling pumps. Different flow cells are used to accommodate different flow ranges. The middle-sized flow cell is typically used for personal sampling for particulates, while the largest cell is used for high volume area sampling and the smallest cell may be needed for certain low flow sorbent tube methods. The total range with the different flow cells is from 1 mL/min to 30 L/min. Gilibrators **should not** be left plugged into the charger for extended time periods because doing so will decrease the service life of the battery.

Another wet-cell calibrator available in some OSHA field offices is the miniBuck™ as shown in Figure F-2. Its operation is similar to the Gilibrator.

The Bios Defender™ shown in Figure F-3 is an electronic dry-piston flow meter used to calibrate sampling pumps that provides immediate and average readings. The device can be used to calibrate either pressure (labeled inlet) or vacuum (labeled outlet) flow sources. The vacuum port is used to calibrate sampling pumps, and the pressure port is used to calibrate the outlet of sampling pumps used to fill gas sampling bags. The Bios Defender has a lead-acid battery and can be left on charge for an indefinite time without damaging the battery. Different models of the instrument cover an optimum flow range of 5 mL/min to 30 L/min.

FIGURE F-1. GILIAN GILIBRATOR PUMP CALIBRATOR

FIGURE F-2. MINIBUCK PUMP CALIBRATOR

If using a Bios Defender to calibrate an MSA Escort® ELF pump, use an isolating flow restriction providing at least 5 inches of water column pressure between the pump and the flow meter. For example, use air sampling media (cassette or sorbent tube) with a Gemini variable orifice. Failure to use such an isolation technique may result in +/- 2% calibration inaccuracy.

The CTC recommends that the Bios Defender not be used in a very dusty environment because dust that flows through the calibrator piston area has the potential to scratch the glass and piston inside the calibrator. The CTC also recommends that neither the Gilibrator nor the Bios Defender flow calibrator be used in corrosive or otherwise contaminated environments.

FIGURE F-3. BIOS DEFENDER PUMP CALIBRATOR

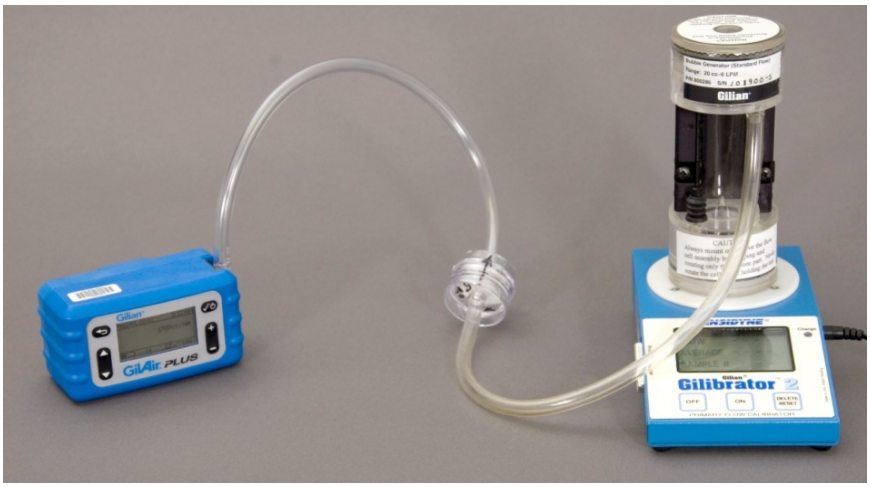
Properly functioning and calibrated Gilibrators and Bios Defenders have an accuracy of approximately 99%. Use the appropriate Gilibrator flow cell or the Bios Defender model with the appropriate range of airflow for the pump airflow to be calibrated.

It is recommended that the flow rates obtained from these devices be reported to three significant figures. For example, a flow rate shown as 1.006 L/min should be reported as 1.01 L/min.

D. Procedures

NOTE: The following instructions and figures were written for the Gilian Gilibrator flow calibrator as shown in Figure F-4, however, the Bios Defender and miniBuck calibrator can be substituted in most cases (for use with MSA Escort ELF pumps, the isolating flow restrictor must be used as described above).

FIGURE F-4. CASSETTE ATTACHED TO ELECTRONIC BUBBLE METER FOR PUMP CALIBRATION



1. Perform the calibration at the pressure (altitude) and temperature where the sampling is to be conducted. If this is not possible, consult the operating manual for the sampling pump to determine if the air volume needs to be adjusted for temperature and pressure. Allow the pump to run for one to five minutes before voltage check and calibration. Consult the CTC regarding correction factors if sampling must be performed at freezing temperatures.

2. Connect the collection device, tubing, pump, and calibration apparatus as shown in Figure F-4 for the cassette (or sorbent tube) sampler. Note that cassette adapters (e.g., plastic or metal Luer taper adapters) should not be used. Luer adapters in front of a filter in a calibration train can potentially generate significant back pressure for which some pressure regulating pumps may not be able to compensate, resulting in inaccurate results. Luer adapters behind filters can affect sample distribution across an open-face cassette, and some Luer adapters are long enough that they may even make contact with the backup pad in the cassette. For this reason their use is not recommended. There are commercially available filter cassette holders with integrated connectors that do not have an adverse effect on back pressure.

3. Visually inspect all plastic tubing connections. Be certain that there are no leaks.

4. Gilibrator: Assemble the Gilibrator as per the equipment manual. Introduce soap solution into the flow cell through the air inlet boss. Add enough soap solution until the angled edge at the bottom of the bubble generator ring is immersed in the solution. After connecting the sampling pump and turning it on, push the button several times to wet the inside of the electronic flow cell with the soap solution.

   Bios Defender: No preparation required.

5. Turn on the pump and adjust the pump rotameter and/or digital flow display (if so equipped) to the appropriate flow rate.

6. Gilibrator: Press the button on the electronic bubble meter. Visually capture a single bubble and electronically time the bubble. The accompanying printer will automatically record the calibration reading in L/min.

   Bios Defender: Press and release the Read button for a single measurement. Press and hold the Read button for consecutive measurements.

FIGURE F-5. BUBBLE ACTUATOR BUTTON ON GILIBRATOR

7. Adjust the sampling pump to the correct flow rate using the calibrator results. Adjust the sampling pump while it is running.

8. Confirm that the sampling pump is adjusted properly and take additional calibrator readings. Three or more consecutive readings should be taken and should be within about 2% of each other and then averaged.

9. Repeat the procedures described above for all pumps to be used for sampling. The same cassette and filter may be used for calibrations involving the same sampling method. Do not use the actual cassette and filter intended for sampling use to perform calibration.

FIGURE F-6. GILIBRATOR DISPLAY PANEL SHOWING FLOW RATE, SIDE BY SIDE WITH GILAIR SAMPLING PUMP WITH DIGITAL FLOW READOUT

E. Instructions for Calibrating MSA Escort ELF Pumps with "Dry" Piston-Type Calibrators

When calibrating Escort ELF pumps with piston-type calibrators, extra steps must be taken to ensure that the pumps are calibrated accurately. The design of Escort ELF pumps make them susceptible to calibration inaccuracies due to pressure spikes created by the mechanical action of Bios International piston-type calibrators, such as the Defender series models. The rubber-walled pulsation dampeners incorporated into the Escort ELF pump design do not sufficiently compensate for the pressure spikes from the Bios calibrators; as a result, these pressure impulses can produce an uncertainty of over 4% (± 4%) in the calibration accuracy of Escort ELF pumps. **THE ESCORT ELF PUMPS SHOULD NOT BE CALIBRATED USING THE BIOS INTERNATIONAL PISTON TYPE CALIBRATORS BECAUSE THEY CAN PRODUCE AN UNCERTAINTY ERROR OF OVER 4%** (compared to the desired margin of error of ±1%). No other type of pumps are affected by this phenomenon, nor do the Escort ELF pumps suffer this susceptibility when wet cell bubble-type air flow calibrators are used or when the pumps are deployed with air sampling media or filter cassettes.

The manufacturers recommend that an isolating flow restrictor, such as a 0.030-inch orifice, be placed between the pump and the flow meter. The 0.030-inch orifice was shown at the CTC to create about 20 inches of water column (WC) of additional loading to the sampling pump at 2,000 mL/min. This additional loading causes the pump to speed up to maintain the required flow setting, which, in turn, makes the small changes in loading caused by the action of the calibrator's piston to have a negligible effect on the airflow within the Escort ELF pump. The use of a 0.030-inch orifice will ensure that there will be a sufficient load on the Escort ELF pump to mitigate the pressure spikes from the Bios piston-type calibrator across the entire effective flow-rate range of the pump, thus enabling the operator not to exceed the required 1 percent (± 1 percent) pump calibration accuracy.

F. Calibration Procedures for Open-Face Filters

Open-face cassettes are used for asbestos and certain chemicals such as isocyanates, crotonaldehyde, and glutaraldehyde.

1. The appropriate way to calibrate an open-face cassette is to use the cover section which comes with the cassette and attach the tubing directly from the electronic flow calibrator to the inlet port on the cassette cover. Be certain there are no leaks and do not use a Luer adapter. This set-up will provide the least amount of flow resistance and represent the open-face conditions while actually sampling.

2. Perform the pump calibration at the pressure (altitude) and temperature where sampling is to be conducted. If this is not possible, consult the operating manual for the sampling pump to determine if the air volume needs to be adjusted for temperature and pressure.

G. Calibration of Impingers and Bubblers

1. Set up the calibration apparatus as shown in Figure F-6, but instead of using a cassette, attach an impinger or bubbler filled with the amount of liquid absorbing solution specified in the sampling method. If a prefilter or cassette is described in the CSI file, include the correct filter in line. Include an adsorbing solution trap if one is to be used in air sampling.

2. Connect the tubing from the electronic bubble meter to the inlet of the impinger or bubbler.

3. Connect the outlet of the impinger or bubbler to the tubing to the pump. Be certain there are no leaks.

4. Calibrate the pump to the flow rate specified in the CSI file for the sampling method.

H. Maintenance and Care of Electronic Calibrators

Consult the manufacturer's instruction manuals for complete details. Periodically, compare the calibrator to another unit to make sure that it is functioning properly. Return the calibrator to the CTC annually to be calibrated and serviced.

Gilian Gilibrator:

1. For units that are used daily, connect the short length of storage tubing to the air outlet (upper) boss and the air inlet (lower) boss of the flow cell. This will prevent evaporation and concentration of the soap solution. Store in a clean area.

2. For units that will not be used for more than a week, remove the flow cell by unplugging the power/data cord and then gripping the bottom of the flow cell and rotating it one quarter turn counter-clockwise. Caution: gripping the top of the flow cell before turning it can stress and crack the flow cell. Then tip the cell horizontally and drain the soap solution out through the air inlet (lower) boss. Allow the flow cell to air dry completely before storage. Do not leave the calibrator plugged into the charger for extended time periods because doing so will decrease the service life of the battery. Store in the case to protect from breakage or dust accumulation.

3. Check the unit before use. Wipe the outside with a damp cloth if needed. If stored properly, routine cleaning is unnecessary. If there is excessive soap residue inside the flow cell, disconnect it and rinse with warm water. The acrylic flow cell can be easily scratched. Do not allow the flow cell (center tube, where sensors detect the soap bubble) to be scratched or to get dirty. Never clean the cell with acetone, alcohol or other cleaning solutions.

4. Leak testing. If leakage is suspected, perform a leak test as described in the Gilibrator manual. No leakage should be observed. Never pressurize the flow cell with more than 25 inches of water pressure. The CTC performs a leak check as part of their annual service.

5. Calibrator Calibration. The calibrator is factory calibrated using a standard traceable to the National Institute of Standards and Technology. The calibrator is linear throughout the entire range. The CTC will calibrate the unit as part of their annual service.

6. When transporting the calibrator, especially by air, it is important that one side of the storage tube which connects the air inlet and outlet be removed to equalize internal pressure within the calibrator. Do not transport the unit with soap solution or with storage tubing in place.

7. The calibrator soap is a concentrated and sterile solution formulated to provide a clean, frictionless soap film bubble over the wide, dynamic range of the calibrator. The sterile nature of the soap is important in order to prevent residue buildup in the flow cell center tube, which could cause inaccurate readings. The use of any other soap is not recommended. Proper soap solution is available from the CTC's expendable supplies program.

Bios Defender*:*

1. Do not use liquid solvents or abrasive cleaners to clean the calibrator; wipe only with a cloth lightly dampened with water. Store the instrument in a clean, dry place and with the unit on charge, if possible.

2. Leak testing. Place the manufacturer supplied leak-test accessory (short piece of tubing with a red plug) over the inlet (top port). Press and hold the STOP button and then press the ON button. The display should read “Leak Test, Invert & Push Read.” Invert the unit and push Read. Turn the unit upright and allow it to stand. Make sure that the piston is at the top of the cell. Allow the calibrator to stand until the piston falls; this may take as long as 15–20 minutes. The unit will display “Test OK Press Read” if it passes the test. Repeat the leak test with the leak-test accessory over the outlet (bottom port).

3. Calibration. Bios recommends that the unit be recalibrated by the manufacturer annually. The CTC will calibrate the unit as part of their annual service.

APPENDIX G

HOW TO APPLY FORM OSHA-21 TO SAMPLING MEDIA

FIGURE G-1. CORRECTLY SEALED CHARCOAL TUBE. CHARCOAL TUBE INSIDE FORM OSHA-21

FIGURE G-2. INCORRECTLY SEALED CHARCOAL TUBE. END CAPS CAN BE REMOVED, ALLOWING SAMPLE INTEGRITY TO BE JEOPARDIZED WITHOUT DISTURBING THE SEAL

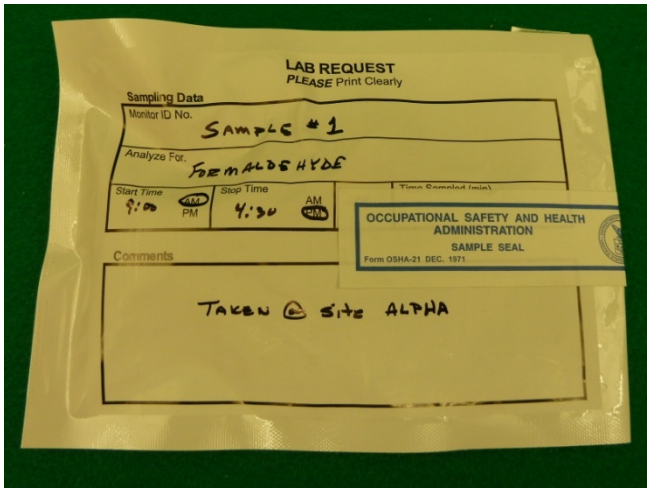
FIGURE G-3. INCORRECTLY SEALED CASSETTE ALLOWS ACCESS TO INLET/OUTLET PORTS AFTER SAMPLE HAS BEEN TAKEN

FIGURE G-4. CORRECTLY SEALED CASSETTE WITH FORM OSHA-21 COVERING INLET/OUTLET PORTS MAINTAINING SAMPLE INTEGRITY

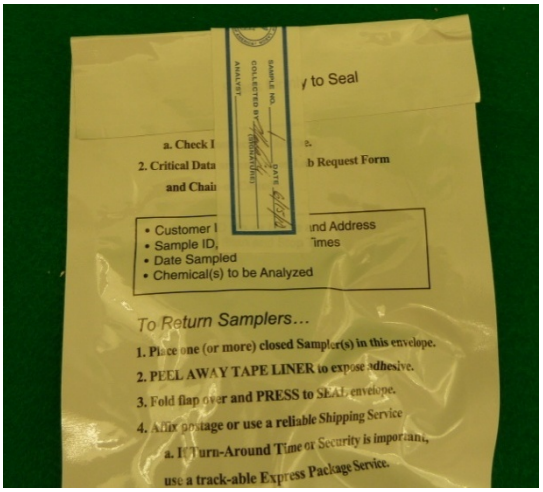
FIGURE G-5. STANDARD ASBESTOS CASSETTE (25mm) CORRECTLY SEALED WITH A FORM OSHA–21

FIGURE G-6. PASSIVE MONITORS CORRECTLY SEALED WITH A FORM OSHA-21

Correctly sealed formaldehyde passive sampler



Backside of correctly sealed formaldehyde passive monitor



Correctly sealed 3M passive monitor

APPENDIX H

EXAMPLE CALCULATIONS FOR MIXTURES

As an example, an exposure to three different substances:

Material	8-hr. Exposure (ppm)	8-hr. TWA PEL (ppm)	SAE
Substance 1	500	1,000	0.089
Substance 2	80	200	0.11
Substance 3	70	200	0.18

Using Equation 3 (from Section III.G.2.):

$$E_m = \left(\frac{C_1}{L_1} + \frac{C_2}{L_2}\right) + \cdots \left(\frac{C_n}{L_n}\right)$$

Where:

E_m is the equivalent exposure severity for the mixture
E_m should be < 1 for compliance
C is the concentration of a particular contaminant
L is the OSHA exposure limit for that substance.

$$E_m = \frac{500}{1000} + \frac{80}{200} + \frac{70}{200} = 1.25$$

Since $E_m > 1$ an overexposure appears to have occurred; however, the SAE for each substance also needs to be considered:

Exposure severity ratio (for each substance) (from Equation 15 from Section IV.D.5. above)

$$Y_n = \frac{C_n}{L_n}$$

Ratio each to total exposure (using Equation 16 from Section IV.D.5.)

$$R_1 = \frac{Y_1}{E_m}, \ldots R_n = \frac{Y_n}{E_m}$$

The SAEs (95% confidence) of the substances comprising the mixture can be pooled by:

Equation H-1

$$R_{st} = \sqrt{[(R_1)^2 \times (SAE_1)^2 + (R_2)^2 \times (SAE_2)^2 + \cdots (R_n)^2 \times (SAE_n)^2]}$$

which is also equivalent to (using Equation 17 from Section IV.D.5.):

$$R_{st} = \sqrt{[(R_1 \times SAE_1)^2 + (R_2 \times SAE_2)^2 + \cdots (R_n \times SAE_n)^2]}$$

From Equation 18

$UCL = 1 + R_{St}$

From Equation 19

$LCL = 1 - R_{St}$

If $E_m < LCL$ then no overexposure has occurred at the 95% confidence level.

If $LCL \leq E_m \leq UCL$ then the exposure cannot be classified as either under or over the PEL at the 95% confidence level; further sampling may be necessary.

If $E_m > UCL$ then an overexposure has occurred (95% confidence).

Using the mixture data above:

$Y_1 = 500/1{,}000$	$Y_2 = 80/200$	$Y_3 = 70/200$
$Y_1 = 0.5$	$Y_2 = 0.4$	$Y_3 = 0.35$
$R_1 = Y_1/E_m = 0.4$	$R_2 = 0.32$	$R_3 = 0.28$

$$(R_{st})^2 = (0.4 \times 0.089)^2 + (0.32 \times 0.11)^2 + (0.28 \times 0.18)^2$$

$$R_{st} = \sqrt{(R_{st})^2} = 0.071$$

$$UCL = 1 + R_{st} = 1.071$$

$$E_m = 1.25$$

Therefore $E_m > UCL$ and an overexposure has occurred within 95 percent confidence limit.

An executable computer program is available which will calculate a control limit for any mixture. Simply input the exposures, limits, and SAEs and the program will calculate a control limit according to the above equation.

Mixture Calculator

APPENDIX I

CYCLONE ASSEMBLY AND CLEANING INSTRUCTIONS

A. Cyclone Assembly

Inspect the cyclone parts for signs of wear or damage such as scoring, rifling, or a loose coupler. Replace the units or parts if they appear damaged. Figures I-1 and I-2 show the parts for MSA and Sensidyne cyclones, respectively.

FIGURE I-1 MSA CYCLONE ASSEMBLY PARTS

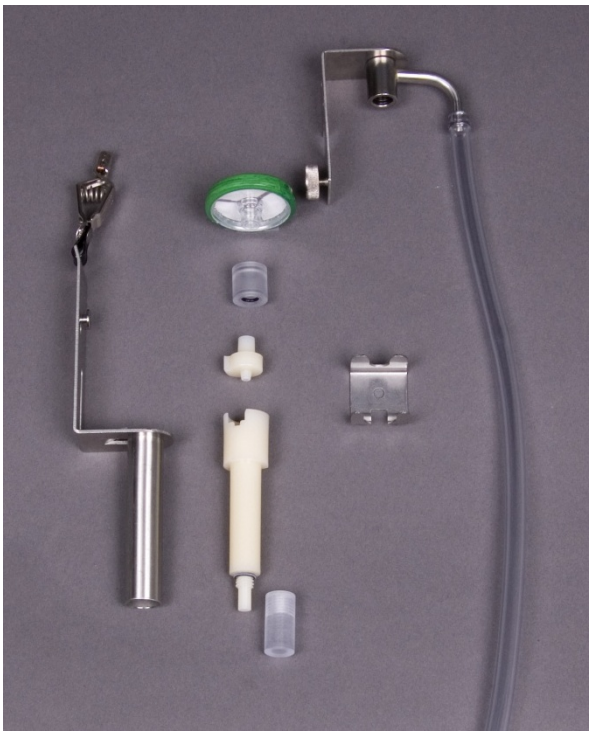
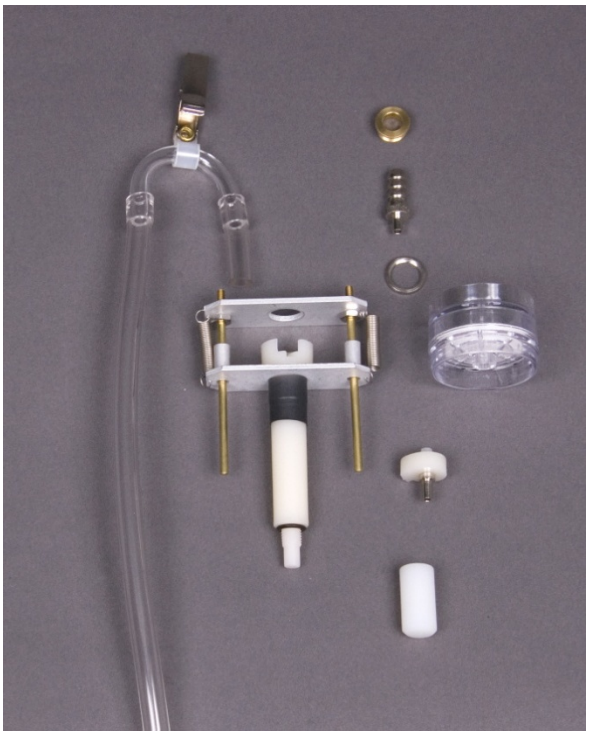


FIGURE I-2 SENSIDYNE CYCLONE ASSEMBLY PARTS



B. Cyclone Leak Test Procedure

Leak test the cyclone before use unless it has been leak tested within the past month. A cyclone leak test kit and cyclone leak test procedure are provided in each Area Office for this purpose.

This section summarizes procedures for leak testing of the Dorr-Oliver cyclone samplers used for collecting respirable dust. Further details on this procedure are contained in the Cyclone Leak Test Procedure (CLTP). CSHOs should review the entire leak test procedure before conducting the leak test as summarized below. See the CLTP for more specific procedures regarding leak tests.

Nylon Part Inspection

- Disassemble the cyclone assembly, clean it, and inspect it for cracks and worn fit between parts. Take care not to scratch the inside surface of the cyclone chamber.

- Replace any worn or cracked units or parts.

O-Ring, Tubing, and Filter Leak Test

- Connect the entire cyclone assembly (minus the cyclone body) to the pressure gauge and aspirator, maintaining the normal spacing between the plastic filter adaptor (coupler) and the vortex finder.

- Seal the cyclone vortex finder opening by placing an airtight cap or your fingertip over the hole.

- Hold the cyclone assembly together with one hand.

- With your other hand, squeeze and gently release the aspirator bulb until the pressure gauge reads between 4 inches and 10 inches of water pressure, then fold the tubing halfway between the "Tee" fitting and the aspirator. If the pressure reading is beyond full scale, release the vacuum and try again.

- Observe the pressure gauge reading for 30 seconds. If the pressure drops less than 25%, the leakage is acceptable and the unit passes the leak test. If the pressure drops more than 25%, corrective action is necessary. Sources of leaks include worn or damaged O-rings, cracked or ill-fitting tubing, and leaky pre-weighed filter cassettes.

Note: Leaks between the filter input and the air sampling pump are more disruptive than leaks at the plastic filter adaptor O-rings.

Final Pump-Fault Leak Test

- Connect the cyclone assembly to the pump in the normal sampling configuration with the air sampling pump running at 1.7 L/min.

- Close the inlet to the cyclone with tape or a finger. If the pump bears down and goes into a fault mode, the assembly passes this final, but crude, pump-fault leak test.

C. Cyclone Cleaning

Unscrew the grit pot from the cyclone. Empty the grit pot by turning it upside down and tapping it gently on a solid surface. Clean the cyclone thoroughly and gently after each use in warm soapy water or, preferably, wash it in an ultrasonic bath. Rinse it thoroughly in clean water, shake off excess water, and set aside to dry before reassembly. Never insert anything into the cyclone during cleaning.

APPENDIX J

SAMPLE CALCULATIONS FOR CRYSTALLINE SILICA

Reference Formulas

A. Construction/Maritime PEL for Crystalline Silica (Quartz) (using Equation 5 from Section III.K.2.):

$$PEL\ (crystalline\ silica, quartz) = \frac{250\ mppcf}{\%\ silica + 5}$$

B. General Industry PEL for Crystalline Silica (Quartz) (using Equation 6 from Section III.K.2.):

$$PEL\ (mg/m^3) = \frac{10\ \ mg/m^3}{2 + \%\ respirable\ quartz}$$

C. OSHA-adopted conversion factor:

$$1\ mppcf\ = 0.1\ mg/m^3\ respirable\ dust \qquad or$$

$$1\ \ mg/m^3\ = 10\ mppcf\ respirable\ dust$$

D. Combining multiple silica samples (single analyte) with different percentages and mass:

$$Recalculated\ \% = \frac{(Pa\ x\ Wa) + (Pb\ x\ Wb)}{Wa + Wb}$$

Where:

P = Lab reported percentage of silica for each sample
W = Mass of silica reported by the lab for each sample

Example 1: Two consecutive samples were collected to monitor the same employee for a combined exposure to silica dusts for one work shift. The analytical results are shown in Table J-1, Sample Silica Exposure Data.

Table J-1
SAMPLE SILICA EXPOSURE DATA

Sample	Sampling period (min)	Total volume (L)	Respirable weight (mg)	Respirable concentration (mg/m^3)	SLTC results (%)
A	238	405	0.855	2.1	5.2 quartz 2.3 cristobalite ND tridymite
B	192	326	0.619	1.9	4.8 quartz 1.7 cristobalite ND tridymite
Total	430	731	1.474		
Key: ND = Not detectable.					

Calculation of the TWA from the sampling and analytical data:

Step 1. Calculate the percentage of quartz, cristobalite, and tridymite in the respirable particulate collected (using Equation 8 from Section III.K.2.).

$$Quartz: 5.2\left(\frac{0.855}{1.474}\right) + 4.8\left(\frac{0.619}{1.474}\right) = 3.0 + 2.0 = 5.0\%$$

$$Cristobalite: 2.3\left(\frac{0.855}{1.474}\right) + 1.7\left(\frac{0.619}{1.474}\right) = 1.3 + 0.7 = 2.0\%$$

Step 2. Calculate the PEL for the mixture (using Equation 12 from Section III.K.2.):

$$PEL_{mixture} = \frac{10\ mg/m^3}{\%\ quartz + 2(\%\ cristobalite) + 2(\%\ tridymite) + 2}$$

$$= \frac{10}{5.0 + 2(2.0) + 2(0) + 2} = \frac{10}{11.0} = 0.91\ mg/m^3$$

Step 3. Calculate the employee's exposure (using Equation 7 from Section III.K.2.). NOTE: 1L = 0.001 m^3

Equation J-1

$$Exposure = \frac{Sample\ wt.A + Sample\ wt.B}{Total\ Volume} = \frac{0.855 + 0.619}{0.731} = 2.0\ mg/m^3$$

Step 4. Adjust (where necessary) for less than 8-hour sampling period.

Equation J-2

$$TWA = (2.0\ mg/m^3)\frac{430\ min}{480\ min} = 1.8\ mg/m^3$$

Step 5. Calculate the severity of the exposure (using Equation 9 from Section III.K.2.):

$$\frac{1.8\ mg/m^3}{0.91\ mg/m^3} = 2.0$$

After Step 5, the upper and lower confidence limits would be determined by applying the SAE as described in Section IV.D. of this document, and as shown in Examples 2 and 3 below.

Example 2: A sample is obtained for a construction jackhammer operator using the gravimetric sampling method specified in OSHA Method ID-142. The sample is run for 240 minutes at a flow rate of 1.7 L/min, yielding a total sample volume of 0.408 m^3. The respirable dust collected on the filter is

determined to weigh 0.857 mg, resulting in a respirable dust concentration of 2.1 mg/m^3. The SLTC reports that the sample contains 55% quartz. The SLTC also reports an SAE of 0.20 for the sample.

Step1. Determine the jackhammer operator's 8-hour TWA respirable dust exposure (assuming zero exposure for the unsampled portion of the 8-hour shift) (using Equation J-2):

$$Exposure = 2.1\ mg/m^3\ x \frac{240\ min}{480\ min} = 1.05\ \ mg/m^3\ respirable\ dust$$

Step 2. Calculate the general industry PEL, assuming the conditions for the jackhammer operator sample containing 55% respirable quartz (using Equation 12 from Section III.K.2.):

$$PEL\ (mg/m^3) = \frac{10\ \ mg/m^3}{2 + 55} = 0.175\ mg/m^3$$

Step 3. Calculate the Severity Ratio (using Equation 9 from Section III.K.2.):

$$Severity = \frac{sample\ results\ (from\ Step\ 1)}{calculated\ PEL\ (from\ Step\ 2)} = \frac{1.05\ \ mg/m^3}{0.175\ mg/m^3} = 6.0$$

Step 4. Calculate confidence limits by applying the SAE (Equations 10 and 11 respectively, from Section III.K.2):

$$Lower\ Confidence\ Limit\ (LCL) = 6.0 - 0.20 = 5.8$$

$$Upper\ Confidence\ Limit\ (UCL) = 6.0 + 0.2 = 6.2$$

Step 5. Based on a confidence limit of 5.8, the sample exceeds the 95% confidence limit for overexposure.

Step 6. Apply the OSHA-adopted conversion factor (using Equation 4 from Section III.K.2.) to the jackhammer operator's exposure result from Step 1 and Reference Formula (B) above:

$$Exposure = (1.05\ \ mg/m^3)\frac{1\ mppcf}{0.1\ \ mg/m^3} = 10.5\ mppcf$$

Step 7. Calculate the applicable construction PEL for jackhammer operator sample containing 55% respirable quartz (using Equation 5 from Section III.K.2.):

$$PEL = \frac{250\ mppcf}{55\% + 5} = 4.17\ mppcf$$

Step 8. Conclusion. The 8-hour TWA exposure of the jackhammer operator exceeds the construction industry PEL for crystalline silica (quartz).

Example 3: Two samples are obtained for a construction foreman overseeing a concrete drill press operation. Both samples are collected at a flow rate of 1.7 L/min. The duration of Sample A is 238 minutes, yielding a total sample volume of 0.40 m^3. The respirable dust collected on the filter is

determined to weigh 0.855 mg, resulting in a respirable dust concentration of 2.1 mg/m^3. The SLTC laboratory reports that Sample A contains 30% quartz. The duration of Sample B is 192 minutes, yielding a total sample volume of 0.326 m^3. The respirable dust weight is 0.619 mg, resulting in a concentration of 1.9 mg/m^3. The total weight of respirable dust collected on both samples is 1.474 mg. The SLTC laboratory reports that Sample B contains 25% quartz. The SLTC reports an SAE of 0.16 for both samples.

Step 1. Determine the foreman's 8-hour TWA respirable dust exposure (using Equation 13 from Section IV.D.4.):

$$Exposure = \frac{(2.1\ mg/m^3 \times 238\ min) + (1.9\ mg/m^3 \times 192\ \text{min})}{480\ min} = 1.8\ mg/m^3$$

Step 2. Determine average quartz content since the SLTC provided two different percentages of quartz, using Reference Formula D, above:

$$Recalculated\ \% = \frac{(30\%\ x\ 0.855) + (25\%\ x\ 0.619)}{(0.855 + 0.619)} = 28\%$$

Step 3. Calculate the general industry PEL, assuming the conditions for the construction foreman sample containing 28% respirable quartz (using Equation 12 from Section III.K.2):

$$PEL(mg/m^3) = \frac{10\ mg/m^3}{2 + 28} = 0.333\ mg/m^3$$

Step 4. Calculate the Severity Ratio (using Equation 9 from Section III.K.2):

$$Severity = \frac{1.8\ mg/m^3}{0.333\ mg/m^3} = 5.4$$

Step 5. Calculate confidence limits by applying the SAE (using Equations 10 and 11 respectively, from Section III.K.2):

$$LCL = 5.4 - 0.16 = 5.24$$

$$UCL = 5.4 + 0.16 = 5.56$$

Step 6. Based on a severity of 5.4, the sample exceeds the 95% confidence limit for overexposure.

Step 7. Apply the OSHA-adopted conversion factor to the construction foreman's exposure result from Step 1 and Reference Formula C above (using Equation 4 from Section III.K.2.):

$$Exposure = (1.8\ mg/m^3)\frac{1.0\ mppcf}{0.1\ mg/m^3} = 18.0\ mppcf$$

Step 8. Calculate the applicable construction PEL, (using Equation 5 from Section III.K.2.) for the foreman's samples containing an average of 28% respirable quartz:

$$PEL = \frac{250\ mppcf}{28 + 5} = 7.58\ mppcf$$

Step 9. Conclusion. The eight
-hour TWA exposure of the foreman exceeds the construction industry PEL for crystalline silica (quartz).

APPENDIX K

CHAIN OF CUSTODY

The SLTC uses OSHA's established chain-of-custody procedures to track whether official Form OSHA-21 seals were properly used to ensure the integrity of samples collected by OSHA CSHOs. The procedure also tracks the history and control of samples received at the SLTC. The chain of custody includes the following dates: the date the sample was collected, the date the sample was shipped to the SLTC, the date the sample was received at the SLTC, the date the analyst received the sample, the date the analysis was completed, the date the analytical results were checked by another analyst, and the date the sample results were released by a supervisor or his/her representative. It is important to follow chain-of-custody requirements because it documents the proper handling of OSHA samples for litigation purposes.

APPENDIX L

HEALTH EFFECTS CODES

When available, the CSI files contain health effects information, including the applicable Health Effects Codes, for each chemical. The complete list of Health Effects Codes is shown below in Table L-1. The Health Effects Codes indicate the principal health effects of exposure to each substance, and are used to determine the seriousness of a violation and severity of the penalty, based on the guidelines contained in Chapter 4 of the FOM.

Table L-1. HEALTH EFFECTS CODES

Code	Health Effects
HE1	Cancer---Currently regulated by OSHA as carcinogen
HE2	Chronic (Cumulative) Toxicity---Known or Suspected animal or human carcinogen, mutagen (except Code HE1 chemicals)
HE3	Chronic (Cumulative) Toxicity---Long-term organ toxicity other than nervous, respiratory, hematologic or reproductive
HE4	Acute Toxicity---Short-term high risk effects
HE5	Reproductive Hazards---Teratogenesis or other reproductive impairment
HE6	Nervous System Disturbances---Cholinesterase inhibition
HE7	Nervous System Disturbances---Nervous system effects other than narcosis
HE8	Nervous System Disturbances---Narcosis
HE9	Respiratory Effects Other Than Irritation---Respiratory sensitization (asthma or other)
HE10	Respiratory Effects Other Than Irritation---Cumulative lung damage
HE11	Respiratory Effects---Acute lung damage/edema or other
HE12	Hematologic (Blood) Disturbances---Anemias
HE13	Hematologic (Blood) Disturbances---Methemoglobinemia
HE14	Irritation-Eyes, Nose, Throat, Skin---Marked
HE15	Irritation-Eyes, Nose, Throat, Skin---Moderate
HE16	Irritation-Eyes, Nose, Throat, Skin---Mild
HE17	Asphyxiants, Anoxiants
HE18	Explosive, Flammable, Safety (No adverse effects encountered when good housekeeping practices are followed)
HE19	Generally Low Risk Health Effects---Nuisance particulates, vapors or gases
HE20	Generally Low Risk Health Effects---Odor

APPENDIX M

CONVERSION EQUATIONS (mg/m^3 to ppm)

Equation M-1

$$ppm_{NTP} = \frac{(mg/m^3)(24.46)}{MW}$$

Where:

24.46 = molar volume at 25°C (298K) and 760 mmHg
MW = molecular weight
NTP = Normal Temperature and Pressure (25°C and 760 mmHg)
mmHg = millimeters of mercury

CSHOs will not usually need to calculate the exposure concentration in ppm at the sampling site (ppm_{PT}) but, if necessary, it can be calculated from the SLTC's results reported in ppm_{NTP} by using the following equation:

Equation M-2

$$ppm_{PT} = (ppm_{NTP})\left(\frac{760}{P}\right)\left(\frac{T}{298}\right)$$

Where:

P = sampling site pressure (mmHg)
T = sampling site temperature (K)
298 = normal temperature in degrees Kelvin (273 + 25)
760 = normal atmospheric pressure in mmHg

Equation M-3

$$\text{Because } ppm_{NTP} = \frac{(mg/m^3)(24.46)}{MW}$$

$$ppm_{PT} = (mg/m^3)\left(\frac{24.46}{MW}\right)\left(\frac{760}{P}\right)\left(\frac{T}{298}\right)$$

NOTE: When a contaminant concentration is converted from mg/m^3 and expressed as ppm_{PT}, that value cannot be compared directly to the PEL table without first converting it to its corresponding ppm_{NTP} value.

NOTE: The **barometric pressure** for the time period sampled can sometimes be obtained from the NOAA website or by calling the local weather station or airport. If air pressures are obtained by this route, it is necessary to obtain the unadjusted barometric pressure (station pressure) for compliance applications. The barometric pressure information most readily available from weather and aviation

sources is the sea-level adjusted barometric pressure which tends to average about 760 mmHg and does not represent the actual air pressure of worksites much removed from sea level.
If the sources above are not readily available or cannot provide the actual station pressure, then the elevation (Elev) in feet of the worksite can be used to calculate the typical barometric pressure (P) in mmHg using the following equation:

Equation M-4

$$P = 760 \times \left[1 - \frac{Elev \times 1.6470 \times 10^{-3}}{295.20 \times (1 + Elev \times 4.9787 \times 10^{-8})}\right]^{6.3222}$$

Equation M-4 is an adaptation of the atmospheric model equation used in the *U.S. Standard Atmosphere* (1976) using a higher average effective sea-level screen temperature (295.2K) and lower temperature lapse rate (5.4K/km) typically observed over land surfaces within the northern latitudes of the U.S. (19ºN to 61ºN). For most of the U.S., the barometric pressures obtained with this equation are better estimates of observed station pressures than the 1976 model, and deviate from mean annual station pressures by about 0.24% RSD (percent relative standard deviation) for elevations below 4,300 feet and 0.52% RSD for elevations below 30,000 feet. These deviations are insignificant compared to the estimated 1.6% RSD for combined normal seasonal, storm, and diurnal station pressure variations observed at any elevation within the year. The 1.6% RSD may be assumed if the worksite elevation can be estimated to within 100 feet. A global positioning system (GPS) elevation measurement is typically within 100 feet of the actual elevation. GPS elevation measurements should be made outdoors and away from tall structures. Example calculations using the equation give 723.2 mmHg for an elevation of 1,400 feet above mean sea level and 569.5 mmHg for an elevation of 8,000 feet above mean sea level. Due to Alaska's high latitudes, Equation M-4 is biased high for significant elevations in Alaska; therefore, the station pressure of a nearby weather station is necessary to obtain accurate air pressures for most of Alaska.

APPENDIX N

EXAMPLE CALCULATION FOR FULL-PERIOD, CONTINUOUS SINGLE SAMPLE

A single glass-fiber filter and personal sampling pump were used to sample for carbaryl for an 8-hour period. The SLTC reported 6.07 mg/m^3. The SAE for this method is 0.23. The PEL is 5.0 mg/m^3.

Step 1. Calculate the exposure severity (using Equation 9 from Section III.K.2):

$$Y = \frac{6.07}{5.0} = 1.21$$

Step 2. Calculate confidence limits
Calculate the $LCL_{95\%}$ (using Equation 10 from Section III.K.2):

.

$$LCL_{95\%} = 1.21 - 0.23 = 0.98$$

Because the $LCL_{95\%}$ does not exceed 1.0, noncompliance is not established.
Calculate the $UCL_{95\%}$ (using Equation 11 from Section III.K.2):

$$UCL_{95\%} = 1.21 + 0.23 = 1.44$$

Step 3. Classify the exposure.

Because the $LCL_{95\%} < 1.0$ and the $UCL_{95\%} > 1.0$, classify as possible overexposure.

APPENDIX O

EXAMPLE CALCULATION FOR FULL-PERIOD CONSECUTIVE SAMPLING

If two consecutive samples had been taken for carbaryl instead of one continuous sample, and the following results were obtained:

Sample Results		
	A	**B**
Sampling rate (L/min)	2.0	2.0
Time (min)	240	240
Volume (L)	480	480
Weight (mg)	3.005	2.808
Concentration (mg/m^3)	6.26	5.85

The SAE for carbaryl is 0.23

Step 1. Calculate the $UCL_{95\%}$ and the $LCL_{95\%}$ from the sampling and analytical results. Using Equation 13 from Section IV.D.4.:

$$TWA = \frac{(6.26\ mg/m^3)(240\ min) + (5.85\ mg/m^3)(240\ min)}{480\ min} = 6.055\ mg/m^3$$

Using Equation 9 from Section III.K.2:

$$Exposure\ severity\ (Y) = \frac{6.055\ mg/m^3}{PEL} = \frac{6.055}{5.0} = 1.21$$

Using Equation 10 from Section III.K.2:

$$Assuming\ a\ continuous\ sample: LCL_{95\%} = 1.21 - 0.23 = 0.98$$

Using Equation 11 from Section III. K.2:

$$UCL_{95\%} = 1.21 + 0.23 = 1.44$$

Step 2. Because the $LCL_{95\%} < 1.0$ and $UCL_{95\%} > 1.0$, the results are in the possible overexposure region. To document an overexposure, the CSHO must reanalyze the data using the more exact calculation for full-period consecutive sampling (Using Equation 14 from Section IV.D.4.):

$$LCL_{95\%} = (1.21) - \frac{0.23\sqrt{(240\ min)^2(6.26\ \ mg/m^3)^2 + (240\ min)^2(5.85\ \ mg/m^3)^2}}{5.0\ \ mg/m^3\ \ (240\ min + 240\ min)}$$

$$= 1.21 - 0.20 = 1.01$$

Since the $LCL_{95\%} > 1.0$, a violation is established.